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A Quantitative Analysis of the Pattern of Consumer Purchases

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INTRODUCTION

The negative binomial distribution has been employed to study the retail purchases of a few selected processed corn products manufactured by the Karnataka State Agro Corn Products Ltd., (KSACPL) Hebbal, Bangalore with a view to (i) estimate the purchase pattern of different corn products of a specific brand, (ii) compute the length of 'waiting time' for a specified number of units of a certain product to be sold and (iii) to know the optimum stocking pattern of different kinds of products of the same brand on the basis of 'popularity Index' and length of waiting time.

The negative binomial distribution has specifically been chosen primarily because it is a waiting time model and hence would facilitate the investigations of the objective in view. In addition a cursory glance at the data suggested the use of such a distribution.

Yule (1910), Greenwood and Yule (1920), Griffiths (1960), Chatifield *et al.* (1966), Goodhardt and Ehrenberg (1967), Morrison and Perry (1970), Ehrenberg (1972), and Paull (1978) have used the negative binomial distribution on different occasions.

Since we are concerned with the retail purchases of consumers of a specific brand, here we denote 'success' as the number of units bought of a particular product and 'failure' as not buying it. Therefore, the total number of trials 'N' consists of number of failures 'x' and number of successes 'r'. Note that

$$N = x + r$$

The NBD indicates the probability of r number of purchases of a given

product (the rth purchase materialising in the Nth trial) and is given by

$$P(x) = \binom{x + r - 1}{r - 1} p^r (1 - p)^x$$

where p is the probability that one unit of a product is purchased. The procedure of fitting this distribution is outlined in standard statistical text books.

POPULARITY INDEX

We use the probability associated with success viz., $p = \bar{x}/V(x)$ as 'popularity Index.' In common language, popularity of a product is associated with relatively larger market share of the product as compared with its competing products. We use the term in an analogous way. Here, popularity is the probability of buying a single product by one consumer. The higher the probability, the greater will be the popularity, and as one can notice, it is the relative popularity over other corn products.

DATA AND FINDINGS

The purchase data (sales data) are obtained from the receipts of Karnataka State Agro Corn Products Ltd., a Public Sector undertaking of Karnataka State Government started in the year 1973. The agency procures raw maize corn (white and yellow variety) and processes them into corn products. The most important of them being :

(i) White flour	(WF)
(ii) Yellow flour	(YF)
(iii) White Maida	(WM)
(iv) Yellow Maida	(YM)
(v) White Flakes	(WFA)
(vi) Yellow Flakes	(YFA)
(vii) White Fine Soji	(WFS)
(viii) Yellow Fine Soji	(YFS)
(ix) White Medium Soji	(WMS)
(x) Yellow Medium Soji	(YMS)
(xi) White Precooked Soji	(WPCS)
(xii) Pre-cooked Flour	(PF)

The present study covers the retail purchase of these products of KSACPL, Hebbal for the period from April 1st 1977 to January 18th

1978. It involves 952 purchasers who had bought at least one of the above mentioned products of KSACPL.

ASSUMPTIONS

It should, perhaps, be pointed out at the outset that the ensuing exposition is limited to statics i.e., we assume that the prices are constant, tastes are given and consumer's purchases are not influenced by price changes of other substitutes, advertisements etc.

We also assume an uninterrupted free supply of goods and no rationing. Thus, the consumer exercises his full sovereignty over purchases.

Since NBD is based on independent Bernoulli trials, we assume that each consumer's purchase is independent of other consumer's decisions, which is not quite true. In fact, Leibenstein (1950) made a mention of the 'band wagon' effect, Snob and Veblen effects on consumer demand. These effects are differentiated in the following manner. The bandwagon effect is explained as the extent to which the demand for a commodity is increased due to the fact that others are also consuming the same commodity in order to be fashionable or stylish. This is similar to the 'demonstration effect' hypothesised by Dusenberry (1952). Snob effect represents the desire of people to reduce their demand for products since others are also consuming the same commodity. Veblen effect refers to the phenomenon of conspicious consumption to the extent to which the demand for a consumer's good is increased because it bears a higher rather than a lower price.

Again this model, being experimentally derived, is applicable only to the specific population underlying the experiment. That is the model is valid only for a particular retailer and to obtain an overall picture, we should repeat this for a number of retail traders which might be next to impossible.

Yet another assumption is that the same consumers do not come and even if they come they are treated as different customers.

Among the purchase data distribution of twelve products, the features of NBD, viz (i) mean is less than variance, (ii) the chi-square value for goodness of fit is insignificant, and (iii) the probability of least success (say, purchase of zero packets of any product) is also the highest, were observed in the case of nine products except for white medium soji, precooked flour and yellow flakes.

The corn products have been ranked according to their popularity index in Table 1. The most popular products seem to be Yellow Fine Soji and Yellow Medium Soji which are bought by 43 percent of purchasers. Probably consumers prefer Corn Soji rather than that of wheat, because

TABLE 1
RANKING OF PRODUCTS BY POPULARITY INDEX

1. Yellow Fine Soji	(0.4349)
2. Yellow Medium Soji	(0.4320)
3. White Fine Soji	(0.3159)
4. White Flakes	(0.2883)
5. White Pre-cooked Soji	(0.2018)
6. White Maida	(0.1811)
7. Yellow Flour	(0.1615)
8. Yellow Maida	(0.1491)
9. White Flour	(0.1252)

of a lower price (Rs, 1.39 per kg of Corn Soji compared with Rs. 2.20 per kg of Wheat Soji). Common observation suggests that corn products are close substitutes to wheat products. But more data to enumerate the cross-elasticity of substitution between the corn and wheat products is needed to support the above conclusion.

This has implication for the seller in terms of disposing of the product i.e., the time he waits before selling one unit of the product. Intuitively, higher popularity implies greater demand for the product, hence the seller can sell it off immediately. In other words, higher the probability, the lower will be the 'waiting time length'. In normal connotation, this term, is understood as the time lapse between the time of registration of one unit of the product and the time of actual delivery (say the time we wait to get a new telephone connection, scooter allotted and so forth). But here, we modify the concept slightly; by the "length of waiting time" we mean the number of customers (n) required to visit the shop to get the required number of packets (r may be = 10, 20, 30,. . .) of a particular product to be sold—the assumption being that p (probability associated with success) remains constant for all the units. The 'length of waiting' time' is obtained by dividing the desired number of packets of a product to be sold (say r = 10, 20, 30, . . . packets) by the popularity index (p). This duration of waiting time for a presumed number of packets say 10, 30, 50 to be sold is presented in Table 2.

The above table confirms that, higher the popularity of the product, lower would be the waiting time in terms of number of trials (consumers), required to pass through the shop to get r units of the packets sold.

TABLE 2
LENGTH OF WAITING TIME IN TERMS OF NUMBER OF CUSTOMERS REQUIRED TO GET '*r*' PACKETS SOLD

Product	*r* = *10*	*30*	*50*
Yellow Fine Soji	23	69	115
Yellow Medium Soji	23	69	116
White Fine Soji	32	95	158
White Flakes	35	104	173
White Pre-cooked Soji	50	150	250
White Maida	55	166	276
Yellow Flour	62	186	310
Yellow Maida	67	201	335
White Flour	80	240	399

Accordingly the most popular, items Yellow Fine and Medium soji have the lowest waiting time.

The underlying theoretical distribution for determining the probability of atleast one of the twelve products will be purchased or sold is the "Geometric distribution", which is a particular case of the Negative Binomial distribution. The geometric probability distribution is given by $P(y) = \alpha(1 - \alpha)^{y-1}$, where $E(y) = 1/\alpha$; $V(y) = (1 - \alpha)/\alpha^2$ and $\alpha = 1/y$ is the probability that atleast one of the products will be purchased at a time, y being the mean number of products purchased. Thus, $y = 1, 2, 3, 4, \ldots$ 12 products in this case. Accordingly, it is estimated that in general, the products of KSACPL have 60 percent probability that atleast one of the twelve products will be bought. In terms of 'waiting time', it would be (approximately) two customers (1/0.6), one of whom would purchase atleast one product among the twelve.

STOCKING PATTERN

As a retailer, one would be interested to know the proportion in which different products would be kept so as to lessen the costs of storage as also to attract the marginal customer. If the retailer piles up the stock of different goods, irrespective of their sales probability, it may account to

keeping an unsold stock over a long period of time, thus adding to the cost of storage. Also, if he does not care to keep products (may be the least popular ones), in the required quantities, some customers may turn disappointed and may hesitate to visit the shop for other purchases since, in general, consumers prefer to make purchases in a shop wherein almost all the products needed by them are available.

This 'optimum' stocking pattern is determined on the basis of the 'popularity Index' (p). Here, the proportion of the probability of one of the products is taken with the probability of all other products. Accordingly, if a small retailer wishes to sell all the nine corn products of KSACPL, then, out of every 100 packets, he has to keep 5 packets of white flour, 7 each of yellow maida and yellow flour, 8 packets of white Maida, 9 of White pre-cooked Soji, 13 of White flakes, 14 of white fine soji, 18 of Yellow medium soji and 19 of Yellow fine soji. That is, for every one unit of white flour, he should keep three units of yellow medium soji, two units of white flakes, because, by the time one packet of white flour is sold, 3 packets of yellow medium soji and 2 packets of white flakes would be sold. Thus, NBD provides a proper guideline to the pattern of maintaining stocks based on the psychology of consumers.

FUTURE LINE OF WORK

The above model can be extended to analyse the products which are always in short supply in relation to demand. Assuming that only 'r' units of a particular product are available and if 'p' is the probability that one unit is sold to a consumer, we can find out what is the probability that there will be an excess demand say for 'n' units, and what is the expected demand-supply gap, $E(n)$ for the particular product in question. Answers to questions of this type could be of considerable importance to an entrepreneur.

Waiting time length can also be estimated in terms of number of days (n) required to get specified units (r) of a product sold.

The popularity index can be considered as a function of the price of corn, price of wheat products and other relevant factors. A regression analysis would highlight the relative importance of these variables.

CONCLUSION

The present paper applied negative binomial and geometric probabilities to the purchase pattern of a few corn products of a particular brand. The results of the application suggested that yellow fine soji and yellow medium soji are the most popular corn products preferred by the consumers. Based on the relative popularities, an 'optimum' stocking pattern for a retailer

is suggested. The limitations of the study are the assumptions that there is uninterrupted supply of goods and no rationing, and that each consumer's purchase is independent of other consumer's decisions. The study is valid only for a specific retailer and has to be carried with data from several retailers to obtain an average estimate. The waiting time is measured in terms of the number of customers (required to pass through the retailer shop to get his product sold) instead of number of days or any other unit of time.

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