TRANSPORT IMPLICATIONS OF CUSTOMER RESPONSE TO PHYSICAL DISTRIBUTION SERVICE

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ABSTRACT: *A demand response function is described which relates changes in the corporate growth rate for a particular product or product group to the comparative customer service package provided. Customer service factors explicitly considered in the function are order cycle time, unit price, probability of a stockout, characteristics of order placement and information about order status and product characteristics. Face validity testing has been performed on the function. An examination is made of the effect changes in the corporate transportation operation have on product sales through the demand response function.*

1. INTRODUCTION

Physical distribution management developed as an almost textbook-like application of systems theory. For the manufacturer or distributor, transportation, inventory control, order processing, materials handling, packaging and facilities location are often controlled by different corporate functions. For example, transportation may be the responsibility of the manufacturing function, packaging the responsibility of marketing and facilities location the responsibility of corporate planning. So the traffic manager will be evaluated on the basis of transportation costs and will often select slower, but less expensive modes. This may well be more costly for the company as a whole because inventory levels will have to be higher and customer service levels may well be lower. Looking at the distribution operation as a system will enable such sub-optimalities to be avoided.

Evaluation of the corporate physical distribution operation is done in terms of the total cost involved and the customer service level achieved. This is normally done in one of two ways. The first way is for the company to set service levels as a matter of policy and then the distribution manager's task is to meet these service standards at least total cost, while the second way is for the distribution operation to be budgeted a certain amount with which the distribution manager provides the highest possible level of customer service. Most companies in Australia use a variant of this first method - physical distribution management then becomes primarily concerned with cutting costs.

Recently a more comprehensive approach has been taken when evaluating the corporate distribution operation - the emphasis has changed from cost reduction to profit generation. This approach requires much greater managerial

skill. The distribution manager must be able to establish the cost of providing different combinations of customer service at different levels. He must then attempt to relate these different customer service levels to customer service and then to revenue. Then with the cost data he can establish the profitability of a range of customer service options.

A major difficulty with this approach occurs at the stage where the response of the customer (in terms of product purchases) is measured against the level of service provided. The aim of this paper is to examine this relationship and to present a preliminary approach to its measurement.

2. CUSTOMER SERVICE

Customer service is a term that is used widely and it is always assumed that the meaning is unambiguous. Heskett (1971) highlighted that this is in fact not the case when he investigated customer service in the United States and developed a list of different interpretations given roughly in order of popularity:

(a) The elapsed time between the receipt of an order at the suppliers warehouse and the shipment of the order from the warehouse.

(b) The minimum size of order, or limits on the assortment of items in an order which a supplier will accept from its customers.

(c) The percentage of items in a supplier's warehouse which might be found to be out-of-stock at any given point of time.

(d) The proportion of customer orders filled accurately.

(e) The percentage of customers, or volume of customers' orders, which describes those who are served (whose orders are delivered) within a certain time period from the receipt of the order at the supplier's warehouse.

(f) The proportion of goods which arrive at the customer's place of business in saleable condition.

(g) The elapsed time between the placement of an order by a customer and the delivery of goods ordered to the customer's place of business.

(h) The ease and flexibility with which the customer can place his order.

In addition to the fact that so many quite different views of customer service exist it is interesting to examine the ranking of these measures - the supplier or manufacturer-oriented definitions are at the top of the list while the customer-oriented ones are at the bottom.

While it is not a difficult process to find out which aspects of service customers or customer groups think important, it is seldom done in any systematic fashion. An Australian study (Gilmour et. al., 1977) found this to be the case in the scientific instrument and suppliers industry. An important point made by the study was that the suppliers in the industry were quite sure that they knew their customers service requirements when in reality they did not. Not enough time had been spent trying to relate the supplier's service package to the customer's real requirements.

It is not always possible to go out and ask customers to list the factors they consider to be important customer service elements. When it is not feasible the distribution manager must adapt to his situation lists prepared by others. Hutchinson and Stolle (1968) developed a classification based on those factors directly related to the distribution operation plus additional factors which are important to the customer but often not of direct concern to the distribution manager. Of direct interest are:

(a) Order processing time: elapsed time from receipt of customer's order

until it is ready for assembly.

(b) Order assembly time: time required to prepare the order for shipment.

(c) Delivery time: time in transit to customer.

(d) Inventory reliability: stockouts, back orders, percentage of demand filled, omission rate, percentage of orders shipped complete, and so on.

(e) Order-size constraint: minimum order size and minimum frequency allowed.

(f) Consolidation allowed: ability to consolidate items from several locations into a single shipment.

(g) Consistency: range of variation in each of the preceding elements.

Factors which are of importance to the customer but which are not under the direct control of the distribution manager are:

(a) Frequency of a salesman's visits to check his customer's needs.

(b) Ordering convenience (telephone, reprinted forms, and so on).

(c) Order progress information (order acknowledgement, shipping notices, and so on).

(d) Inventory backup during promotions, new product introductions, and competitive tests.

(e) Format and organization of the invoice.

Perreault and Russ (1974) add some additional factors which the distribution manager should consider in their list of seventeen customer service elements shown in Table I.

Exactly what is selected to comprise the customer service "package" will depend on the characteristics of a particular industry. It is essential to consider every element which may be regarded as important by the customer.

TABLE I

CUSTOMER SERVICE ELEMENTS LISTED BY PERREAULT AND RUSS

1. Order processing time
2. Order assembling time
3. Inventory reliability
4. Order-size constraints
5. Ordering convenience
6. Delivery time
7. Consistency
8. Invoice format
9. Claims procedure
10. Inventory backup
11. Condition of goods
12. Salesmen's visits
13. Billing procedures
14. Order status information
15. Consolidation allowed
16. Technical after sales service
17. Product information

3. MEASURING THE EFFECT OF CUSTOMER SERVICE ON SALES

Little effort has been made to try and measure the response of customers to varying service offerings. Probably the main reason for this is the extreme difficulty of the task. Many factors exist which confuse the relationship between customer service and sales. A long standing relationship between supplier and customer might in itself be enough to offset superior service offerings of other suppliers. Communication is often another problem - the customer may not be aware of the type of service the supplier can provide. Internal management policies can seriously impede the ability of the distribution manager to use customer service options most effectively.

Theoretically the relationship between customer service and demand can be represented by a "customer service function" or a "demand response function" If average order cycle time and order cycle time variability are taken to be the essential components of customer service then these two factors can be related to dollar sales. The nature of the relationship will depend upon how the average order cycle time and order cycle time variability of the particular supplier measure up to those provided by his competitors. Obviously if a supplier provides faster and less variable customer order filling than his competitors he will obtain a larger proportion of the market. A hypothetical relationship of this kind is shown in Fig 1.

Trying to establish the nature of this fuction in an actual corporate situation is most difficult. Ballou (1971) suggests four different methods by which the task might be attempted:

(a) By conducting experiments

(b) By developing a simulation model

(c) Using an opinion survey and

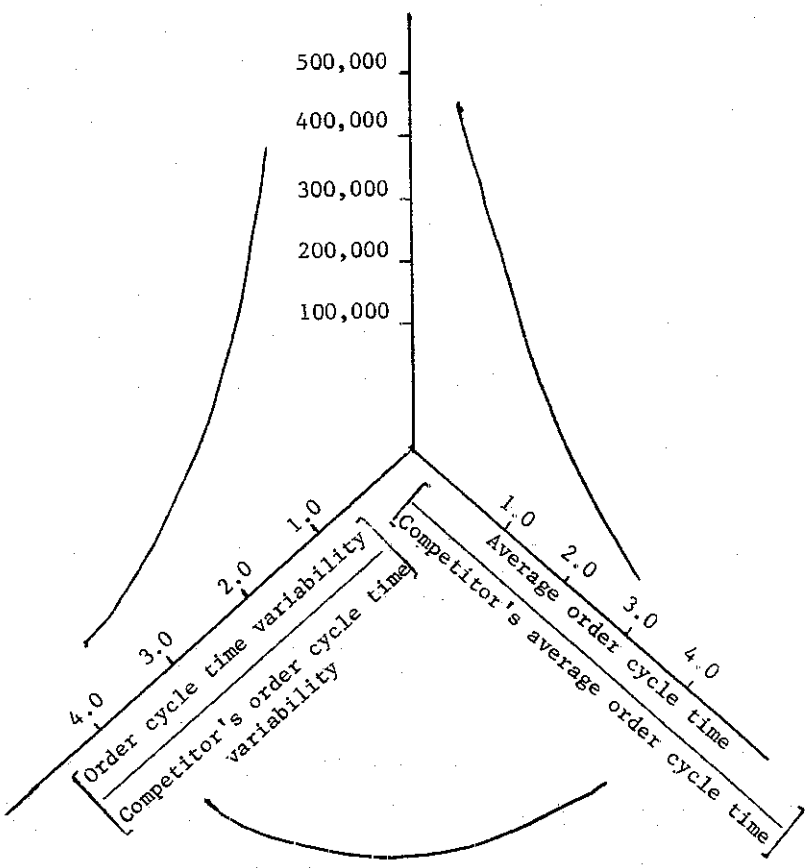

Fig 1 - A hypothetical customer service function

(d) Developing an historical description from company records.

An experimental approach presents many practical problems. This approach involves providing different groups of customers with different levels of service and then measuring the effect on sales of the different service offerings. It is to be expected that general management will object to such an approach because it involves providing service levels considered non-optimal to at least some customers.

With an opinion survey the problem is that it must be assumed that what the customer says now will correspond with what he will do later. This obviously is not always the case.

Historical descriptions developed from company records also have shortcomings. The major drawback is that not all customer service options worthy of consideration will have been used by the company in the past.

Simulation involves developing a model which can accurately replicate the current situation. Changes can then be made to the model to reflect different service conditions and the effect on sales examined. If the model is an accurate representation of reality the difficulties involved with simulation can be avoided.

In order to give an idea of the research that has been done on the relationship of demand to physical distribution service two demand response functions are briefly described.

Stephenson and Willet (1968) developed a function relating one attribute of customer demand, lead time, to sales generation. The form of the function

was:

$$Pr = \frac{c}{1 + e^{-(a + b\ (si - s))}}$$

where Pr = probability that the supplier receives the order

si = lead time offered by the supplier

s = mean lead time offered by all suppliers

c = natural log

a,b,c = parameters derived empirically

The parameters a, b and c enabled the function to reflect the characteristics of a particular supplier's situation. But as might well have been expected not a particularly good fit to reality was obtained because of the many aspects of customer service not considered in the function.

Schary and Becker (1972/73) developed the following demand response function:

$$\frac{dS}{dt} = rL \left(\frac{M - S}{M}\right) - lS$$

where S = sales level at time t

$\frac{dS}{dt}$ = rate of change in sales level at time t

L = level of distribution expense at time t

r = sales response constant

M = saturation level of sales

l = sales decay constant

This function assumes that the total level of distribution expenditure is related to customer service and so all aspects of customer service are accounted for in this aggregated fashion. An important aspect of this function

is that it does take into account the total size of the market by the factor M, the saturation level of sales. But aggregating customer service to this extent makes it difficult to use this function as a tool for corporate policy determination and implementation.

4. A DEMAND RESPONSE FUNCTION

An initial attempt, using a range of different customer service elements, has been made to describe the relationship for Australian companies between these factors and market share.

The customer service factors considered were order cycle time, unit price, probability of a stockout, characteristics of order placement and information about orders and products. These were combined into a function on an iterative empirical basis. Information about the ordering process and about products was provided by customers using the questionnaire shown in Table II. The demand response function is given in Fig 2.*

Data from approximately 40 Australian companies has been used to test the validity of the function. In order to facilitate the collection of this data the function was imbedded in a simple FORTRAN program and used on-line to a Burroughs 6700. Some of these results are shown in Table III. Values for the parameters λ_1, λ_2 and λ_3 were also provided by the customers: a mean value of one together with a usual range of from 0.5 to 1.5 was suggested. In all cases in Table 3 the company growth rate (for the product or product group under consideration) anticipated by the company was within a few percentage points of that generated by the function.

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*Madhavi Tembe assisted in the development of the model.

TABLE II

CUSTOMER SERVICE QUESTIONNAIRE

Below is a list of some customer service elements covering, in particular, order characteristics and order/product information. Could you please think of particular product or product group from your product range and then rate each of the customer service elements as follows:

1. Your performance is far better than that of your nearest competitor
2. Your performance is slightly better than that of your nearest competitor
3. Your performance is the same as that of your nearest competitor
4. Your performance is slightly worse than that of your nearest competitor
5. Your performance is far worse than that of your nearest competitor

Also could you estimate the amount (percentage) by which your sales and costs would increase/decrease if your service on each element was improved/reduced to the same level as your nearest competitor.

Order Characteristic	Far Better	Slightly Better	Same	Slightly Worse	Far Worse	% change in sales	% change in cost
Ordering convenience	1	2	3	4	5		
Minimum order size constraint	1	2	3	4	5		
Condition of goods at delivery	1	2	3	4	5		
Consolidation allowed	1	2	3	4	5		
Order/Product Information							
Number of salesmen's visits per year	1	2	3	4	5		
Effectiveness of salesmen's visits	1	2	3	4	5		
Technical after sales service	1	2	3	4	5		
Product information	1	2	3	4	5		
Convenience of invoice format	1	2	3	4	5		
Claims procedure	1	2	3	4	5		
Billing procedures	1	2	3	4	5		
Order Status information	1	2	3	4	5		
Do salesmen make regular visits?	YES	NO					
Do salesmen call only when requested by customer?			YES	NO			

Product/product group considered _____

Industry _____

$$G = \tfrac{1}{2} K \left[\left(\frac{I1 + I2}{2} \right) \left\{ e^{(1 - t/to)} \right. \right. + (1 - \alpha/\alpha_o) \cdots + e^{(1-p/pc)} \cdots$$

$$= \tfrac{1}{2} K \left[\left(\frac{I1 + I2}{2} \right) \left\{ e^{-(\lambda_1 \Delta t/to - \lambda_2 \Delta\alpha/\alpha c)} + e^{-\Delta p/po} \right. \right.$$

where:

K	=	industry growth rate	(%)
I1	=	order characteristic index	($\overline{I1}$ = 100)
I2	=	order/product information index	($\overline{I2}$ = 100)
t	=	order cycle time	(hours)
to	=	competitor's order cycle time	(hours)
λ_1	=	degree of industry competition	($\overline{\lambda_1}$ = 1)
α	=	probability of a stockout	(%)
α_o	=	competitor's probability of a stockout	(%)
λ_2	=	elasticity of demand	($\overline{\lambda_2}$ = 1)
p	=	unit price	($)
po	=	competitor's unit price	($)
λ_3	=	product brand image	($\overline{\lambda_3}$ = 1)
e	=	natural antilog = 2.718	

Fig 2 - The demand response function

TABLE III

TEST RESULTS FROM THE DEMAND RESPONSE FUNCTION

Company	Constant 1 λ_1	Constant 2 λ_2	Constant 3 λ_3	Relative order cycle time $t/_{to}$	Relative price $p/_{po}$	Relative stock out probability $\alpha/_{\alpha o}$	Order characteristic index I1	Order-product information index I2	Industry growth rate K	Company growth rate G
1	0.97	1.00	1.10	100	100	70	100	110	0.08	0.10
2	0.01	1.50	1.02	1000	118	200	80	55	0.03	0.01
3	1.10	0.90	1.10	100	90	80	110	110	0.20	0.24
4	1.10	1.00	1.05	90	100	110	100	110	0.12	0.13
5	1.10	0.90	1.02	90	100	90	90	110	0.20	0.22
6	1.10	1.00	1.10	110	110	120	110	120	0.15	0.13
7	1.00	1.00	1.10	50	90	110	130	140	0.20	0.31
8	1.00	1.00	1.10	120	110	90	118	80	0.04	0.04
9	1.10	1.00	1.10	100	90	95	105	100	0.17	0.19
10	1.10	1.05	1.10	80	100	90	120	110	-0.10	-0.07
11	1.10	1.10	1.05	95	100	90	120	100	0.05	0.06
12	1.10	1.10	1.10	95	100	85	105	105	0.02	0.02
13	1.80	1.50	1.20	100	109	50	120	120	0.12	0.21
14	1.00	0.50	1.00	100	114	100	100	120	0.12	0.12
15	1.50	0.50	0.80	200	107	10	80	90	0.00	0.00
16	1.50	0.50	0.95	109	101	75	100	120	0.06	0.06

Note: $t/_{to}$, $p/_{po}$ and $\alpha/_{\alpha o}$ all multiplied by 100.

Tables IV and V show some sensitivity analyses on the parameters and variables of the function. The results of Table III could be made more sensitive by using a less optimistic mean for γ_1, γ_2 and γ_3 (even a value of zero) and a wider range. It can be seen from Table IV that with a wider range of parameter values and a reasonable difference in the level of service provided on a factor the company growth rate changes quite markedly. A next possible step would be to establish the values of these parameters analytically from data provided by each particular company. In any event the form taken by the figures in Tables IV and V were passed for face validity by several of the organizations participating in the study.

If an organization was to use the function for decision making purposes a higher level of data analysis would be required to ensure that the function characterized the particular circumstances of that company. Once that was done however, the function will be a useful tool for evaluating the effect of the five customer service factors on the demand for a product or product group. Management can then concentrate their efforts on the service factors which have a strong influence on demand.

5. IMPLICATIONS FOR TRANSPORTATION

The order cycle time is the sum of order transmission time, the time needed to process the documents when received by the supplier, order picking time, time delays for out of stock items, and the shipment time. From Table V it is seen that one day's competitive advantage in order cycle time provides an increase in the growth rate of three percentage points. A competitive disadvantage of one day decreases the growth rate by two points. Although delivery time is only one component of the order cycle time greater transportation efficiency could reduce the order cycle time by a day as could such innovations as night

TABLE IV

SENSITIVITY OF THE PARAMETERS λ_1, λ_2 and λ_3

G when				λ_2	G when			λ_3	G when			(Revised Model) G when			
λ_1	t=5	t=4	t=2	t=i		α=0.01	α=0.03	α=0.07		p=15	p=17.50	p=20	p=15	p=17.50	p=20	p=25
-2.4	44.6	24.2	10.9	9.0					-2.4	11.6	13.i	21.2	10.4	11.5	12.8	17.3
-2.0	36.0	22.i	11.4	9.5					-2.0	12.0	13.3	19.9	10.9	11.8	13.i	16.7
-i.5	27.9	19.9	12.0	10.3					-1.5	12.7	13.7	18.4	11.5	12.3	13.3	16.0
-i.0	22.i	18.0	12.9	11.4					-i.0	13.3	14.i	17.1	12.3	12.9	13.6	15.4
-0.5	18.0	16.4	13.8	12.9					-0.5	14.1	14.5	16.0	13.2	13.6	14.0	14.8
0.0	15.0	15.0	15.0	15.0	0.0	15.0	15.0	15.0	0.0	15.0	15.0	15.0	14.3	14.3	14.3	14.3
0.5	12.9	13.8	16.4	18.0	0.5	12.5	13.6	16.7	0.5	16.0	15.5	14.1	15.6	15.1	14.6	13.8
i.0	11.4	12.9	18.0	22.i	i.0	10.9	12.5	18.7	i.0	17.i	16.0	13.3	17.i	16.0	15.0	13.3
i.5	10.3	12.0	19.9	27.9	i.5	9.8	11.6	21.2	i.5	18.4	16.5	12.7	19.0	17.0	15.4	12.9
2.0	9.5	11.4	22.1	36.0	2.0	9.0	10.9	24.2	2.0	19.9	17.1	12.0	21.2	18.i	15.8	12.5
2.5	8.9	10.8	24.8	47.2	2.5	8.6	10.4	27.9	2.5	21.5	17.8	11.5	23.8	19.4	16.2	12.2

Note: Unless otherwise noted λ_1=1, λ_2=i, λ_3=i, t=3, t_o=3, α=0.05, α_o=0.05, p=20, p_o=20, I1=100, I2=100

TABLE V

SENSITIVITY OF VARIABLES AND INDICES

Order Cycle Time				Stockout Probability				Price				Order and Product Indices	
Own		Competitors		Own		Competitors		Own		Competitors			
t	G	t_o	G	α	G	α_o	G	p	G	p_o	G	I1 or I2	G
0.1	27.2	0.1	7.5	0.01	24.2	0.01	7.5	0	24.9	1	7.5	0	11.3
0.5	24.8	0.5	7.6	0.025	19.9	0.025	10.3	5	23.4	5	7.9	20	12.0
1.0	22.1	1.0	8.5	0.05	15.0	0.05	15.0	10	19.9	10	10.3	40	12.8
1.5	19.9	1.5	10.3	0.075	12.0	0.075	18.0	15	17.1	15	12.9	60	13.5
2.0	18.0	2.0	12.0	0.1	10.3	0.1	19.9	20	15.0	20	15.0	80	14.3
2.5	16.4	2.5	13.6	0.125	9.2	0.125	21.2	25	13.3	25	16.7	100	15.0
3.0	15.0	3.0	15.0	0.15	8.4	0.15	22.3	30	12.0	30	17.9	120	15.8
3.5	13.8	3.5	16.2	0.175	8.1	0.175	22.9	35	11.0	35	19.0	140	16.5
4.0	12.9	4.0	17.1	0.2	7.8	0.2	23.5	40	10.3	40	19.9	160	17.3
4.5	12.0	4.5	18.0	0.225	7.7	0.225	23.9	45	9.6	45	20.6	180	18.0
5.0	11.4	5.0	18.7									200	18.8
												220	19.5

Note: Unless otherwise noted $\lambda_1=1$, $\lambda_2=1$, $\lambda_3=1$, $t=3$, $t_o=3$, $\alpha=0.05$, $\alpha_o=0.05$, $p=20$, $p_o=20$, $I1=100$, $I2=100$

deliveries. Naturally the cost of these changes would have to be evaluated against the contribution provided by the increased sales.

Fast and efficient transportation will reduce the probability of stock-out. Table V shows that an advantage in stockout probability can have a considerable influence on the growth rate with the comparative disadvantage from a higher stockout probability being not so great.

Comparative price is not related to transportation although a higher absolute product price enables the product to absorb the larger transportation expenditure required for faster and more efficient services.

6. CONCLUSION

Although some degree of success has been achieved with the empirically derived demand response function further modifications can still be made. For example it is reasonable to expect brand image to have some effect when the price is equal to competitive prices. This does not occur with the function as formulated and so the following change was made:

$$G = \tfrac{1}{2} K \left[\left(\frac{I1 + I2}{2} \right) \left\{ e^{(1 - t/t_o)\lambda_1 - (1 - \alpha/\alpha_o)\lambda_2} \right\} + e^{0.1\lambda_3 - 0.1 e^{(1 - p/p_o)\lambda_3}} \right]$$

The effect of this change is shown in the four right hand columns of Table IV. Analytical determination of the parameters from empirical data would increase the closeness of fit of the function to a particular product or product grouping of any given organization.

Transportation is one of the most important aspects of the corporate physical distribution system and this importance is reflected in the response

of demand through the demand response function to transportation-related changes in the customer service offering.

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