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Predicting Sales Effects of Discount Changes

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Sometimes an elaborate method of solving a problem can save money for a small client and still give him reliable results. Here's such a story, of a marketing problem solved without costly research —

PREDICTING SALES EFFECTS OF DISCOUNT CHANGES

by Philip L. Blumenthal, Jr.
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The following article, describing as it does the application of a fairly sophisticated approach to a common problem (anticipating the effect of altering discount rates to customers in the hope of increasing their volume of purchases), is based on a paper presented by the author before a recent Operations Research Society of America meeting.

As such, some of the terms used may not be familiar to all our readers. The "Markov chain" which is mentioned in the first paragraph refers to calculations in which the probability of transition from one state to another is considered as a conditional probability, much as the letter "q" in the English language is always followed by the letter "u."

As used by the author's firm, the approach permitted use of the client's salesmen's subjective opinions to form a reliable prediction of what effect such discount changes would have on the marketing volume of a small wholesale establishment.

THIS article describes a case in which the concepts of the Markov chain and the transition probability matrix were useful in marketing planning, even though there was no requirement for such rigorous treatment.

The problem presented was that of an old, established consumer goods wholesale house with these symptoms:

FIGURE 1

Monthly sales volume, (not appreciably seasonal)	$893,000 (February, 1970)
Gross profit rate, February	14½ per cent after discounts
Customers	496 (133 city, 363 country)
Salesmen	18
Inventory items	23,000
Trucks operated	5 on city routes, 10 on country routes
Scheduled deliveries per week (city and county)	5 per customer
Discount rate, average	3.66 per cent
Discount rate proposed	5 to 8 per cent

FIGURE 2

	Present	Proposed
Discount on total monthly sales:		
Under $4,000	Various, averaging 3.21 per cent	No change (3.21 per cent)
$4,000-$6,000	Various, averaging 3.74 per cent	5.0 per cent
$6,000-$8,000	Various, averaging 4.46 per cent	6.5 per cent
Over $8,000	Various, averaging 3.35 per cent	8.0 per cent
Deliveries per week, city customers	5	5
Deliveries per week, country customers	5	2
Orders per week, city customers	5	5
Orders per week, country customers	5	5, if desired

A customer might be induced by the program to move up to the $4,000 monthly minimum to qualify . . . or he might decide that he could not attain this volume and drop back to some lesser volume . . .

1. Volume had been eroded by competition from limited-line discount wholesalers and by growing price consciousness of retailers, caused by their own rising costs and narrowing margins.

2. Reduced volume had not resulted in corresponding reductions of expenses that *should* be variable costs, particularly in order picking and delivery.

Quantitative aspects of the problem are shown in Figure 1, at the top of this page.

As consultants, we were asked to assess the effects on volume and profitability of the management proposals illustrated in Figure 2, above.

The proposed program had recently (February) met with favorable response by test customers in two sales territories.

Customers in this trade have a tendency to divide their business among several wholesalers because of:

1. Shopping for lowest price
2. Avoiding a single source of supply
3. Changes in level of service available from each wholesaler.

Market share for each customer's business is therefore subject to sudden change.

Each salesman was believed to have a good intuitive feel for:

1. Potential (total business potentially available from each customer)
2. Incentive (willingness of each customer to divert more of his buying from other wholesale sources with this additional inducement)
3. Customer relations (the salesman's ability to sell the program to this customer).

A customer might be induced by the program to move up to the $4,000 monthly minimum to qualify for the program, or he might decide that he could not attain this volume and drop back to some lesser volume, enough to warrant

EXHIBIT I

Customer _____ City _____ Salesman _____

PROBABLE RESPONSE	PRESENT VOLUME	POTENTIAL VOLUME
STAY AT PRESENT	0	.5 M
UP 1	.5	1
UP 2	1	2
UP 3	2	3
UP 4	3	4
	4	5
DOWN 1	5	6
DOWN 2	6	7
DOWN 3	7	8
DOWN 4	8	9
OUT	10	+

DELIVERIES PER WEEK

BUYING ON DISCOUNT NOW

☐ YES

☐ NO

The technical problem was to predict the effect on volume, costs, and profitability of the proposed program.

FIGURE 3

Group	Monthly Volume	Number of Customers, February, 1970
0.	None (used for new customers coming into the system or old ones dropping out)	
1.	$ 1-$ 500	107
2.	$ 501-$ 1,000	105
3.	$1,001-$ 2,000	133
4.	$2,001-$ 3,000	65
5.	$3,001-$ 4,000	41
6.	$4,001-$ 5,000	18
7.	$5,001-$ 6,000	11
8.	$6,001-$ 7,000	10
9.	$7,001-$ 8,000	1
10.	$8,001-$ 9,000	2
11.	$9,001-$10,000	0
12.	Over $10,000	3
Total		496

EXHIBIT 2

A PRIORI TRANSITION PROBABILITY MATRIX

(Constructed in April, Data as of February)

NO. CUSTOMERS	Group	0 (OUT)	1	2	3	4	5	6	7	8	9	10	11	12	ROW SUM
0	0 (New)	*0	0	0	0	0	0	0	0	0	0	0	0	0	0
107	1	.052	*.887	.005	.009	.005	.027	0	.005	.005	0	.005	0	0	1.00
105	2	.02	0	*.84	.01	.03	.031	.04	0	.02	0	0	.01	0	1.00
133	3	.02	0	.01	*.76	0	.05	.16	.01	.01	0	.01	0	0	1.00
65	4	0	0	0	0	*.62	.02	.26	.03	.03	0	.03	0	.01	1.00
41	5	0	0	0	0	0	*.52	.27	0	.18	.01	.02	0	0	1.00
18	6	.05	0	0	0	0	0	*.70	0	.20	0	.05	0	0	1.00
11	7	0	0	0	0	0	0	0	*.43	.27	0	.30	0	0	1.00
10	8	0	0	0	0	0	0	0	0	*.70	0	.23	0	.08	1.00
1	9	0	0	0	0	0	0	0	0	0	*.25	.50	0	.25	1.00
2	10	0	0	0	0	0	0	0	0	0	0	*.88	0	.12	1.00
0	11	0	0	0	0	0	0	0	0	0	0	0	*0	0	0
3	12	0	0	0	0	0	0	0	0	0	0	0	0	*1.00	1.00
496															

*Diagonal.

being kept on the delivery schedule. Once past the $4,000 level, the additional 1½ per cent and 3 per cent discounts at $6,000 and $8,000 were added inducements to shift more volume to this supplier.

The reduced country delivery schedule (to twice weekly) had been proposed to several country customers and was expected to be accepted without repercussions.

In summary, the marketing problem was to induce customers to move into the discount program ($4,000) or, once in the program, into a higher bracket ($6,000 or $8,000).

The technical problem was to predict the effects on volume, costs, and profitability of the proposed program. This article deals only with the prediction of volume changes.

Since this was a low-budget study, no surveys of customer attitudes were possible. Instead, the approach used was to make maximum use of information already available in the client's information system.

Although the system included a Model 360/20 computer, its principal use at the time was for billing and obtaining associated billing statistics. A manually maintained card record of month-by-month sales to each customer was used as the basis for analysis of customer response. In this type of distribution, customers tended to be relatively stable—an established customer was set up on a regular order and delivery schedule, and his orders tended to be regular rather than sporadic. Occasionally, one would drop out or become inactive, and new ones would be added, but the underlying expec-

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EXHIBIT 3

A POSTERIORI TRANSITION PROBABILITY MATRIX

Data as of September 28

	0	1	2	3	4	5	6	7	8	9	10	11	12	ROW TOTAL
0.	*0	.470	.294	.177			.059							1.00
1.	.140	*.561	.187	.084	.019			.009						1.00
2.	.057	.219	*.438	.248	.019	.009				.010				1.00
3.	.075	.053	.143	*.428	.105	.075	.030	.008	.015	.008				1.00
4.	.015	-	.031	.262	*.400	.200	.062	.015	.015					1.00
5.	.073	-	.025	.073	.195	*.220	.244	.025	.073	.024	.024	.024		1.00
6.			.055	.056	.111	.111	*.389	.278						1.00
7.				.090				*.273	.273	.182	.182			1.00
8.					.100			.200	*.400	.300				1.00
9.										*0			1.000	1.00
10.											*.500	.500		1.00
11.												*0		0
12.											.333	.334	*.333	1.00
MEAN VALUE	.068	.191	.183	.228	.125	.066	.051	.025	.025	.018	.010	.006	.004	

* Diagonal.

tation was that the initial 496 customers would be the basis for measuring change over a period of several months.

The Markov approach was believed to be a good vehicle for communicating, quantifying, and summarizing salesmen's subjective opinions. Each salesman was asked to complete a simple diagrammatic work sheet for each customer (Exhibit 1, page 39) which showed his own evaluation of the probable customer reaction to the program. This took into account, without need for distinction among them, the three factors (potential, incentive, and customer relations) listed earlier. The salesman was free to estimate as many probabilities as he wished, but three estimates sufficed for nearly every customer.

Size groups were decided upon as shown in Figure 3, page 39.

In each size group, the estimated number of customers moving to each other group, or not moving, was determined by summing the estimates made by all salesmen, after review and discussion with the sales manager in cases where the estimates looked improbable. Most estimated "jumps" of more than one or two groups were found to have a reasonable basis—such as "Customer is dissatisfied with service he is getting from his principal source and would shift most of his business to us if given this incentive" or "Customer may be about to drop us anyway; if we announce a program for which he cannot easily qualify, he will probably drop out altogether."

In explaining the effects on cus-

EXHIBIT 4

SUMMARY--PROBABILITY OF TRANSITIONS AFTER 5 MONTHS

Number Of Customers At Start		Moved Down (Below Diagonal) Actual	Moved Down (Below Diagonal) Estimated	Remain Same (Diagonal) Actual	Remain Same (Diagonal) Estimated	Moved Up (Above Diagonal) Actual	Moved Up (Above Diagonal) Estimated
107	1 (0-$.5M)	.14	.05	.56	.89	.30	.06
105	2 ($.5 M-$1 M)	.28	.02	.43	.84	.29	.14
133	3 ($1-$2 M)	.27	.03	43	.76	.30	.21
65	4 ($2-$3 M)	.31	Ø	.40	.62	.29	.38
41	5 ($3-$4 M)	.37	Ø	.22	.52	.41	.48
18	6 ($4-$5 M)	.33	.05	.39	.70	.28	.25
11	7 ($5-$6 M)	.09	Ø	.27	.43	.64	.57
10	8 ($6-$7 M)	.30	Ø	.40	.70	.30	.30
1	9 ($7-$8 M)	-	-	Ø	.25	1.00	.75
2	10 ($8-$9 M)	-	-	.50	.88	.50	.12
0	11 ($9-$10 M)	-	-	-	-	-	-
3	12 ($10 M +)	.67	Ø	.33	1.00	-	-
496							

tomer size groups and on total volume to management, the transition probability matrix (Exhibit 2, page 40) proved in fact to be a useful conceptual tool, rather than being a significant computational aid.

A matrix multiplication routine on a time sharing computer terminal was used to obtain the dollar volumes shown in Exhibits 5 below and 6, page 43. This was accomplished by multiplication of a (13 $\times$ 13) diagonal matrix, with the original number of customers in each group as the diagonal, by the probability matrix (Exhibit 2) to obtain a similar-sized (13 $\times$ 13) matrix of expected number of customers in each size group. Multiplication of column totals of the resulting matrix by the mid-range volume for each group yielded an approximation of expected dollar value. In a problem of this small size, computer matrix methods

EXHIBIT 5

PROBABILITY THAT A CUSTOMER'S MONTHLY VOLUME EXCEEDS A GIVEN VALUE

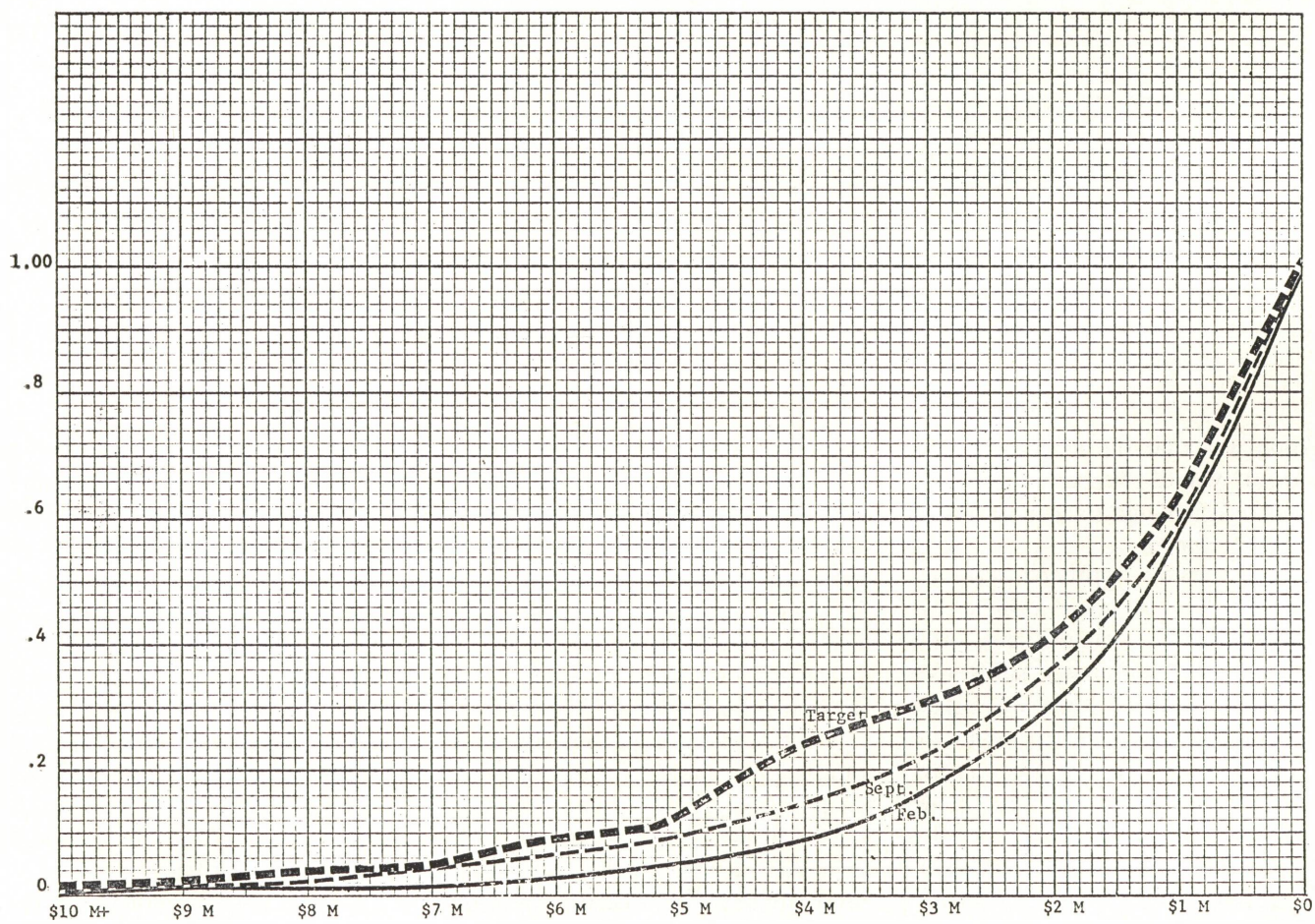
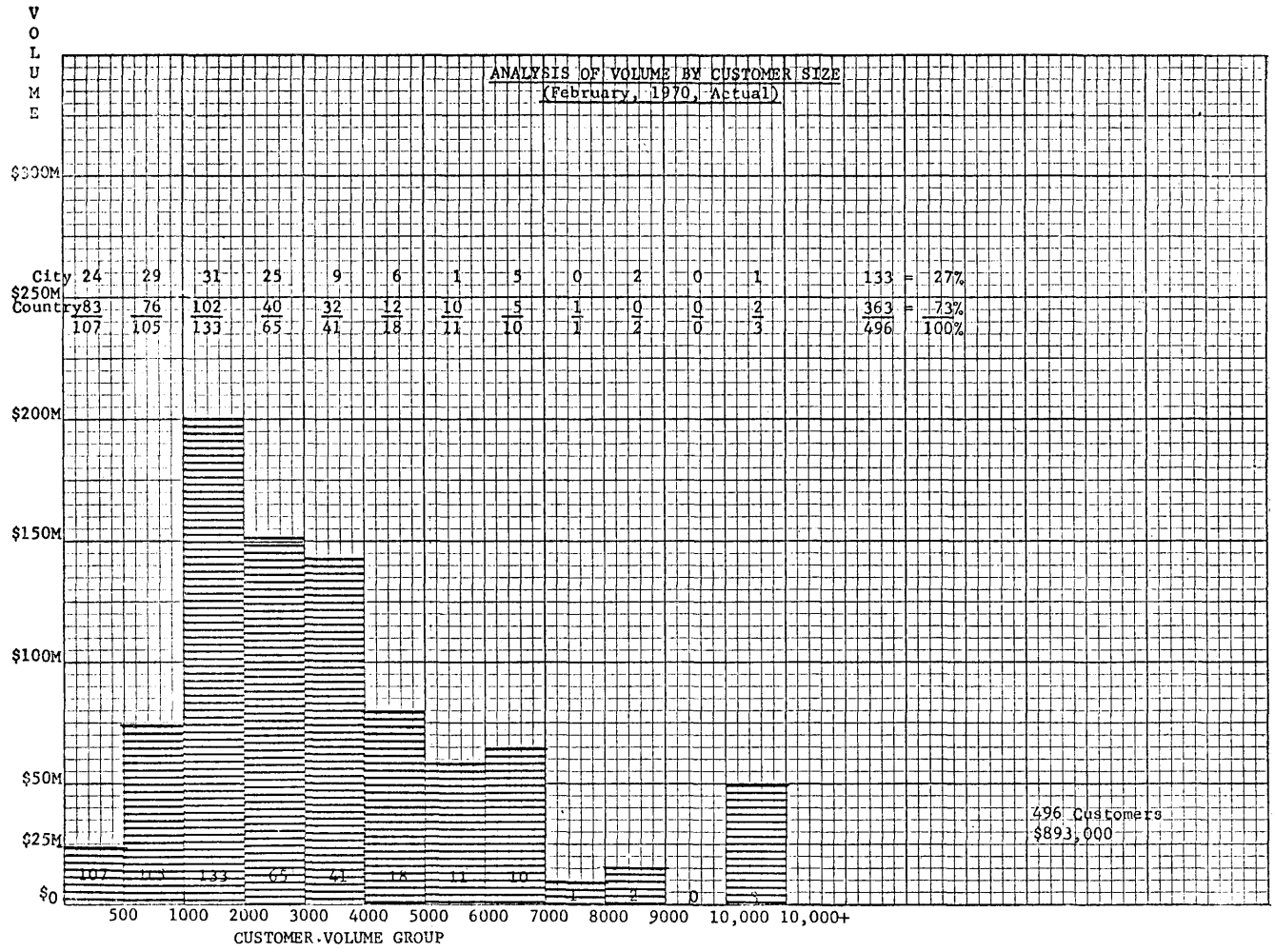


EXHIBIT 6



had no significant computational advantage over a desk calculator. Their value lay in their use as a conceptual and communications tool. They would have been computationally useful had the problem been larger in scope or duration.

Entries on the diagonal of the transition probability matrix (Exhibit 2) are the expected probability of "no move"; $(P_n) \cdot (1\text{-}P_n)$ gives an indication of the susceptibility of customers in a group to moving.

All entries above (to the right of) the diagonal represent "improvement"—customer moves to a larger-volume size group.

Entries below (to the left of) the diagonal represent "loss"—customer moves to a lower-volume group or drops out.

Exhibit 3, page 41, shows the actual response after five months. This is summarized in Exhibit 4, page 42. It is interesting to note that for approximately 95 per cent of the customers, the probability of "moving up" was actually in the region of .3, whereas it had been underestimated for the small customers. Estimates for larger customers ($2,000 and up) were relatively good. This is undoubtedly due to better knowledge of these customers by the salesmen who handle their accounts and to closer attention being paid to them.

The tendency for customers to drop back (.2-.4 for most customers) had been severely underestimated. This was assessed as being due to several causes:

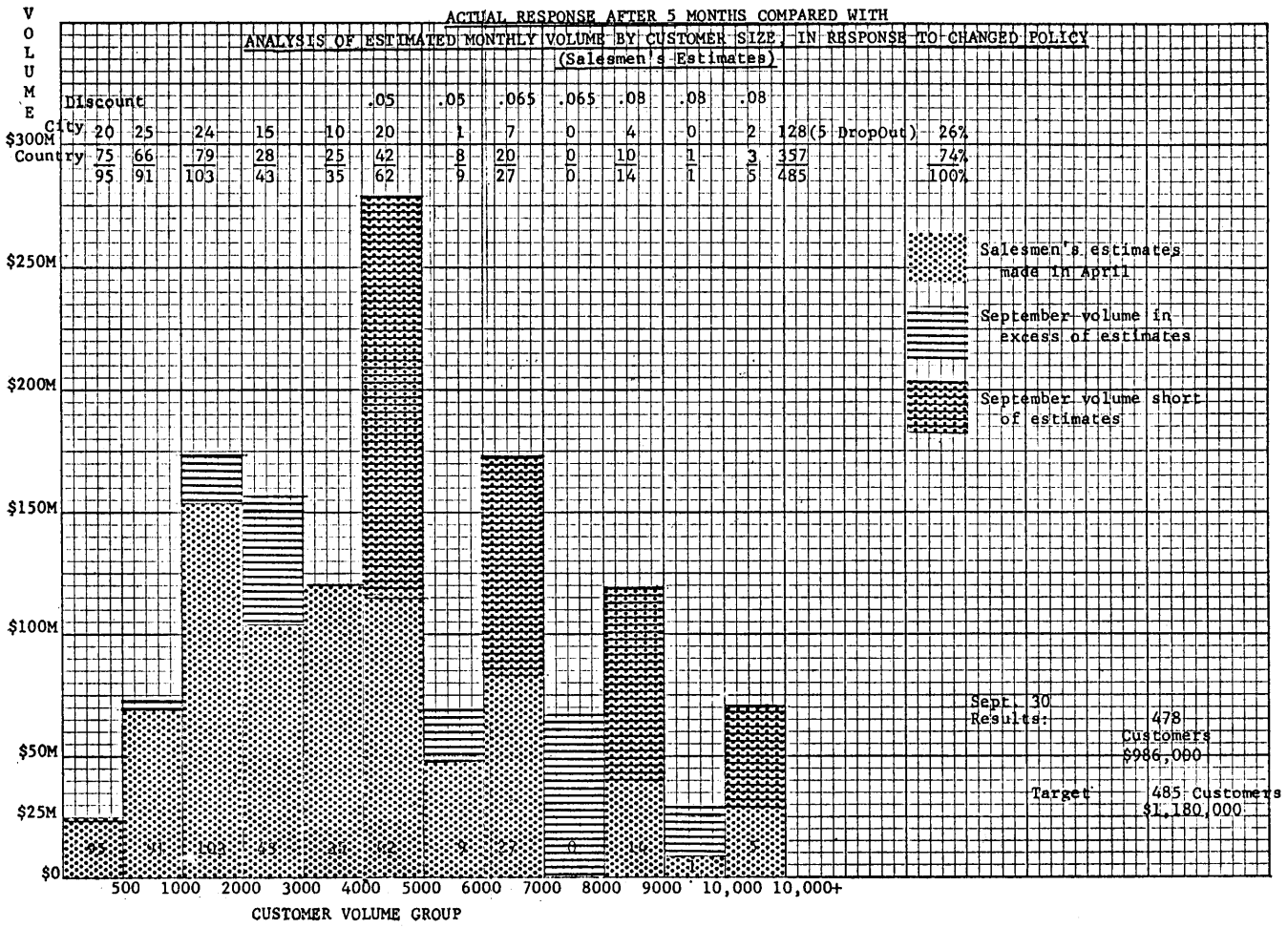
1. There was less stability than had been expected. Among several hundred retailers, some will undoubtedly die, become disabled, or otherwise go out of business during a six-month period. This was accentuated because of uncertain business conditions, even in consumer goods, in 1970.

2. Competitive response was not given sufficient weight.

3. The tendency for a customer who could not qualify for the discount program to shift his business to a competitor was underestimated.

Exhibit 5 shows that the effects of this dropping back were not entirely detrimental. The aim had been to raise the central portion of the cumulative probability distribution—customers at the high-volume (left) end of the curve already tended to be near their total potential, whereas customers at the low-volume (right) end tended to be unprofitable. Those in the center ($2,000-$6,000) were the ones

EXHIBIT 7



at which the program was aimed.

Exhibits 5, 6, and 7 (above) indicate that after five months, approximately one-third of the target additional volume had been attained. There have been significant shifts to the right, and management is pleased with the results to date.

(Statistical forecasting had indicated that had the historical seasonal pattern been followed, there would have been no significant difference between February volume and September volume.)

The following assumptions were made to simplify the calculations:

1. No time frame was specified for transition. "Over several months" was purposely left loosely defined, since salesmen would spend several weeks in their efforts to announce, explain, and convince customers of the advantages of the new program.

2. No measure was made of the effects of competitors' response.

3. No attempt was made to relate specific customers or salesmen to the "total market" information available from published sources.

4. No weight was given to seasonal influence, since statistical forecasting techniques had indicated low seasonal influence.

5. No attempt was made to separate the effects of this program from special promotions and deals which were offered continuously during the period. Such "specials" were regular trade practice and had been for many years, although some innovations were introduced in the current year.

Related work that was performed but not discussed in this article includes the following:

1. Estimates of market penetration by sales territory, given trade information on total retail sales by Standard Metropolitan Statistical Area

2. Estimates of volume and penetration of specialized segments of the market

3. Studies of truck routings and number of deliveries, miles run, schedules, and related transportation costs

4. Studies of arrival times of incoming orders and suggested shifts to balance the workloads in order-picking, billing, and truck dispatch, with resulting changes in warehouse and order handling costs

5. Estimate of overall effects on profits of changes in volume, discounts, sales commissions, warehouse, and delivery costs.

References

[1] Kemeny, Schleifer, Enell, & Thompson, *Finite Mathematics with Business Applications,* Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1962, pp. 193-199.

[2] Hare, *Systems Analysis: A Diagnostic Approach,* Harcourt, Brace, & World, New York, 1967, pp. 457-472.