AN EMPIRICAL ANALYSIS OF
TWO STOCKOUT MODELS

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

By

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* * * * *

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CHAPTER I

INTRODUCTION

Inventory control has been described as the minimization of the costs of obtaining and carrying inventory, and of not carrying sufficient inventory to meet demand.¹ This dissertation was directed to the third category, the cost of inventory stockouts. The purpose of the study was to explore the collection and application of empirical data for decision models of two stockout situations. Using data gathered from a specific retail purchase situation, the models were tested for their feasibility as descriptive and predictive instruments.

Background

Basic concepts of inventory management.--The basic physical distribution functions of transportation and storage create place and

time utility. A management's decisions regarding inventory policy may be stated in its inventory strategy which determines "when to hold what and in what quantities." The maintenance of an inventory incurs procurement costs and carrying costs, which include costs of storage and materials handling, interest, taxes and record keeping. If the demand for particular goods is known with certainty, knowledge of these basic costs will provide the inventory policy maker with sufficient information for calculating efficient storage levels.

However, if the demand schedule is not known with certainty, costs of not storing correct quantities may be incurred. There are two types of costs possible in this case: the costs of insufficient stock and the costs of an overstock. The costs of having too much stock, in addition to normal carrying costs, include the risk of obsolescence, spoilage, and deterioration.

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5 Enrick, *Inventory Management*, p. 5.


7 Enrick, *Inventory Management*, p. 3.
The possible costs of not having sufficient stock were listed by Miller and Starr as:

1. Sale irrevocably lost with an attendant loss of the profit that could have been made,
2. considerable loss in the goodwill of the customer,
3. cost associated with processing the special order required to get more stock,
4. expediting costs,
5. extra transportation costs.  

If one sale is lost for all time, the cost or decrease in profit can be readily calculated. Also, special ordering, expediting and transportation costs can be measured in terms of out-of-pocket expenses and additional labor. But the category called "loss in the goodwill of the customer" remains rather vague and undefined. Its size, in terms of costs, is an unknown. Bowersox, Smykay and La Londe explained:

The vexing problem in balancing inventory costs and service levels revolves around the difficulty of measuring the impact of an out-of-stock condition. A stockout, reflects immediate lost sales, which may or may not be measurable, and potential loss of a permanent customer. The full impact of a lost sale is directly related to the service policies of competitors. A customer who is denied by one supplier and serviced by a competitor may become a customer again only through the use of substantial sales and promotional effort. 

The cost information required for inventory control is considered in three categories: obtaining inventory, carrying inventory, and inventory stockouts. The first two types of costs are out-of-pocket costs; the third is a foregone opportunity cost. The out-of-

---

8 Miller and Starr, Executive Decisions, p. 537.

pocket costs were defined in twenty-seven categories by Robeson.\textsuperscript{10}

The third category presented a problem recognized by Magee; Alexander and Berg; Scheele, Westerman and Wimmert; and Fetter and Dalleck:

The cost of lost sales--revenue losses because the merchandise was not there when and where the customer wanted it--is extremely difficult to measure in most businesses. Even where the direct cost can be estimated from a tally of lost orders, it is hard to assess the effect on potential future orders from the customers. In a competitive economy, where costs of manufacture are increasingly rigid, the "unit cost" of lost sales is probably growing in most businesses.\textsuperscript{11}

It does not require mathematical genius to prepare from these factors an equation or equations that will yield an economical inventory figure and an economical order quantity. The only one of the factors that is apt to be hard to quantify is the loss of business through stock shortages.\textsuperscript{12}

Theoretically, the safety-stock level should be so established that the cost of maintaining it equals the cost of stock-outs. However, this criterion is not normally used because of the difficulty of putting an accurate dollar figure on the cost of stockouts.\textsuperscript{13}

The costs involved in failing to meet a demand frequently present the most difficult estimation problem in inventory planning.\textsuperscript{14}

Fetter and Dalleck tended to reduce the importance of accurate measurement of depletion costs: "Fortunately, decisions are quite

\textsuperscript{10} J. F. Robeson, "Physical Distribution Management: A System Approach; Session V - Inventory Management" (unpublished notes for Continuing Management Education Company), Appendix C.


\textsuperscript{12} Alexander and Berg, Dynamic Management in Marketing, p. 187.


\textsuperscript{14} Fetter and Dalleck, Decision Models, p. 33.
often very insensitive to errors in estimating this cost as well as other parameters.\footnote{15} But, they did add a word of caution: "The important question that arises here is the extent to which any estimate must be refined in order to give optimal decisions."\footnote{16}

\textit{Cost measurements for inventory management.}--Cost information is used in the management of inventories for evaluating past activities, forecasting future requirements, and as a basis for inventory strategy decisions. Magee discussed principles for defining costs used in distribution studies. He said that the costs considered should be out-of-pocket expenditures, either in cash or foregone profit opportunities, and only those potentially affected by distribution system changes. He criticized the practice of ignoring cost factors that may not be readily estimated while continuing the use of existing measures that are accurate although not necessarily applicable to the distribution study. Magee concluded:

\begin{quote}
If major errors are to be avoided, it is more important that the right costs be recognized and estimated even roughly than that data be gathered under irrelevant cost definitions for the sake of precision.\footnote{17}
\end{quote}


\footnote{16}Fetter and Dalleck, \textit{Decision Models}, p. 34.

The list of possible costs of stockouts by Miller and Starr appears to fit the Magee criteria with the exception of the cost for the "loss of goodwill of the customer." While the attitudes of customers cannot readily be measured in terms of costs, the decisions of customers do have effects that may be stated in monetary values. If a method were available that facilitated the definition and measurement of the decisions made by customers in stockout situations and their attendant financial effects, then the expected costs of an out of stock condition could be estimated. A specific out of stock condition may be described by customer, establishment and product type variables. If out of stock costs differ by these parameters, the use of a costing method with increased accuracy is necessary for optimal decision making. Conversely, if a costing method incorporating the additional variables did not improve the accuracy of cost measurements, the method should not be suggested for use by inventory managers. Based upon the previously cited opinions, a method for costing stockouts is desired for application in inventory management systems.

Chang's stock depletion cost model.--Among the best of published efforts to quantitatively measure the effects of stockouts was the model developed by Chang, working along with Niland, his adviser. The present study utilized and extended the decision model concepts described by Chang. His model was developed for measuring stock depletion costs for a metal wholesaling firm.\textsuperscript{18} Unlike most retail

situations, the model allowed for different lead times to be accepted by customers. Product substitution was not an integral part of this model as most customer needs were rather precisely defined by engineering specifications; branding was insignificant. Chang furnished a scheme of terminology which is reviewed below.

The basic Chang model, with possible outcomes specified, is shown in Figure 1. Lead times are those initially accepted or specified by the customers. If a customer approved an extension of his lead time, the action was termed 'postponement.' If the supplier judged that he could meet the lead time requirements specified by the customer, including any postponement, he would accept the order. Then the buyer would confirm the order, thus halting his search for another source of supply. The particular order was then filled, incurring some added costs for expediting which were paid at the 'compensation' step.

The more involved portion of the model was that with short lead times that were not postponed. In this case, the supplier could either accept the order or 'withdraw' from contention for this particular order. If the supplier chose the 'withdrawal,' the customer was forced to search elsewhere for the desired items, a 'departure.' Chang and Niland explained this crucial section:

The outcomes following a departure are potentially the most costly to the supplier. If, for the item involved, the buyer comes back to the same supplier for his future requirements--despite the fact that this source could not meet them the last time--the outcome is a 'return.' The only damage to the supplier, in other words, is the loss involved in a single lost sale plus any effect on 'goodwill.' On the other hand, the buyer, following such a departure may send his future
Figure 1.--Possible outcomes of a stock depletion.

orders for this item to another source of supply, such as the warehouse which meets his needs following such a departure from the original supplier. The loss in this event is not confined to a single order, but involves the loss of all future orders, as well, for this particular item. These consecutive losses are termed 'cessation.' Finally, a cessation may trigger another set of alternative events that are called 'continuation' and 'termination,' respectively. A continuation results when the buyer continues to place orders with his original supplier for all items except the one involved in the cessation. A termination occurs when, as the result of an immediately preceding cessation, the buyer also decides to sever all relations with the supplier. The latter's loss is then extended to include the future sales of all other items typically purchased by the buyer from this supplier. In other words, a termination is the complete loss of a customer.19

By assigning values to the individual outcomes and the probabilities of each chance move, Chang calculated the expected value of a single stockout. Example values were: termination = $50,000; continuation = $0; compensation = $20 to $50, depending on expediting effort.20

For measuring the effects of repeated stockouts, Chang discussed the concept of the 'period of cognition.' This period was the time in which previous departures affected a customer's decision when forced to another departure:

Consider a sequence of two departures involving one inventory item. The likelihood that the occurrence of the second departure would result in a cessation would certainly be greater where the interval between the two departures was only four months than would be the case if the interval between the two occurrences were eighteen months.21

20 Ibid., pp. 432-435.
21 Ibid., p. 431.
Repeated departures were treated as a Bernoulli process with the two possible outcomes being either a departure or a nondeparture, following directly a withdrawal or an acceptance. This process was diagramed in Figure 2. The probability of a withdrawal, hence a departure, was chosen as .15, the cost of the first departure was $105, and the cost of a second departure was $705. The cost of a nondeparture was calculated to be $39.35. The model was extended to provide a general equation for calculating $K_{ij}$, the expected cost of the jth stockout, given i preceding departures within the period of cognition.\(^{22}\)

The cognition period was recognized by Chang and Niland as a problem area. An exponential function was assumed to describe the probability of cessation. In actual calculations, a simple step function was used, as shown in Figure 3. Several assumptions were developed pertaining to the concept of a period of cognition:

1. The period of cognition is based on the seriousness of a typical case of departure as it would be almost impossible to ascertain the degree of seriousness of an actual departure for every case. . . .

2. The duration of a cognition period may be affected by the number of instances of satisfactory service following a departure, and their value to the buyer. . . .

3. The occurrence of a second or third departure during one cognition period may serve to lengthen the cognition period. . . .

4. The use of an exponential distribution is no more than an approximation to the shape of a 'retention' curve, and the

Figure 2.--Decision tree for two stockouts.

Figure 3.--Theoretical and simplified exponential distributions for the departure of a customer.

psychological evidence to support this contention is not
great.\textsuperscript{23}

In another article produced from the same study, Chang summa-
ized his findings:

\ldots it was shown that the major determinant of stock-out
cost was not the size of the order but the subsequent reaction
of the customer who had encountered stock-out cases, and the
customer's reaction depended largely on the frequency of prior
stock-outs he had experienced during a relevant time period.\textsuperscript{24}

In Chang's study, a stockout typically involved an order for several
hundred units of a metal product. Except for emergencies, a short
lead time, on the order of several days, was the industry norm.

The models to be described in the present study are of similar
form to that of Figure 1. However, the decision alternatives used by
Chang were for application in the wholesale business that he studied.
His was not a general method which could be applied to other specific
stockout situations. For instance, retail purchase situations would
differ greatly from the model developed by Chang. Differences in
stockouts at various levels in marketing channels are reviewed in
Chapter II.

Further research in this area is required to formulate models
of a variety of stockout situations. From these models may be drawn
conclusions concerning the general nature of the effects of stockouts.
As demonstrated by Chang, specific model development and testing may

\textsuperscript{23}Chang and Niland, "A Model for Measuring Stock Depletion
Costs," pp. 442, 444.

\textsuperscript{24}Yu Sang Chang, "Reorder Point Models with Non-Decreasing
Stock-out Costs," \textit{Journal of Industrial Engineering}, Vol. 18 (June,
be an incremental but necessary contribution to the problems of measuring the effects of stockouts.

Statement of the Problem

Before the effects of an out of stock situation can be measured, knowledge of the decisions of the potential buyers is necessary. Are customers likely to purchase substitute products, switch sources of supply temporarily, become permanently lost customers or simply postpone their demands?

For each of these alternatives, an activity cost can be calculated, based on individual product costs, prices, and average sales generated by each customer. Then, the activities and their costs may be used for constructing decision models, similar to Chang's, to describe the purchasing decisions made when customers encounter out of stock situations. If information were obtained about the relative frequency with which each of the alternatives is chosen, probability measures could be derived for that specific stockout situation. With the activities, their costs and probabilities of occurrence, expected values of an out of stock could be calculated. These expected values would then be related to the other inventory costs to complete the total cost picture for inventory management.

The objectives of the dissertation were to:
1. Formulate models which (a) described the decisions of retail customers who encountered specific out of stock conditions, and (b) provided useful financial measures of the effects of these customer decisions.
2. Develop and employ a procedure for gathering empirical data applicable to the specific stockout situations modeled.

3. Empirically test the models in a retail purchasing situation to observe their compliance or noncompliance with pre-conceived hypotheses for the specific stockout situations.

Scope

The study was developed around the two stockout models to be described in Chapter III. While variations of these and other models may be valuable for further understanding of the problems of measuring the effects of inventory stockouts, the objectives were to demonstrate measurements for these specific stockout situations.

The stockout situations considered were those that may occur in the retail liquor stores operated by the Ohio Department of Liquor Control. Stockout effects were measured and reported as they affected the individual store, rather than as they may have affected the operations of the Department as a whole.

Although the present study describes the analysis of the two stockout models and demonstrates the measurement of the effects of stockouts, it is still one part of a larger problem, that of minimizing the total cost of inventory management. For this reason, an introduction to basic inventory control literature is provided in Chapter II. The purpose of this review is to place the problems of stockout measurement in perspective with other elements of inventory management. More extensive treatments of these elements are provided in the literature and were not considered requisite to the nature of the
present study.

**Hypotheses**

**Assumptions.**—It was assumed that the models developed did, in fact, describe the stated stockout situations. The models were of two conditions: the single stockout case and the repeated stockout case. It was furthermore assumed that the questions asked of customers were related directly to the elements of the models.

**Hypothesis 1.**—The actions of customers who encounter a single stockout situation do not vary by product group.

**Discussion.**—The rejection of this hypothesis would indicate that customers who encountered a stockout of an item in product group X might readily substitute another item but customers who were searching for an item in product group Y might tend to substitute sources of supply rather than substitute items.

**Hypothesis 2.**—To a seller, the cost of a single stockout does not depend upon the product group in which the stockout occurs.

**Discussion.**—This hypothesis follows directly from Hypothesis 1 with the addition of the cost effects of each separately identified customer decision in the stockout situation. Hypothesis 2 might be rejected because of widely differing cost effects for the various product groups even if Hypothesis 1 indicated that customer activities did not tend to vary by product group. Conversely, the rejection of Hypothesis 1 does not imply the rejection of Hypothesis 2 because varying cost effects could tend to cancel the effects of different customer decisions.
**Hypothesis 3.**--The actions of customers who encounter repeated stockouts of a specific item do not vary by product group.

Discussion.--If a desired item is not available on several trials, the customer must choose a substitute item or alternate source of supply if his demand is to be satisfied. The rejection of this hypothesis would indicate that customers for items in different product groups do not tend to make similar decisions with the same frequency under these repeated stockout conditions.

**Hypothesis 4.**--The cost of repeated stockouts, to a seller, does not vary according to the product group in which the stockout occurs.

Discussion.--This hypothesis is a parallel of Hypothesis 2. If Hypothesis 4 were rejected, it would indicate to a seller that repeated stockouts of one product group tend to be more serious, in terms of cost to him, than repeated stockouts of another product group.

**Hypothesis 5.**--The actions of customers who encounter a single stockout situation do not vary by specified demographic variables.

Discussion.--The demographic variables included were age, family income, marital status, sex, and years of education. This hypothesis is more precisely stated as five sub-hypotheses:

**Hypothesis 5a.**--The decisions of customers encountering a single stockout situation do not vary by age.

**Hypothesis 5b.**--The decisions of customers encountering a single stockout situation do not vary by family income.
Hypothesis 5c.--The decisions of customers encountering a single stockout situation do not vary by marital status.

Hypothesis 5d.--The decisions of customers encountering a single stockout situation do not vary by sex.

Hypothesis 5e.--The decisions of customers encountering a single stockout situation do not vary by education.

Rejection of any one or more of these sub-hypotheses would indicate that the decisions of customers in stockout situations, as specified, tend to vary for different demographic groupings. Rejection of these hypotheses would also suggest that the corresponding variables might contribute to the accuracy of a predictive model of stockout costs.

Hypothesis 6.--The decisions of customers encountering a repeated stockout situation do not vary by specified demographic variables.

Discussion.--Like Hypothesis 5, this broad hypothesis is separated into five sub-hypotheses:

Hypothesis 6a.--The decisions of customers encountering a repeated stockout situation do not vary by age.

Hypothesis 6b.--The decisions of customers encountering a repeated stockout situation do not vary by family income.

Hypothesis 6c.--The decisions of customers encountering a repeated stockout situation do not vary by marital status.

Hypothesis 6d.--The decisions of customers encountering a repeated stockout situation do not vary by sex.
Hypothesis 6e.--The decisions of customers encountering a repeated stockout situation do not vary by education.

Rejection of any of the above would indicate that customers in different demographic groups tend to make different decisions in the specified stockout situation. The construction of a predictive model of stockout costs for the repeated stockout situation should include the variables associated with any of the above rejected sub-hypotheses.

Hypothesis 7.--The use of product variables and demographic variables in a predictive model does not increase the accuracy with which the cost of a single stockout situation can be estimated.

Discussion.--Rejection of this hypothesis would indicate that a simple stockout model which included only the relative frequencies of each customer decision and their respective cost effects was not as accurate an estimator as a model which also included product and demographic variables.

Hypothesis 8.--The use of product variables and demographic variables in a predictive model does not increase the accuracy with which the cost of a repeated stockout situation can be estimated.

Discussion.--As with the discussion for Hypothesis 7, the rejection of this hypothesis would indicate that the more involved model did provide increased accuracy. If the hypothesis were not rejected, it would be difficult to justify the collection of the additional product and customer data and to include this data in the costing procedure.
Methodology

Decision models based upon the actions of customers who encountered both a single out of stock situation and a repeated stockout situation were developed in the first part of the study. Alternative activities considered in the models were purchase decisions affecting product, brand and source selection. Monetary measures were assigned to each purchase decision so that an expected monetary value of a stockout could be calculated in a procedure similar to that described by Raiffa. Dollar sales figures were used as one monetary measure for each alternative since price information is a readily accessible and accurate financial measure. Another indicator was the gross sales margin, a measure of the amount of revenue available to cover operating expenses and contribute to net profit.

Empirical data were gathered under conditions described below. The operation of the models and testing of the hypotheses were done using this data base.

One marketing institution where stockouts have been recognized as a problem area and where there is relatively little customer feedback information is the retail liquor marketer. In the state of Ohio, all retail liquor establishments are controlled by the Department of Liquor Control, making the retail liquor distribution industry an effective monopoly. Liquor may be sold by the drink only in

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26 Howard Huntzinger, "Top Brand Stock Low In Some State Stores," Columbus Dispatch, May 16, 1971, p. 2A.
establishments that have obtained permits from the Department.\textsuperscript{27} Bottles of alcoholic beverages in excess of 42 proof\textsuperscript{28} are retailed by the Department's stores and contracted agencies.\textsuperscript{29} Liquor products are supplied to permit holders by the Department's wholesale outlets. Both wholesale and retail outlets receive inventory from five warehouses contracted by the Department and responsible for operations within defined warehouse districts.\textsuperscript{30}

Because the Department's operations are within a closed system, with marketing elements such as store and warehouse locations, product offerings and pricing all regulated and matters of public record, the Department was described by La Londe as "an ideal lab to test the most advanced thinking."\textsuperscript{31} All liquor customers must purchase their supplies through Department-controlled outlets or illegally transport them into the state.

\textsuperscript{27}Ohio, Department of Liquor Control, Annual Report: 1969, p. 18.

\textsuperscript{28}Ibid., p. 17.

\textsuperscript{29}Ibid., p. 22: "Agencies are privately-owned outlets located in sparsely populated areas of the state where people need service, but where the operation of a state store would be economically unprofitable."

\textsuperscript{30}Ibid., p. 41. Districts are: Cincinnati, Toledo, Columbus, Massillon and Cleveland.

Customers' responses to stockout situations at the retail level were surveyed by questionnaires distributed in state liquor stores. The method was efficient because only actual liquor customers were included, as opposed to a random population sample mailing, for instance. Furthermore, since most of the bottled liquor purchased at retail in the state is supplied through Department channels, allowing for some leakage across state borders, the sample obtained could be directly related to the total retail liquor market in Ohio.

Liquor store customers were asked about their expected purchase decisions under stockout conditions, their actual purchases made the day of the sampling, their opinions about various elements of the store's service mix, and several demographic questions.

Questionnaire responses were key-punched and analysed through the use of available counting and tabulating programs. Hypotheses 1, 3, 5 and 6 were tested for group differences by the chi-square test.\textsuperscript{32} Analysis of variance techniques were used to test hypotheses 2 and 4. Hypotheses 7 and 8 were tested through the application of a multiple discriminant analysis program.\textsuperscript{33}

Limitations

The particular type of business in which the study was conducted presented some possible limitations to the accuracy and


utilization of the results obtained. First, the products considered may have carried severe social connotations for some customers. It was observed that people may be rather sensitive to being queried about their liquor purchasing practices. This sensitivity may have affected the responses. Some customers may have declined the invitation to complete the questionnaire because of the subject matter. Others may have intentionally misrepresented their replies to the questions. It cannot be stated with certainty that the distribution of the respondents, along demographic variables, was the same as the distribution of recipients of the questionnaires.

A second attribute of the business situation studied was the fact that it was owned and operated by the state of Ohio. Comments written by respondents indicated that there was some degree of adverse feeling about a government-controlled business and the possible political overtones inherent. These feelings may have been reflected in the opinions recorded in the data.

The wording of the questions was designed to suggest anonymity with the objective being that few, if any, customers would feel that their rights of privacy were being infringed upon. In addition, the questionnaire contained a short introductory letter from the director of the Department which associated the study with the Ohio State University Research Foundation, an organization with a less direct political connotation.

The accuracy of predicting the cost of a future stockout based on decisions made for a past stockout will depend on the likelihood of
customers making the alternative purchase decisions with the same relative frequencies. Since most of the questions were asked in the "What would you do if . . . ?" form, there may be discrepancies between what the respondents indicated and what their actual decisions would be. The accuracy of predicted stockout costs will be an unknown factor because both selling prices and customers' attitudes are subject to change. However, reasonable magnitudes of the costs of specific product shortages were calculated.

By virtue of the business organization involved, the results of the study may not be directly applicable to private business firms. Customers were aware that the liquor stores were controlled by a government body and that alternative sources of supply within the state were under identical control. The parameters measured may have been affected by this particular business environment, to the extent that it influenced customers' decisions. It would be difficult to justify a direct application of the results of this study to a situation with independently owned and operated business establishments, price competition and other marketing dissimilarities. However, the methods developed in the study are not considered to be dependent upon the form of business organization and may be readily adaptable to a variety of inventory management situations.

Possible contributions of the study

Users of the total cost concept of inventory management require a method which will provide information about the cost of an out of stock situation with accuracy approaching that of the recognized
costs of obtaining and carrying inventory. A method based upon the stockout models formulated as part of this study would meet the above requirements. Such a method would replace the practice of selecting some level of service which one wishes to maintain, or of estimating a penalty cost for a stockout, or of ignoring that cost entirely. The ability to measure the cost of individual stockout situations would be valuable to inventory managers in determining priorities among product lines.

The findings of the study apply to the products and marketing environment specified. While there may be a desire by some to draw general conclusions from the results and apply them to other retail consumer products, this was not the expressed objective of the research. What was intended was that the feasibility of model-building and testing in stockout situations be demonstrated.

Organization

The subject studied was introduced in Chapter I, with both a general background and specific problem statement included. A review of the literature related to inventory control in general and stockout situations specifically will be included in Chapter II. Recent literature pertaining to the business environment which served as the data source for this study will be briefly reviewed. Also included in Chapter II are writings which describe the model-building and data analysis methods employed in this study.

The specific research design is described in Chapter III. This chapter, along with associated appendices, includes the complete
procedure followed in the study. The findings of the research, based mainly upon the tests of the eight hypotheses listed in the first chapter, are contained in Chapter IV. Included in the fifth chapter are a summary of the study and implications for use of the findings in actual practice and in further research activities.
CHAPTER II

EXISTING INVENTORY MANAGEMENT MODELS AND OPINIONS

Introduction

The general background of thought applicable to the question of stockouts and their costs is developed in this chapter. Opinions expressed in the literature furnish an insight into inventory management problems in general and stockout problems more specifically. The extent of these problems has been perceived differently by writers of various times, business establishments and markets.

Knowledge of existing inventory management models may explain the need for methods of costing inventory stockouts. Familiarity with the literature may also establish reasons for the relative lack of emphasis in the area of stockout cost measurement.

The problems of inventory stockouts were first discussed in the general literature of inventory management. Stockouts were not usually treated as situations to be analyzed but as problems to be avoided through adequate control of inventory levels and reordering policies. Economic ordering quantities, based on a simplified total cost equation which did not contain a cost of inventory shortage, were calculated to implement these policies. Fundamental considerations of total cost analysis are examined in this chapter, including a derivation of the basic economic ordering quantity.
The purpose of many of the writers discussed in this section was to define the costs of inventory management so that the total inventory costs might be controlled. Writers gradually began to describe the effects that stockouts had on a business. Although it was recognized that stockouts were ultimately reflected in financial statements, they were often discussed in terms of their effects on the firm's service level and customer goodwill. These effects were difficult to quantify because of unknown factors such as product substitution and backlogging of orders.

More recently, the out of stock condition has been treated directly as a cost incurring activity. Allowance for the costs of stockouts has been made in total cost equations by the addition of a depletion penalty function. The present study is basically concerned with providing methods to evaluate this penalty, or cost, of a stockout. Although the recent literature includes extensive theoretical treatments of total cost formulations which include depletion penalties, the brief review of depletion penalties in this chapter was intended to provide insight into the necessity for empirical data to be applied to stockout measurements. In addition to the Chang model, described in Chapter I, other attempts to quantify the effects of inventory stockouts are reviewed in this chapter.

Before formulating stockout decision models in Chapter III, basic writings on models and model building are briefly reviewed in this chapter. Several definitions of models are developed
and the terminology of model builders and users is examined.

A section on the marketing aspects of the liquor industry concludes the chapter. The intent of this short section is to acquaint the reader with the types of products handled and with the kinds of information being generated for use by marketers of liquor products.

Early literature

The earlier writers concerned with inventory management viewed it mainly from the position of the manufacturer. This procession was natural for those in the industrial engineering field and those concerned with efficient management of production facilities. Cartmell discussed the factors to be considered in determining ordering quantities. He used the term "economic ordering quantity" but did not suggest procedures for calculating specific values.

The ordering quantity is the smallest quantity which ordinarily it is economical to procure either by purchase or manufacturing at any one time. In setting the minimum figure for this ordering quantity, the length of time required to secure the new stock, the cost of beginning production, or the loss of the gains of large-scale purchase are matters taken into consideration. The upper limit of the quantity is governed by the costs of and convenience of storing the materials during the period it lies in the storeroom awaiting use.¹

An "economic ordering quantity" is too low when it increases the unit cost unnecessarily. . . . In practice the upper limit of the ordering quantity is set by the sales or consumption schedule.²

²Ibid., pp. 135-136.
Davis described the basic mathematical relationships for calculating ordering quantities. Note that he called for the greatest quantity while Cartmell discussed the smallest quantity.

The maximum ordering quantity, Q, is the greatest quantity in which the material is normally ordered. It should also be the quantity which can be manufactured at the least unit cost. . . . Other things being equal, the quantity that can be manufactured at least unit cost varies directly as the square root of the preparation cost of manufacturing and inversely as the square root of the interest and storage charges.\(^3\)

Wilson, writing in the *Harvard Business Review* and later in *Purchasing*, presented specific instructions to purchasing agents for finding the economic ordering quantities. He eased their burden of calculating by furnishing a circular slide rule designed to provide direct readings of economic ordering quantities. Wilson did not stress the manufacturer but discussed the subject in more general terms. He recognized the problem area of stockout conditions and considered it in his system objectives:

. . . any system for the efficient control of merchandise should aim at operating each individual stock item at maximum efficiency. In order to do this it is necessary for the system to provide a means for accurately determining for each stock item: (1) the most economical amount of stock to order (ordering amount), and (2) the minimum amount of stock which should be on hand when a fresh supply is ordered to control the "out-of-stock" condition at minimum cost (ordering point).\(^4\)


Arrow noted that the earlier literature contained the individual elements found in later inventory models, "though the form was frequently rather imprecise and little was done to integrate them into a consistent framework." He noted also that "economic theory has had remarkably little to say about inventories," but acknowledged the "very considerable literature on a closely related topic, the demand for money." He cited Keynes' motives for holding cash, namely the transaction, precautionary, and speculative motives, and he developed parallel reasoning for holding inventories of economic goods. A more recent article produced an example of circular development: Orgler suggested that basic inventory control techniques be applied to the cash requirements of commercial banks.

Economic ordering quantity

A short derivation of the economic ordering quantity (E.O.Q.), using the terminology of Fetter and Dalleck, is developed below. E.O.Q. is also called economic purchase quantity, economic batch quantity and economic lot-size.

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6 Ibid.


8 Fetter and Dalleck, Decision Models, pp. 8-9.
TC = total cost per time period
D = demand rate
C = price/unit
S = ordering cost
I = carrying cost rate for the demand period
Q = order quantity

The total cost equation shows the relationships of the above elements:

\[ TC = C \cdot D + S \cdot D/Q + (I \cdot C) \cdot Q/2 \]

Differentiating with respect to Q, and setting equal to zero:

\[ \frac{d(TC)}{dQ} = -\frac{D \cdot S}{Q^2} + \frac{I \cdot C}{2} = 0 \]

Solving for Q:

\[ Q^2 = \frac{2 \cdot D \cdot S}{I \cdot C} \]
\[ Q = \sqrt{\frac{2 \cdot D \cdot S}{I \cdot C}} \]

Refinements of the basic E.O.Q. method have appeared in several articles. Snyder explained that E.O.Q. "can be interpreted as a quantity range, rather than a fixed quantity," because, on a graph of total cost vs. quantity, "the curve near the EOQ is almost flat. The

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EOQ is merely the precisely calculated low point of this flat section.\textsuperscript{10} Hence, relatively small variations around the calculated quantity have little effect on the unit cost.

Another criticism of the simple E.O.Q. formula is that it does not take into account price changes for large lot sizes. Metaxas suggested that the E.O.Q. be calculated for each possible unit price. Then, the closest available lot sizes, at each price break, would be used to calculate total equivalent costs by the original total cost equation. The quantity which produced the lowest annual total equivalent cost became the ordering quantity; it may be quite different from that calculated by the E.O.Q. formula.\textsuperscript{11}

A major criticism of the E.O.Q. method is that it assumes known demand schedules and lead times. Wagner and Whitin described an algorithm for a solution to the dynamic version of the economic lot size model. Their method allowed "the possibility of demands for a single item, inventory holding charges, and setup costs to vary over N periods."\textsuperscript{12} The Wagner-Whitin algorithm was recommended by Kaiman

\begin{itemize}
\end{itemize}
usage." Philippakis compared the E.O.Q. formula and the Wagner-Whitin algorithm and presented a method for computing the error resulting from the application of the E.O.Q. formula, stating flatly that "The Wagner-Whitin method is the correct one." Kaimann recognized the fact that, for constant or nearly constant demand, the E.O.Q. formula provides the lowest cost quantity. He suggested using a coefficient of variation of demand as "a criterion value to use in determining when each of the two philosophies is most appropriate." Emphasis on minimizing costs

Most writers of inventory control literature discussed the costs included in the basic E.O.Q. model and the criterion that called for the minimization of these costs. One critic was Eilon:

For batch production and for many inventory control systems I consider the classical model as a poor exercise in sub-optimization. It is neither justified nor realistic to ignore the interdependence of products, so that solutions . . . cannot and should not be used on their own. As for the more fundamental but equally practical problems--determination of cost parameters and use of criteria--discussions are likely to continue for some time to come. Tate defended the classical E.O.Q. model from attacks on the

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criteria of minimizing costs in favor of maximizing net profits and return on investment. He showed mathematically that "optimizing any of the alternative functions would be equivalent or inferior to minimizing costs."\textsuperscript{17} Stephenson and Willett did not accept this conclusion because the effects on revenue due to varying customer service levels were not considered:

When the company objective is profit performance, an optimal relationship must be found between the costs of operating a physical distribution system and the revenue created by the service that customers receive. Unfortunately, companies are generally unable to identify this relationship due to the difficulty of measuring the revenues generated by different degrees of service. Thus, some try to minimize the costs of meeting a predetermined service standard, or they attempt to improve present service while holding costs constant.\textsuperscript{18}

The emphasis on minimizing costs may be explained by recognizing them as variables to be measured and controlled. This idea was developed by Johnson, Kast and Rosenzweig:

The main objectives of cost control are to measure operating efficiency and to keep costs within a specified range. . . . If it were possible to distribute costs more accurately, it would also be possible to maintain better control. Most problems arise because of the inability to plan or to measure cost performance accurately.\textsuperscript{19}

The manner in which the cost elements are controlled determines the


levels of customer service and profit. If customer service levels were to be measured in terms directly comparable to other costs, perhaps Stephenson and Willett would have accepted the criteria of minimizing total costs. In this way, total cost would account for changes in revenue due to variable service levels, and the most efficient level could then be projected.

Costs of Inventory Control

The classical E.O.Q. model was developed using only the costs of procuring and carrying inventory. With a known demand pattern, this model was complete. As rationalized by Brown and Beik:

Under these conditions, the complicating factors of shortages and safety stocks are eliminated. We do not even have to account for the costs of being out of stock.²⁰

To allow for variations in demand and in lead times, practitioners maintained safety stocks calculated to assure their chosen levels of customer service. This practice was a departure from total cost control because two cost elements of maintaining an inventory were being compared with some non-cost factor instead of the cost of not maintaining an inventory. The reason for this departure was the difficulty of measuring the cost of a lack of inventory.

Current literature on inventory management presents nearly identical control objectives. For example, consider Fetter and Dalleck, Parker, and then Barrett:

The right level of inventory— the optimal inventory — is that which results in minimizing the total of the following

²⁰Brown and Beik, Marketing Research and Analysis, p. 491.
categories of cost:
1. Cost of acquiring inventory.
2. Cost of carrying inventory.
3. Cost of demand lost or deferred owing to inventory shortage.21

The most important cost, and the cost on which attention should be focused in any attempt to improve efficiency and reduce costs, is the total cost of performing the physical distribution activity—not the separate costs of the individual segments. In other words, it is a mistake to concentrate on reducing the cost of one factor only—such as transportation—when to do so has the effect of increasing the cost of another factor by an amount greater than the amount saved. Conversely, it is wise from the standpoint of improved efficiency and reduced marketing costs to increase one cost if, by decreasing other related costs, the net effect is to reduce the total cost of physical distribution.22

The purpose of an inventory control system is to reduce the costs associated with maintaining an inventory. These costs fall under three main headings: the cost of holding stock, the cost of not holding stock, and the cost of the work-load caused by movements of merchandise in and out of the inventory and the corresponding movements of information.23

Bronner defined four principle objectives of inventory management for a manufacturing company. While they are broader in scope than the above three statements, the same general theme was included in his second and third objectives:

The first is to improve customer service. . . .
The second objective of this concept of inventory management is to lower operating costs. . . .
The third objective is to reduce inventory investment to a point where it represents maximum return on the investment.

21Fetter and Dalleck, Decision Models, p. v. Also see Brown and Beik, Marketing Research and Analysis, p. 490.


23Barrett, Automatic Inventory Control Techniques, p. 1.
consistent with all other considerations. . . .
The fourth objective is to stabilize employment.²⁴

The cost elements discussed by Fetter and Dalleck and by
Barrett are surveyed individually below.

Procurement costs.--These are the costs of obtaining inventory
and have been described as "transfer" costs.²⁵ The cost items in-
cluded in this category were presented by Enrick and by Alexander and
Berg:

1. Requisitioning.
2. Preparation of purchase order.
3. Placement of order.
4. Followup of order.
5. Receipt of shipment.
6. Movement to storeroom.
7. Accounting.²⁶

The cost of buying an order, which includes the expense of
time and materials used in negotiating and preparing it and
all expenses involved in receiving a shipment and merging it
with inventory.²⁷

Enrick estimated that the cost per order ranged from $4 to
$15.²⁸ The difficulty of measuring procurement costs was described by
Smith. He suggested that all variable procurement costs be considered:

²⁴ Stanley Z. Bronner, "Organizational Aspects of Inventory
²⁵ Alfandary-Alexander, Models of Inventory Systems, p. 22.
²⁶ Norbert L. Enrick, "Modern Inventory Management--Part 1:
Determining Optimum Lot Sizes," Textile World, Vol. 114 (February,
(1) It is a procurement cost per shipment received.
(2) Only costs which vary with the number of shipments received should be included.
(3) These costs should be included regardless of which department they are charged against.
(4) Making sure that all the pertinent costs are included is more important than the precision with which they are measured.\(^{29}\)

**Carrying costs.**—This cost category generally receives the most extensive treatment in the literature, probably because it is the largest apparent cost of inventory management. Heskett, Ivie and Glaskowsky estimated the magnitude of the national annual inventory carrying costs as more than five percent of the gross national product.\(^{30}\) The costs of carrying inventory were classified by Enrick as: interest, obsolescence, deterioration, spoilage, materials handling, insurance, taxes, and record systems.\(^{31}\) In a study for the textile industry, Enrick listed cost ranges as percentages of the inventory value:\(^{32}\)


<table>
<thead>
<tr>
<th>Element</th>
<th>Approximate Percent of Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interest on money tied up in inventory</td>
<td>Low 5</td>
</tr>
<tr>
<td></td>
<td>High 15</td>
</tr>
<tr>
<td>Obsolescence, depreciation and spoilage</td>
<td>Low 2</td>
</tr>
<tr>
<td></td>
<td>High 8</td>
</tr>
<tr>
<td>Storage and handling</td>
<td>Low 1</td>
</tr>
<tr>
<td></td>
<td>High 5</td>
</tr>
<tr>
<td>Insurance</td>
<td>Low 1</td>
</tr>
<tr>
<td></td>
<td>High 3</td>
</tr>
<tr>
<td>Taxes</td>
<td>Low 0</td>
</tr>
<tr>
<td></td>
<td>High 2</td>
</tr>
<tr>
<td>Total</td>
<td>Low 9</td>
</tr>
<tr>
<td></td>
<td>High 33</td>
</tr>
</tbody>
</table>

At the retail level, holding cost rates for department stores were studied by Edwards. He computed, for fourteen staple inventory items, the costs of the following elements:

1. Cleaning and Handling Labor
2. Imputed interest on the Inventory Investment
3. Depreciation of Fixtures
4. Deterioration and Obsolescence
5. Insurance on Contents
6. Real and Personal Property Taxes
7. Utilities
8. Rent
9. Maintenance

The highest cost element was interest on the inventory investment. Total holding cost rates were computed to range from 11.56 per cent to 33.32 per cent of the sales dollar.\(^{34}\)

An annual carrying cost of 15 to 30 per cent of inventory value was estimated by Gring.\(^ {35} \) Inventory of maintenance parts was


\(^{34}\)Ibid., p. 55.

reported to average between 12 and 14 per cent of a trucking fleet's revenue.36 These figures were all of the same order of magnitude as the 25 per cent of inventory cost presented by Alford and Bangs in 1954.37

Richmond presented a qualitative financial viewpoint while discussing the holding of inventory:

The advantage of having a balanced and reduced inventory investment can be recognized from the fact that inventories are considered as current assets with full realizable value in a reasonable time. This definition does not fit slow-moving, excessive, or obsolete items where the supply is excessive or obsolescence factors exist.38

Groot and Groot described a general carrying cost formula used in Europe. The annual carrying cost for 100 units average inventory was:

\[
(Tu) + \frac{(100*v*s)}{c}
\]

Where:
\[
T = \text{Total present cost (interest, obsolescence, deterioration, insurance and taxes).}
\]
\[
U = \text{Unit price.}
\]
\[
V = \text{Volume in cubic feet of one container in which the commodity is packed.}
\]
\[
S = \text{Yearly cost of 1 cubic foot of net storage space in the warehouse.}
\]


C = Contents of one container in units of the commodity. 39

The authors made a point of the European practice of calculating the ordering cost and the carrying cost for each individual commodity instead of applying a constant cost factor for all commodities. For each product, a cost factor was calculated as: 40

\[
\text{Cost factor} = \frac{\text{Ordering cost (per order)}}{\text{Carrying cost (per 100 units of average inventory)}}
\]

In practice, a set of tables was used to relate the cost factors to economic order quantities and order frequencies. Certain advantages were claimed for this method. 41

Calculation of E.O.Q. based on the constant cost factor ignores the effect of the unit price change. The resulting inaccuracy in determining order quantity is a rather costly oversimplification. Under the European method, the cost factor varies substantially—from 0.1 to 3.0.

Ammer advised inventory managers to use marginal cost analysis for decision making that may affect inventory levels: "Cost of possession is subject to wide swings even when there is almost no change in other costs." 42

Because inventory requires an investment of funds, Burgin and

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40 Groot and Groot, "European Practice," p. 27.

41 Ibid., p. 31.

Wild advocated a criteria for determining stock investment which was based on return on capital.\textsuperscript{43} The use of average inventory levels for calculating interest costs was commented on by Beranek. He cautioned that this assumption of an inventory level was not always valid; the investment of funds was actually determined by the cash inflow which governed the repayment of the funds. Otherwise, "cash is implicitly borrowed from other segments of the firm,"\textsuperscript{44} thus understating carrying costs. Dickinson suggested the use of an interest rate close to that for a cash loan secured by the inventory. He reasoned:

\[\ldots\text{inventory is close to cash, or at least closer to cash, than most alternative forms of investment. The risk factor is, therefore, lower, so that a large penalty is not in order.}\textsuperscript{45}\]

One inventory control situation where net return appeared to be the more generally applied criteria was that of products with limited selling seasons, hence significant obsolescence costs. The importance of this particular carrying cost was emphasized by Hertz and Schaffir:

The cost of obsolescence--that is, of having stock left over at the end of a season--overshadows all other costs of


carrying inventories.\(^{46}\)

For fashion merchandise, Barrett cited "the cost of not holding stock and the cost of obsolescence"\(^{47}\) as the major cost factors for a retail operation.

A standard illustration of obsolescent inventory problems was the newsboy case, referred to in the Hertz and Schaffir article. Magee provided a general background for this type of problem:

The question boils down to how much stock to have on hand when the main selling season opens. The objective basically is to have enough on hand so that the company can expect, on the average, to break even on the last unit produced; that is, to carry enough so that on the last unit the expected risk of loss due to inability to fill demand equals the expected cost of carrying the unit through to next season.\(^{48}\)

Magee called this situation a "crash" problem and furnished generalized mathematical expressions for maximizing expected profit.\(^{49}\)

Stockouts--general writings

Definition.--A stockout was defined by Boot as: "When a product is demanded and there is no stock to satisfy demand."\(^{50}\) It is not sufficient to say that the inventory of a product is zero; if the


\(^{47}\) Barrett, Automatic Inventory Control Techniques, p. 15.


\(^{49}\) Ibid., p. 60.

\(^{50}\) Boot, Mathematical Reasoning, p. 138.
demand for this product were also zero, the optimum inventory level would be in effect. To repeat: there must be an unfilled demand. The above definition differs little from a somewhat less precise one published in the retail grocery industry: "A product of any brand, size, shape, flavor, color or type is out-of-stock if the item is usually carried in the store, but is not found on the shelf at a given time." An added refinement was the condition that the product be usually carried, not one that may have been offered only in special situations.

**Impact of stockouts.** --The significance of stockouts has been debated in many articles and books. A short collection of opinions shows some lack of agreement in the seriousness of the effects of stockouts although most writers acknowledged the difficulty of measuring these effects. In describing factors for inventory standards, Alexander and Berg concluded:

The only one of the factors that is apt to be hard to quantify is the loss of business through stock shortages. Proper records should enable management to set a minimum figure for this in the form of immediate losses of sales due to inability to meet requests for merchandise. Long-run losses due to damaged goodwill must probably be estimated.52

Ammer recognized the importance of considering the risk of stockouts and balancing their effects against the cost of carrying safety stocks. For example, he said that safety stocks of low-cost


items were almost always better values than safety stocks of expensive items. "The high-value items have lower safety stocks because the cost of protection is so high." \(^{53}\) Thus, a given investment in inventory could protect against many more stockouts of low value items than expensive items. Ammer also criticized managements for their over-protection against stockouts:

All too often they are unwilling to accept the idea that if they want tight inventory control they must be willing to risk an occasional stockout. It takes a courageous materials manager to risk running out of stock when he knows it pays to take the risk. When the stockout does occur, his boss is all too likely to think only of the immediate loss and forget the enormous gains that come from low safety stocks and close control. \(^{54}\)

**Service level.**—The level of customer service was directly related to the incidence of stockouts by Barrett: "'level of service' . . . the sales of an item made immediately from stock, divided by the item demand." \(^{55}\) Constantin defined it nearly the same, allowing time for order-filling: "... the percentage of products available for shipment to customers on the day an order is received." \(^{56}\) Daykin criticized the above definitions and suggested one based on time:

Service levels can be more meaningfully expressed in most situations in terms of the per cent of time that stock is available to satisfy a demand. It is easier to comprehend


\(^{54}\) Ibid., p. 255.


being out of stock for 18 days during the year (95% service level) than to think of the same situation in terms of numbers of orders back ordered or lost during the same period.57

Barrett claimed that the service level was a better assessment of the stock controller's efficiency than was the number of stockouts which occurred:

We are not so interested in the number of times he runs out of stock as in the total demand which is lost, or otherwise affected, by the stock-outs. There must be a measure of how serious a stock-out is likely to be, as well as the probability of its occurrence.58

It follows, then, that the cost of a stock-out is related to the level of service. Writers agreed on this connection but presented differing views of how to account for this cost. As explained by Oravec and by Fichtl, it appeared to be more feasible to set standards for service than to express stockout costs in monetary terms:

Since the cost implication of a stock shortage of an item is one of the main cost elements to be weighed against the cost of carrying protective stock, it is clear that some means must be found for establishing the direct or indirect costs incurred as a result of such a shortage. In most cases it thus becomes necessary to devise alternative measures for giving dollars-and-cents expression to actual or potential "stock-outs." Naturally these alternative measures must be designed for full utilization of the intuitive judgment of management regarding the level of service that must be provided, with due regard to the more directly measurable costs of maintaining such a level of service.59

57 Philip D. Daykin, "Inventory Costs, Service Levels And Reorder Points," Production and Inventory Management, Vol. 7 (October, 1966), p. 53.

58 Barrett, Automatic Inventory Control Techniques, p. 25.

How is an acceptable level of customer service determined? It is the point at which the cost of carrying additional safety stock exceeds the cost of being out of stock. Since it is difficult to determine these costs accurately or readily by mathematical formula, management should set the level of customer service they feel is desirable in order to be competitive, weighing the costs of carrying additional safety stock.  

The use of alternative measures was extended by Morgan, "because we do not always know what the costs are if we should fail to fill an order."  

Morgan summarized:

Generally, rather than using the cost of shortage, we set up a criterion on being out of stock a certain proportion of the time. This specification gives a customer service level. Because inventory must be on hand to give this service and since inventory costs money, this setting of the service level essentially imputes a cost of shortage.  

Heskett, Ivie and Glaskowsky were more direct, stressing the relationship between poor service and lost sales:

In all trade institutions, solutions to the problem of balancing the costs of adequate service against the consequential costs of poor service, especially in regard to lost sales, are debatable. That is, an area of decision exists, because at some point the marginal costs of improved physical distribution service will exceed the marginal costs of lost sales.  

Parks called for explicit measurement of the costs of a stockout rather than the reliance upon set service levels. He defined these costs to be the loss of profit and the possible loss of

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62 Ibid.

63 Heskett, Ivie, and Glaskowsky, Business Logistics, p. 163.
customers. 64

The costs of not having an item in stock when a customer asks for it should be explicitly considered in any attempt to find an optimal inventory policy because it is better to compute explicitly some approximate estimate for the cost of being out of stock than to start with a stated service level which implies an exact but unknown figure for that cost. . . . In other words, the reorder point . . . is determined by matching the marginal cost of maintaining extra service with the marginal cost of being out of stock. 65

An inventory model described by Beesack used a "stockout constraint" in setting reordering policies. His constraint was really the same as a service level criteria stated inversely:

Specifically, we shall insist that the ordering policy be such that the ratio of the expected number of stockouts to the expected demand . . . does not exceed a preassigned fraction. 66

Levels in the marketing channel. While stockouts may naturally occur at any level in the market channel, the literature appeared to register more problems at the retail level than at wholesale or


65 Ibid., p. 90.

manufacturing levels. But, this emphasis would not follow from the
descriptions furnished by Heskett, Ivie and Glaskowsky:

The cost and importance of an out-of-stock situation at a
single retail store is generally minor. . . . At the wholesale
level, an out-of-stock situation may create a series of chain
reactions which carry forward to various retail customers and
ripple backward to supplying firms. . . . Here the cost of a
stock-out is clearly more serious.

At the manufacturing level, a stockout may close a production line.
Herein lies the reason for the lack of consideration given to stock-
outs at primary channel levels: their costs are so high, compared
with normal inventory procurement and carrying costs, that, for plan-
ning purposes, the probability of a stockout occurring is constrained
to zero. Heskett, Ivie and Glaskowsky gave the example of an auto-
mobile manufacturer who resorted to air freight, in carload lots if
necessary, when normal delivery schedules were not maintained:

When the possibility of supply exhaustion becomes apparent,
there is no decision to be made. No cost of physically sup-
plying the needed component could exceed the cost of shutting
down the assembly line. . . .

67 For examples, see "The A&P Study--Part VII: How Merchandise
Moves in the Modern Super Market," Progressive Grocer, Vol. 49 (Sep-
tember, 1970), pp. 38-62; "Charting the course for better Inventory
J. Dalrymple, "Controlling Retail Inventories," Journal of Retailing,
Vol. 40 (Spring, 1964), pp. 9-14 ff.; How To Stamp Out Stockouts (New
York: Progressive Grocer, 1969); Charles Ingram, Jr.; Earl H. Brown;
and Wendell Earle, "Out-of-Stocks in Supermarkets," Research Highlights
in Food Distribution, Report No. 4 (Spring, 1969); R. W. Mueller, "The
Editor's Page: Out-of-Stock a Growing Threat To Sales, Profits,
shown to be related to case size," Progressive Grocer, Vol. 48 (Novem-
ber, 1969), p. 46; Swanson advertisement, Progressive Grocer, Vol. 49

68 Heskett, Ivie, and Glaskowsky, Business Logistics, p. 163.
The probability of a stock-out of raw materials sufficient to cause a production shut-down must be planned at such a low level of occurrence that the determination of the level of internal physical supply service in the industrial firm poses no problem for the logistician; often it must be perfect.69

Barrett discussed the retailer's inventory shortage problems at length. For example, he described the practice of customers who wish to purchase many items at one location. If their desires are frustrated because of outages, they will tend to patronize a retailer with a better in-stock position, eventually causing the complete loss of a customer at the original location: "Consistent out-of-stock situations can cause a retailer to lose his customers in the long term, as well as losing him individual sales in the short term."70 Thus, the cost of a stockout may be considerably higher than the lost sales figures would have indicated.

For a wholesaler, "the penalty for being understocked is apparently much less."71 The wholesaler may have an out of stock position on some desired item when he receives an order. But, since the wholesaler's customer "is accustomed to a delay between making an order and receiving the merchandise requested,"72 the wholesaler's stock position may be corrected during the lead time, with no loss in sales or customers.

The reactions to stockouts at the retail level may be traced

69 Heskett, Ivie, and Glaskowsky, Business Logistics, p. 163.
70 Barrett, Automatic Inventory Control Techniques, p. 15.
71 Ibid., p. 9.
72 Ibid.
to the immediacy of the retail buying situation, in which backlogging of orders is not practiced. In Alfandary-Alexander's classification, this situation is the finite case; the facility with the stockout condition loses sales. The infinite case includes the situation in which customers' orders are backlogged for an indefinite period of time.73

Substitution.--A factor that may relieve the seriousness of a stockout of one item is the substitution of another similar item. This explanation was given by Heskett, Ivie and Glaskowsky for considering stockouts at retail as having minor importance.74 Although his regard for the consumer appeared as rather demeaning, Brown expressed a similar view:

In some instances, particularly in retail sales to consumers, the customer has a general idea of what she wants, but if one item is not in stock, she'll be satisfied with an alternative. She may never even know that you sometimes stock the other item.75

Barrett acknowledged the practice of substitution but explained:

Normally the importance of substitution in retail is minimized, because it is so difficult to define. Very few retailers feel able to state precisely what degree of substitutability exists between the various items in their merchandise range.76

His more complete discussion also included the possibility of a customer simply deferring his purchase until the item was re-stocked.

73 Alfandary-Alexander, Models Of Inventory Systems, pp. 29-30.
74 Heskett, Ivie, and Glaskowsky, Business Logistics, p. 163.
76 Barrett, Automatic Inventory Control Techniques, pp. 8-9.
This decision by the customer would result in fewer lost sales than would be expected during the stockout condition.

Elton and Mercer studied the effects of variety on sales. They calculated that the probability of losing a sale decreased exponentially as a function of the number of models carried in a product line. They, like Barrett, concluded that additional information was required:

The aggregate statistics usually kept within an organization are inadequate for a study of the sales-variety problem because they give no information on lost sales. Moreover, the true contribution of a model to a range will be larger than its actual sales if it makes the whole range more attractive. Equally, a model serves a less useful purpose if it simply draws sales from the other models of the range. 77

The economics of nonfunctional variety were discussed by Schaffir. The decision to add an item to a product line necessitated the increase of supporting inventory. He considered the increased inventory to be the "greatest single element of the cost of adding an item." 78

Backlogged orders. --Inventory systems where backlogging of orders is permitted furnish an alternative means for measuring stockout performance, according to Hausman. His paper proposed a method


for imputing a backorder cost per unit or customer line item back-ordered. Brown had rejected this method ten years before for its narrow scope:

Most authors, in discussing safety factors, are beguiled by the mathematical convenience of assuming that there is a known cost of being in backorder and derive elaborate models for selecting a safety factor that will balance the cost of carrying inventory against the expected cost of being in backorder. Frequently this assumption is merely a confusion between the value of avoiding a backorder and the cost of having a backorder, which may not be the same at all.

The effect of time during the backordering process was considered by Alfandary-Alexander in the infinite case:

However, even in the infinite case, there is a loss of good-will and the cost of conciliating the customer whenever the latter has to wait for delivery of his order, to be taken into account. It is true that those costs may be lower than the costs involved in a runout. The cost of a backlogged order was considered not only proportional to the amount of the unsatisfied demand, but also to the duration of the delay before the customer's order is satisfied.

Other alternatives.--When inventories on certain items are lower than expected immediate demand, maximum effective service may be obtained by establishing priorities among customers; the remaining units are then reserved for the most important customers. Evans defined sales and restocking policies for two types of customers and explained their application:


... it is assumed that all customers are not equal in the eyes of the firm, and, therefore, they should not receive equal treatment. ... In some cases companies may avoid using formal customer priority systems because they would find it difficult to justify them to a customer who discovered their existence. In contrast, there is no hesitation in using priorities in military spare parts inventory whenever an item is used in several different weapons or by units with different missions. The principle of different worths for different uses of the item is firmly established; only the relative importance is debatable.

Another alternative is not stocking certain items at all. This decision would appear reasonable if the costs of obtaining and carrying those items exceeded the costs of not carrying them. However, common practice is not so precise; Fenske explained:

The holding costs, profit margin, and other variables affecting this decision are usually only cursorily examined. In fact, in many cases, they are not even considered in determining what then turns out to be a completely arbitrary limit.

Stockout cost factors.--To determine the costs of an out of stock condition, the factors that are affected must be ascertained. Stephenson and Willett discussed service failure as having two types of effects:

A supplier's profitability is linked to his logistics services through two major mechanisms: transactional opportunity costs and compensatory customer response. The first of these mechanisms, ... resulting from periodic service failures, is composed of two types of costs. ... the irretrievable lost sale /and/ ... patronage diversion.

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The second major mechanism, compensatory customer actions, consists of attempts by the customer to counteract service deficiencies by demanding certain concessions. These could include pressure for price reductions, exceptional return privileges, and promotional considerations.\footnote{Stephenson and Willett, "Selling With Physical Distribution Service," p. 77.}

The task of defining stockout costs, other than the simple component of lost gross margin, is complicated by the occurrence of patronage diversion. Parks mentioned one practice used to prevent diversion of customers:

For example, in some industries the seller will promise to deliver an out-of-stock item to his customer and then obtain it from one of his competitors. In this way he retains the customer. Here the cost is the profit lost plus the cost of shopping for and buying the item. Presumably, the value of the customer is greater than the cost of buying the item.\footnote{Parks, "Simplified Inventory Control for Computer," p. 90.}

The value of a lost customer and the attendant loss of revenue is difficult to calculate and has been described as "bordering upon sheer guesswork . . . ."\footnote{Bowersox, Smykay, and La Londe, Physical Distribution Management, p. 212.}

Specific costs.—Writing mainly for industrial users, Enrick described the nature of the costs involved with stockouts:

Warehouse: Inadequate stocks, particularly of finished merchandise, entail frequent partial-load shipments to keep a minimum of urgently needed stocks on hand everywhere. Expensive air freight, special handling, and related costs will occur.

Quality: Unavailability of the designed, planned and intended items or materials may force people to utilize substitutes that result in inferior quality or performance.
Customer: Unwarranted failures to have merchandise on hand or to deliver goods on time results in customer annoyance and, ultimately, losses.\textsuperscript{87}

In one article, Enrick included the cost effect of "Generally confused methods of doing business . . ."\textsuperscript{88}

James considered other sales activities to be wasted when stockouts occurred:

In all cases of marketing, the potential diseconomies of an 'unselling' act must be clearly estimated; in this case the whole complex of sales promotion through advertising and packaging with all the associated costs would be partially wasted by the unselling activity of faulty distribution preventing the product from being on display.\textsuperscript{89}

Alfandary-Alexander stressed the loss of contribution to fixed overhead as the primary shortage cost.\textsuperscript{90} Five possible costs of not having sufficient stock were listed by Miller and Starr as:

1. Sale irrevocably lost with an attendant loss of the profit that could have been made,
2. considerable loss in the goodwill of the customer,
3. cost associated with processing the special order required to get more stock,
4. expediting costs,
5. extra transportation costs.\textsuperscript{91}

Goodwill.--The most frequently mentioned stockout cost

\textsuperscript{87}Enrick, \textit{Inventory Management}, p. 6.


\textsuperscript{90}Alfandary-Alexander, \textit{Models Of Inventory Systems}, p. 103.

\textsuperscript{91}Miller and Starr, \textit{Executive Decisions}, p. 537.
appeared to be the loss of goodwill.\textsuperscript{92} This may also be the factor which is most difficult to measure. As admitted by Boot, "these goodwill costs are intangible and difficult to determine."\textsuperscript{93} Because of the goodwill effects, a stockout cost may depend not on the amount of the stockout but just on the fact that a stockout exists.\textsuperscript{94} This may bring about a change in the customer's attitude, as in the illustration by Boot: "The customer is thoroughly disgusted and simply goes to another supplier."\textsuperscript{95} Thus, the loss may include both the current unfilled demand and all future demands of the distressed customer.

\textbf{Measuring stockout costs}

\textbf{Depletion penalty.}--As seen in a previous section on economic ordering quantities, early inventory models assumed known demand schedules. When uncertainty was added to the modeling situation, the effect of possible stockouts was considered by including a depletion penalty in the total cost equations. In one of the basic works on inventory policy, Arrow, Harris and Marschak explained the importance of the penalty:

We assume the penalty function as given. The organization--whether commercial or noncommercial--has a general idea of the value it would attach to the damage that would be caused by the nonavailability of an item. It knows the cost

\textsuperscript{92}Alfandary-Alexander, \textit{Models Of Inventory Systems}, p. 103; Barrett, \textit{Automatic Inventory Control Techniques}, p. 15; Miller and Starr, \textit{Executive Decisions}, p. 537.

\textsuperscript{93}Boot, \textit{Mathematical Reasoning}, p. 138.

\textsuperscript{94}Fetter and Dalleck, \textit{Decision Models}, p. 34.

\textsuperscript{95}Boot, \textit{Mathematical Reasoning}, p. 138.
and the poorer performance of emergency substitutes. The penalty for depleted stocks may be very high: "A horse, a horse, my kingdom for a horse," cried defeated Richard III.  

Alfandary-Alexander and Barrett made statements in a similar vein:

Penalty costs occur whenever demand exceeds inventory. They represent foregone contributions to burden, loss of customer goodwill, expediting charges, and in the case of spare part stocks, loss of machine output to the firm.  

The penalty for being out of stock is usually higher than the penalty for carrying excessively high stocks, . . .  

Fromovitz defined a stockout penalty function for use instead of a shortage cost. In his inventory model, the probability of a stockout was constrained by imposing an upper bound on the ratio of the expected stockout penalty, derived from the penalty function, to the maximum possible stockout penalty. He justified his substitution by the following:

This approach becomes useful when a shortage cost is difficult to measure, cannot be expressed in the same units as the other costs, or is even conceptually hard to define because of the many indirect factors involved, such as goodwill, tradition, etc.

A connecting link between the two approaches of assessing a stock-out cost and imposing a stock-out constraint is the concept of an 'imputed shortage cost'—what the shortage cost might have to be to make a given policy optimal.


Arrow, Harris and Marschak defined the depletion penalty, \( \Pi \), as follows, where \( x \) is the demand and \( S \) is the stock level: 100

If \( x \leq S \), there is no unsatisfied demand, and \( \Pi = 0 \); but if \( x > S \), the organization would be willing to pay an amount \( \Pi > 0 \) to satisfy the excess, \( x - S \), of demand over available stock. . . .

We shall assume

\[
\Pi = A + B(x - S) \text{ if } x > S, \\
\Pi = 0 \text{ otherwise},
\]

where \( A, B \) are nonnegative constants, not both zero. Then is a random variable, with expectation

\[
(A - BS)\overline{1 - F(S)} + B \sum_{S}^{\infty} x \, dF(x).
\]

Dvoretzky, Kiefer and Wolfowitz showed various ordering policies based on the Arrow, Harris and Marschak model. They inquired into the effects of varying the penalty constant, \( A \), and the ordering cost constant. 101 For unknown distributions of demand, they developed their "risk function" to use instead of the penalty constant term, \( A \).102

The probability of being out of stock has been related to the penalty cost in single-product inventory models. Baker observed that:

... the optimum reorder point is the highest level for which the probability of being out of stock is greater than \( h/(h+p) \),

100 Arrow, Harris, and Marschak, "Optimal Inventory Policy," pp. 256-257.


where \( h \) denotes the unit holding cost and \( p \) denotes the unit penalty cost. More generally, \( h \) and \( p \) can be interpreted as representing the surplus and shortage costs per item, so that it is possible to include in the critical ratio such elements as purchase cost, selling price, salvage value, etc.\(^{103}\)

He found the same property in more complicated models. Under certain conditions, the critical ratio could be applied with confidence even though the relationships between several products inventoried was not able to be described mathematically.

**General quantitative examples.**--Examples attempting to quantify the effects of stockouts have appeared in texts for courses including retailing, physical distribution management and operations research. Davidson and Brown suggested that, since most of the expenses associated with retailing were not variable, "The amount of gross profit lost when sales cannot be made because of an out-of-stock condition is essentially lost net profit."\(^{104}\) Their example showed the amount of additional inventory that could be financed by the potential profits lost because of stockouts. Since only financing costs, at a rate of five per cent, were included, they greatly overstated the rationale for increasing the amount of inventory.

Bowersox, Smykay and La Londe gave a simple probability example which provided a cost estimate for an out of stock condition. Three events were considered as possible in the stockout situation:

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(1) a back order, (2) a lost sale and (3) a lost customer. Each of these events was assigned a cost or a loss of revenue. Next, the probability of each event was assigned, based on records of past customer activity and on the judgement of the inventory model builder. The sum of the individual costs times their associated probabilities gave the "product loss" for a stockout situation.\(^{105}\) A similar routine was described by Constantin.\(^{106}\)

The operations research literature contains much of the quantitative work related to inventory management and, especially, considerations of the effects of stockouts. Sasieni, Yaspan and Friedman included a simple example of an automobile dealer's inventory problem, based on a known distribution of future demand and an assumed $100 loss for each customer who could not get immediate delivery of an automobile. With ordering costs of $40 per order and holding costs of $6 per car per week, the cost of a stockout was assumed to be more significant than earlier writers had implied.\(^{107}\)

Lampkin and Flowerdew presented a method of calculating optimum re-order levels and quantities with the criterion of optimality being the minimization of total expected cost. They credited their method with increased accuracy because they did not make approximations


\(^{106}\) Constantin, Principles of Logistics Management, p. 340.

to simplify the mathematics. They assumed the cost of shortage to consist of two parts, "one proportional to the number of demands which are not met immediately, and the other proportional to the average number of outstanding demands (back-up)."

In other examples, British authors Eilon and Elmaleh illustrated their inventory control limits with "runout costs" of 1.2 pounds sterling, equal to the cost of a unit of finished goods. Philips and Dawson described a routine using Bayesian statistics to assist retailers in their problems of inventory management. The relationship was claimed that "the probability of lost customers in the future is directly related to the number of stockouts experienced by a retail organization." McMillan and Gonzalez included a chapter on Monte Carlo simulation of an inventory system under uncertainty. In it they discussed the expected stockout cost per lead time period and the expected annual stockout cost. But in their example case, the unit cost of a stockout was assumed rather than calculated.


The conclusion derived from this section of the literature search was that more recent writers recognized the possible impact of being out of stock and, though little attempt was made to accurately assess this impact, they made more allowance for it than did former writers.

Specific stockout measurement studies.--In addition to the Chang study, cited in Chapter I, several other research projects have described the frequency of stockouts and attitudes toward them. The grocery industry appeared to be actively interested in this problem area. The trade magazine, Progressive Grocer, ran a series of five articles titled "The Out-of-Stock Study"\textsuperscript{112} and republished them in book form as \textit{How To Stamp Out Stockouts}.\textsuperscript{113} The report was based on the results of a survey by the A. C. Nielsen Co. Data was presented showing frequencies of shelf and reserve stock outages by product class, brand, item and by day of the week.\textsuperscript{114} Shopper reaction to out of stocks was surveyed; these results are summarized below:

1. An average of 42 per cent, ranging from 23 to 62 per cent, were classified as "shoppers refusing to buy substitute brand when favorite


\textsuperscript{114}Out of six selling days, Monday was worst with 29.4\% of all stockouts, Tuesday and Saturday, 17.6\% each, and Wednesday, Thursday and Friday, 11.8\% each. "The Out-of-Stock Study--Part II. Growing Problem of Stockouts Verified by Nielsen Research," \textit{Progressive Grocer}, Vol. 47 (November, 1968), p. S21.
brand is out-of-stock."\textsuperscript{115}

2. An average of nearly 20 per cent, ranging from 13 to 24 per cent, were classified as "shoppers refusing to buy substitute brand or size for out-of-stock."\textsuperscript{116} Based on these two figures, the report concluded that "About half of 'loyal' customers will accept another size."\textsuperscript{117}

3. Reactions to stockouts on favorite brands, by demographic group, showed: 118

   a. Between one-third and one-fourth would buy elsewhere.

   b. "Almost half of all customers . . . would rather switch brands than go elsewhere or come back later."\textsuperscript{119}

   c. "Only a quarter of all shoppers indicated they would return later for a particular brand."\textsuperscript{120}

   d. Negro and blue collar shoppers were least likely to switch either brands or stores.

Other data listed product characteristics of out of stocks: fast movers, seasonal items, national labels, and new items.


\textsuperscript{116}\textit{Ibid.}, pp. S26-S27.

\textsuperscript{117}\textit{Ibid.}, p. S30.

\textsuperscript{118}\textit{Ibid.}, pp. S30-S31.


\textsuperscript{120}\textit{Ibid.}
In a study for the Department of Agricultural Economics of Cornell University, Ingram, Brown and Earle compared stockouts of supermarkets and their warehouses. Based on four weeks of observations of 95 dry grocery products, the percentage of out of stocks in retail supermarkets was reported as 5.9 and in warehouses, 7.6.\(^{121}\) In contrast to the *Progressive Grocer* findings, the Cornell group found that private label stockout rates exceeded the rates for national brands. Both studies provided quantitative measures of the severity of stockouts although neither attempted to define it in monetary terms. The Cornell study concluded:

> It is difficult to determine the actual dollars and cents cost of stockouts in lost sales and profits. Income lost as a result of stockouts depends upon the percentage of stockouts and the willingness of customers to buy substitute brands and sizes.\(^{122}\)

Schwartz' perturbed demand model.—Schwartz criticized conventional treatments of stockout penalties because "the question of loss of good will has been considered amenable only to inexact or subjective treatment."\(^{123}\) Furthermore, the penalty cost was often based on the number of units backordered or cancelled at the time of the stockout. Schwartz claimed: "It is the demand experienced in the future, 


not the expense incurred at the present, that is affected by goodwill."^{124} He developed his perturbed demand model to measure the reduction in future demand that reflects customers' loss of goodwill towards the supplier. The basic model was:

\[ \lambda = \frac{\lambda_0}{1 + \alpha I} \]

where \( \lambda \) is the expected demand rate that would prevail with no stockouts, \( \lambda_0 \) is the demand rate that will prevail when stockouts occur, \( \alpha \) is the relative number of stockouts, (that is, the ratio of demand occurring when stock is exhausted to total demand), and I is a constant parameter of the model related to customer response.^{125}

The constant, I, was actually the lost future sales and could be calculated from the equation when \( \lambda_0 \), \( \lambda \), and \( \alpha \) were specified from past sales data. Thus, the model did provide an empirical measure of the goodwill effects caused by stockouts.

Schwartz also studied the effects of time on customer demand. His time response model was in the form of:^{126}

\[ \phi(t) = k e^{-at} \]

where \( k \) and \( a \) were constants, \( \phi \) was response as a function of time. This exponential decay response is seen to be similar to the Chang concept of the period of cognition, described in Chapter I.

Other quantitative studies related to stockouts.—A quantitative relationship between the number of days out of stock and lost sales because of the stockout was described by Burgin. He assumed

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that a monetary value could be placed on these lost sales; his method calculated the units of lost sales. The basic formulation was:  

\[ V = u z - a z e^{-bz} \]

where:

- \( V \) = lost sales in units
- \( z \) = number of days out of stock
- \( u \) = normal demand rate (units/day)
- \( a, b \) = constants.

The general form of the above equation is shown in Figure 4.

Burgin admitted that his contribution was incomplete as he added a rather encompassing disclaimer:

No account is taken of intangible considerations ("loss of customer goodwill") or of possible long-term effects (customer waits this time but in future may go elsewhere). Similarly, no account is taken of interaction with other items (because one particular item is not available the customer may not place the rest of his order), or the possibility of an in-stock item being substituted for the item out of stock.  

His main point was that, where back ordering was practiced, direct losses due to stockouts were relatively small for the first few days, increasing exponentially thereafter until they reached some constantly increasing value.

Another model applied to backordering situations, but with specified waiting times, was described by Sasieni. His application

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128 Ibid., p. 453.
Figure 4.--A plausible form of the lost sales/time out of stock relationship.

grew out of a broader study of queuing theory.¹²⁹

Kaplan applied two levels of penalty costs, for low and high priority users, to backorders in his model for stock rationing. At some point to be calculated by the model, the supplier incurs a lower total expected penalty cost by serving only high priority users.¹³⁰

Models--basic literature

Definitions.--Numerous authors have furnished similar general definitions of a model. The following sampling was written by Kuehn, Massy, Miller and Starr, and Montgomery and Urban:

A model is a simplified representation of a concept, system, or process usually expressed as a mathematical or logical relationship.¹³¹

A model can be viewed as an hypothesis about the way the world operates. In the most general sense, it is a collection of statements about the way in which certain variables are causally related to one another.¹³²

A model is a representation of reality intended to explain the behavior of some aspect of it. Since a model is an explicit representation it is generally less complex than the reality itself. But it must be


sufficiently complete to approximate those aspects of reality which are being investigated.\textsuperscript{133}

A model is simply a representation of some or all of the properties of a larger system. The system is the total environment surrounding the problem, whereas the model is a description of the aspects of the system that are essential to the analysis.\textsuperscript{134}

Specific types of models have been defined which may be applied to management problems. Montgomery and Urban classified models as descriptive, predictive and normative.\textsuperscript{135} The first two types were for understanding problems; the third was for solving problems.

Carr and Howe considered the quantitative aspects of model building and defined a model as a "set of relationships among the various parameters and variables."\textsuperscript{136} Their concept of a model was basically a group of equations and constraints. Alderson's statement was broader: "The very term 'Quantitative model' suggests the combination of empirical data with the logical structure of the system which the model represents."\textsuperscript{137}

McMillan and Gonzalez further divided quantitative models into mathematical models, which consist of "a set of equations whose

\textsuperscript{133} Miller and Starr, \textit{Executive Decisions}, p. 145.


\textsuperscript{135} \textit{Ibid.}, p. 14.

\textsuperscript{136} Carr and Howe, \textit{Quantitative Decision Procedures}, p. 9.

solution explains or predicts changes in the state of the system," and probabilistic models, which "by definition, are those which include the representation of stochastic processes or their results."

**Rationale for using models.**--Arrow, Karlin and Scarf viewed the formulation of a model as the first part of a decision problem. With it they hoped to achieve an optimal solution, or, when the optimal solution could not be found, the model should help arrive at a descriptive solution.

King called a model an "imperfect representation" because some aspects of the real world were excluded:

But in its imperfection lies its great value, since the need for models emanates from the impracticability or costliness of studying real-world systems.

Kuehn called for simplicity in models but cautioned:

Models can be misleading--the results provided are no better than the model from which they are derived. . . . The ultimate test of the model's adequacy is whether the model provides the perspective needed to reach improved decisions or new understanding.

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139 Ibid., p. 11.


142 Ibid., p. 18.

The emphasis on understanding was echoed by McMillan and Gonzalez:

Models are neither true or false; their value is judged by the contribution they make to our understanding of the system they represent.\textsuperscript{144}

The publications cited have demonstrated the place for models in management science. A comprehensive discussion of models and model building was given by Miller and Starr.\textsuperscript{145} Montgomery and Urban devoted a chapter to models of market response.\textsuperscript{146} These works were preceded by Forrester's \textit{Industrial Dynamics} and benefited from his groundwork.\textsuperscript{147}

Probability models have been applied to various decision making situations. Raiffa described a decision-flow diagram and applied it to games of chance and investment decisions. The bases for his decisions were outcomes expressed as expected monetary values.\textsuperscript{148} Green\textsuperscript{149} and Roberts\textsuperscript{150} applied similar probability methods to marketing decisions. In the field of inventory management, Veinott reviewed

\begin{flushleft}
\textsuperscript{144}McMillan and Gonzalez, \textit{Systems Analysis}, p. 7.


\textsuperscript{146}Montgomery and Urban, \textit{Management Science in Marketing}, pp. 28-93.


\end{flushleft}
studies which sought optimal policies for dynamic inventory models.\textsuperscript{151} The important point to note is that the necessary model building techniques have been developed even if they have not had widespread application to the measurement of stockout costs.

\textbf{Literature pertaining to the retail liquor industry}

The retail liquor industry has been used as the source of data for several marketing oriented research studies. The reasons for its use include: ease of identifying suppliers and outlets, largely because government control is commonplace, either through licenses or outright ownership of the establishments; much published data, often from government sources;\textsuperscript{152} a distinct and relatively limited line of consumer products; common packaging sizes, common product categories, national brands; unit prices usually between two and fifteen dollars; and stabilized market patterns. Also, the products being retailed have definite social and moral implications, factors that might contribute to an interest in studies related to the retail liquor industry.

\textbf{Examples of research.}--Swan compared the advertised price changes of privately owned liquor stores and supermarkets in his study


\textsuperscript{152} For example, see Ohio, Department of Liquor Control, \textit{Annual Report: 1969}. 
of competition for differential advantage. Simon utilized sales data from seventeen government liquor monopoly states in studying the effect of advertising on liquor brand sales. His data base included sales for a ten-year period for each of fifteen brands. Wales used sales figures and prices from both government control and free-enterprise states in formulating a model to estimate the extent of interstate liquor traffic.

Market research efforts have been made expressly for the use of liquor marketers. Linden discussed consumption patterns of alcoholic beverages based on U.S. Department of Labor income, age and education statistics. Other writings emphasizing demographic characteristics have appeared in business publications.

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issue, noted by Business Week, was the gradual change in liquor taste preferences.  

Published data.--Product sales and readership profile statistics have been published by nationally read magazines, such as Ebony, Newsweek, Time, and True and by newspapers for the use of liquor advertisers. An industry association also collects and disseminates information.

Product categories.--In the state of Ohio, beverages with at least 21 per cent alcoholic content are considered to be liquor products. The two basic liquor product classifications are whiskey and non-whiskey. The major members of the whiskey group were defined as:


165 Ohio, Department of Liquor Control, Annual Report: 1969, p. 17.
Bourbon—Distilled from mash of at least 51% corn. Straight is at least two years old.

Blend—At least 80 proof, containing at least 20% 100 proof straight.

Canadian—Made in Canada and at least two years old.

Scotch—Made in Scotland and at least three years old.\textsuperscript{166}

The whiskey group accounted for nearly three-fourths of the total case sales of liquor products in Ohio.\textsuperscript{167}

The major members of the non-whiskey group were gin and vodka. Others included, with considerably fewer sales, brandy, rum, cordials and liqueurs, and specialties and cocktails.

Package sizes.—The following basic sizes are common in the industry: pint (16.0 ounces), fifth of a gallon (25.6 ounces), quart (32 ounces), half-gallon (64 ounces). In addition, some products are also packaged in smaller tenth of a gallon bottles and in decorative decanters, usually in the fifth of a gallon size.\textsuperscript{168}

\textsuperscript{166}"Drinkers seek the 'light,'" p. 83.

\textsuperscript{167}Cleveland Press, \textit{Ohio Liquor Sales}, p. viii.

\textsuperscript{168}Ohio, Department of Liquor Control, \textit{Price List, 1970: Retail and Wholesale}, p. v.
CHAPTER III

METHODOLOGY

The methodology described in the following chapter was applied to potential stockout situations of retail liquor stores of the Ohio Department of Liquor Control.

Basic stockout model

The basic stockout model was designed to describe the decision alternatives which may be chosen by customers who encounter stockout situations. The model for the single stockout situation is shown in Figure 5. In this case, a customer visits a store, selected by him, where he intends to make a purchase which may be described by a product type, price, brand, size and quantity. If that item is in stock, the purchase will be made, providing revenue to the store and satisfying the customer's requirements for the item. However, if the desired item is not in stock, the customer must make one or more decisions.

Suppose the customer chose a particular brand and size of a desired liquor product and then learned, either from a store clerk or by observation of an empty shelf, that this item was not available. Perhaps there were other, less convenient, sizes of the desired brand and other brands of the same product type in several price ranges.
Figure 5: Basic Stockout Model
available. The customer must first decide whether or not to substitute for his original choice. If he does substitute, which one of the four alternatives listed shall he choose?\(^1\) If he does not substitute, will he decide to return to this store at some later date which would allow time for replenishment of stocks or will he attempt to purchase the item from some other source? Each activity may have some effect on his expenditures which, in turn, would directly affect the revenue received by the store. Since each purchase or non-purchase may be described in absolute dollar amounts, the revenue effects may be readily measured through the use of price data.

**Alternative 1.**—Suppose the customer decided first to substitute for the out of stock item. As a substitute he chose a different brand of the same product at a higher price. In this case, the revenue difference, \(RD\), between the intended purchase and the actual purchase would be positive. This difference may be stated in equation form:

\[
RD = PA - PO
\]

where:

\(PO = \text{price of out of stock item}\)

\(PA = \text{price of item actually purchased}\)

For alternative 1, \(PA > PO\), and the revenue difference may be interpreted as a negative cost to the store. In common terminology, a cost would be indicated by some \(RD < 0\).

**Alternative 2.**—If the customer chose a substitute item of a different brand but in the same price range, \(PA = PO\), so \(RD = 0\).

\(^1\) Other quantity, size and price combinations are conceivable. For purposes of simplification, they have been omitted from the explanation.
The indicated cost of a stockout in this case is zero.

Alternative 3.—Another substitute considered is a brand from a lower price range. Here, \( PA < PO \), and \( RD = PA - PO \) is negative, an actual cost to the store.

Alternative 4.—The substituting customer may select an alternate size of the first-choice brand. The effect on revenue will then be the difference in price between the original, but out of stock, item and the size substituted. The same equation applies, \( RD = PA - PO \), where \( RD \) may be greater or less than zero, depending on \( PA \) and \( PO \). \( RD \) will not equal zero for this substitution because, in the business considered, price varied with size.

Alternative 5.—The decision not to substitute for the original item but to return at some later date entails some additional reasoning. The customer may decide to wait for another shopping trip, allowing sufficient time for delivery of his desired brand and size from the store's source of supply. An average waiting time might be one week: the state liquor stores customarily were serviced weekly and weekly retail shopping trips by customers are not uncommon. Thus, the customer's intended purchase would ultimately be made, indicating an apparent revenue difference of zero. However, consider the situation where the customer had exhausted his home supply of the beverage before the first shopping trip. For the next week, while he awaited delivery to the store, his product demands are unfilled. Since this is not a demand that may be accumulated, such as the demand for laundry service, it represents the sale of one week's supply for this
customer that is permanently lost to the store. If the customer consumed an average of one-half of a bottle per week, at $5.21 per bottle, the revenue difference should be recorded as $5.21/2 = $2.605, not zero. Thus, the revenue difference equation can be expanded to:

$$RD = PA - PO - AU \times WT \times PA$$

where:

- $AU =$ annual number of units of the item purchased under in-stock conditions
- $WT =$ waiting time as a fraction of a year

The number, or fractional number, of units foregone is found by multiplying the waiting time and the annual units purchased. The revenue lost due to the time lag in delivery is the product of the foregone units and the price of the item purchased on the return visit. The use of $PA$ in this term instead of $PO$ allows the customer to substitute items on his second visit. Although this is not the expected customer practice, the flexibility of the equation is increased by this form.

**Alternative 6.**—If the customer decides to shop elsewhere, the minimum revenue difference would be:

$$RD = PA - PO$$

$$RD = 0 - PO$$

$$RD = - PO$$

In addition to this minimum revenue difference, the customer may take with him to the other source potential immediate purchases for other

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2\$5.21 average bottle price arrived at by weighting the prices of fifths of a gallon size of the top five brands of liquor products by the total 1970 case sales of each. Data source: Cleveland Press, Ohio Liquor Sales, p. ix.
products, as well as potential future purchases.\(^3\)

**Adjustment for quantity differences.**—Although the present explanation deals with the demand and stockout of a single item, the equation may be readily expanded to the general situation:

\[
RD = UA \times PA - UO \times PO - AU \times WT \times PA
\]

where:

\(UA = \text{units actually bought}\)

\(UO = \text{units desired but out of stock}\)

The added provisions allow description of customers who would substitute both quantities and items.

**Repeated stockout model**

If a customer repeatedly encounters a stockout condition for a desired item, he must make decisions similar to those described above but from a slightly larger set of alternatives. As before, he must decide whether or not to substitute items, switch brands, price ranges and sizes. If he refuses to substitute items, he may enter a special order, switch stores, or keep requesting the original item, possibly making temporary substitutions. These alternatives are diagramed in Figure 6, which is generally an expansion of the single stockout model of Figure 5. The differences in the two models are the assumptions that the first-choice item has been out of stock on two previous trips, and there are more alternatives open to the customer.

**Assumptions.**—It is assumed that the customer represented in

\(^3\)When the original and alternative stores are under common ownership, this term would not be included to measure revenue differences to the system. However, the more general case is being studied from the perspective of the single store.
Figure 6: Model for Repeated Stockouts

1. Higher
2. Same
3. Lower
4. Other Size
5. Special Order
6. Ask Here Again
7. Another Store

- Switch Price
- Switch Brand
- Substitute
- Switch Stores

Customer
the model has shopped for an item, specified by product group, price, brand and size, at this store on two previous occasions. It was out of stock each time. The decisions he made about the stockout on either of these two occasions are not known but do not enter into the present consideration in any case. The question is, what will the customer do on his next trip? He might forecast that the item is probably no longer carried regularly and decide, without benefit of a search or inquiry, to substitute another brand, represented by the different price ranges of alternatives 1, 2 and 3, or another size of the original brand, alternative 4. He might also be prepared to enter a special order, alternative 5, subject to an extra service charge. Or, he may simply expect the desired item to be in stock this time and conduct his normal purchasing decision routine, represented by alternative 6. A less patient customer, after being twice discouraged, might decide to switch stores, alternative 7.

The repeated stockout situation may be the result of a change in the product lines offered by the store. The Department of Liquor Control referred to this adjustment as "de-listing" of items sold.\(^4\) Since the effects of repeated stockouts are not restricted to the relatively short time-span of the single stockout case, the costs of repeated stockouts will be calculated as an annual rate. For example, if a customer, whose purchases averaged $5.21 per month, switched stores because of repeated difficulty in finding his preferred item,  

the effect would be stated as an annual cost to the original store of $62.52, the revenue difference in one year. The one-year period is not to be confused as implying that the effects last one year; it is simply a rate of cost to provide a basis for comparison of stockout costs for several products, brands and stores.

Separate revenue difference equations are developed below for each purchase alternative in the repeated stockout model. They are similar to the costs developed for the single stockout situation but are adjusted for the time factor and for the added decision branches of the second model. The same variables apply to both models.

**Alternatives 1, 2 and 3.**—The revenue difference is the difference between the intended transaction and the actual transaction for a substituted item which may be from the same or a higher or lower price range. This single revenue difference is then multiplied by the average number of purchases, AP, the customer makes in a year, to obtain the annual rate of revenue difference:

\[
RD = (PA - PO) \times AP
\]

**Alternative 4.**—This decision is treated exactly like 1, 2 and 3 above. It is described separately so that the effects on a single brand could be studied apart from the effects on a single store or product group.

**Alternative 5.**—For this alternative, it is assumed that the customer has decided to place a special order, not wishing to take his chances that the store may or may not have his product in stock. This decision is assumed to have been made before he arrived at the store;
he has had sufficient time to calculate the amount of the product to include in his special order, and he is aware of the extra service charge and ordering procedure at the time he enters the store. Even if the product were on hand this time, he is prepared to place the special order to assure his personal supply in the future. The revenue difference equation must make allowance for the larger than average order quantity, if any, and the extra service charge which becomes revenue for the store:  \(^5\)

\[
RD = (PO \times UA + SC) \times AS - PO \times UO \times AP
\]

where:

- \(AS\) = annual number of special orders by a customer
- \(SC\) = extra service charge, in dollars per order

**Alternative 6.**--The customer disregards part stockouts and attempts to purchase the same item at the same store once again. With the store still out of the item, the problem becomes exactly that of the single stockout situation of Figure 1 but expressed as an annual rate. The real difference between alternative 6 and the others surrounding it is the timing of the decision. Here, the customer chooses substitutes for his product or source after arriving at the original store and learning that his preferred item is not available again; the other decisions in this model are made before the customer arrives at the store. The outcomes could be different because the customer's

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\(^5\)Although the costs of handling a special order are not known, they were assumed to be similar to the store's normal record keeping and ordering operations. There is little opportunity for error in these calculations, even if this assumption does not hold, because the extra service charge is expected to be small, compared with the price of the products purchased, and because relatively few special orders are entered.
in-store decisions might not agree with those he would make after a longer study of the situation.

Alternative 7.- *After two consecutive stockouts, the customer may decide to search for another source of supply for this item and, possibly, other related items. In this case, the minimum revenue difference will be:* \[ RD = - PO \times AP \]

If it is assumed that the brand and size desired are available at other stores, there would be no difference in sales to the brand supplier.

**Expected monetary value of stockout situations**

Let the revenue differences be written as \( RDi \), with \( i = 1 \) to \( N \). \( N = 6 \) for the single stockout model; \( N = 7 \) for the repeated stockout model. A certain proportion of customers encountering an out of stock situation will choose alternative 1, another group will choose alternative 2, and so on. Let these relative frequencies, or proportions, be written as \( Pi \), with \( i = 1 \) to \( N \), as before. Then, the expected monetary value, \( EMV \), will be the summation:

\[ EMV = \sum Pi \times RDi \]

This \( EMV \) may take on any value, depending on the sizes of the relative frequencies, \( Pi > 0 \), and the revenue differences, \( -\infty > RDi > +\infty \). With the exception of the number of alternatives, \( N \), the \( EMV \) for the two models is calculated identically.

The capability to calculate the expected monetary value of the revenue differences for each of the two stockout models would be one of the major contributions of the stockout study. Information
required for the calculations includes the relative frequencies of
each consumer decision and the prices and purchase frequencies of the
products involved. But to further test the models as descriptive and
predictive instruments, additional information is required.

Summary of hypotheses 6

Hypothesis 1.--The actions of customers who encounter a single
stockout situation do not vary by product group.

Hypothesis 2.--To a seller, the cost of a single stockout does
not depend upon the product group in which the stockout occurs.

Hypothesis 3.--The actions of customers who encounter repeated
stockouts of a specific item do not vary by product group.

Hypothesis 4.--To a seller, the cost of repeated stockouts
does not depend upon the product group in which the stockouts occur.

Hypothesis 5.--The actions of customers who encounter a single
stockout situation do not vary by specified demographic variables.

Hypothesis 6.--The actions of customers who encounter repeated
stockout situations do not vary by specified demographic variables.

Hypothesis 7.--The use of product variables and demographic
variables in a predictive model does not increase the accuracy with
which the cost of a single stockout situation can be estimated.

Hypothesis 8.--The use of product variables and demographic
variables in a predictive model does not increase the accuracy with
which the cost of a repeated stockout situation can be estimated.

6 For discussion, see Chapter I.
Information required to test hypotheses

Six of the eight hypotheses suggested that customers might make different decisions concerning purchases in stockout situations depending on the product group in which the stockout occurred. Therefore, in addition to measuring the frequencies with which each decision was chosen and the monetary effects of each, it was necessary to define which product group was concerned. The seven liquor product groups considered were: (1) bourbon, (2) spirit blends, (3) Canadian, (4) Scotch, (5) gin, (6) vodka, (7) other non-whiskeys.\(^7\) Within each product group there were, of course, numerous brand names. For example, the Department listed 54 brands of spirit blends, 24 Canadians and 71 Scotches.\(^8\) The initial hypotheses were developed using only the seven major product groupings.

Another product variable considered was the size of the package or container. The most frequently purchased size was the fifth of a gallon.\(^9\) Some brands listed a quart size instead of a fifth, providing 32 ounces instead of 25.6 ounces. However, it was assumed that a bottle, unless otherwise specified, was the standard fifth of a gallon, also labeled as the equivalent four-fifths of a quart. The

\(^7\)See Appendix A for composition and sales within each group.

\(^8\)Cleveland Press, Ohio Liquor Sales: 36th Annual Analysis, pp. 14-29.

\(^9\)Ibid., pp. 1-59. Also, Ohio, Department of Liquor Control, Annual Report: 1969, p. 22: figures indicated that 14,107,079 gallons in 69,523,234 bottles were handled during the year. The average amount per bottle was thus 0.2029 gallons, slightly over one fifth.
second most popular size was the pint. Because of this ranking of size requests, it was assumed that when a customer in a stockout situation chose alternative 4, in either model, the revenue difference referred to the switch in size from the most requested size to the next most requested. Therefore, $P_0 =$ price of a fifth, and $P_A =$ price of a pint. While it might be argued that the customer might substitute the largest standard size, the half-gallon, a contradictory argument would suggest that it was more likely for the half-gallon to be the size out of stock, because of the greater space requirements for each unit, and that the fifth of a gallon size would be substituted for it. But, based on published sales figures, the assumption that the second most requested size would be substituted for the most requested size, in the stockout situations in which the customer refused to switch brands, was supported.\(^{10}\)

For each product group, individual price lines were defined which corresponded to a customer's decision for alternative 1, 2 or 3 to switch to another brand in a higher, the same, or a lower price range. A method for defining three price lines is described in Appendix B. The assumption was made that the consumer choosing one of these three alternatives had intended to purchase a middle-priced product. If he chose the alternative 1, the revenue difference would be

\(^{10}\)Cleveland Press, Ohio Liquor Sales, pp. 1-59: data provided shows the number of cases of each size handled during the year. With the added information that a case of fifths or quarts contains 12 bottles, a case of pints contains 24 bottles, and a case of half-gallons contains 6 bottles, the size rankings were found to be as stated for most brands.
the increase from the middle to the higher priced line. If he chose alternative 3, the revenue difference would be the decrease from the middle to the low priced line. Some error may be introduced by this assumption because the differences between price lines are not the same. However, the assumption does provide a feasible method for obtaining the magnitude of the effects of the indicated brand switching.

Hypotheses 5, 6, 7 and 8 were concerned with the decision patterns of customers of varying demographic characteristics. The specific information requirements were indications of age, income, marital status, sex and education.

Additional information.--The models under consideration were part of a broader research project for the Ohio Department of Liquor Control. The Department requested additional data to provide measurements of the levels of service being achieved by its stores. Also required was information which would indicate customers’ attitudes towards the state stores as retail establishments. Customers’ responses to a suggestion of an extra service charge on special orders was to be collected as part of the study.

How information was obtained

Selection of the population.--The source of information was the population consisting of liquor customers shopping at the 367 retail stores and agencies operated or otherwise controlled by the

\[11\text{See Appendix B.}\]
Ohio Department of Liquor Control. This definition excluded those who do not purchase packaged liquor products even though they may be actual consumers of liquor by means of their purchases in taverns and restaurants or by having another party supply their needs. Also excluded were those who may purchase these products outside the state of Ohio. By limiting the population to only those who shop at the retail outlets, the data was spared from possible biases from wholesale buyers who may have different purchase motives than retail buyers, and from those non-purchasing citizens who may have personal opinions about the products concerned different from actual consumers.

Selection of the sample.--From the standpoint of administering a survey, it was felt that a sample involving ten stores would be the largest feasible size. With the state being divided into five warehouse districts, this number of stores allowed for an average of two stores from each district to be included, thus assuring a statewide spread. Also, since the collection of information required the cooperation and effort of the employees of state stores, it was desirable to limit the number of days they would be involved. Furthermore, if the collection period were to exceed two or three days, the information might include double responses from more frequent customers.

It must be emphasized that the source of information was the

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12 Figure calculated from Ohio, Department of Liquor Control, Annual Report: 1969, pp. 41-58.

13 This was later enlarged to include the collection of information from the customers of one agency outlet, a relatively small addition to the actual number of customers involved.
population of packaged liquor customers, not the state liquor stores themselves. But the customers included in the sample were identified by the stores at which they shopped, hence the reasons for specifying the sample by stores rather than customers. The end result was, in fact, a sample of customers' responses.

An analysis of the 367 units reporting retail sales in 1969 showed that 47 per cent of the total retail dollar sales were made by 21 per cent of the total stores, those with over $1,000,000 volume each. The stores with sales between $250,000 and $1,000,000, or 53 per cent of total stores, reported an additional 47 per cent of total sales. The smaller stores and agencies, with less than $250,000 annual volume, comprising 26 per cent of all outlets, handled only 6 per cent of total retail sales. These relationships are shown in Figure 7.

It was decided to consider only stores handling $250,000 and above in annual retail sales. This decision reduced the number of outlets under consideration by 98 but omitted only 6 per cent of total retail sales. From the 269 stores with retail sales of over $250,000, ten were selected according to a systematic selection procedure that designated specific stores throughout the sales range and located throughout the state. The procedure followed is described in Appendix C. The ten stores selected accounted for 5.13 per cent of total sales.

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14 Figures calculated from Ohio, Department of Liquor Control, Annual Report: 1969, pp. 41-58.

Figure 7.--Retail sales vs. number of stores.
retail sales in 1969.\textsuperscript{16}

Using the retail figures for an average month, the daily sales rate was calculated to be approximately $721,000 for the state store system.\textsuperscript{17} The ten stores in the sample would account for 5.13 per cent of that rate, or $37,000 per day. The average retail price per unit sold was $4.75.\textsuperscript{18} If the average purchase were 2.4 bottles, as reported,\textsuperscript{19} the average expenditure per customer visit was $11.40. Therefore, the ten stores served about 3,250 customers per day or about 19,500 per week, assuming six working days per week.

It was decided to sample customers on a Friday and a Saturday, assuming that about one-half of the week's business was transacted on these two days, and on the following Monday, to provide the Department with data for comparing weekend and weekday patterns. The number of customers in a sample determined by this time period would be approximately 13,000.\textsuperscript{20} If responses were obtained from one-tenth of these customers, the data base would be on the order of 1,300. This was

\textsuperscript{16}Calculated from Ohio, Department of Liquor Control, Annual Report: 1969, pp. 41-58.

\textsuperscript{17}Cleveland Press, 1970 Ohio Liquor Dollar Sales (mimeographed, n.d.): Consider July as an average month, with 8.3 per cent of sales, approximately 1/12. Monthly sales of $19,473,101, divided by 27 selling days, averages about $721,000 per day.

\textsuperscript{18}See Appendix D.

\textsuperscript{19}Interview with J. H. Olberding, Assistant Director, Ohio Department of Liquor Control, Columbus, May 27, 1971.

\textsuperscript{20}Friday and Saturday were assumed to account for one-half the week's customers, or 9,750. Adding one average day's customer count of 3,250 gives a total of 13,000 for the ten stores.
considered to be adequate for testing the hypotheses stated although the different product groups would, of course, have unequal representation in the data, depending on their individual sales quantities. For example, the bourbon and blends product groups each accounted for between twenty and thirty per cent of total sales. Therefore, it would be expected that these products would represent similar proportions of the data. The smallest product group was the "other non-whiskeys," with seven per cent of total sales. This group might be expected to represent about 90 responses from a data base of the estimated size.

*Questionnaire objectives.*--Based upon the information required and the size of the sample, it was decided to utilize a printed questionnaire containing multiple-choice and short-answer write-in questions. A set of objectives to be met by the questionnaire was prepared, and included both information objectives and feasibility objectives. The information objectives were:

1. To learn how customers react when they encounter a stockout situation: (a) what they do at the time and (b) how their future consumption patterns may be altered because of repeated stockouts.
2. To gather information on liquor purchasing patterns in terms of products, brands and purchasing frequency.
3. To collect basic demographic information about state liquor store customers.
4. To gather measures of the level of customer service at the time the customers received the questionnaire and the level of customer
service, in general, perceived by customers.

The feasibility objectives were those which placed realistic constraints on the form of questioning and the extent of what may be asked of the customers. These objectives were the following:

1. The questionnaire must be readily understood by the majority of state store customers. Questions asked must be clear in meaning, multiple-choices must be definite and include most possible responses. Questions requiring the respondents to write answers must be kept few in number and restricted to those which could be answered in a few words or numbers.

2. The customer should not be expected to spend more than five minutes at the task of filling out the questionnaire. Too long a form might be too easily discarded. The actual questions should be clearly printed and contained within two standard, 8½ by 11 inches, pages.

3. The questionnaire should not give customers the feeling that someone is prying upon them about a possibly delicate subject. Some people do not freely answer demographic questions. They might be sensitive about giving their home address, feeling that this may lead to a mailing list or other irritation. For this reason, the questionnaire should ask only the city and zip codes of their residence. Where possible, demographic variables should be multiple-choice questions, specifying only groups of ages or incomes, for example.

4. Since people do decline to answer certain questions or may simply ignore one or more questions in haste, the questionnaire should be constructed so that no single omission would invalidate a customer's
responses. For example, suppose a respondent refused to designate his age and income group. His opinions would still be valuable when viewed as a bourbon purchaser, a resident of Cleveland, and so forth.

5. The questionnaire should be relatively easy to code for card punching and provide statistics which are directly applicable to the models of stockout costs with a minimum of additional calculations.

Initial testing of the questionnaire and methods of distribution.—Sample questionnaires were written and printed for purpose of initial testing. Although it was intended that the final questionnaire would be printed on one sheet of paper, 17 by 11 inches, and folded to provide four pages, the sample questionnaires were single sheets, stapled together.

The first page contained a short message of three lines, requesting the customer's assistance, implying that it would help provide better service and lower costs. The letter was signed, "Ohio Department of Liquor Control." Pages two and three contained the questions.

Trial I.—The next procedure to be determined was that for distributing the questionnaires to customers and collecting their responses. One possible method consisted of stationing a researcher, possibly a part-time state store employee or a student, in each store and instruct him to give each customer entering the store a questionnaire and request that the customer fill out the questionnaire while on the premises, depositing his responses in a collection box. This method was tested in a downtown store. Descriptions of this trial and
of the trial outlined below are contained in Appendix E.

Trial II.--Another distribution method involved handing out the questionnaires in the state stores but asking the customers to mail back their responses in a postage-paid envelope which was provided. This procedure reduced the amount of time the customer was required to remain in the store if his responses were to be obtained. It also would not interrupt the normal flow of the transaction. With one modification, this method was tested at a store in a neighborhood shopping area. Instead of employing a separate person to confront the customers and give them the materials, the questionnaires and return envelopes were placed in the paper bags, along with the purchases, by the store clerks. This process avoided most active participation by the customers while in the store; seldom was any explanation of the questionnaires requested. All responses would thus be completely voluntary and would be made, hopefully, when the customers had time to consider their answers in more compatible surroundings. Although the costs of postage and printing of envelopes would be incurred, no additional labor, at ten stores, would be required. This second method of distribution was chosen as the better one for the present study.

Questionnaire used.--Samples of the actual questionnaire and return envelope used appear in Appendix F. The rationale for the selection of the individual questions and their wording appears in Appendix G. The first page of the questionnaire consisted of a letter from the director of the Department of Liquor Control which explained the reasons for the questionnaire and requested the assistance of the
customer. The director's letter also identified the Ohio State University Research Foundation as the body directing the survey. The questions were on the inside two pages. On the right-hand side of each of these pages was a column for coding the responses. By coding responses directly on the form, both coding and key-punching procedures were simplified: the key-punch operators could read directly from the columns without the necessity for further coding or transcribing. The back page of the questionnaire was blank; customers were invited to comment in that space.

Based on the estimate of 13,000 customers during the distribution period, and including a fifteen per cent safety factor, 15,000 questionnaires and envelopes were ordered to be printed. Because of the need for a means of identifying which responses were from Friday-Saturday customers and which were from Monday's customers, a color coding scheme was established. In addition, colors were used to differentiate responses among the two stores in the Cleveland area and the two stores in Columbus.\footnote{Friday and Saturday questionnaires were white for all stores except for one store in Cleveland and one in Columbus where they were yellow. Monday questionnaires were blue except for the same two stores in which the questionnaires were pink.} The other stores were to be identified by the customer's city and zip code. If these were not provided by the customer, the post-mark on the envelope would designate the store, there being only one store in each of the other areas of the state.
Distribution of questionnaires

All materials were delivered to the sample stores by the researcher between August 4 and August 6, 1971, for distribution to customers on Friday, August 6, Saturday, August 7, and Monday, August 9. A total of 14,820 questionnaires were delivered.

Preceeding the distribution, the director of the Department sent a letter, dated July 30, to each store manager, alerting him to the impending visit of the researcher, describing the nature of the project, and requesting cooperation from the manager and his employees. At the time of the store visit, the researcher was identified by a second letter, hand carried, from the director. The researcher then described the project to the manager or acting manager and gave him a sheet of instructions, printed on Department letterhead. While the manager read the instructions, the researcher unloaded the questionnaires and envelopes and brought them into the store, usually to the manager's office area.

The instructions were reviewed with the manager, emphasizing the importance of placing the questionnaires and envelopes in the paper bags with the purchased products rather then handing the materials directly to the customers. The managers were assured that this method had been tested and found satisfactory. Also noted to each manager was the significance of the different colors of questionnaires, one being for the Friday and Saturday customers and the other for Monday customers. The researcher discussed the instructions, the

22 See Appendix H.
project and Department matters in general until he was convinced that the manager had complete understanding of his task. In all cases the managers appeared to be interested in the project and were willing to cooperate. The researcher's observations at the individual stores appears in Appendix I, along with facts about each store visited and the materials distributed to each.

**Coding and key-punching procedures**

Questionnaires were returned directly to the Ohio State University, through the use of standard postage-paid business-reply envelopes. By September 1, 1971, the date chosen as a cut-off time, 1,433 questionnaires had been received in completed or nearly completed form. This date was slightly more than three weeks after the final distribution on August 9. It was felt that customers would possibly have difficulty recalling exactly what had been purchased and how much had been spent in that visit to the state store.

All questionnaires were coded by the researcher as they were received. The coding scheme used is described in Appendix J. Immediately after coding, any written responses in blanks marked "other" and all comments by customers were transcribed for later reference. All batches of coded questionnaires were then taken to key-punch operators who punched one data card for each questionnaire. The coded information used a card field of forty-seven characters.

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23 Responses to "other" blanks are explained in Appendix K for questions 6, 7 and 9. Additional comments generally did not apply to stockout situations so are not included. Comments were offered by 366 customers.
Analysis of data

In keeping with the objectives stated in Chapter I, the first step in the analysis of the data was to obtain the relative frequencies of response for the different customer decisions described in the two models. When the relative frequencies were used in conjunction with the monetary values of each event, the methods of calculating the cost of a stockout or of repeated stockouts could be demonstrated.

The second major objective was to test the data according to the eight hypotheses proposed in Chapter I. This was done using published computer programs for standard statistical testing techniques.

Relative frequency measures.--Based on the definition of objective probability used by Sasaki, the relative frequency of each alternative was used as a measure of the probability of its occurring.

\[ p = \frac{s}{n} \]

It was assumed that the customers' reactions to stockouts, plus the wording of the questions, qualified the situations in this study as being repeated. Since all liquor shopping in the study was conducted in stores which were similar in atmosphere, by virtue of them being operated by the same governmental body, conditions were essentially the same for potential purchasers of similar products.

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Basic stockout model.--The six alternatives of the basic stockout model, Figure 5, were included in question 7 of the questionnaire. To obtain the relative frequencies, \( p_i \), for each alternative, it was necessary to simply accumulate the responses for each choice in question 7 and divide by the total number of responses. Before accumulating responses, the data were grouped by product type purchased, as noted by responses in question 2. Multiple line-item purchasers were counted in both product groups coded. The assumption behind the double inclusion of multiple line-item purchasers was that their responses to question 7 did not exclude one or the other of the products purchased. Furthermore, multiple line-item purchasers were expected to have a larger market impact, in terms of amounts spent, than single item purchasers.

Other measurements from the data were required for the time-lag effects of alternative number 5 of Figure 5. For purposes of demonstration, it was assumed that the amount of time the average customer would wait before making a return trip was one week. Expressed as a fraction of a year, this waiting time, \( WT \), would be \( 1/52 \). A measure of \( AU \), the annual number of units of the item purchased under in-stock conditions, was taken to be the number of units

\[ 25 \text{See Appendix F.} \]

\[ 26 \text{For example, one customer may have purchased both bourbon and gin. His responses would be counted both as a bourbon customer and as a gin customer. Therefore, in cases where customer-item requests were tabulated, the size of the sample tabulated appears larger than the sample consisting only of customers.} \]
of the product purchased, from question 2, times the monthly shopping
frequency, SF, from question 4, times twelve months per year, or:

\[ \text{AU} = \text{UA} \times \text{SF} \times 12. \]

Revenue differences, RDi, were calculated for each alternative
according to the equations developed earlier in this chapter, using
price lines described in Appendix B and the additional factors de-
veloped above. Therefore, for each product group, the expected
monetary value of a single stockout situation was calculated by:

\[ \text{SSO} = \sum_{i=1}^{i=6} p_i \times \text{RDi} \]

Repeated stockout model.--The demonstration of this model,
Figure 6, was somewhat more complicated because the responses to both
question 7 and question 9 were used, along with slightly different
revenue difference forms. As with the basic stockout model calcula-
tions, multiple line-item purchasers were included in both product
groups purchased.

Since alternatives 1 and 4 of question 9 referred back to the
responses to question 7, it was necessary to first cross-tabulate the
responses of the two questions. Then, the relative frequencies of
each of the seven alternatives were calculated as before.

All revenue differences for the repeated stockout model were
stated as described above. The summation term was then multiplied by
the average number of state store shopping trips per year to obtain an
annual rate of revenue difference for the repeated stockout situation.
The expected monetary value of this annual rate was calculated, for
each product group, by:

$$\text{RSO} = \text{AP} \times \sum_{i=1}^{i=n} \text{P}_i \times \text{RD}_i$$

where: AP is the annual number of purchases.

Testing of hypotheses.---Hypotheses 1, 3, 5 and 6 were tested using chi-square analysis techniques with an available program for contingency table analysis. The procedure followed was similar to that described by Maxwell and by Ferber. Significance was tested at the 0.05 probability level; as explained by Ferber,

... the 0.05 probability level is generally used as the boundary line between significance and nonsignificance. That is, if the probability of obtaining a value of $X^2$ larger than the computed value is greater than 0.05, the observed differences are ascribed to sampling variations and the null hypothesis is accepted; if the probability is less than 0.05, the observed relationships are assumed really to exist in the population and the null hypothesis is rejected.

Hypotheses 2 and 4 were tested by analysis of variance. Hypotheses 7 and 8 were tested with a programmed discriminant analysis.

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27 Terry Scott, "Contingency Table Analysis--(BMD02S)," Data Center, College of Administrative Science, The Ohio State University, April 25, 1967. (Duplicated.)

28 A. E. Maxwell, Analyzing Qualitative Data, pp. 11-51.


30 Ibid., p. 261.

procedure. The separate tests for each hypothesis are briefly described below. Results of the testing are discussed in the following chapter.

Hypothesis 1.--This hypothesis compared the decisions of customers in stockout situations and the product groups which these customers purchased. First, customer decisions, according to the responses to question 7, were cross-tabulated with the product groups indicated in question 2. Next, using this cross-tabulation, a chi-square value was calculated and compared with the five per cent significance level of the Fisher chi-square table, for the appropriate number of degrees of freedom. If the calculated chi-square were greater than the significant value listed in the table, the group differences would be said to be significant and the hypothesis, stated in null form, would be rejected. If the calculated chi-square were less than the five per cent value, the hypothesis would not be rejected.

32 Terry Scott, "Stepwise Discriminant Analysis--(BMD07M)," Data Center, College of Administrative Science, The Ohio State University, May 4, 1967. (Duplicated.)


34 Degrees of freedom are calculated from: \( df = (r - 1)(c - 1) \) where: \( r \) = number of rows; \( c \) = number of columns. For example, if \( r = 6 \) and \( c = 7 \), then: \( df = (6 - 1)(7 - 1) = 5 \times 6 = 30 \). Source: Maxwell, Analysing Qualitative Data, p. 18; Ferber, Market Research, p. 262.
Hypothesis 2.--The hypothesis suggested that the financial effects on the seller did not vary according to the product group in which the single stockout occurred. The data for testing this hypothesis was obtained from the calculations of the SSO's, the expected monetary values of single stockouts, for each product group. Using analysis of variance, the F statistic was calculated and compared with the tabulated F for the 0.05 significance level. If the calculated F were less than the critical value, the hypothesis would not be rejected; if F were calculated as greater than the critical value, the hypothesis would be rejected.

Hypothesis 3.--A parallel to Hypothesis 1, Hypothesis 3 compared customer decisions in the repeated stockout situation with the product groups which they purchased. The responses to question 9 were cross-tabulated with the product groups and a value for chi-square calculated. A significant value for chi-square would lead to the rejection of the hypothesis.

Hypothesis 4.--In a manner similar to Hypothesis 2, Hypothesis 4 suggested that the financial effects of a repeated stockout situation were the same. Data from the calculations of the RSO's, the expected monetary values of repeated stockouts, were used in an analysis of variance. The calculated F statistic was compared with the tabulated F at the 0.05 significance level.

Hypothesis 5.--Hypothesis 5 compared decisions pertaining to a single stockout situation with demographic variables. The responses to question 7 were cross-tabulated with the variables of age, family
income, marital status, sex, and years of education. Chi-square values were calculated and tested at the 0.05 probability level as before.

Hypothesis 6.--Similar to the above hypothesis, but for the repeated stockout situation, hypothesis 6 was based on the alternative decisions of question 9. These responses were cross tabulated with the same five demographic variables; chi-square values were calculated and compared with the 0.05 probability level. Both Hypotheses 5 and 6 were treated as five sub-hypotheses, each tested separately.

Hypothesis 7.--Hypothesis 7 suggested a predictive model for estimating the costs of a single stockout. The model would be composed of six variables: age, family income, marital status, sex, educational level, and liquor product group purchased. This hypothesis was tested using a program for discriminant analysis. The procedure was described by Fisher, Rulon, Bryan, and Cooley and Lohnes. Respondents were grouped according to their choices of the

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35 Scott, "Stepwise Discriminant Analysis."
39 Cooley and Lohnes, Multivariate Procedures.
decision alternatives of question 7; therefore, the number of groups, N, was 6. The number of variables, p, in the model also happened to be 6, as described above.

The purpose of using discriminant analysis was to determine if a model containing the listed variables would predict more accurately the different group membership than the use of relative frequencies, calculated earlier. By using a step-wise procedure, the discriminant analysis program also determined which of the variables entered contributed most to the explanation of variance among groups. The significance of the discriminant analysis was tested with the approximate F statistic.\(^ {40}\)

For each k group, a discriminant function, \(z_{ki}\), was found, such that:\(^ {41}\)

\[
z_{ki} = b_{ok} + b_{1k} x_{1i} + b_{2k} x_{2i} + \ldots + b_{pk} x_{pi}
\]

where: \(x_{qi}\) is the \(i^{th}\) individual's value for the \(q^{th}\) variate.

In order to assign an individual response to the group most likely to have other members displaying similar characteristics, as explained by Massy:

\[\ldots\] all N of the discriminant values (the \(z_{ki}\)) are calculated for each individual in the sample and each is assigned to the population for which his value is the largest. \[\ldots\]
If \(z_{1i}\) is greater than \(z_{2i}\), it follows that the probability ratio of population 1 to 2 is greater than one and the

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\(^{40}\) Cooley and Lohnes, Multivariate Procedures, pp. 61-63.

individual should be classified in population 1. The reverse is true for \( z_{1i} \) less than \( z_{2i} \).\(^{42}\)

Hypothesis 8.--This hypothesis suggested a similar model formulation for use in estimating repeated stockout situation costs. The only major difference between this model and the above were that the responses to question 9 were used to designate group membership. Thus, \( N = 4 \), instead of \( N = 6 \). The same list of variables was employed in the stepwise procedure. Also, only four discriminant functions, the \( z_{ki} \)'s, were necessary. The same significance testing and classification procedures were followed as for testing Hypothesis 7.

Other calculations performed on data collected.--Additional customer data were collected on the questionnaire as part of the larger study sponsored by the Department of Liquor Control. Other findings of the study are summarized in the following chapter for informational purposes. Included were measurements of indicated customer service levels of the stores in the sample, the reasons for store choice, frequency of shopping trips to state stores, and the amounts spent per trip. Also, respondents' reactions to the inquiries about special ordering costs and delivery times were tabulated.

\(^{42}\) Massy, "Discriminant Analysis of Audience Characteristics," p. 47.
CHAPTER IV

FINDINGS

Parameters of the basic stockout model

The parameters of the basic stockout model\textsuperscript{1} were calculated in terms of the relative frequencies of occurrence and the revenue differences of each purchase alternative. To demonstrate the general workings of the model, the relative frequencies, expressed as probabilities, measured from the collected data and the respective revenue differences are listed in Table 1. The expected monetary value of an average single stockout situation was calculated as negative $1.26. The figure might be more clearly explained as the expected revenue difference between what would have been received by the store and what was actually received from each customer who encountered a stockout.

The stockout cost may be translated into a time basis if the average number of units sold, during instock conditions, were known. For example, if a product achieved sales of 3,000 units during the year at a given store, and if that store were open for business 300 days during the year, the average daily sales rate was 10 units. Therefore, the daily expected cost of being out of stock of an average

\textsuperscript{1}See Figure 5, Chapter III.
TABLE 1

BASIC STOCKOUT MODEL PARAMETERS

<table>
<thead>
<tr>
<th>Alternatives</th>
<th>Revenue difference</th>
<th>Probability</th>
<th>Weighted value, $</th>
</tr>
</thead>
<tbody>
<tr>
<td>higher price(^a)</td>
<td>+ .61</td>
<td>.026</td>
<td>+ .02</td>
</tr>
<tr>
<td>same price</td>
<td>.00</td>
<td>.591</td>
<td>.00</td>
</tr>
<tr>
<td>lower price(^a)</td>
<td>- .61</td>
<td>.024</td>
<td>- .01</td>
</tr>
<tr>
<td>other size(^b)</td>
<td>-1.93</td>
<td>.193</td>
<td>- .37</td>
</tr>
<tr>
<td>return trip(^c)</td>
<td>-6.61</td>
<td>.025</td>
<td>- .17</td>
</tr>
<tr>
<td>other source(^d)</td>
<td>-5.21</td>
<td>.141</td>
<td>- .73</td>
</tr>
</tbody>
</table>

Expected monetary value: .................................. - $1.26

\(^a\)Using average difference between price ranges, as found in Appendix B.

\(^b\)This RD is the average difference between fifths and pints, found by using price data for the top five brands, weighted by total cases sold in 1970. These five brands accounted for 21.8 per cent of total liquor sales. Source: Cleveland Press, *Ohio Liquor Sales*, p. ix.

\(^c\)It was assumed that the desired item was available on the return trip. Therefore, the revenue difference was due to the time lag, explained in Chapter III. The median number of units bought per year was 66. The waiting period was assumed to be one week and the unit price was assumed to be the average of $5.21. The revenue difference was then: $5.21 * 66 * 1/52 = $6.61.

\(^d\)The revenue difference was the average cost of one fifth. This average of $5.21 was found by weighting the prices of fifths of the top five brands of liquor products by the total 1970 case sales of each. Source: Cleveland Press, *Ohio Liquor Sales*, p. ix.
liquor product would be $12.60 in revenue not received by the store.

**Parameters of the repeated stockout model**

The values for the parameters used to measure the expected monetary value of repeated stockouts\(^2\) were obtained from questionnaire responses to question 9, in addition to question 7. The basic revenue difference data was the same as described in Table 1 except for the addition of the special order charge. The weighted value was adjusted to provide an annual rate by multiplying it times the average number of state store shopping trips per year. The average relative frequencies and revenue differences used to calculate the average cost of the repeated stockout situation, in terms of revenue differences per year, are listed in Table 2. This stockout situation was stated as an annual rate to facilitate comparison between specific product groups. The repeated stockout situation would take place over time; this time period would not be the same for all customers affected.

**Tests of Hypotheses**

**Hypothesis 1.** The actions of customers who encounter a single stockout situation do not vary by product group.

The responses to the alternatives of question 7, for each of the seven product groups defined, are contained in Table 3. A chi-square test indicated that differences between groups were not significant at the 5 per cent level, although differences were significant

\(^2\)See Figure 6, Chapter III.
### TABLE 2
**REPEATED STOCKOUT MODEL PARAMETERS**

<table>
<thead>
<tr>
<th>Decisions</th>
<th>Revenue Difference</th>
<th>Probability</th>
<th>Wtd. Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>change item requested:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>higher price</td>
<td>.027 * +.61</td>
<td>= +.02</td>
<td></td>
</tr>
<tr>
<td>same price</td>
<td>.790 * .00</td>
<td>= .00</td>
<td></td>
</tr>
<tr>
<td>lower price</td>
<td>.040 * -.61</td>
<td>= -.02</td>
<td></td>
</tr>
<tr>
<td>other size</td>
<td>.143 * -1.93</td>
<td>= -.28</td>
<td>-.28 * .246 = -.07</td>
</tr>
<tr>
<td>request special order</td>
<td>+ .50b * .029</td>
<td>= +.01</td>
<td></td>
</tr>
<tr>
<td>select different store</td>
<td>-5.21 * .399</td>
<td>= -2.08</td>
<td></td>
</tr>
<tr>
<td>do not change item requested:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>substitute:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>higher price</td>
<td>.031 * +.61</td>
<td>= +.02</td>
<td></td>
</tr>
<tr>
<td>same price</td>
<td>.607 * .00</td>
<td>= .00</td>
<td></td>
</tr>
<tr>
<td>lower price</td>
<td>.037 * -.61</td>
<td>= -.02</td>
<td></td>
</tr>
<tr>
<td>other size</td>
<td>.204 * -1.93</td>
<td>= -.39</td>
<td></td>
</tr>
<tr>
<td>no substitute:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>return trip</td>
<td>.034 * -6.61</td>
<td>= -.22</td>
<td></td>
</tr>
<tr>
<td>other store</td>
<td>.087 * -5.21</td>
<td>= -.45</td>
<td>-1.06 * .326 = -.35</td>
</tr>
</tbody>
</table>

*Expected monetary value (EMV) of revenue difference . . . . . . . . - $2.49

*Times average number of shopping trips per year . . . . . . * 36

Annual EMV rate, repeated stockout situation . . . . . . . . . . . . . . . - $89.64

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\(^{a}\)Values appearing in columns marked "(prob.)" are from cross-tabulation of responses to questions 7 and 9. Values for "(rev. diff.)" are as in Table 1.

\(^{b}\)A special order charge of $.50 per bottle was assumed. This charge is added revenue for the store.
### TABLE 3

**TEST OF HYPOTHESIS 1**

<table>
<thead>
<tr>
<th>Decisions</th>
<th>bourbon</th>
<th>blends</th>
<th>Canadian</th>
<th>Scotch</th>
<th>gin</th>
<th>vodka</th>
<th>other</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>other size</td>
<td>101</td>
<td>59</td>
<td>22</td>
<td>59</td>
<td>49</td>
<td>37</td>
<td>23</td>
<td>350</td>
</tr>
<tr>
<td>same price</td>
<td>259</td>
<td>193</td>
<td>81</td>
<td>148</td>
<td>206</td>
<td>126</td>
<td>61</td>
<td>1074</td>
</tr>
<tr>
<td>lower price</td>
<td>10</td>
<td>5</td>
<td>5</td>
<td>6</td>
<td>9</td>
<td>2</td>
<td>6</td>
<td>43</td>
</tr>
<tr>
<td>higher price</td>
<td>10</td>
<td>13</td>
<td>3</td>
<td>7</td>
<td>7</td>
<td>5</td>
<td>3</td>
<td>48</td>
</tr>
<tr>
<td>other store</td>
<td>68</td>
<td>33</td>
<td>31</td>
<td>46</td>
<td>38</td>
<td>19</td>
<td>21</td>
<td>256</td>
</tr>
<tr>
<td>return here</td>
<td>8</td>
<td>10</td>
<td>4</td>
<td>6</td>
<td>7</td>
<td>5</td>
<td>5</td>
<td>45</td>
</tr>
<tr>
<td><strong>totals</strong></td>
<td>456</td>
<td>313</td>
<td>146</td>
<td>272</td>
<td>316</td>
<td>194</td>
<td>119</td>
<td>1816</td>
</tr>
</tbody>
</table>

Chi-square = 40.968

df = 30

5 per cent level = 43.773
at the 8.7 per cent level. Because of the relatively small numbers of respondents who indicated they would substitute a lower or higher priced product, and the small difference in expected monetary value caused by the selection of these alternatives, the grouping of the data was modified to include all those who would change brands, whether they changed price ranges or not, in the same group. The hypothesis was also modified to reflect the decreased number of alternative decisions:

Hypothesis 1a.--The expected frequencies of customers who would switch brands, sizes, or stores, or return later to the original store in which a stockout occurred, do not vary by product group.

The re-grouped data are contained in Table 4. Largely because of the reduction in the number of degrees of freedom, differences between groups were significant at the 5 per cent level. Thus, hypothesis 1a was rejected. It was concluded that certain customer decisions pertaining to the single stockout situation do tend to vary according to the product group involved.

Hypothesis 2.--To a seller, the cost of a single stockout does not depend upon the product group in which the stockout occurs.

The expected monetary values for a single stockout, SS0, in each product group were calculated as demonstrated in Table 1. These individual values appear in Table 5. The analysis of variance procedure explained by Hicks\(^3\) was applied to the data, referring to the

\(^3\)Hicks, *Fundamental Concepts in the Design of Experiments*, pp. 21-49.
### TABLE 4

**TEST OF HYPOTHESIS 1a**

<table>
<thead>
<tr>
<th>Decisions</th>
<th>bourbon</th>
<th>blends</th>
<th>Canadian</th>
<th>Scotch</th>
<th>gin</th>
<th>vodka</th>
<th>other</th>
<th>totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>other size</td>
<td>101</td>
<td>59</td>
<td>22</td>
<td>59</td>
<td>49</td>
<td>37</td>
<td>23</td>
<td>350</td>
</tr>
<tr>
<td>other brand</td>
<td>279</td>
<td>211</td>
<td>89</td>
<td>161</td>
<td>222</td>
<td>133</td>
<td>70</td>
<td>1165</td>
</tr>
<tr>
<td>other store</td>
<td>68</td>
<td>33</td>
<td>31</td>
<td>46</td>
<td>38</td>
<td>19</td>
<td>21</td>
<td>256</td>
</tr>
<tr>
<td>return here</td>
<td>8</td>
<td>10</td>
<td>4</td>
<td>6</td>
<td>7</td>
<td>5</td>
<td>5</td>
<td>45</td>
</tr>
<tr>
<td>totals</td>
<td>456</td>
<td>313</td>
<td>146</td>
<td>272</td>
<td>316</td>
<td>194</td>
<td>119</td>
<td>1816</td>
</tr>
</tbody>
</table>

Chi-square = 29.501

$df = 18$

5 per cent level = 28.869
TABLE 5
TEST OF HYPOTHESIS 2

<table>
<thead>
<tr>
<th>Decisions</th>
<th>Bourbon</th>
<th>Blends</th>
<th>Canadian</th>
<th>Scotch</th>
<th>Gin</th>
<th>Vodka</th>
<th>Other</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>other size</td>
<td>- .42</td>
<td>.32</td>
<td>- .31</td>
<td>- .80</td>
<td>- .26</td>
<td>- .31</td>
<td>- .37</td>
<td>-2.79</td>
</tr>
<tr>
<td>same price</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>lower price</td>
<td>- .01</td>
<td>0</td>
<td>- .01</td>
<td>- .05</td>
<td>0</td>
<td>0</td>
<td>- .03</td>
<td>- .10</td>
</tr>
<tr>
<td>higher price</td>
<td>+ .01</td>
<td>+ .03</td>
<td>+ .03</td>
<td>0</td>
<td>0</td>
<td>+ .01</td>
<td>+ .02</td>
<td>+ .10</td>
</tr>
<tr>
<td>other store</td>
<td>- .77</td>
<td>- .49</td>
<td>- 1.17</td>
<td>- 1.27</td>
<td>- .53</td>
<td>- .43</td>
<td>- .92</td>
<td>-3.58</td>
</tr>
<tr>
<td>return here</td>
<td>- .12</td>
<td>- .19</td>
<td>- .19</td>
<td>- .21</td>
<td>- .12</td>
<td>- .14</td>
<td>- .28</td>
<td>-1.25</td>
</tr>
<tr>
<td>totals</td>
<td>-1.31</td>
<td>- .97</td>
<td>-1.65</td>
<td>-2.33</td>
<td>- .91</td>
<td>- .87</td>
<td>-1.58</td>
<td>-9.62</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>F,95</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blocks (decisions)</td>
<td>5</td>
<td>3.5827</td>
<td>.7165</td>
<td>40.03</td>
<td>2.53</td>
</tr>
<tr>
<td>Treatments (products)</td>
<td>6</td>
<td>.3672</td>
<td>.0612</td>
<td>3.42</td>
<td>2.42</td>
</tr>
<tr>
<td>Error</td>
<td>30</td>
<td>.5383</td>
<td>.0179</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td>41</td>
<td>4.4882</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
decision groupings as blocks and to the products as treatments. The hypothesis that the mean revenue differences were equal for all treatments was rejected.\(^4\) Therefore, hypothesis 2 was rejected. The finding may be stated that the cost effects of stockouts, to the seller, are not the same for the different product groups observed. Therefore, cost measurement accuracy would be increased by using individual product group calculations rather than the average for all liquor products as calculated in Table 1.

It may be noted that the major contribution to variance was shown to be the differences between blocks, due to the decision alternatives chosen by the respondents.\(^5\) However, this result was expected from the design of the model.

**Hypothesis 3.**—The actions of customers who encounter repeated stockouts of a specific item do not vary by product group.

The responses to question 9 were tabulated with product groups; see Table 6. A chi-square test indicated that differences between groups were significant at the 5 per cent probability level. Therefore, the hypothesis was rejected. It was concluded that customers encountering repeated out of stock situations do tend to make decisions that are dependent upon the type of product which is not in stock.

\[^4_{F_{6,30}}\] was calculated as 3.42 and found to be greater than 2.42, the critical value of \(F\) at the 0.05 significance level.

\[^5_{F_{5,30}} = 40.03,\] very much larger than 2.53, the critical value of \(F\).
### Table 6

**Test of Hypothesis 3**

<table>
<thead>
<tr>
<th>Decisions</th>
<th>bourbon</th>
<th>blends</th>
<th>Canadian</th>
<th>Scotch</th>
<th>gin</th>
<th>vodka</th>
<th>other</th>
<th>totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>change item requested</td>
<td>128</td>
<td>86</td>
<td>31</td>
<td>60</td>
<td>74</td>
<td>53</td>
<td>18</td>
<td>450</td>
</tr>
<tr>
<td>request special order</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>6</td>
<td>13</td>
<td>8</td>
<td>2</td>
<td>53</td>
</tr>
<tr>
<td>select different store</td>
<td>162</td>
<td>114</td>
<td>64</td>
<td>124</td>
<td>130</td>
<td>74</td>
<td>62</td>
<td>730</td>
</tr>
<tr>
<td>do not change item requested</td>
<td>160</td>
<td>105</td>
<td>48</td>
<td>81</td>
<td>101</td>
<td>61</td>
<td>39</td>
<td>595</td>
</tr>
<tr>
<td>totals</td>
<td>458</td>
<td>313</td>
<td>151</td>
<td>271</td>
<td>318</td>
<td>196</td>
<td>121</td>
<td>1828</td>
</tr>
</tbody>
</table>

Chi-square = 30.732

df = 18

5 per cent level = 28.869
Hypothesis 4.—The cost of repeated stockouts, to a seller, does not vary according to the product group in which the stockouts occur.

The expected monetary values for repeated stockouts, RSO, in each product group were calculated as demonstrated in Table 2. The individual values appear in Table 7. An analysis of variance procedure was used, with the decisions as blocks and the product groups as treatments. The hypothesis that the mean revenue differences were equal for all product groups was not rejected.\(^6\) Therefore, hypothesis 4 was not rejected. It was concluded that the costs of repeated stockouts did not vary significantly by product group. As in the test for hypothesis 2, the major portion of the variance was accounted for by the differences between blocks.\(^7\)

\(^6\)\(^{t_{6,18}}\) was calculated to be 1.90. This value was less than the critical value for F at the 0.05 significance level which was 2.66.

\(^7\)\(^{F_{3,18}}\) was calculated as 78.36, far greater than the critical value which was 3.16.
TABLE 7

TEST OF HYPOTHESIS 4

<table>
<thead>
<tr>
<th>Decisions</th>
<th>Bourbon</th>
<th>Blends</th>
<th>Canadian</th>
<th>Scotch</th>
<th>Gin</th>
<th>Vodka</th>
<th>Other</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>change item requested</td>
<td>- .14</td>
<td>- .09</td>
<td>- .08</td>
<td>- .23</td>
<td>- .07</td>
<td>- .09</td>
<td>- .07</td>
<td>.77</td>
</tr>
<tr>
<td>request special order</td>
<td>+ .01</td>
<td>+ .01</td>
<td>+ .03</td>
<td>+ .01</td>
<td>+ .02</td>
<td>+ .02</td>
<td>+ .01</td>
<td>.11</td>
</tr>
<tr>
<td>select different store</td>
<td>-1.84</td>
<td>-1.69</td>
<td>-2.34</td>
<td>-3.45</td>
<td>-1.82</td>
<td>-1.65</td>
<td>-2.67</td>
<td>-15.46</td>
</tr>
<tr>
<td>do not change item requested</td>
<td>- .46</td>
<td>- .32</td>
<td>- .52</td>
<td>- .70</td>
<td>- .29</td>
<td>- .27</td>
<td>- .51</td>
<td>3.07</td>
</tr>
<tr>
<td>totals</td>
<td>-2.43</td>
<td>-2.09</td>
<td>-2.91</td>
<td>-4.37</td>
<td>-2.16</td>
<td>-1.99</td>
<td>-3.24</td>
<td>-19.19</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>F, .95</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blocks (decisions)</td>
<td>3</td>
<td>22.4254</td>
<td>7.4751</td>
<td>78.36</td>
<td>3.16</td>
</tr>
<tr>
<td>Treatments (products)</td>
<td>6</td>
<td>1.0883</td>
<td>.1814</td>
<td>1.90</td>
<td>2.66</td>
</tr>
<tr>
<td>Error</td>
<td>18</td>
<td>1.7164</td>
<td>.0954</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td>27</td>
<td>25.2301</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Hypothesis 5.--The actions of customers who encounter a single stockout situation do not vary by specified demographic variables.

The responses to question 7 were cross-tabulated with each of the five demographic variables measured and the chi-square test applied. The measured values and calculations appear in Tables 8, 9, 10, 11, and 12 for the variables of age, family income, marital status, sex, and education, respectively.

Differences between group responses were found to be significant when customers were differentiated by age. Older customers were more likely to switch stores than were younger customers. Therefore, hypothesis 5a was rejected. However, significant differences between groups defined by income, marital status, sex and education were not found. Thus, hypotheses 5b, 5c, 5d and 5e were not rejected. It was concluded that, in general, those actions of stockout-encountering customers do not tend to vary by the measured demographic variables. The exception to this general conclusion was the variable of age.
### TABLE 8

**TEST OF HYPOTHESIS 5a: AGE**

<table>
<thead>
<tr>
<th>Decisions</th>
<th>under 35</th>
<th>35-44</th>
<th>45-54</th>
<th>55-64</th>
<th>65 and over</th>
<th>totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>other size</td>
<td>62</td>
<td>61</td>
<td>75</td>
<td>42</td>
<td>27</td>
<td>267</td>
</tr>
<tr>
<td>same price</td>
<td>159</td>
<td>196</td>
<td>218</td>
<td>161</td>
<td>68</td>
<td>802</td>
</tr>
<tr>
<td>lower price</td>
<td>10</td>
<td>5</td>
<td>10</td>
<td>5</td>
<td>2</td>
<td>32</td>
</tr>
<tr>
<td>higher price</td>
<td>4</td>
<td>7</td>
<td>12</td>
<td>8</td>
<td>7</td>
<td>38</td>
</tr>
<tr>
<td>other store</td>
<td>34</td>
<td>32</td>
<td>48</td>
<td>49</td>
<td>27</td>
<td>190</td>
</tr>
<tr>
<td>return here</td>
<td>3</td>
<td>6</td>
<td>13</td>
<td>8</td>
<td>6</td>
<td>36</td>
</tr>
<tr>
<td>totals</td>
<td>272</td>
<td>307</td>
<td>376</td>
<td>273</td>
<td>137</td>
<td>1365</td>
</tr>
</tbody>
</table>

Chi-square = 31.322

\( df = 20 \)

5 per cent level = 31.410
<table>
<thead>
<tr>
<th>Decisions</th>
<th>under $5,000</th>
<th>$5,000-9,999</th>
<th>$10,000-14,999</th>
<th>$15,000 and over</th>
<th>totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>other size</td>
<td>16</td>
<td>46</td>
<td>65</td>
<td>109</td>
<td>236</td>
</tr>
<tr>
<td>same price</td>
<td>43</td>
<td>127</td>
<td>250</td>
<td>337</td>
<td>757</td>
</tr>
<tr>
<td>lower price</td>
<td>2</td>
<td>10</td>
<td>8</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td>higher price</td>
<td>3</td>
<td>8</td>
<td>10</td>
<td>18</td>
<td>39</td>
</tr>
<tr>
<td>other store</td>
<td>10</td>
<td>30</td>
<td>50</td>
<td>84</td>
<td>174</td>
</tr>
<tr>
<td>return here</td>
<td>1</td>
<td>4</td>
<td>9</td>
<td>19</td>
<td>33</td>
</tr>
<tr>
<td>totals</td>
<td>75</td>
<td>225</td>
<td>392</td>
<td>577</td>
<td>1269</td>
</tr>
</tbody>
</table>

Chi-square = 12.193

df = 15

5 per cent level = 24.996
<table>
<thead>
<tr>
<th>Decisions</th>
<th>presently married</th>
<th>presently not married</th>
<th>totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>other size</td>
<td>192</td>
<td>54</td>
<td>246</td>
</tr>
<tr>
<td>same price</td>
<td>601</td>
<td>155</td>
<td>756</td>
</tr>
<tr>
<td>lower price</td>
<td>27</td>
<td>5</td>
<td>32</td>
</tr>
<tr>
<td>higher price</td>
<td>26</td>
<td>9</td>
<td>35</td>
</tr>
<tr>
<td>other store</td>
<td>141</td>
<td>37</td>
<td>178</td>
</tr>
<tr>
<td>return here</td>
<td>28</td>
<td>8</td>
<td>36</td>
</tr>
<tr>
<td>totals</td>
<td>1015</td>
<td>268</td>
<td>1283</td>
</tr>
</tbody>
</table>

Chi-square = 1.306

df = 5

5 per cent level = 11.070
<table>
<thead>
<tr>
<th>Decisions</th>
<th>female</th>
<th>male</th>
<th>totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>other size</td>
<td>78</td>
<td>170</td>
<td>248</td>
</tr>
<tr>
<td>same price</td>
<td>210</td>
<td>540</td>
<td>750</td>
</tr>
<tr>
<td>lower price</td>
<td>10</td>
<td>21</td>
<td>31</td>
</tr>
<tr>
<td>higher price</td>
<td>12</td>
<td>22</td>
<td>34</td>
</tr>
<tr>
<td>other store</td>
<td>51</td>
<td>123</td>
<td>174</td>
</tr>
<tr>
<td>return here</td>
<td>14</td>
<td>22</td>
<td>36</td>
</tr>
<tr>
<td>totals</td>
<td>375</td>
<td>898</td>
<td>1273</td>
</tr>
</tbody>
</table>

Chi-square = 3.459

df = 5

5 per cent level = 11.070
<table>
<thead>
<tr>
<th>Decisions</th>
<th>grades completed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 - 11</td>
</tr>
<tr>
<td>other size</td>
<td>30</td>
</tr>
<tr>
<td>same price</td>
<td>58</td>
</tr>
<tr>
<td>lower price</td>
<td>2</td>
</tr>
<tr>
<td>higher price</td>
<td>4</td>
</tr>
<tr>
<td>other store</td>
<td>17</td>
</tr>
<tr>
<td>return here</td>
<td>4</td>
</tr>
<tr>
<td>totals</td>
<td>115</td>
</tr>
</tbody>
</table>

Chi-square = 13.570

df = 10

5 per cent level = 18.307
Hypothesis 6.--The decisions of customers encountering a repeated stockout situation do not vary by specified demographic variables.

The responses to question 9 were cross-tabulated with each of the five demographic variables measured and the chi-square test applied. The measured values and calculations for the variables appear in Tables 13, 14, 15, 16 and 17 for the variables of age, family income, marital status, sex and education, respectively.

Differences between group responses were found to be significant at the 5 per cent level when customers were differentiated by age and sex. Therefore, hypotheses 6a and 6d were rejected. In the repeated stockout situation, younger customers were more inclined to select a different store while older customers were rather evenly divided among the alternatives of changing item requests, switching stores and asking again for the originally desired item.

In Table 16, it is seen that women are more likely to ask for the same item again after experiencing repeated stockouts than are men. Men are more inclined to ask for another item than are women.

The chi-square tests did not indicate significant differences between groups defined by income, marital status and education. Thus, hypotheses 6b, 6c and 6e were not rejected. It was concluded that decisions of customers who encounter a repeated stockout situation do tend to vary by age and by sex but not by the other demographic variables measured.
### TABLE 13

TEST OF HYPOTHESIS 6a: AGE

<table>
<thead>
<tr>
<th>Decisions</th>
<th>under 35</th>
<th>35-44</th>
<th>45-54</th>
<th>55-64</th>
<th>65 and over</th>
<th>totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>change item requested</td>
<td>61</td>
<td>68</td>
<td>92</td>
<td>82</td>
<td>48</td>
<td>351</td>
</tr>
<tr>
<td>request special order</td>
<td>16</td>
<td>12</td>
<td>14</td>
<td>4</td>
<td>1</td>
<td>47</td>
</tr>
<tr>
<td>select different store</td>
<td>131</td>
<td>123</td>
<td>134</td>
<td>92</td>
<td>49</td>
<td>529</td>
</tr>
<tr>
<td>do not change item requested</td>
<td>66</td>
<td>106</td>
<td>134</td>
<td>102</td>
<td>43</td>
<td>451</td>
</tr>
<tr>
<td>totals</td>
<td>274</td>
<td>309</td>
<td>374</td>
<td>280</td>
<td>141</td>
<td>1378</td>
</tr>
</tbody>
</table>

Chi-square = 38.469

df = 12

5 per cent level = 21.026
TABLE 14
TEST OF HYPOTHESIS 6b: FAMILY INCOME

<table>
<thead>
<tr>
<th>Decisions</th>
<th>under $5,000</th>
<th>$5,000-9,999</th>
<th>$10,000-14,999</th>
<th>$15,000 and over</th>
<th>totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>change item requested</td>
<td>27</td>
<td>63</td>
<td>103</td>
<td>133</td>
<td>326</td>
</tr>
<tr>
<td>request special order</td>
<td>0</td>
<td>5</td>
<td>17</td>
<td>20</td>
<td>42</td>
</tr>
<tr>
<td>select different store</td>
<td>22</td>
<td>88</td>
<td>144</td>
<td>234</td>
<td>488</td>
</tr>
<tr>
<td>do not change item requested</td>
<td>28</td>
<td>68</td>
<td>136</td>
<td>192</td>
<td>424</td>
</tr>
<tr>
<td>totals</td>
<td>77</td>
<td>224</td>
<td>400</td>
<td>579</td>
<td>1280</td>
</tr>
</tbody>
</table>

Chi-square = 13.357

df = 9

5 per cent level = 16.919
<table>
<thead>
<tr>
<th>Decisions</th>
<th>presently married</th>
<th>presently not married</th>
<th>totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>change item requested</td>
<td>253</td>
<td>74</td>
<td>327</td>
</tr>
<tr>
<td>request special order</td>
<td>34</td>
<td>7</td>
<td>41</td>
</tr>
<tr>
<td>select different store</td>
<td>395</td>
<td>111</td>
<td>506</td>
</tr>
<tr>
<td>do not change item requested</td>
<td>334</td>
<td>87</td>
<td>421</td>
</tr>
<tr>
<td>totals</td>
<td>1016</td>
<td>279</td>
<td>1295</td>
</tr>
</tbody>
</table>

Chi-square = 0.952

df = 3

5 per cent level = 7.815
TABLE 16

TEST OF HYPOTHESIS 6d: SEX

<table>
<thead>
<tr>
<th>Decisions</th>
<th>female</th>
<th>male</th>
<th>totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>change item requested</td>
<td>85</td>
<td>240</td>
<td>325</td>
</tr>
<tr>
<td>request special order</td>
<td>14</td>
<td>28</td>
<td>42</td>
</tr>
<tr>
<td>select different store</td>
<td>141</td>
<td>358</td>
<td>499</td>
</tr>
<tr>
<td>do not change item requested</td>
<td>147</td>
<td>271</td>
<td>418</td>
</tr>
<tr>
<td>totals</td>
<td>387</td>
<td>897</td>
<td>1284</td>
</tr>
</tbody>
</table>

Chi-square = 8.514

df = 3

5 per cent level = 7.815
### TABLE 17

**TEST OF HYPOTHESIS 6e: EDUCATION**

<table>
<thead>
<tr>
<th>Decisions</th>
<th>grade completed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 - 11</td>
</tr>
<tr>
<td>change item requested</td>
<td>38</td>
</tr>
<tr>
<td>request special order</td>
<td>1</td>
</tr>
<tr>
<td>select different store</td>
<td>38</td>
</tr>
<tr>
<td>do not change item requested</td>
<td>40</td>
</tr>
<tr>
<td><strong>totals</strong></td>
<td>117</td>
</tr>
</tbody>
</table>

Chi-square = 11.003

df = 6

5 per cent level = 12.592
Hypothesis 7. -- The use of product variables and demographic variables in a predictive model does not increase the accuracy with which the cost of a single stockout situation can be estimated.

A stepwise discriminant analysis program was utilized to provide a test of the hypothesis. The six definite responses to question 7 were used to classify individuals into groups. Variables used as inputs were age, family income, marital status, sex, educational level, and liquor product group purchased. The output of the procedure included the coefficients, \( b_{pk} \), of the discriminant function, \( z_{pk} \), for each group, \( k \); see Table 18.

The order in which the variables were entered into the computations is an indication of the relative importance of the particular variable in explaining group differences. The first variable entered was the liquor product group, with an F-statistic significant at the .95 and .99 levels, meaning that the variances of the groups compared were different.\(^8\) The second variable entered was family income, also with an F-statistic significant at both the .95 and .99 levels. The other variables entered, in order, were education, sex, age and marital status. Their F values were not significant at the .95 level. Thus, their contributions to the explanation of variances of the groups were less than those for product group and family income.

\(^8\)For 5 and 1795 degrees of freedom, F was calculated as 16.0661. Critical values of F, with 5 and \( \infty \) degrees of freedom were: \( F_{.95} = 2.21 \) and \( F_{.99} = 3.02 \). Source: Charles R. Hicks, Fundamental Concepts in the Design of Experiments (New York: Holt, Rinehart and Winston, 1966), p. 274.
<table>
<thead>
<tr>
<th>Variable</th>
<th>$k = 1$</th>
<th>$k = 2$</th>
<th>$k = 3$</th>
<th>$k = 4$</th>
<th>$k = 5$</th>
<th>$k = 6$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NEWSIZ</td>
<td>NEWSIZ</td>
<td>NEWSIZ</td>
<td>NEWSIZ</td>
<td>NEWSIZ</td>
<td>NEWSIZ</td>
</tr>
<tr>
<td>0 (constant)</td>
<td>-23.74487</td>
<td>-23.46570</td>
<td>-24.81648</td>
<td>-25.77820</td>
<td>-25.23924</td>
<td>-22.75818</td>
</tr>
<tr>
<td>1 (age)</td>
<td>2.64787</td>
<td>2.55646</td>
<td>2.60364</td>
<td>2.37542</td>
<td>2.55838</td>
<td>2.60059</td>
</tr>
<tr>
<td>2 (income)</td>
<td>0.07930</td>
<td>0.12551</td>
<td>-0.17422</td>
<td>0.43908</td>
<td>0.43991</td>
<td>0.39446</td>
</tr>
<tr>
<td>3 (marital)</td>
<td>3.46825</td>
<td>3.13920</td>
<td>3.04619</td>
<td>3.29218</td>
<td>3.17774</td>
<td>3.21822</td>
</tr>
<tr>
<td>4 (sex)</td>
<td>1.51207</td>
<td>1.86969</td>
<td>2.02850</td>
<td>1.73902</td>
<td>1.80517</td>
<td>1.36610</td>
</tr>
<tr>
<td>6 (product)</td>
<td>2.88380</td>
<td>3.04207</td>
<td>10.07365</td>
<td>2.39264</td>
<td>2.41711</td>
<td>2.11747</td>
</tr>
</tbody>
</table>

*Acronyms of group names stand for, respectively: new size, same price, lower price, higher price, new store, come back.*
Using the coefficients listed in Table 18, the program calculated the set of discriminant functions for each case of the input data. Each case was then assigned to the group for which the calculated discriminant function was the largest. Table 19 allows comparison between actual group memberships and the calculated and assigned posterior group memberships. The program correctly assigned 19.5 per cent of the cases to the correct group membership. Also shown in Table 19 are the assignments of 9.9 times the actual number of cases to the group which would substitute a higher priced product, and 8 times the actual group membership in the group that would make a return trip to the store for the out of stock item.

As another means of checking the accuracy of prediction, the expected monetary value calculations from Table 1 were made using the posterior group assignments as relative frequency measures. See Table 20. The calculated expected monetary value of negative $2.59 exceeds, in absolute terms, the original calculation by 106 per cent.

It was therefore concluded that, although definite differences in group variances were found, the ability of this particular model to predict responses to the single stockout situation, hence the revenue differences associated with those responses, is not accurate. The hypothesis should not be rejected.

The testing of Hypothesis 7 lent support to the rejection of Hypothesis 1: the variable which most explained the differences in group variances was the product group purchased.
TABLE 19

CONFUSION MATRIX:
ACTUAL GROUP MEMBERSHIP VS. PREDICTED GROUP MEMBERSHIP

<table>
<thead>
<tr>
<th>Actual group membership</th>
<th>NEWSIZ</th>
<th>SAMEPR</th>
<th>LOWRPR</th>
<th>HIGHPR</th>
<th>NEWSTR</th>
<th>COMEBK</th>
<th>totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEWSIZ</td>
<td>79</td>
<td>48</td>
<td>8</td>
<td>74</td>
<td>67</td>
<td>71</td>
<td>347</td>
</tr>
<tr>
<td>SAMEPR</td>
<td>198</td>
<td>153</td>
<td>27</td>
<td>275</td>
<td>194</td>
<td>218</td>
<td>1065</td>
</tr>
<tr>
<td>LOWRPR</td>
<td>8</td>
<td>6</td>
<td>12</td>
<td>4</td>
<td>9</td>
<td>4</td>
<td>43</td>
</tr>
<tr>
<td>HIGHPR</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>23</td>
<td>15</td>
<td>4</td>
<td>48</td>
</tr>
<tr>
<td>NEWSTR</td>
<td>21</td>
<td>20</td>
<td>1</td>
<td>90</td>
<td>65</td>
<td>56</td>
<td>253</td>
</tr>
<tr>
<td>COMEBK</td>
<td>5</td>
<td>8</td>
<td>0</td>
<td>9</td>
<td>4</td>
<td>19</td>
<td>45</td>
</tr>
<tr>
<td>totals</td>
<td>316</td>
<td>236</td>
<td>48</td>
<td>475</td>
<td>354</td>
<td>372</td>
<td>1801</td>
</tr>
</tbody>
</table>

\(^a\)Correct assignments are on the diagonal of the matrix. Therefore, the number of correct assignments is: 79 + 153 + 12 + 23 + 65 + 19 = 351. The accuracy percentage is then: 351/1801 = .195 or 19.5 per cent.
<table>
<thead>
<tr>
<th>Decision</th>
<th>Revenue difference&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Probability</th>
<th>Weighted value</th>
</tr>
</thead>
<tbody>
<tr>
<td>higher price</td>
<td>+.61</td>
<td>.264</td>
<td>+$ .16</td>
</tr>
<tr>
<td>same price</td>
<td>.00</td>
<td>.131</td>
<td>.00</td>
</tr>
<tr>
<td>lower price</td>
<td>-.61</td>
<td>.027</td>
<td>-.02</td>
</tr>
<tr>
<td>other size</td>
<td>-1.93</td>
<td>.175</td>
<td>-.34</td>
</tr>
<tr>
<td>return trip</td>
<td>-6.61</td>
<td>.206</td>
<td>-1.36</td>
</tr>
<tr>
<td>other source</td>
<td>-5.21</td>
<td>.197</td>
<td>-1.03</td>
</tr>
</tbody>
</table>

Expected monetary value ................. -$2.59

<sup>a</sup>Revenue difference values from Table 1.
Hypothesis 8. --The use of product variables and demographic variables in a predictive model does not improve the accuracy with which the cost of a repeated stockout situation can be estimated.

The stepwise discriminant analysis program was again used to test the hypothesis. The four defined responses to question 9 were used to denote group membership. As before, variables were age, family income, marital status, sex, educational level and liquor product group purchased. The calculated coefficients for the discriminant functions are listed in Table 21. The first variable entered, with an F value significant at both the .95 and .99 levels, was income. Next entered was sex, followed by marital status, then product group, all with F significant at the .95 level. The variables of education and age were entered in the last steps, neither one providing significant contributions to the explanation of group variances. The overall approximate F statistic, with 18 and 5100 degrees of freedom, was significant at the .95 and .99 levels, indicating definite differences among group variances.

The program assigned posterior group membership, using the calculated discriminant functions. The confusion matrix is shown in Table 22. The accuracy of prediction was 31.3 per cent. In Table 23, the predicted group proportions were used to calculate the expected monetary value of the repeated stockout situation, according to the method established in Table 2. When the predicted EMV of an annual rate of negative $44.64 was compared to the original calculation of negative $89.64, the predicted value was seen to be 49.9 per cent of
TABLE 21

$z_{ki} = b_{0k} + b_{1k} x_{1i} + b_{2k} x_{2i} + b_{3k} x_{3i} + b_{4k} x_{4i}$

<table>
<thead>
<tr>
<th>Variable</th>
<th>k = 1 OTRPRO&lt;sup&gt;a&lt;/sup&gt;</th>
<th>k = 2 SPLORD</th>
<th>k = 3 NEWSTR</th>
<th>k = 4 HRAGN</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (constant)</td>
<td>-25.05426</td>
<td>-22.19817</td>
<td>-24.58267</td>
<td>-25.20210</td>
</tr>
<tr>
<td>1 (age)</td>
<td>2.76701</td>
<td>2.57674</td>
<td>2.69735</td>
<td>2.68278</td>
</tr>
<tr>
<td>2 (income)</td>
<td>-0.13289</td>
<td>-0.16223</td>
<td>-0.07210</td>
<td>0.08240</td>
</tr>
<tr>
<td>3 (marital)</td>
<td>3.72358</td>
<td>3.30925</td>
<td>3.33026</td>
<td>3.32502</td>
</tr>
<tr>
<td>4 (sex)</td>
<td>1.83017</td>
<td>1.63121</td>
<td>2.18301</td>
<td>2.03117</td>
</tr>
<tr>
<td>5 (education)</td>
<td>7.32314</td>
<td>7.00921</td>
<td>7.24417</td>
<td>7.34031</td>
</tr>
<tr>
<td>6 (product)</td>
<td>2.79358</td>
<td>4.61285</td>
<td>3.13473</td>
<td>3.03039</td>
</tr>
</tbody>
</table>

<sup>a</sup>Acronyms of group names stand for, respectively: other product, special order, new store, here again.
TABLE 22

CONFUSION MATRIX:
ACTUAL GROUP MEMBERSHIP VS. PREDICTED GROUP MEMBERSHIP

<table>
<thead>
<tr>
<th>Actual group membership</th>
<th>Predicted group membership</th>
<th>OTRPRO</th>
<th>SPLORD</th>
<th>NEWSTR</th>
<th>HRAGN</th>
<th>totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>OTRPRO</td>
<td></td>
<td>144</td>
<td>94</td>
<td>67</td>
<td>140</td>
<td>445</td>
</tr>
<tr>
<td>SPLORD</td>
<td></td>
<td>11</td>
<td>18</td>
<td>4</td>
<td>20</td>
<td>53</td>
</tr>
<tr>
<td>NEWSTR</td>
<td></td>
<td>182</td>
<td>150</td>
<td>142</td>
<td>249</td>
<td>723</td>
</tr>
<tr>
<td>HRAGN</td>
<td></td>
<td>132</td>
<td>104</td>
<td>91</td>
<td>264</td>
<td>591</td>
</tr>
<tr>
<td>totals</td>
<td></td>
<td>469</td>
<td>366</td>
<td>304</td>
<td>673</td>
<td>1812</td>
</tr>
</tbody>
</table>

*Correct assignments, from the diagonal, are:
144 + 18 + 142 + 264 = 568. Percentage accuracy = 568/1812 = .313 or 31.3 per cent."
TABLE 23

EMV CALCULATIONS USING GROUP MEMBERSHIP PROPORTIONS PREDICTED BY DISCRIMINANT MODEL FOR REPEATED STOCKOUTS

<table>
<thead>
<tr>
<th>Decision</th>
<th>Revenue difference</th>
<th>Probability</th>
<th>Weighted value</th>
</tr>
</thead>
<tbody>
<tr>
<td>change item requested</td>
<td>- .28</td>
<td>.259</td>
<td>- $ .07</td>
</tr>
<tr>
<td>request special order</td>
<td>+ .50</td>
<td>.202</td>
<td>+ .10</td>
</tr>
<tr>
<td>select different store</td>
<td>-5.21</td>
<td>.168</td>
<td>- .88</td>
</tr>
<tr>
<td>do not change</td>
<td>-1.06</td>
<td>.371</td>
<td>- .39</td>
</tr>
</tbody>
</table>

Expected monetary value ............... -$1.24

Times average number of shopping trips per year * 36

Annual EMV rate, repeated stockout situation ........ -$44.64

*aRevenue difference values from Table 2.
the absolute size of the original value.

The accuracy of prediction, 31.3 per cent, although higher than the accuracy of the model for single stockouts, was not considered as being indicative of an accurate estimator. From the testing of Hypotheses 3, 6a and 6d, it might have been expected that the variables of product group, age and sex would have been the greatest contributors to the explanation of group variances. Although sex was entered second, the product group and age variables were entered fourth and sixth, respectively. The application of the posterior group assignments in the repeated stockout situation was seen to lead to erroneous calculations of the cost effects of these stockouts. Hypothesis 8 was therefore not rejected.

Other findings

Additional information related to the questions of stockouts and customer service was available from the data collected. These findings are described in the following sections.

Response to questionnaire.--Questionnaires were distributed to 13,506 customers during the three days of the sampling. A total of 1,433 completed or nearly completed questionnaires were received by the cut-off date which was approximately three and one-half weeks after distribution. The return rate was thus 10.6 per cent.

Customer service level indicated.--In response to question 1, customers indicated that 15.6 per cent of their total item requests during the store visit in which they received the questionnaire were not filled. This figure did not vary significantly by product group
requested. Therefore, the indicated customer service level was 84.4 per cent.

**Reasons for store choice.**--Question 6 asked: "Why did you come to this particular state store?" Responses are tabulated in Table 24. Most respondents shopped closest to where they lived. The smallest group indicated that they were here because of a stockout at another store. These responses did not vary significantly by product group purchased.

**Number of store visits per month.**--The numbers of times the respondents or some member of their families had visited a state store in the last 30 days are listed in Table 25. The median number of trips per month was three.

**Amounts spent on a single visit to a state store.**--The amounts spent on the surveyed visit are listed in Table 26, by percentiles. The median amount spent was $9.57, slightly more than twice the overall average bottle price of $4.75. The amounts spent were not found to vary significantly with the frequency of store visits.

**Comparison of responses to stockout situations.**--A cross-tabulation of the responses to questions 7 and 9 is contained in Table 27. Differences between group responses were significant at both the 5 and 1 per cent levels. Several conclusions may be drawn from Table 27, knowing that the group differences indicated are significant. First, of those who would change their item request in the repeated stockout situation, labeled OTRPRO, 76 per cent would change brands but stay within the same price range. This proportion was larger
<table>
<thead>
<tr>
<th>Response</th>
<th>Number&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>It is closest to where I live.</td>
<td>1491</td>
<td>79.2</td>
</tr>
<tr>
<td>It is closest to where I work.</td>
<td>131</td>
<td>7.0</td>
</tr>
<tr>
<td>Another state store didn't have what I wanted.</td>
<td>24</td>
<td>1.3</td>
</tr>
<tr>
<td>I was doing some other shopping in the area.</td>
<td>195</td>
<td>10.3</td>
</tr>
<tr>
<td>Other.</td>
<td>42</td>
<td>2.2</td>
</tr>
<tr>
<td>totals</td>
<td>1883</td>
<td>100.0</td>
</tr>
</tbody>
</table>

<sup>a</sup>Number of customer-item requests
TABLE 25
NUMBER OF STORE VISITS IN 30 DAYS

<table>
<thead>
<tr>
<th>store visits</th>
<th>number</th>
<th>percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>231</td>
<td>16.2</td>
</tr>
<tr>
<td>2</td>
<td>282</td>
<td>19.8</td>
</tr>
<tr>
<td>3</td>
<td>242</td>
<td>17.0</td>
</tr>
<tr>
<td>4 - 5</td>
<td>446</td>
<td>31.2</td>
</tr>
<tr>
<td>6 - 7</td>
<td>92</td>
<td>6.4</td>
</tr>
<tr>
<td>8 - 9</td>
<td>50</td>
<td>3.5</td>
</tr>
<tr>
<td>10 - 14</td>
<td>51</td>
<td>3.6</td>
</tr>
<tr>
<td>15 - over</td>
<td>33</td>
<td>2.3</td>
</tr>
<tr>
<td></td>
<td>1427</td>
<td>100.0</td>
</tr>
</tbody>
</table>
TABLE 26
AMOUNTS SPENT ON A SINGLE STORE VISIT

<table>
<thead>
<tr>
<th>Percentile&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Dollars spent</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>.00 - 4.45</td>
</tr>
<tr>
<td>20</td>
<td>4.46 - 4.97</td>
</tr>
<tr>
<td>30</td>
<td>4.98 - 5.32</td>
</tr>
<tr>
<td>40</td>
<td>5.33 - 7.38</td>
</tr>
<tr>
<td>50</td>
<td>7.39 - 9.57</td>
</tr>
<tr>
<td>60</td>
<td>9.58 - 10.55</td>
</tr>
<tr>
<td>70</td>
<td>10.56 - 12.20</td>
</tr>
<tr>
<td>80</td>
<td>12.21 - 15.45</td>
</tr>
<tr>
<td>90</td>
<td>15.46 - 21.80</td>
</tr>
<tr>
<td>100</td>
<td>21.81 - over</td>
</tr>
</tbody>
</table>

<sup>a</sup>Based on a sample size of 1432. Each ten-percentile group contained 143 responses except for the 50th and 60th which contained 144 responses.
<table>
<thead>
<tr>
<th>Single stockout situation</th>
<th>Repeated stockout situation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OTRPRO</td>
</tr>
<tr>
<td>NEWSIZ</td>
<td>32</td>
</tr>
<tr>
<td>SAMEPR</td>
<td>177</td>
</tr>
<tr>
<td>LOWRPR</td>
<td>9</td>
</tr>
<tr>
<td>HIGHPR</td>
<td>6</td>
</tr>
<tr>
<td>NEWSTR</td>
<td>2</td>
</tr>
<tr>
<td>COMEBK</td>
<td>0</td>
</tr>
<tr>
<td>Other</td>
<td>6</td>
</tr>
<tr>
<td>Totals</td>
<td>232</td>
</tr>
</tbody>
</table>

Chi-square = 131.746

df = 24

5 per cent level = 36.415
than any other column percentage calculated from Table 27. In this same column, 14 per cent indicated a preference of changing sizes in the original brand, a smaller proportion than seen under the other repeated stockout responses. Another observation was that a large proportion, 72.4 per cent, of respondents who would switch stores in question 7, labeled NEWSTR, would also switch in question 9. Thus was demonstrated a consistency of response to the questions asked. Also, only 3.7 per cent of the responses were indicated as some "other" decision, not listed in questions 7 and 9, possibly evidence that the alternatives provided were a representative selection.

**Measures of item substitution.**--Question 8 asked: "How important is it that your first-choice brand name and size be available?" Responses, cross-tabulated with product groups purchased, are listed in Table 28. Group differences were significant at the 5 per cent level. A majority of respondents indicated that they do switch brands and sizes within product groups. Among whiskey products, the blended whiskey purchasers displayed the most substitution, Scotch and Canadian purchasers, the least.

**Responses to questions on special orders.**--Questions 10 and 11 pertained to customers' opinions about special orders of products not normally carried in the state stores. These responses indicated what the customers considered to be reasonable waiting times for delivery of the special orders to the store and reasonable extra-service charges. A majority, 57.6 per cent, requested delivery within one week and 47.7 per cent felt that the service should be offered free
\begin{table}[h]
\centering
\begin{tabular}{lcccccccc}
\hline
\textbf{Response} & \textbf{bourbon} & \textbf{blends} & \textbf{Canadian} & \textbf{Scotch} & \textbf{gin} & \textbf{vodka} & \textbf{other} & \textbf{totals} \\
\hline
\textit{It doesn't matter} & 86 & 78 & 17 & 33 & 47 & 41 & 15 & 317 \\
\textit{Not too important} & 214 & 143 & 73 & 128 & 170 & 106 & 60 & 894 \\
\textit{Very important} & 166 & 98 & 62 & 117 & 110 & 56 & 51 & 660 \\
\textbf{totals} & 466 & 319 & 152 & 278 & 327 & 203 & 126 & 1871\textsuperscript{a} \\
\hline
\end{tabular}
\end{table}

Chi-square = 37.490

\textit{df} = 12

5 per cent level = 21.026

\textsuperscript{a}Number of customer-item requests.
of charge. A service charge of the magnitude of fifty cents per bottle was acceptable to 22.9 per cent of the respondents. The median charge indicated as acceptable was twenty cents per bottle. The median waiting time was one week. There were significant differences between groups.

Product groups purchased compared with demographic variables.--In most comparisons of product groups purchased with the demographic variables of age, family income, marital status, sex and educational background, significant differences in purchasing patterns were indicated. All group differences were significant at the 5 per cent level, except for marital status, which displayed group differences significant at the 10 per cent level. These findings would tend to support the suggestion that the product group was the critical variable of those included in the study. The product group and demographic comparisons are summarized briefly below. In the following discussion, it should be noted that the figures reflect the numbers of product group purchases and not the amounts of the products purchased.

Age.--Bourbon was not requested by younger age groups as frequently as other products. Approximately two-thirds of the bourbon purchasers were 45 years old and over. At the other end of the product line, nearly 65 per cent of the "other non-whiskeys" were purchased by those under 45. The under 45 age group, accounting for 43 per cent of total item requests, was also more heavily represented in Scotch purchases, 48.8 per cent of this product group, and vodka purchases, 48.5 per cent.
Income.--Over one-half of the purchasers of gin, vodka and Scotch, 59.5 per cent, 56.2 per cent and 55.5 per cent, respectively, indicated family incomes in excess of $10,000 per year. The product having the least relative appeal to that income group was blended whiskey; 32.1 per cent of purchasers of blends indicated $10,000 or higher incomes. Also notable was the lack of respondents in the lower income categories. This observation may be an indication of an unwillingness to complete the questionnaire rather than the absence of the lower income groups from the liquor market.

Marital status.--Nearly 80 per cent of the respondents were married. The product group requests followed this proportion closely with the exception of gin: 87 per cent of the gin purchases were made by married customers.

Sex.--Male respondents outnumbered female respondents by a 7 to 3 ratio. Apparent differences in product requests were for bourbon, which was more popular among men, and for the "other non-whiskey" products, where women asked for 37.4 per cent of the purchases.

Education.--Seventy per cent of the product requests indicated an educational level which included schooling past high school. This figure was greatly in excess of the 20 per cent which would be expected from general population characteristics. There may be a tendency among customers with less than average schooling to respond to questionnaires. Even with the skewness, some conclusions may be drawn

9See Appendix G.
from the product requests made by the higher educated segment versus the high school and lower group. The higher educated group purchased less than their proportional numbers of blended whiskeys, with 56.3 per cent of total purchases of this product group, Canadian whiskey, 63.4 per cent, and bourbon, 67.8 per cent. More popular with those with higher educational levels were gin, other non-whiskeys, vodka and Scotch, with 81.3 per cent, 77.0 per cent, 76.0 per cent and 74.0 per cent, respectively, of those product group purchases.
CHAPTER V

SUMMARY AND CONCLUSIONS

Summary of the research

Background.--From a survey of the literature of inventory management, it was concluded that, in general, the objective of inventory control was to minimize costs. Three basic cost categories were normally considered: procurement costs, carrying costs, and costs of inventory shortages. Cost measurement methods had been applied generally to the first two categories but only infrequently to the third. Rather than attempt to measure the costs of inventory stockouts, a more common practice was to define some level of customer service and then specify inventory policies around it. Cost control was emphasized only for procurement and carrying costs, often using an economic ordering quantity procedure.

Objective.--Although inventory management writers discussed the importance of controlling inventory stockouts, few procedures were offered which would explain the factors which cause this out-flow of funds or decrease in revenue. Knowledge of the events which transpired, causing these supposed adverse financial effects, might allow the events to be better defined and could facilitate the measurement of their effects in financial terms. Thus, the objective of the
research became one of defining or modeling the events surrounding stockout situations, and developing a procedure which would enable the measurement of the possible changes in revenues received by the institution incurring the stockout.

Stockout models.--The events which may take place when a single item is not available when a customer desires it were considered as the single stockout situation. A model of this situation was diagramed in Figure 5, Chapter III. Another case considered was the set of events that may transpire if an institution were out of stock of a desired item on each of several occasions that a customer attempted to purchase it. This situation might take place if an item were deleted, without announcement, from a product line, or where long ordering lead times were required and all inventory of the item was depleted. This case, referred to as the repeated stockout situation, was modeled in Figure 6, Chapter III.

The events considered in the stockout models were based on decisions made by customers who were denied the purchase of their desired items. The alternatives in the models were listed with the assumption that they were the ones most likely to be considered by the customer encountering the stockout situations. The selection of each alternative would have some effect on the revenue that would be received by the institution in question. If the proportion of customers who could be expected to choose each alternative were known, a weighted average, or expected monetary value, of the revenue difference could be calculated. This expected value would be one measure of
the cost of a stockout.

**Empirical research conditions.**—The empirical portion of the research was conducted in cooperation with the Ohio Department of Liquor Control, through its retail liquor stores. There were several advantages to working with the Department. The number of marketing variables to be considered was reduced: all retail liquor sales in the state were handled by the Department; there was no price competition since all prices were uniform throughout the state; the decisions to be made under stockout conditions were entirely due to the customers' reactions because no promotional or persuasive activities were permitted in the state stores; and any alternative sources of supply, being other state stores, were known. Also important was the fact that stockouts had recently occurred in the state store system so customers might have been expected to be familiar with purchasing under these conditions.

It was considered desirable to obtain information from customers of the state liquor stores that could be applied directly to the two models formulated to enable the calculation of the expected revenue differences. If values for the parameters of the models were available, the models could be used as actual stockout cost measurement procedures. To gain insight into the decisions made by customers under stockout conditions, it was also desired to gather data to permit the study of these decisions as they might vary by product and by available demographic variables. Apparent correlations among variables would be useful in constructing mathematical models for
predicting stockout decisions. Hypotheses were written to parallel the above ideas so that empirical data could be tested statistically.

**Data collection procedure.**--A questionnaire was designed for distribution to state liquor store customers to gather the information discussed above. In addition, the Department desired information pertaining to the level of customer service and general attitudes about its retail stores. The questionnaire was two pages in length, utilizing mostly multiple-choice questions, with several questions which asked the respondent to fill in some blank spaces with quantities, brand names and types of liquor products purchased or not available. The questionnaire was prefaced by a short letter from the director of the Department, requesting the customer's assistance.

Questionnaires were distributed in ten state stores throughout Ohio. At the time a customer made a purchase, the store employee included a questionnaire and a postage-paid business reply envelope with the items being wrapped. In most instances, the customer first encountered the questionnaire when he unwrapped the bottles. The decision to respond to the questionnaire was thus entirely left up to the customer; in most cases, no discussion of the inserted materials took place in the store.

Questionnaires in usable form were received from 1,433 respondents. The following statistical techniques were used to analyze the data: simple accumulation of responses to questions, cross-tabulation with chi-square analysis, basic expected monetary value calculations, analysis of variance, and a stepwise discriminant
analysis program. The techniques were chosen for their applicability to the models and to the hypotheses and for their availability.

Conclusions from the research

Models.--Average values for the parameters of the basic stock-out model indicated that 59.1 per cent of the respondents would switch brands, staying in the same price range. The effect on revenue due to this decision was minimal and would be zero if the switch were to an identically priced item. A smaller group, 19.3 per cent, would substitute a different size of their originally desired brand. Based on sales figures of liquor packages, by size, the most likely size substitution would be a smaller bottle, causing a decrease in revenue received by the store from this transaction. Another group, 14.1 per cent, would purchase at another store. This activity had the largest effect on the first store's revenue because an entire sale was lost. The remaining three alternative decisions each received responses on the order of 2.5 per cent. Those who would choose a substitute product in a higher price range tended to cancel out those who would move to a lower price range. However, the customer who would prefer to wait until the store incurring the stockout received a new shipment of the desired product might, in effect, cause a revenue loss because of the irretrievable loss of product demand during the stockout period.

The expected monetary value of a single stockout of a typical liquor product in the fifth of a gallon size was calculated as a negative $1.26, or 24.2 per cent of the retail price. This expected value was the summation of the individual revenue differences weighted
by the relative frequencies of the consumer decisions discussed above.

The values for the parameters of the repeated stockout situation provided similar information. Under the stated conditions, the largest group, 39.9 per cent of respondents, indicated they would shop at a different store to obtain the desired brand and size. This proportion was larger than in the single stockout model and would have a greater effect on the loss of revenue. A slightly smaller proportion, 32.6 per cent, would expect the item to be back in stock on their third attempt to purchase it. The effects of this group would be similar to the single stockout situation. A third group, 24.6 per cent, who would change the item they requested on the next shopping trip, had little effect on revenue because most of them, 79.0 per cent, said they would remain in the same price range. Only 2.9 per cent considered placing a special order for the missing item.

Since the repeated stockout situation takes place over an extended period of time, the effects would not be felt by the store except over time. These revenue differences were thus weighted by the average number of trips made by customers to the state stores in a year. The average annual revenue difference rate was calculated to be negative $89.64 per affected customer for the typical liquor item.

Hypotheses.—It was shown that the decisions made by customers who encountered stockout situations tended to vary according to the product group in which the stockout occurred. Although the product groups involved in the research were all liquor products, the different groups had distinct attributes, such as taste, appeal and
image, and different consumption patterns. There were also varying pricing patterns within and between groups. It was expected that customers' decisions might depend upon the out of stock product. This conclusion was shown to be valid for both models tested. The tests of the hypotheses are summarized in Table 29.

In the single stockout situation, Hypothesis 1, purchasers of bourbon and Scotch were more inclined to buy a different size of their preferred brand than were users of the other product groups. While 21.2 per cent of Canadian whiskey purchasers tended to look for their first-choice brand and size at another store, users of blends, gin and vodka switched stores about one-half as frequently. In the repeated stockout situation, Hypothesis 3, purchasers of Scotch whiskey and other non-whiskey products tended to opt for another store. Users of bourbon, blends and vodka tended to change the items requested, usually to another brand in the same price range, more often than other customers.

To the seller, the costs of being out of stock a single time depended upon the product group in which the stockout occurred; see Hypothesis 2. Most costly was a stockout of a Scotch product, which was estimated to cost the seller $2.33 in reduced revenue, 85 per cent higher than the average liquor product stockout. For repeated stockouts, the magnitudes of the revenue differences for the various product groups, as tested for Hypothesis 4, were not widely separated. This effect may have been due to the fact that customers for most product groups indicated intentions to switch stores in repeated
<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Variables</th>
<th>Test</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>decisions, products</td>
<td>chi-square</td>
<td>rejected</td>
</tr>
<tr>
<td>2</td>
<td>revenue diff., products</td>
<td>analysis of variance</td>
<td>rejected</td>
</tr>
<tr>
<td>3</td>
<td>decisions, products</td>
<td>chi-square</td>
<td>rejected</td>
</tr>
<tr>
<td>4</td>
<td>revenue diff., products</td>
<td>analysis of variance</td>
<td>not rejected</td>
</tr>
<tr>
<td>5</td>
<td>decisions, age</td>
<td>chi-square</td>
<td>rejected</td>
</tr>
<tr>
<td></td>
<td>family income</td>
<td></td>
<td>not rejected</td>
</tr>
<tr>
<td></td>
<td>marital status</td>
<td></td>
<td>not rejected</td>
</tr>
<tr>
<td></td>
<td>sex</td>
<td></td>
<td>not rejected</td>
</tr>
<tr>
<td></td>
<td>education</td>
<td></td>
<td>not rejected</td>
</tr>
<tr>
<td>6</td>
<td>decisions, age</td>
<td>chi-square</td>
<td>rejected</td>
</tr>
<tr>
<td></td>
<td>family income</td>
<td></td>
<td>not rejected</td>
</tr>
<tr>
<td></td>
<td>marital status</td>
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<tr>
<td></td>
<td>sex</td>
<td></td>
<td>rejected</td>
</tr>
<tr>
<td></td>
<td>education</td>
<td></td>
<td>not rejected</td>
</tr>
<tr>
<td>7</td>
<td>decisions, products and demographics</td>
<td>discriminant analysis</td>
<td>not rejected</td>
</tr>
<tr>
<td>8</td>
<td>decisions, products and demographics</td>
<td>discriminant analysis</td>
<td>not rejected</td>
</tr>
</tbody>
</table>

*Hypotheses 1, 2, 5 and 7 applied to the single stockout model; hypotheses 3, 4, 6 and 8 applied to the model for repeated stockouts.*
stockout cases although this tendency was not so prevalent in single stockout situations.

When customer decisions were compared with demographic variables, significant group differences were found for age, for both stockout models, and for sex, for the repeated stockout situation only; see Hypotheses 5a, 6a and 6d. In the single stockout situation, older purchasers were more inclined to switch stores than younger buyers and less inclined to purchase another brand of a product group. In the repeated stockout situations, older customers appeared to more readily accept the non-availability of a deleted product and were prepared to request something else. Although it may be argued that the above statements are somewhat in contradiction of one another, one could reason that the older customer, in the long run, is more likely to purchase from his established source of supply although he may make departures occasionally for specific items. The data may have reflected purchasing habits acquired over a long period of time by these customers.

In the repeated stockout situation, female shoppers appeared to display more persistence in attempting to obtain the out of stock item at their regular store. Male shoppers were more likely to ask for a substitute product rather than attempt the purchase of the previously unavailable item again.

For the single stockout case, one out of five demographic variables measured demonstrated definite differences in decision patterns; see Hypotheses 5a through 5e. For the repeated stockout
case, two of the demographic variables indicated group differences; see Hypotheses 6a through 6e. The remaining demographic variables indicated no significant relationships to the customer decisions tested. It was concluded that, in general, the demographic variables would not be expected to display useful predictive capabilities.

Predictive models containing demographic and product variables were developed using discriminant analysis techniques. Both the single stockout and repeated stockout situations were studied; see Hypotheses 7 and 8. A stepwise discriminant analysis procedure was employed to allow variables which tended to better explain group variances the most weight in the predictive equations. The two predictive models formulated did not produce accurate cost estimations.

General conclusions

The method of measuring the cost effects of a single stockout situation were based on a plausible set of consumer decision alternatives. Values provided by the use of this model were of a consistent order of magnitude. Since the total expected monetary value was the sum of several smaller parts, the magnitude of possible error terms was reduced. Based on tests of the stated hypotheses, it appeared that a separate set of model parameters should be measured for each product group to which the model is applied, rather than using overall average responses for all products.

The same conclusions were applied to the model of the repeated stockout situation with a few reservations. First, its use depended upon the concurrent availability of information about the
corresponding single stockout situation. It should be possible to devise a question, and a related set of responses, to provide proper measurements of customers' actions for this model alone. In the general case, there would not be an alternative of a special order. But, as few respondents indicated their choice of this decision, it had little bearing on the results. Stating the financial effects of the repeated stockout situation as an annual rate should facilitate its understanding among inventory managers. As with the single stockout model, a separate set of measurements would be advised for each product group considered, rather than the use of overall averages.

The general result to be drawn from the testing of the hypotheses was that the products affected were better predictors of the customers' reactions to inventory stockouts than were customer demographics. It may be that liquor product preference served as a valid proxy variable for other customer life-style information.

It may be argued that the study was successful in demonstrating that the problem of measuring the costs of inventory stockouts is more one of measuring overall group responses to a defined inventory situation and less a problem of individual consumer behavior patterns. This conclusion may be valuable from an operational point of view because it is generally easier to observe group purchase patterns than to obtain individual demographic data.
Implications for management

The most obvious implication for managers of inventories is that the models of the two defined stockout situations have been tested empirically and found to provide methods for calculating expected revenue differences due to stockouts. In the case of liquor products, the expected cost, in terms of lost revenue to the store, of a single stockout was 24 per cent of the retail price of the average product. This magnitude may provide a basis of comparison for potential users of the method.

The procedures described for obtaining customer decision data may be applied in other business situations involving stockouts. The alternatives open to the customers and the frequencies of choice of each of these alternatives may be varied considerably from those of the present study. Situations that may be possible candidates for application of these methods may be those involving products with distinctive product attributes and moderate unit prices, probably on the order of several dollars. Lower priced items also may fit a similar decision pattern although the implied purchase risk is less than for higher priced items. The types of outlets utilized in the study were not typical of retail establishments. Data collection in other establishments might follow a similar procedure although results of the data collected under other conditions may be expected to vary from those described due to influences of the customers' perceptions of the establishment, product, purchase alternatives and other factors.

Inventory managers may find the suggested methods for costing
stockouts most useful by transforming the expected revenue differences into differences in gross margins. If cost-plus pricing had been employed for a product line, the margin differences may be calculated by a simple multiplication of price times a constant discount factor. Other pricing schemes would be somewhat more difficult to transform, possibly reflecting different pricing policies for several items within a single product line. When the effects of stockouts are expressed as reductions in margin, rather than reductions in revenue, they may be more validly compared with the costs of procuring and carrying inventory to obtain a true total cost picture. These reductions in margin may be viewed as empirically obtained measurements of the stockout penalty costs discussed in Chapter II. Therefore, this extension of the results of the study may also be a contribution to the accuracy of calculations based on the several variations of total cost equations which contain penalty functions.

The equations developed for calculating the expected monetary values of stockouts, in terms of revenue differences, were simple linear equations and could easily be programmed in a routine to calculate the EMV of single and repeated stockouts for every item in a given product line. Then, given the necessary product cost information, the EMV of revenue differences could be converted to the EMV of gross margins. The EMV of the gross margin difference due to a single stockout might be especially useful in determining whether or not to incur extra costs of expediting an order to avoid a stockout.

The repeated stockout cost model may prove beneficial for
managers considering the deletion of a product line. For example, a proposed product line revision might include the deletion of one item and the addition of another. To a customer desiring the deleted item, the change in product lines has produced a repeated stockout situation. If the decision were being considered by the manager of a state liquor store, he might first calculate the annual revenue difference due to the deletion of that product, according to the method shown in Table 2. If procurement and carrying costs were assumed to be the same for the present product and the proposed product, the manager might simply compare the expected revenue loss, adjusted by his estimate of the numbers of customers affected, with the total expected revenue from the new product. If the proposed new product did not more than compensate for the losses due to the impending repeated stockout situations, the product line revisions would not be approved.

In cases where procurement costs and carrying costs were not the same for the products considered, the annual revenue difference, adjusted by the number of customers affected, would be converted to an annual gross margin difference and the total inventory costs for each alternative calculated and compared.

As an extension of the above discussion, all products in a line might be ranked according to the adjusted annual revenue differences due to repeated stockouts. This ranking would indicate possible candidates for deletion from the line and would also indicate the products which would produce the most serious revenue effects were they to be out of stock repeatedly. In cases where prices were not
determined on a cost-plus basis, gross margin differences would again be calculated and the ranking based on margins, instead of revenues. A ranking such as this might be useful when it is possible to carry only the most critical items, because of physical space or other limitations. By expressing these costs on an annual basis, the figures will be compatible with standard fiscal accounting reports and should facilitate the use of the suggested costing methods.

**Implications for marketing theory**

The research demonstrated the development and use of one method for measuring the financial effects of inventory stockout situations. Although empirical evidence was gathered for only one type of product, there were no product restrictions inherent in the method. The procedures shown should advance the use of the total cost concept of inventory control because they include the ultimate effects of the level of customer service as a financial element. Rather than establish an arbitrary service level to be achieved, for planning purposes, an inventory policy conceivably might be stated as simply to provide the lowest total cost of operation, with the understanding that total costs included cost effects due to the level of customer service. The level of customer service, in terms of the proportion of requests fulfilled from inventory, would be measured only to ascertain what level was established by the lowest total cost criterion but not as a measure of attainment of objectives.

The research provided examples of data collection procedures applicable to stockout situations. Based on the results of the
questionnaire used in the study, the problems of conducting similar marketing research should be reduced. The questioning techniques may be considered as established and directly applicable to the stockout situations described. The models developed were conceptually simple yet provided adequate flexibility for the decision alternatives without contributing computational complications.

The type of marketing research that may be conducted in an isolated marketing environment was demonstrated by the study. The results obtained in this manner were not subject to variations due to uncontrollable marketing variables, such as price and promotional competition. Other marketing studies may be developed for empirical research in a controlled business environment. This study benefited because information collected was from an actual business situation, rather than a simulation or laboratory arrangement. Also, the collection of data was from a large sample size but questionnaire distribution was not a complicating factor due to the coordination by the controlling body. A disadvantage of conducting research in an isolated business environment is the restriction that the conclusions reached cannot be directly applied to other businesses in more common competitive environments.

Use of models such as those described in this study may assist market researchers in their analysis of the value of product line additions. Are seemingly redundant product lines, with additional opportunities for inventory shortages, more profitable for a firm than fewer, but more consistently stocked, products? These breadth of
assortment problems require methods to measure the effects of various resource allocations, such as the case where a limited inventory investment must be applied to either relatively large inventories of a few items or small inventories, more subject to stockouts, of many items.

Suggestions for further research

One suggestion which may be derived from the above discussions would be to apply the stockout models to additional products and customers for these products. Each potential stockout situation may have an individual set of possible decision alternatives for the affected customers to choose from. The present study concluded that product variables were better indications of customers' decisions in stockout situations than were demographic variables. Future research may attempt to define product attributes that are likely to influence customers' stockout decisions.

Probably the greatest obstacle to the application of the models described herein is the necessity for collecting information at the consumer level. While the distribution of lengthy questionnaires to many groups of customers may be prohibitive, it should be possible to develop a short set of basic stockout decision questions which could be administered on an inexpensive basis. A postcard reply form might be applicable in obtaining responses from customers of specified business establishments. Or, stockout responses in relation to certain products might be included among questions given to existing consumer survey panels.
The specialized marketing environment in which the study was conducted may have affected the results obtained from customers. A parallel study might be conducted in a state with privately owned liquor stores, using the same type of questionnaire, and the results compared with the findings reported above. Customers encountering stockouts in another environment might indicate different propensities to substitute products, sizes, price lines or sources of supply. The cost effects of stockouts may be affected also by different pricing policies, including varying gross margins and possibly higher or lower price levels in general.

The most conclusive evidence of the usefulness of the models described would be to establish them as operational methods in a total cost inventory management system. Only under actual use conditions could the procedures be conclusively proved beneficial as an inventory management technique.
APPENDIX A

LIQUOR PRODUCT GROUPS AND RETAIL CASE SALES IN OHIO, 1970a

<table>
<thead>
<tr>
<th>Product Groups</th>
<th>Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bourbon group</strong></td>
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<tr>
<td>Bonded</td>
<td>92 154</td>
</tr>
<tr>
<td>Straight</td>
<td>828 387</td>
</tr>
<tr>
<td>total bourbon</td>
<td>920 541</td>
</tr>
<tr>
<td>Rye--bonded</td>
<td>2 275</td>
</tr>
<tr>
<td>Rye--straight</td>
<td>3 729</td>
</tr>
<tr>
<td>Corn--straight</td>
<td>2 522</td>
</tr>
<tr>
<td></td>
<td>929 067</td>
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<tr>
<td><strong>Blends group</strong></td>
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<tr>
<td>Spirit blends</td>
<td>1 012 732</td>
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<tr>
<td>Australian</td>
<td>37</td>
</tr>
<tr>
<td>Belgium</td>
<td>4 385</td>
</tr>
<tr>
<td>Irish</td>
<td>1 612</td>
</tr>
<tr>
<td></td>
<td>1 018 766</td>
</tr>
<tr>
<td><strong>Canadian</strong></td>
<td>426 895</td>
</tr>
<tr>
<td><strong>Scotch</strong></td>
<td>387 797</td>
</tr>
<tr>
<td><strong>Total Whiskey</strong></td>
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<tr>
<td><strong>Gin group</strong></td>
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<tr>
<td>domestic</td>
<td>321 094</td>
</tr>
<tr>
<td>imported</td>
<td>22 162</td>
</tr>
<tr>
<td></td>
<td>343 256</td>
</tr>
<tr>
<td><strong>Vodka group</strong></td>
<td></td>
</tr>
<tr>
<td>domestic</td>
<td>313 938</td>
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<tr>
<td>imported</td>
<td>233</td>
</tr>
<tr>
<td></td>
<td>314 171</td>
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<tr>
<td><strong>Other Non-Whiskeys group</strong></td>
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<tr>
<td>Brandy</td>
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</tr>
<tr>
<td>domestic</td>
<td>36 019</td>
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<tr>
<td>imported</td>
<td>17 770</td>
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<tr>
<td></td>
<td>53 789</td>
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<tr>
<td>Rum</td>
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<tr>
<td>domestic</td>
<td>80 013</td>
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<tr>
<td>imported</td>
<td>940</td>
</tr>
<tr>
<td></td>
<td>80 953</td>
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<tr>
<td>Cordials &amp; Liqueurs</td>
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<tr>
<td>domestic</td>
<td>80 915</td>
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<tr>
<td>imported</td>
<td>14 170</td>
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<td></td>
<td>95 085</td>
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APPENDIX A--continued

<table>
<thead>
<tr>
<th>Product Groups</th>
<th>Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specialties &amp; Cocktails</td>
<td></td>
</tr>
<tr>
<td>domestic</td>
<td>25 534</td>
</tr>
<tr>
<td>imported</td>
<td>2 580</td>
</tr>
<tr>
<td>Total other than Whiskey</td>
<td></td>
</tr>
<tr>
<td>Total, all liquor product groups</td>
<td></td>
</tr>
</tbody>
</table>

APPENDIX B

PRICE RANGES

The stockout models included decision alternatives of brand substitution in the same, lower and higher price ranges. Because price distributions vary by liquor product groups, it was necessary to analyze the pricing patterns for major brand items.\(^1\) Then, price ranges and representative prices within the ranges were defined so that the effects of the substitutions could be calculated.

A general method of defining price ranges will be described. First, the brand items within each product group were ranked from low price to high price and unit sales accumulated. The percentile spectrum was then divided into thirds, constituting the low, middle and high price ranges. For the purpose of calculating price range differences, the median prices, the 16 2/3, 50 and 83 1/3 percentiles, in each of these ranges were taken as representative. It may be argued that the prices so chosen are not the actual weighted averages for each range. However, the price defined for each range will be the mid-point of that range, with the number of units sold on or above that price equal to the number sold on or below that price. Furthermore, since the objective of this analysis was to arrive at a measure of the difference in price ranges, the use of these median prices

\(^1\)Major brands were considered to be those reporting sales of 10,000 cases at retail in Ohio during 1970. Prices analyzed were for quantities of a fifth of a gallon. When prices were listed for a quart rather than a fifth, they were adjusted by a factor of 0.8, arrived at by dividing 25.6 oz. by 32 oz. Sales figures and prices from: Cleveland Press, Ohio Liquor Sales, pp. 1-59.
achieves that objective without extensive calculations. Even in those cases where there are two clearly defined price ranges, such as with Scotch, this method is still effective.\(^2\) The three median prices for Scotch are $5.32, $7.53 and $7.59. The price range differences are then $2.21 and $.06. Since there is only one major difference between price ranges in this case, that between the low and middle ranges, there remains, for all practical purposes, only two real price ranges.

The median prices for six product groups are listed in Table 30, along with the price range differences and spreads.\(^3\) The average difference between price ranges is seen to be $.61. This average figure will be applied to the "other non-whiskey" products because few of them were identified separately as major brands.

Further analysis of Table 30 shows the usefulness of this method for defining price ranges. For example, when the spread is small, as with gin, there is, essentially, only one general price range. Where most of the spread is accounted for by only one difference, there are two main price ranges. The figures indicate that both Canadian and Scotch fit that description. However, the higher price

\(^2\)Cleveland Press, *Ohio Liquor Sales*, p. 23: 44 per cent of the major brands sell for between $4.96 and $5.79 per fifth (lower price range) and 56 per cent sell within the $7.45 to $7.59 range.

\(^3\)The price spread is defined as the difference between the low median price and the high median price. It is equal to the sum of the individual price range differences.
### TABLE 30
PRICE RANGES

<table>
<thead>
<tr>
<th>Product Group</th>
<th>Low</th>
<th>Diff.</th>
<th>Middle</th>
<th>Diff.</th>
<th>High</th>
<th>Spread</th>
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</thead>
<tbody>
<tr>
<td>bourbon</td>
<td>4.59</td>
<td>.61</td>
<td>5.20</td>
<td>.59</td>
<td>5.79</td>
<td>1.20</td>
</tr>
<tr>
<td>blends</td>
<td>4.38</td>
<td>.25</td>
<td>4.63</td>
<td>.62</td>
<td>5.25</td>
<td>.87</td>
</tr>
<tr>
<td>Canadian</td>
<td>5.24</td>
<td>.27</td>
<td>5.51</td>
<td>1.59</td>
<td>7.10</td>
<td>1.86</td>
</tr>
<tr>
<td>Scotch</td>
<td>5.32</td>
<td>2.21</td>
<td>7.53</td>
<td>.06</td>
<td>7.59</td>
<td>2.27</td>
</tr>
<tr>
<td>gin</td>
<td>4.34</td>
<td>.10</td>
<td>4.44</td>
<td>.22</td>
<td>4.66</td>
<td>.32</td>
</tr>
<tr>
<td>vodka</td>
<td>3.95</td>
<td>.42</td>
<td>4.37</td>
<td>.43</td>
<td>4.80</td>
<td>.85</td>
</tr>
</tbody>
</table>

*aData source: Cleveland Press, Ohio Liquor Sales, pp. 1-59.

range for Scotch predominates while there were more indicated sales of the lower priced Canadian whiskeys. The method described here may be useful for product lines other than liquor products and could be modified to define any number of price ranges desired.
APPENDIX C
STORE SELECTION PROCEDURE

The procedure described below was used to select the individual stores included in the sample. It was required that the stores include a distribution throughout the retail sales range of $250,000 and over, annually. Two stores were to be chosen from each warehouse district with one exception: taking note of the relative differences in sales between the Cleveland district, $85 million, and the Toledo district, $23.5 million, it was decided to allot them three stores and one store, respectively, instead of two each. ¹

Procedural steps

1. All stores with retail sales volume of $250,000 and above were ranked by sales, in descending order.

2. Cumulative sales were recorded for each store, again in descending order. Total sales for this group of 269 stores were $217,277,072; for all retail outlets, total sales were $231,048,837.

3. From the ordered list, the stores that accounted for the first million dollars in sales, the 24th, 47th (stepping by 23 million), 70th, 93rd, 116th, 139th, 162nd, 185th, and 208th were selected. These ten stores, identified by store number, district and retail sales dollars, were:

¹ All figures from: Ohio, Department of Liquor Control, Annual Report: 1969, pp. 41-58.
<table>
<thead>
<tr>
<th>Store</th>
<th>District</th>
<th>Retail sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>150</td>
<td>E</td>
<td>$3,059,686</td>
</tr>
<tr>
<td>140</td>
<td>E</td>
<td>1,674,695</td>
</tr>
<tr>
<td>301</td>
<td>B</td>
<td>1,512,555</td>
</tr>
<tr>
<td>269</td>
<td>D</td>
<td>1,320,170</td>
</tr>
<tr>
<td>139</td>
<td>E</td>
<td>1,120,560</td>
</tr>
<tr>
<td>213</td>
<td>C</td>
<td>937,624</td>
</tr>
<tr>
<td>004</td>
<td>C</td>
<td>798,770</td>
</tr>
<tr>
<td>036</td>
<td>A</td>
<td>638,076</td>
</tr>
<tr>
<td>260</td>
<td>D</td>
<td>513,162</td>
</tr>
<tr>
<td>161</td>
<td>E</td>
<td>334,183</td>
</tr>
</tbody>
</table>

4. The spread among stores, by districts and sizes, was observed to be nearly satisfactory but with two exceptions: (1) there were four stores, including the two largest in the sample, from the Cleveland (E) district and, (2) there was only one store from the Cincinnait (A) district and it was among the smaller stores represented. Referring again to the ordered list of stores, it was found that the largest store in the A district, store number 238, accounted for the 27th million in retail sales. This store was substituted for store number 140, district E, in the second position on the list of ten, thus correcting the deficiencies noted above.

5. Finally, the addresses and store layouts, whether self-service or perimeter types, for the individual stores were reviewed with a Department of Liquor Control spokesman to avoid any unnecessary
duplication or omission.² Although only three of the stores were of the self-service type, they were among the largest, accounting for nearly one-half of the sales of the ten stores. A desired diversity in city locations was noted in the Cleveland area and Columbus. The only section of the state not represented was the lightly populated southeastern area.
APPENDIX D

CALCULATION OF AVERAGE PRICE PER BOTTLE

Total bottles = 69,523,234\textsuperscript{a}

Store activity = 94.7\% of total; Agency activity = 5.3\% of total\textsuperscript{b}

Bottles handled in stores = 69,523,234 \times 0.947 = 65,838,503

Retail activity in stores = 68.4\% of total; Wholesale activity = 31.6\% of total\textsuperscript{c}

Bottles sold at retail in stores = 65,838,503 \times 0.684 = 45,033,535

Retail store sales = $214,047,209\textsuperscript{d}

Therefore, average price per bottle sold by a store at retail =

$214,047,209/45,033,535 = $4.75$

\textsuperscript{a}Ohio, Department of Liquor Control, Annual Report: 1969, p. 22.

\textsuperscript{b}Ibid., p. 29.

\textsuperscript{c}Ibid.

\textsuperscript{d}Ibid.
APPENDIX E

DESCRIPTION OF TESTS OF QUESTIONNAIRE DISTRIBUTION METHODS

Questionnaire trial I

A test of the customer survey was made on June 16, 1971, between the hours of 1 and 3:30 PM. The store used was state store number 212, located in the heart of downtown Columbus at 50 North High Street. A total of 99 customers were approached during the period.

Method of distribution.—During the first hour, the researcher stood near the cashier's counter and approached each customer by offering him or her a questionnaire and a pencil, explaining that this was a survey and asking if he or she had a minute to fill it out. If the customer asked for more information, he was told that the survey was designed to learn about his opinions regarding the service provided by the state store so that it could be improved. At this point, the customer usually had decided to either accept or reject the questionnaire; a few entered into longer discussions with the researcher.

The researcher moved toward the front of the store for the final one and one-half hours and attempted to get the questionnaires passed to the customers while they were making their selections. The same opening remarks were employed. Unless the customer immediately requested more information, the researcher would tend to retreat before the customer could return the questionnaire without inspecting it.

Results.—During the first hour, 24 out of 44 customers accepted the questionnaire; this acceptance rate was 54 per cent. In the next period, 28 out of 45 customers, or 62 per cent, accepted
questionnaires. Based on the somewhat better response rate of the second group, it was concluded that customers were less likely to reject the survey if it were offered to them early in their visit. At this time, they expected to spend a few minutes looking and waiting anyway; a few minutes more might not alter their schedule appreciably. But when the customers had completed their part of the transaction, they were ready to leave as soon as the products were handed to them. This appeared to be especially true of people who were office or professional employees, many of whom were shopping during their lunch hours or coffee breaks and were, in fact, pressed for time.

Observations.—Several customers commented that service was just fine and nothing they might say in a survey could help it. The result of this action would be to lower the indicated service level measured from collected data because these satisfied customers would not be represented. On the other hand, this excuse may have been offered to avoid further confrontation with the researcher. Other customers commented that they did not have the time but might be interested. Some of these people asked if they could send in the completed questionnaire or even return it the next day. It was the opinion of the researcher that the return would have been greater if these people had been given the opportunity to mail their responses. Furthermore, it was felt that the responses obtained from those who remained in the store to fill out the questionnaire might not be truly representative of the customer population: only those people with time to spare at that particular period of the day would be counted.
The other truly busy people, whose opinions might be completely dif-ferent, especially about levels of service, and with widely varying demographic characteristics, would be omitted.

Too much time was required by several customers who agreed to fill out questionnaires. While the questions did appear to the researcher to be clearly stated, it should be remembered that many citizens do extremely little reading and writing: some spent upwards of ten minutes to complete the questions. Although the return rate appeared to be over fifty per cent, only thirty questionnaires were filled out either completely or nearly so. It was recommended that the sample questionnaire be shortened where possible by deleting some questions and re-wording others. It was further recommended that the questionnaire be printed with larger type; two customers complained that they could not read the questionnaire without their glasses and others appeared to have trouble focusing.

Questionnaire trial II

A second questionnaire distribution method was tested on June 28, 1971. Store number 20, located at 1399 Grandview Avenue, in the Grandview Heights area of Columbus, furnished the test sample of customers. The store was described by the manager as a "neighborhood store."

The purpose of this second test was to try a mail-back return of the questionnaires. Standard business-reply envelopes were printed, using the Ohio State University return address. Postage was indicated as having been paid by the addressee.
Store employees were instructed to place a questionnaire and an envelope in the paper bag in which each purchase was wrapped. No additional verbal contact with the customer was requested. The store was supplied with 100 questionnaires and envelopes and employees were asked to continue their distribution until that supply was exhausted.

Observations.--As in the first store tested, the manager and employees were highly cooperative and appeared to function well as a group. The manager expressed some apprehension about surveying his customers about their liquor purchases. It was agreed that this was a problem area and that some people were quite sensitive about what they might interpret as interference. While the distribution was being observed, one male customer removed the questionnaire from the sack, looked at it, mumbled something about "mind their own business," and walked away, leaving the questionnaire and envelope on the counter.

This method of questionnaire distribution definitely was less intrusive than that used in trial I. The store manager seemed to have an understanding of his local customers, having also been employed in other state stores in the Columbus area. He felt that his customers would not like to remain in the store to fill out a questionnaire. During the observation, the customers did appear to transact their business without delay, neither in the search for the products, at the cashier station, nor at the receiving counter. It may be true that these people would attach some social stigma to being seen standing in a liquor store for an extended period, even for the sake of market research.
From the standpoint of placing the questionnaires in the hands of potential respondents, the second method was much more desirable. Although the actual response rate was on the order of ten per cent, the advantages offered more benefits as a research procedure. First, the questionnaires were more likely to be inspected by a broader spectrum of the customers. Most customers carried the questionnaires out of the store with their purchases, presumably to some location where they might have time enough to read at least a few lines before deciding whether or not to cooperate. Second, there was less disruption of the normal store activity; customers were not detained on the premises. Third, no additional manpower was required, a potential problem when ten stores were considered. The existing clerks readily handled the temporary additional tasks. Also, no signs or collection boxes were required, an especially desirable attribute in the self-service stores where there were no built-in writing surfaces and supplies of pencils. Finally, the second method avoided discussions with customers about a possibly sensitive subject.
APPENDIX F

QUESTIONNAIRE AND RETURN ENVELOPE

Dear Customer:

The Ohio Department of Liquor Control is conducting a statewide survey of customers' buying patterns to improve the selections offered for sale and update their operations. The Ohio State University Research Foundation is directing the survey, the first one ever done by the Ohio Liquor Department.

Will you help us by taking a few minutes to fill out this form and return it in the pre-stamped, self-addressed envelope. In this way your opinion can be counted with other Ohio citizens.

Thank you.

R. E. Guggenheim
Director

OHIO DEPARTMENT OF LIQUOR CONTROL
PLEASE CHECK ( ) THE BEST ANSWER FOR EACH QUESTION OR FILL IN THE BLANKS. THANK YOU.

1. Were there any items (either size or brand) that you wanted to purchase but could not find here today?
   ( ) NO
   ( ) YES   If YES, please list below.

<table>
<thead>
<tr>
<th>How many</th>
<th>Size</th>
<th>Brand name</th>
<th>Product (Kurken, Blended, etc.)</th>
</tr>
</thead>
</table>

2. What items did you purchase here today?

<table>
<thead>
<tr>
<th>How many</th>
<th>Size</th>
<th>Brand name</th>
<th>Product (Kurken, Blended, etc.)</th>
</tr>
</thead>
</table>

3. How much did you spend here today? $__________

4. In the last 30 days, including today, about how many times did you or some member of your family visit a state liquor store? __________ times.

5. On these shopping trips to state stores, were you or some member of your family not able to find the items you intended to buy?
   ( ) NO
   ( ) YES   If YES, how many times? __________ times

6. Why did you come to this particular state store?
   ( ) It is closest to where I live.
   ( ) It is closest to where I work.
   ( ) Another state store didn’t have what I wanted.
   ( ) I was doing some other shopping in the area.
   ( ) Other. Please specify: ____________________________

7. When your first-choice brand and size is not available, what do you usually do?
   ( ) Substitute a different size in my first-choice brand.
   ( ) Substitute another brand in the same price range.
   ( ) Substitute another brand in a lower price range.
   ( ) Substitute another brand in a higher price range.
   ( ) Try to find my first-choice at another state store.
   ( ) Wait until a new shipment arrives here.
   ( ) Other. Please specify: ____________________________
8. How important is it that your first-choice brand name and size be available?
( ) It doesn’t matter; for a given price, the products are about the same.
( ) Not too important; I use several kinds.
( ) Very important; it’s the only one I will buy.

9. Suppose a product you wished to buy were not available the last time you shopped for it, and today.
   What would you do on your next visit to a state store?
( ) Ask for something else.
( ) Request a special order.
( ) Try another state store.
( ) Ask for it here again.
( ) Other. Please specify:____________________________________________________________

10. If you wanted to order a special liquor product not normally carried in this store, how long would you
     consider to be a reasonable time to wait for it to arrive at the store?_______ days.

11. What do you think would be a reasonable extra-service charge for a special order?_______ per bottle.

12. Beside each statement, check (/) the space which best reflects your opinion.

   a. Store employees are usually friendly and well-mannered.
     __ STRONGLY AGREE ______ AGREE _______ DON’T KNOW _______ DISAGREE _______ STRONGLY DISAGREE ______
   b. There is a lack of adequate parking near the store.
     __ STRONGLY AGREE ______ AGREE _______ DON’T KNOW _______ DISAGREE _______ STRONGLY DISAGREE ______
   c. Store is a clean, pleasant place to shop.
     __ STRONGLY AGREE ______ AGREE _______ DON’T KNOW _______ DISAGREE _______ STRONGLY DISAGREE ______
   d. I often have to wait too long to be served.
     __ STRONGLY AGREE ______ AGREE _______ DON’T KNOW _______ DISAGREE _______ STRONGLY DISAGREE ______
   e. The brands and sizes I want are usually available.
     __ STRONGLY AGREE ______ AGREE _______ DON’T KNOW _______ DISAGREE _______ STRONGLY DISAGREE ______

13. Your age: ______ under 35 ______ 35 to 44 ______ 45 to 54 ______ 55 to 64 ______ 65 and over

14. Your family’s annual income:
     ( ) under $5,000 ( ) $5,000 to $9,999 ( ) $10,000 to $14,999 ( ) $15,000 and over

15. Are you presently married?
     ( ) YES ( ) NO

16. Sex: ( ) female ( ) male

17. Where do you live? (city and zip code only) __________________________ city __________________________ zip code

18. Please circle the highest grade in school you completed:

   1   2   3   4   5   6   7   8   9   10   11   12   13   14   15   16   17   over

Thank you for helping. Please feel free to write any comments on the back.
APPENDIX G

EXPLANATION OF QUESTIONS USED

Question 1.--This question included a basic service level measure, in terms of the per cent of item requests fulfilled at the time the questionnaires were distributed. In addition, the areas of lower service level might be further defined in terms of the products, brands and sizes through written information.

Question 2.--The items purchased the day of the questionnaire distribution were listed by quantity, size, brand and product group. Although more than two different items might have been purchased, only the two of the greatest quantity or major brand names were separately identified. It was observed that most customers did not buy more than two line items.

Question 3.--The amount spent on that one shopping trip was assumed to be typical for the customer and will be useful in reporting dollar sizes of purchases by product and customer groups.

Question 4.--The frequency of purchases times the assumed average purchase size would provide a monthly spending rate for liquor products.

Question 5.--Customers who have had recent stockout experiences could be compared with those who have not had such experiences. This question would provide data on an additional measure of customer service level.

Question 6.--Although the prime objective of this question was to provide information which might assist the Department in store
location policy, it also included a measure of the amount of actual store switching that takes place because of stockouts.

**Question 7.**--The choices in this question corresponded directly with the alternatives in the basic stockout model. A space marked "other" was included in case the customer was not satisfied with the alternatives furnished.

**Question 8.**--The alternatives in this question were to provide an indication of the customers' feelings of brand loyalty.

**Question 9.**--The alternatives corresponded with parts of the model for repeated stockouts. If the customer checked "ask for something else," it was assumed that he would have asked for the same group checked previously in Question 7, choices 1 through 4. If he checked "ask for it here again," his response to being informed of another stockout was assumed to be the same as in Question 7, with all parts being potentially applicable.

**Questions 10 and 11.**--These questions were included to measure the customers' feelings about a proposed special order and associated service charge.

**Question 12.**--The individual parts, (a) through (e), provided measures of the customers' perceptions of the state stores as retail establishments. Parts (a), (c) and (e) were positively worded, parts (b) and (d) were negatively worded. Customers were thus encouraged to completely read each part instead of simply making a blanket "agree" or "disagree" response.

**Question 13.**--The age groupings were so chosen because they
corresponded to standard census reporting. The first group was an exception to standard practice because the legal drinking age in Ohio was 21 years, which would fall in the standard 15 to 24 years age group. Forty per cent of the population in Ohio were reported as being under 21 years of age. The percentage breakdown for the categories included in the questionnaire were as follows:

<table>
<thead>
<tr>
<th>Age group</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>under 35</td>
<td>18</td>
</tr>
<tr>
<td>35-44</td>
<td>13</td>
</tr>
<tr>
<td>45-54</td>
<td>12</td>
</tr>
<tr>
<td>55-64</td>
<td>8</td>
</tr>
<tr>
<td>65 and over</td>
<td>9</td>
</tr>
<tr>
<td>total</td>
<td>60%</td>
</tr>
</tbody>
</table>

Question 14.--The income categories were based on standard statistical reporting categories. Broad classifications were used in an attempt to convince respondents that they were not divulging their own exact income, nor was it really being sought.

Question 15.--A demographic characteristic of family units, marital status was simplified from common "married, single, divorced, widowed" categories to encourage response.

Question 16.--Sex was asked by standard categories.

Question 17.--Location of residence was worded in a manner that, hopefully, convinced respondents that anonymity was truly an

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1Ohio, Statistical Abstract of Ohio: 1969, p. 82. The "under 35" group was composed of the listed 25-34 age group and a partial extrapolation from the 15-24 age group, to include those from 21-24.
objective of the survey.

**Question 18.**—Although education was asked on a continuous scale for ease in the customers' responding, it was actually considered as five groups. The five groups were defined from Census data on the educational level of persons 25 and over:

<table>
<thead>
<tr>
<th>Group</th>
<th>Percentage</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>No school years completed or elementary: 1 to 4 years</td>
<td>5.9%</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>5 to 7 years</td>
<td>9.8</td>
</tr>
<tr>
<td>Elementary: 8 years</td>
<td>14.1</td>
<td>2</td>
</tr>
<tr>
<td>High school: 1 to 3 years</td>
<td>17.6</td>
<td>3</td>
</tr>
<tr>
<td>High school: 4 years</td>
<td>32.5</td>
<td>4</td>
</tr>
<tr>
<td>College: 1 to 3 years</td>
<td>9.6</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>4 years or more</td>
<td>10.5</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

**Comments.**—An invitation to the customers to make comments on the back of the questionnaire was added at the end of the questions. These comments were to be transcribed and would be another source of customer opinion for the Department's edification.
APPENDIX H

LETTER OF INSTRUCTIONS

STATE OF OHIO
DEPARTMENT OF LIQUOR CONTROL

RICHARD E. GUGGENHEIM
DIRECTOR
33 NORTH THIRD STREET
COLUMBUS, OHIO 43215

JOHN J. GILLIGAN
GOVERNOR

To: Store Manager

From: James Dibendig, Assistant Director, Ohio Department of Liquor Control and C. K. Walter, The Ohio State University research group

Subject: Research Project for Ohio Department of Liquor Control

Date: August 4, 1971

1. Please instruct your cashiers to place one questionnaire and one envelope in the bag with the product purchased. The easiest way to do this is to simply wrap the questionnaire and envelope around a bottle before bagging it. There is no harm done to the handouts by folding or bending. The main point is to have each customer leave your store with a questionnaire and an envelope.

2. Some customers may be curious and ask about the enclosures. Just explain that it is a survey for the Department to improve service in the state stores. A small percentage of the customers may feel that the State is prying on them and may remove the enclosures. This is their privilege. Don't argue with them or make any remarks which they might construe as being offensive or embarrassing. A few missed questionnaires will make no difference in the study.

3. The white questionnaires will be distributed on Friday and Saturday (only), August 6 and 7. The blue questionnaire are to be distributed on Monday, August 9. These are the only days the survey will be run.

4. On Tuesday, please send back, in the large envelopes provided, any remaining questionnaires and return envelopes. If all questionnaires were distributed, please send a note to this effect to Mr. Jim Dibendig of the Department of Liquor Control.

On behalf of the Ohio Department of Liquor Control and The Ohio State University research group, may we extend our thanks to you and your employees for your cooperation.
APPENDIX I

FACTS AND OBSERVATIONS ABOUT STORES IN THE SAMPLE

The researcher carried basic information about each store visited including name of manager, full address, hours of operation, and quantities of questionnaires to be delivered. Questionnaires and envelopes were counted and packed in boxes to facilitate handling. At each location, the researcher recorded observations about the store and its surroundings. Information for each store appears below, in the order in which the stores were visited. The following format is used:

CITY

store number, district
street address
zip code
telephone number
operating hours
name of manager
name of employee spoken to
if not manager

annual retail sales
date and time of visit
number and color of questionnaires
and envelopes

Observations.--Researcher's comments follow store data.

CINCINNATI

store 036, A
5806 Madison Road
45227
513-271-2120
11 AM - 6 PM
Charles Ruffin

$638,076
August 4, 1971; 12 AM
650 white
810 blue

1Warehouse location: A = Cincinnati, B = Toledo, C = Columbus, D = Massillon, E = Cleveland.

Observations.--The store was situated among a group of small shops on a main street in what appeared to be a middle class residential neighborhood with a predominantly Negro population. The manager questioned the selection of his store, rather than a larger one, as the only Cincinnati outlet in the survey. The store was a typical perimeter layout store, with products displayed in glass cases around the walls. Parking was limited to metered spaces on the street.

DAYTON

store 238, A $1,622,074
4123 Town & Country August 4, 1971; 1:30 PM
45429 1600 white
513-299-8655 400 blue
12 AM - 9 PM 2000 envelopes
Dewitt Fisher (not present)
Charles Cockrell, assistant manager

Observations.--The store was located in the active Town and Country Shopping Center and was also a perimeter store. The assistant manager explained that they served "all types of customers." On the subject of stockouts, he said that there were four local state stores in shopping centers, making it fairly easy for customers to shop more than one store, if necessary. He claimed that he could sense stockouts at the other local stores by changes in buying patterns at his store. Special orders were of great interest to him; he interrupted the discussion to assist a customer who inquired about several items not usually carried and he described his handling of another special situation in which he successfully expedited delivery of an unusual order for a customer's Christmas entertaining.
COLUMBUS (Central Point Shopping Center)

store 213, C  $937,642
689 Harrisburg Pike  August 4, 1971; 3:30 PM
43223  1000 white
614-276-1766  250 blue
10 AM - 9 PM  1250 envelopes
Kenneth E. Marshall (not present)
Clarence Huskey, assistant manager

Observations.--This was a self-service store with two aisles running front to back. The location was an older shopping center surrounded by small commercial establishments and middle class residential dwellings.

COLUMBUS (North High Street)

store 004, C  $798,770
2659 North High Street  August 4, 1971; 5 PM
43202  800 yellow
614-268-0022  200 pink
10 AM - 6 PM  1000 envelopes
Charles H. Clark

Observations.--The store was a small perimeter store of the board type. The products themselves were not on display but lists of products, prices and stock numbers were mounted on the walls in the customer area. The store was the liquor store nearest the university area, although the sample, taken in August, would not be weighted by student purchases as much as it might have been between September and June, when student population would be higher. The location was on a main city artery, among a series of small retail stores.
TOLEDO

store 301, B
3402 Glendale Avenue
43614
419-385-3371
11 AM - 7 PM

$1,512,555
August 5, 1971; 12 AM
1500 white
375 blue
1875 envelopes

Andrew J. Ludwikoski

Observations.--The store was a larger self-service unit located in the Southland Shopping Center. The area appeared to be rather recently developed with suburban residences and inhabited by probably higher than average income families. The manager explained that this was the largest store, in terms of retail sales, in the Toledo area. He claimed to have stockouts fairly well under control although a small percentage of customers complained when they found the shelves empty. Even though store traffic was heavy, breakage by customers was extremely light. He said that most of the business was done towards the weekend.

CLEVELAND

store 139, E
11607 Detroit Ave.
44102
216-228-3810
11 AM - 6 PM

$1,120,560
August 5, 1971; 2:45 PM
1200 yellow
300 pink
1500 envelopes

Lawrence Twitchell

Observations.--The store was in an older section of small shops and surrounded by aging houses and apartment buildings. Parking was at a premium on the street. The manager related that a large proportion of his daytime customers were women, a change he had noted in the last several years. Men shopped later, after their working hours. The store was a perimeter store.
SHAKER HEIGHTS

store 150, E
17116-18 Chagrin Blvd.
44120
216-561-0495
11 AM - 6 PM
Joseph Combos

$3,059,686
August 5, 1971; 4 PM
2500 white
600 blue
2680 envelopes (approx.)

Observations.--The store was a large self-service unit, located in a modern shopping district on a main city street. Off-street parking was available. Although the area was known as being rich and fashionable, the customers appeared to be from a variety of backgrounds and races. Possibly, this was due to the fact that they worked in the area, traveled this route frequently, or were attracted by the self-service feature. The manager was proud of the fact that his store had consistently recorded sales in excess of $3 million per year, the largest sales volume in the state, and was ahead of the former record sales pace this year.

AKRON

store 269, D
804 Copley Road
44320
216-434-6285
11 AM - 6 PM
Kenneth Carter

$1,320,170
August 5, 1971; 5:30 PM
1325 white
330 blue
1655 envelopes

Observations.--The location was in a middle-class racially mixed neighborhood. It was a perimeter store on a street leading directly downtown. Parking was not abundant.
STRUTHERS

store 260, D $513,162
44 Main St. August 6, 1971; 11 AM
44471 550 white
216-755-3512 140 blue
11 AM - 6 PM 690 envelopes
Joseph A. Briganti (not present)
Pete Nespecia, clerk

Observations.--The store was in the steel-mill section of
town, surrounded by factories, parking lots and a few very low income
families. This was a perimeter store. Main Street was actually a
one-way side street leading away from the mills and connecting with
a state highway.

CONNEAUT

store 161, E $334,183
237 Broad St. August 6, 1971; 12:45 AM
44030 400 white
216-595-2091 100 blue
11 AM - 6 PM 500 envelopes
Richard Metcalf

Observations.--The store was of the board type, located in
the shopping district of a small, quiet town. The store's customers
probably included many vacationers because of the town's location on
the shores of Lake Erie.
APPENDIX J

EXPLANATION OF CODING SCHEME

Requirements

It was desired to specify separately as many items, brands and sizes purchased as possible but to maintain key-punching requirements to a minimum. Based on information received from the two trial distributions, over 77 per cent of those customers replying purchased one line item only. Although a majority of purchases might be included if the questionnaire provided for coding one line item per customer, it was decided to separately code up to two line items purchased. This would allow for comparison between single item buyers and multiple item buyers, and would result in more complete data collection in general.

Each of the multiple-choice questions was to be coded in one space on a punch-card. Short-answer, write-in responses, such as the amount spent, number of trips, days, and special order costs, were to be coded as entered.

Item Identification

One line item in question 1 and up to two line items in question 2 could be separately identified. Four spaces were allotted for each identification. The first space was for quantity, up to 9. The second digit was a size code, as shown in Table 31. Note that for quantities above 9, the size was assumed to be a case, with a quantity of 1, even though a standard case of fifths contained 12 units. This
stipulation was inserted to conserve space on the punch-card; the situation was seldom encountered.

<table>
<thead>
<tr>
<th>Size</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>quart</td>
<td>1</td>
</tr>
<tr>
<td>1/5 gallon (same as 4/5 qt.)</td>
<td>2</td>
</tr>
<tr>
<td>pint</td>
<td>3</td>
</tr>
<tr>
<td>1/2 gallon</td>
<td>4</td>
</tr>
<tr>
<td>special</td>
<td>5</td>
</tr>
<tr>
<td>Christmas decanter</td>
<td>6</td>
</tr>
<tr>
<td>tenths of a gallon (same as 2/5 qt.)</td>
<td>7</td>
</tr>
<tr>
<td>case (includes any quantity 10 or more)</td>
<td>8</td>
</tr>
</tbody>
</table>

The hypotheses outlined in Chapter I involved the various product groupings for the types of liquor available. It was further desired to identify as many individual brands of liquor products as feasible for further detailed study. But it was not considered necessary to identify each of the 704 brand-items listed because a majority of total sales was accounted for by a minority of brand-items: the 50 leading brands, which were 7.1 per cent of the total number, had 63.1 per cent of the 1970 total case sales. Each of these 50 brand-items had sales of from 24,973 to 362,089 cases, including both wholesale and retail sales. Expanding on the list of 50 brand-items, a coding scheme was developed which included every branded product with reported retail case sales of 10,000 or more during 1970. This step

---

1 See Appendix A for product groupings.
2 Cleveland Press, Ohio Liquor Sales, p. ix.
increased the number of leading brands identified to 73, an increase of 46 per cent, and included 68.5 per cent of all retail case sales. The remaining 31.5 per cent of retail sales, 1,159,833 cases, was accounted for by the remaining 631 brand-items, averaging about 1,840 cases each; they would be included within the codes for the broader product-group categories.

The specific brands coded within the product groups are shown in Table 32. There were several advantages apparent in identifying only those products with retail case sales of 10,000 or more per year. Besides being visually easier to identify those brand-items from sales data, more detailed information would not have increased the usefulness of the survey results. The cut-off figure represented approximately ten cases per week in the stores of the sample, or 120 bottles. Assuming that the sample time period included 67 per cent of the weekly sales, with each customer buying two bottles, and ten per cent of the customers replying, the lower volume brands would receive an average of four responses each. Clearly, the cut-off point for separate identification might have been chosen at a higher level because it would not be feasible to base a predictive model containing at least five variables on a sample this small. However, it was decided that survey responses would be coded according to the brands listed in Table 32 and then reviewed, to determine which brands had low responses and should be grouped with their overall categories.

\[3\text{Assuming one-half for Friday-Saturday and one-sixth for Monday.}\]
**TABLE 32**

**CODE NUMBERS AND BRAND NAMES**

<table>
<thead>
<tr>
<th>Code</th>
<th>Brand name</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOURBON</td>
<td></td>
</tr>
<tr>
<td>00</td>
<td>bourbon, except listed separately below</td>
</tr>
<tr>
<td>01</td>
<td>Echo Spring</td>
</tr>
<tr>
<td>02</td>
<td>Bourbon Supreme Rare</td>
</tr>
<tr>
<td>03</td>
<td>Ancient Age</td>
</tr>
<tr>
<td>04</td>
<td>Old Taylor</td>
</tr>
<tr>
<td>05</td>
<td>Old Crow</td>
</tr>
<tr>
<td>06</td>
<td>Jim Bean</td>
</tr>
<tr>
<td>07</td>
<td>Old Kentucky Tavern</td>
</tr>
<tr>
<td>08</td>
<td>Hiram Walker Ten High</td>
</tr>
<tr>
<td>09</td>
<td>Bond &amp; Lillard</td>
</tr>
<tr>
<td>10</td>
<td>Mattingly &amp; Moore</td>
</tr>
<tr>
<td>11</td>
<td>Old Log Cabin</td>
</tr>
<tr>
<td>12</td>
<td>Old J.T.S. Brown (straight)</td>
</tr>
<tr>
<td>13</td>
<td>Old Grand Dad (straight)</td>
</tr>
<tr>
<td>14</td>
<td>J.W. Dant--Olde Bourbon (straight)</td>
</tr>
<tr>
<td>15</td>
<td>Old Forester</td>
</tr>
<tr>
<td>16</td>
<td>Barclay's Bourbon</td>
</tr>
<tr>
<td>17</td>
<td>Old Quaker</td>
</tr>
<tr>
<td>18</td>
<td>Heaven Hill Old Style</td>
</tr>
<tr>
<td>19</td>
<td>Early Times</td>
</tr>
<tr>
<td>20</td>
<td>Beam's Choice</td>
</tr>
<tr>
<td>21</td>
<td>Old J.T.S. Brown (bonded)</td>
</tr>
<tr>
<td>22</td>
<td>Old Grand Dad (bonded)</td>
</tr>
<tr>
<td>23</td>
<td>J.W. Dant (bonded)</td>
</tr>
<tr>
<td>24</td>
<td>all rye, corn</td>
</tr>
<tr>
<td>Code</td>
<td>Brand name</td>
</tr>
<tr>
<td>------</td>
<td>------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td><strong>BLENDS</strong></td>
</tr>
<tr>
<td>30</td>
<td>blends, except listed separately below</td>
</tr>
<tr>
<td>31</td>
<td>Seagrams 7 Crown</td>
</tr>
<tr>
<td>32</td>
<td>Kessler</td>
</tr>
<tr>
<td>33</td>
<td>Imperial</td>
</tr>
<tr>
<td>34</td>
<td>Haller's S.R.S.</td>
</tr>
<tr>
<td>35</td>
<td>Calvert Extra</td>
</tr>
<tr>
<td>36</td>
<td>Corby's Reserve</td>
</tr>
<tr>
<td>37</td>
<td>Governor's Club</td>
</tr>
<tr>
<td>38</td>
<td>Burke &amp; Barry</td>
</tr>
<tr>
<td>39</td>
<td>Four Roses</td>
</tr>
<tr>
<td>40</td>
<td>Carstairs</td>
</tr>
<tr>
<td>41</td>
<td>Golden Wedding</td>
</tr>
<tr>
<td>42</td>
<td>Mount Vernon</td>
</tr>
<tr>
<td>43</td>
<td>Schenley Reserve</td>
</tr>
<tr>
<td>44</td>
<td>Fleischmann's Preferred</td>
</tr>
<tr>
<td>45</td>
<td>P.M. Deluxe</td>
</tr>
<tr>
<td></td>
<td><strong>CANADIAN</strong></td>
</tr>
<tr>
<td>50</td>
<td>Canadian, except listed separately below</td>
</tr>
<tr>
<td>51</td>
<td>Canadian Club</td>
</tr>
<tr>
<td>52</td>
<td>Windsor Supreme</td>
</tr>
<tr>
<td>53</td>
<td>Seagrams V.O.</td>
</tr>
<tr>
<td>54</td>
<td>Canadian Mist</td>
</tr>
<tr>
<td>55</td>
<td>McNaughton</td>
</tr>
<tr>
<td>56</td>
<td>Canadian Lord Calvert</td>
</tr>
<tr>
<td>57</td>
<td>Black Velvet</td>
</tr>
<tr>
<td></td>
<td><strong>SCOTCH</strong></td>
</tr>
<tr>
<td>60</td>
<td>Scotch, except listed separately below</td>
</tr>
<tr>
<td>61</td>
<td>Cutty Sark</td>
</tr>
<tr>
<td>62</td>
<td>Justerini &amp; Brooks Rare</td>
</tr>
<tr>
<td>63</td>
<td>Inver House Green Plaid</td>
</tr>
<tr>
<td>64</td>
<td>Johnnie Walker Red Label</td>
</tr>
<tr>
<td>65</td>
<td>Lauders Extra Light</td>
</tr>
<tr>
<td>66</td>
<td>Grand MacNish</td>
</tr>
<tr>
<td>67</td>
<td>King George 4th</td>
</tr>
<tr>
<td>68</td>
<td>Highland Cream</td>
</tr>
<tr>
<td>69</td>
<td>MacArthurs</td>
</tr>
<tr>
<td>Code</td>
<td>Brand name</td>
</tr>
<tr>
<td>------</td>
<td>----------------------------------------</td>
</tr>
<tr>
<td>GIN</td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>gin, except listed separately below</td>
</tr>
<tr>
<td>71</td>
<td>Gilbey's</td>
</tr>
<tr>
<td>72</td>
<td>Gordon's</td>
</tr>
<tr>
<td>73</td>
<td>Seagram's Extra Dry</td>
</tr>
<tr>
<td>74</td>
<td>Haller's</td>
</tr>
<tr>
<td>75</td>
<td>Calvert</td>
</tr>
<tr>
<td>76</td>
<td>Fleischmann</td>
</tr>
<tr>
<td>77</td>
<td>Beefeater</td>
</tr>
<tr>
<td>78</td>
<td>Canada Dry</td>
</tr>
<tr>
<td>VODKA</td>
<td></td>
</tr>
<tr>
<td>80</td>
<td>vodka, except listed separately below</td>
</tr>
<tr>
<td>81</td>
<td>Gordon's</td>
</tr>
<tr>
<td>82</td>
<td>Hallers Vodka 80 Proof</td>
</tr>
<tr>
<td>83</td>
<td>Kamachatka</td>
</tr>
<tr>
<td>84</td>
<td>Smirnoff</td>
</tr>
<tr>
<td>85</td>
<td>Wolfschmidt</td>
</tr>
<tr>
<td>86</td>
<td>Gilbey's</td>
</tr>
<tr>
<td>87</td>
<td>Paramount 80 Proof</td>
</tr>
<tr>
<td>88</td>
<td>Paramount 90 Proof</td>
</tr>
<tr>
<td>OTHER NON-WHISKEY</td>
<td></td>
</tr>
<tr>
<td>90</td>
<td>brandy, except listed separately below</td>
</tr>
<tr>
<td>91</td>
<td>Coronet V.S.Q.</td>
</tr>
<tr>
<td>93</td>
<td>rum, except listed separately below</td>
</tr>
<tr>
<td>94</td>
<td>Bacardi (silver or amber)</td>
</tr>
<tr>
<td>96</td>
<td>cordials &amp; liqueurs</td>
</tr>
<tr>
<td>98</td>
<td>specialties &amp; cocktails, except listed below</td>
</tr>
<tr>
<td>99</td>
<td>Southern Comfort</td>
</tr>
</tbody>
</table>

*By product group, ranked by 1970 retail case sales.
Source: Cleveland Press, Ohio Liquor Sales, pp. 1-59.*
In this manner, brands that may have had high seasonal sales rates when the survey was taken would be analyzed in as much detail as possible.

Another advantage in using the given list of products was that a simple two-digit coding scheme could be developed which led to more efficient coding and key-punching. The ten's digit identified a major category: 0, 1 and 2 are bourbon, 3 and 4 are blends, 5 is Canadian, 6 is Scotch, 7 is gin, 8 is vodka, 9 includes the other non-whiskey products. The unit's digit, with the ten's, identified a particular brand or grouped product type. For questions 1 and 2, the encoder would write single digits for the quantity and size. Next, he would read the product type, which would direct him to a particular section of Table 32, and then the brand name. If the brand name were found in that section of Table 32, the corresponding two-digit number was entered. If the brand name were not found, the number corresponding to "other" of that product group was entered. With a little experience, the encoder was able to quickly recognize the more frequently mentioned brand names, thus reducing the search time to a minimum. It was felt that this scheme was much more efficient than using the Department's four-digit identification number for each brand-item. Search time would have been greatly expanded and the product groupings would not have been in as convenient a form.
Other coding instructions

The instructions below are listed for each question on the questionnaire, by number. The coding spaces, with numbered columns, appeared opposite their corresponding questions; they are not further identified below.

In most cases, blanks were left blank, rather than code them as zeros. However, if the customer's zip code was not filled in, an attempt was made to obtain it from the envelope. Also, if any of the respondent's comments mentioned marital status, sex or educational level, this information was used to fill in any blanks that may have been left in these areas. The additional instructions were:

1. NO = 0, YES = number of line items not found. Enter four-digit number, if applicable, as described earlier.
2. Enter one or two groups of four digits, as applicable.
3. Enter amount spent, right-hand justified, in cents: $7.10 would appear as 0710. Maximum amount is $99.99 which would appear as 9999.
4. Enter number of times, right-hand justified, with a zero in ten's column if number is less than 10. Minimum number is 01.
5. NO = 0, YES = number of times, 9 maximum.
6. Enter 1 through 5.
7. Enter 1 through 7.
8. Enter 1 through 3.
9. Enter 1 through 5.

See Appendix F for questionnaire.
10. Enter number of days.

11. Enter service charge in cents per bottle. If answer was given as a percentage of price per bottle, and the price of one of the customer's bottles was given in question 3, calculate and enter that amount; otherwise, assume a price per bottle of $5.21 and calculate.

12. For each section, a through e, enter 1 through 5, from strongly agree to strongly disagree.

13. Enter 1 through 5.

14. Enter 1 through 4.

15. Enter 1 or 2.

16. Enter 1 or 2.

17. Enter zip code.

18. Enter code from Table 33.

**TABLE 33**

**EDUCATION CODES**

<table>
<thead>
<tr>
<th>years circled</th>
<th>code</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 to 7</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>9 to 11</td>
<td>3</td>
</tr>
<tr>
<td>12</td>
<td>4</td>
</tr>
<tr>
<td>13 and over</td>
<td>5</td>
</tr>
</tbody>
</table>
In columns 45 and 46, enter store code from Table 34.

**TABLE 34**

**STORE CODES**

<table>
<thead>
<tr>
<th>store</th>
<th>code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shaker Heights</td>
<td>01</td>
</tr>
<tr>
<td>Dayton</td>
<td>02</td>
</tr>
<tr>
<td>Toledo</td>
<td>03</td>
</tr>
<tr>
<td>Akron</td>
<td>04</td>
</tr>
<tr>
<td>Cleveland (yellow or pink)</td>
<td>05</td>
</tr>
<tr>
<td>Columbus (white or blue)</td>
<td>06</td>
</tr>
<tr>
<td>Columbus (yellow or pink)</td>
<td>07</td>
</tr>
<tr>
<td>Cincinnati</td>
<td>08</td>
</tr>
<tr>
<td>Struthers</td>
<td>09</td>
</tr>
<tr>
<td>Conneaut</td>
<td>10</td>
</tr>
<tr>
<td>Reynoldsburg</td>
<td>11</td>
</tr>
</tbody>
</table>

In column 47, enter day code from Table 35.

**TABLE 35**

**DAY CODES**

<table>
<thead>
<tr>
<th>day</th>
<th>color</th>
<th>code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Friday-Saturday</td>
<td>white or yellow</td>
<td>1</td>
</tr>
<tr>
<td>Monday</td>
<td>blue or pink</td>
<td>2</td>
</tr>
</tbody>
</table>
APPENDIX K

DISCUSSION OF CONSUMERS' WRITTEN RESPONSES

Questions 6, 7 and 9 on the questionnaire were multiple-choice questions. Each included, as a final alternative, the following:

( ) Other. Please specify: _______________________

In cases where it was apparent to the researcher that the written response could be reasonably translated as one of the given options, it was so coded. The remaining "other" responses are discussed below for each question.

**Question 6.** "Why did you come to this particular state store?" Of the 33 "other" responses examined, the most frequently found reason was that the particular store was self-service; 12 responses indicated this reason. Hours of operation were mentioned 6 times, friendly personnel, 4 times, and convenient parking or good service, 3 times. Eight other, more varied, reasons were also offered, including dislikes of other stores or their locations.

**Question 7.** "When your first-choice brand and size is not available, what do you usually do?" Twenty-four out of 31 "other" responses indicated that this has never happened; the respondents did not surmise what they might do in that situation. Five customers said that they would do without the item.

**Question 9.** "Suppose a product you wished to buy were not available the last time you shopped for it and today. What would you do on your next visit to a state store?" Twelve written responses were examined. Four said that they would complain, three would do
without; the others were varied, usually not applicable to the question.

Slightly over two per cent of the respondents wrote answers to questions 6 and 7; less than one per cent required other responses to question 9. These percentages were interpreted as indicating insignificant differences from the alternatives provided. The responses examined here were not included in the general analysis of data for these respective questions.
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"Drinkers seek the 'light.'" Business Week, February 23, 1963, pp. 81-83.


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Interview

Interview with J. H. Olberding, Assistant Director, Ohio Department of Liquor Control, Columbus, May 27, 1971.