

# ( $T, R_{N,\alpha,p}$ ) Inventory Policy for a FMCG Retail Supply Chain

Prasun Kumar Das\*, Susanta Kumar Gauri

SQC & OR Division

Indian Statistical Institute

Kolkata, West Bengal, India

\*dasprasun@rediffmail.com

**Abstract**—The scope of this study is limited to the supply chain of a FMCG retail business spreading through retail outlets and connected with the central warehouse. Manual intervention of requisitioning quantity of footwear on daily basis, from the retail outlets to the warehouse, was creating frequent problems of both stock-out resulting loss of sale and higher inventory resulting higher holding cost. A simple exponential smoothing model, using 99th percentile point of distribution of daily sales data for recent past 30 days, is proposed for determination of requisitioning quantity. The model was validated across outlets. It was further noted that the average inventory would have reduced by 31% without increase in average stock-out%, and the sales-to-inventory ratio would have increased by 75%. The cost-benefit analysis was done on new sale data to see the expected gain. This scientific inventory policy is, in general, applicable for any FMCG retail business environment.

**Keywords**—FMCG Retail, supply chain, exponential smoothing, requisitioning quantity, stock-out, holding cost

## I. INTRODUCTION

Fast moving consumer goods (FMCG) companies typically deal with low-value products with a regular high turnover of product. An FMCG company usually maintains a central warehouse and its own retail sales networks. Depending on the inventory policy, the retail outlets place order quantities for different products on a daily basis to the warehouse. The central warehouse compiles the order quantities received from the outlets and distributes the same on a daily basis to the outlets according to their requirements.

Lesser order quantity or requisitioning quantity i.e. maintenance of lesser quantity of daily stock of an item leads to stock-out of the item resulting loss of sale and larger requisitioning quantity i.e. maintenance of larger quantity of daily stock implies higher inventory resulting higher holding cost. Both the inventory as well as stock-out% of an item can be within an acceptable level only if the order quantity or requisitioning quantity is appropriate, which depends on the accuracy of the forecasting of the daily demand of different items.

The literature on short-term load forecasting contains a variety of univariate methods that could be implemented in an online prediction system. The range of different approaches includes state-space methods with the Kalman filter [1], general exponential smoothing [2], artificial neural networks [3], spectral methods [4], seasonal ARIMA models [4,5]; Data mining [6]. Reference Boylan et al. [7] discusses about

formation of seasonal group and application of seasonal indices. Reference Boylan et al. [8] highlights importance of reproducibility in forecasting research. The most noticeable development in demand forecasting over the last decade has been the increasing interest shown by researchers and practitioners in artificial neural networks [9]. However, the one short-term forecasting method that has remained popular over the years and appears in many papers as a benchmark approach, is multiplicative seasonal ARIMA modelling [10]. Reference Makridakis et al. [11] has shown that exponential smoothing is a competitive alternative to ARIMA models with a variety of different types of data. Reference Gebre and Singh [12] compared different quantitative forecasting methods and developed a monthly short term sales forecasting model specifically on shoes. They found that exponential smoothing forecasting method was the most appropriate for short term forecasting of sales of shoes.

This paper present a study limited to the supply chain of an Indian FMCG footwear retail business spreading through retail outlets and connected with the central warehouse. A simple exponential smoothing model, using  $p^{th}$  percentile point of distribution of daily sales data for past recent  $N$  days, is proposed for determination of requisitioning quantity. Keeping in mind that the overall stock-out% should remain at a low level, the optimal values of  $N$ ,  $\alpha$  and  $p$  were determined empirically as 30 days, 0.3 and 0.99 respectively. A software was developed for implementation of the proposed ROL determination system. It was noted that the average inventory would have reduced by 31% without increase in average stock-out%, and the sales to inventory ratio would have increased by 75%.

## II. THE BUSINESS PROCESS AND THE PROBLEM

The company has its own retail sales network consisting of thirty outlets spread over different parts of India. Footwear of more than 1500 designs/types is stored in a central warehouse located at eastern part of the country and is distributed to those retails outlets for sale to the customers. The stock level of an item (called ROL quantity by the company) to be maintained on a daily basis in an outlet was decided subjectively, through brainstorming among the relevant personnel, based on the likely demand, lead time of supply from warehouse and other marketing information, if any. The company, essentially, follows the ( $T, R$ ) inventory model for stocking, reviewing and replenishing, where the ROL quantity is the requisitioning quantity ( $R$ ) of an item and reorder time point ( $T$ ) is 1-day. The

order quantities of the footwear, received from the outlets, are compiled and distributed proportionately based on the available stock in the warehouse. Further, the ROL quantities of the items are modified, on a subjective basis, due to demand fluctuations during different seasons/festivals.

### A. The Problem

Lesser requisitioning quantity ( $R$ ) i.e. maintenance of lesser quantity of daily stock of an item leads to stock-out of the item resulting loss of sale and larger requisitioning quantity i.e. maintenance of larger quantity of daily stock implies higher inventory resulting higher holding cost. Both the inventory as well as stock-out% of an item can be within an acceptable level if the requisitioning quantity truly reflects a specified upper percentile point of its daily demand distribution.

Due to the existing practice of manual intervention, the requisitioning quantity was often inappropriately specified, particularly towards higher side since the management policy was to keep the stock-out% at low level as much as possible. Consequently, the inventories in the outlets used to increase to a very high level. On the other hand, modification of ROL quantities for the large number of items (to adjust seasonal/festival effects) becomes a tedious task, since done manually.

## III. OBJECTIVE AND APPROACH

Both the inventory as well as stock-out% of items in an outlet can be reduced if the requisitioning quantities of the items can be determined based on actual sales data. The objective of this study was, therefore, to develop a scientific system for determination of requisitioning quantity (ROL quantity in terminology of the company people) for the items, based on actual sales data at retail outlets, which can capture the change of demand patterns over time. The connected software should be developed for implementation of the

scientific system and integration in the organization's online system.

It may be noted that although ordering from retail outlets and stock transfer from the warehouse are done with size wise break-up of the items, it was planned to develop scientific system for determination of requisitioning quantity for the items without their size wise break-up due to the following reasons:

- Distribution of size requirements for the Indian people is well known. Therefore, once the requisitioning quantity of an item is known, the size wise break-up of the requisitioning quantity can be obtained easily.
- If size-wise daily sales of an item are considered, there will be too many days having zero sales. Consequently, it would be difficult to determine an effective scientific system.

## IV. DATA

There were about 1500 running items in about 30 retail outlets spread over various states of the country. Daily sales data of 5% sampled items of 20% sampled outlets, considering two-stage cluster sampling method based on simple random sampling, was captured for two consecutive years along with records of re-order levels (ROL).

## V. ANALYSIS AND RESULTS

### A. Developing Scientific System for Determination of Requisitioning Quantity

The time series plots of randomly selected items in two consecutive years are shown in Figure 1 and Figure 2 respectively. The plots clearly revealed that the demands of items change over time within a year. Further, the changes occur in the similar time points in the two years implying that there are strong seasonal and festive effects.

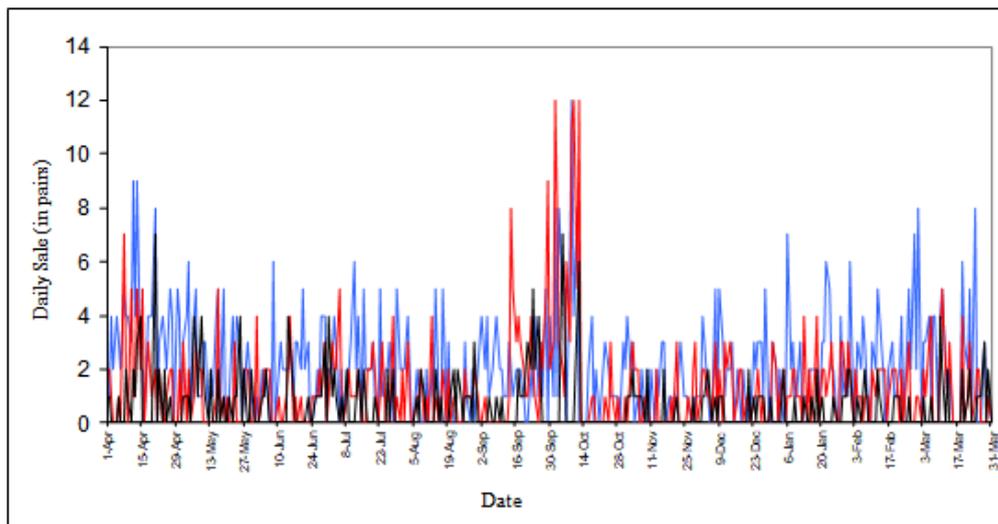


Fig. 1. Time Series Plot of daily sale quantity of randomly selected three items in 1<sup>st</sup> year.

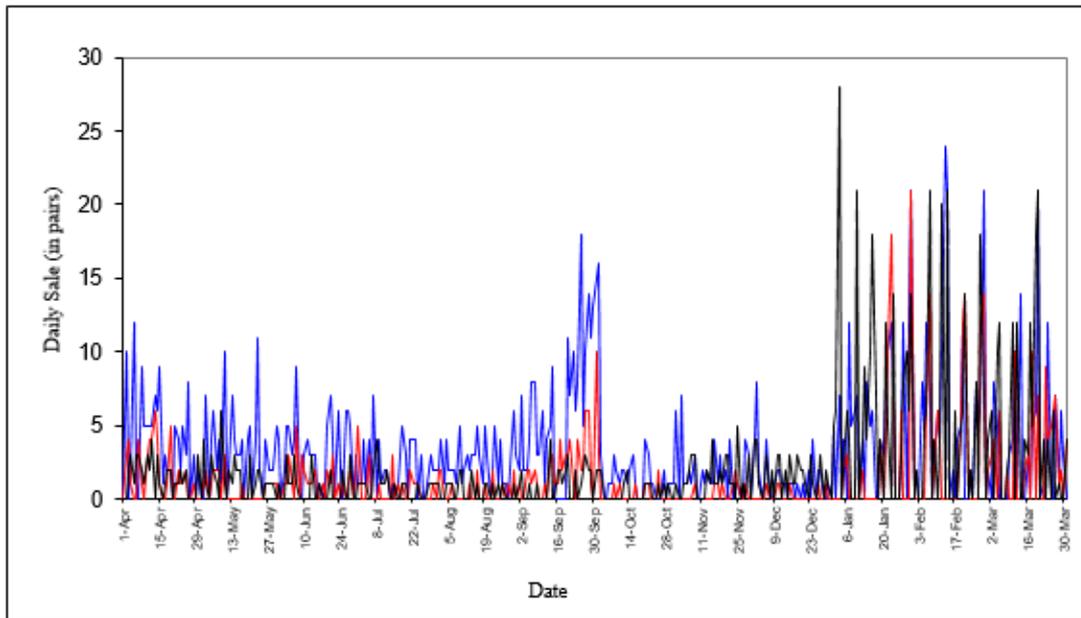


Fig. 2. Time Series Plot of daily sale quantity of randomly selected three items in 2nd year.

Traditional forecasting models, like seasonal ARIMA or Holt Winter method [4], might describe the underline demand patterns adequately and therefore requisitioning quantity might be determined based on forecast of demand and the estimate of forecast error. But it would require *i)* fitting models for each item and, *ii)* changing requisitioning quantity too frequently which are operationally inconvenient. Further, fitting of seasonal patterns would require data for at least three years, which was not available.

Therefore, it was planned to develop a system for determination of requisitioning quantity based on extreme values of observed sales distribution of an item in the most recent time points (days). In order to understand the behavior of the sales distribution and extreme values in consecutive periods of  $N$  days in a year, the daily sales data of an item in a year were divided into six periods of approximately 60 days

each. Then histograms were constructed from the sales data for each period and are shown in Figure 3(a) & 3(b) (Annexure II) for the first three and the last three periods respectively. It was observed from these histograms that both the mean and variability of demand change over time. The changes in mean are relatively lesser than the variability. The extreme values of observed sales distribution of items accommodate both effects of mean and variability, and change in the set of recent time points ( $N = 30$  or 60 days) reflects the seasonal/festive effects on mean and variability. Therefore, system for determination of requisitioning quantity based on the extreme value in the recent  $N$  days can minimize the stock-out% and avoid piling of unnecessary inventory. With this understanding the following model is proposed for determination of requisitioning quantity of an item, which is essentially simple exponential smoothing forecast of  $p^{\text{th}}$  percentile point of distribution of daily sales data for past recent  $N$  days.

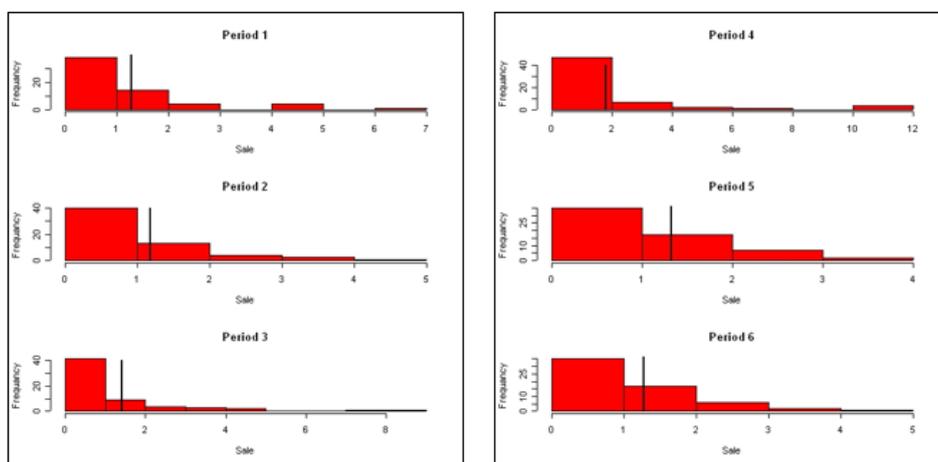


Fig. 3. (a): Histogram of daily sale of an item in consecutive first three periods of 60 days, (b): Histogram of daily sale of an item in consecutive last three periods of 60 days.

The requisitioning quantity for the interval between  $i^{th}$  and  $(i+1)^{th}$  time points is given by

$$Z_i = \alpha X_i + (1 - \alpha) Z_{i-1} \quad (1)$$

where,

$X_i$  :  $p^{th}$  percentile value of daily sales in the past  $N$  days from the  $i^{th}$  time point

$Z_{i-1}$  : Estimated requisitioning quantity at the  $(i-1)^{th}$  time point

$\alpha$  : Exponential smoothing constant ( $0 < \alpha \leq 1$ )

Here,  $N$ ,  $p$  and  $\alpha$  are the three model parameters associated with eqn.(1).

The successive time points mentioned above imply the successive days when the requisitioning quantities of an item are estimated. For the running items, the prevailing ROL quantity can be considered as  $Z_{i-1}$ . For new item, the requisitioning quantity can be determined after  $N$  days sale only.

It may be noted that the method described above is easily understandable by the company personnel and it does not require modification of requisitioning quantity frequently. Rather, the interval for ROL modification is flexible here.

**B. Determination of Optimal Values of the Model Parameters**

It is obvious that lower value of  $p$  will lead to higher stock-out%. Since the management policy was to keep the stock-out% as low as possible, it was considered that  $p = 0.99$ . On the other hand, it was known from literature [2] that  $\alpha$  varies usually in the range of 0.20 - 0.35. Further, it was known that the feasible values for  $N$ , from practical consideration, could be in the range of 15 days to 60 days. Therefore, the question of determination of optimal values for  $\alpha$  and  $N$  aroused.

It was not feasible to determine the optimal values mathematically. Therefore an empirical method was planned. For this purpose four discrete levels for  $N$  and  $\alpha$  were selected (Table I). The best combination of levels of  $N$  and  $\alpha$  (when  $p = 0.99$ ) was found using the itemwise daily sales data of 1<sup>st</sup> year, and then to validate the fitted model against the itemwise daily sales data of 2<sup>nd</sup> year.

TABLE I. SELECTED LEVELS FOR  $N$  AND  $\alpha$

Model parameter	Levels			
	15 days	30 days	45 days	60 days
$N$	15 days	30 days	45 days	60 days
$\alpha$	0.20	0.25	0.30	0.35

The possible overall average stock-out% (an item is considered stock-out if its sale in a day is greater than or equal to requisitioning quantity) and average inventory for different combination of values of  $N$  and  $\alpha$  (and  $p = 0.99$ ) in the model were estimated with respect to daily sales of randomly selected 5% items during 1<sup>st</sup> year. The summarized result is given in Table II.

It is noted from Table II that the average inventory is the minimum (7.6) when the value of  $N$  and  $\alpha$  are 15 and 0.3 respectively, but with this model average stock-out% is very high (6.02%). On the other hand, the average stock-out% is minimum (2.6%) when the values of  $N$  and  $\alpha$  are 30 days and 0.3 respectively and, with this model, the average inventory also remains at intermediate level (9.8). Since the management policy was to minimize the overall inventory ensuring that overall stock-out% is as low as possible, the optimal values of  $N$  and  $\alpha$  were selected as 30 days and 0.3 respectively. Thus the best-fitted model for the purpose of determination of requisitioning quantity was defined as

$$Z_i = 0.3X_i + 0.7Z_{i-1} \quad (\text{with } p = 0.99, N = 30 \text{ days}) \quad (2)$$

It is to be noted that both stock-out% as well as average inventory are impacted highly by the choice of value of  $N$ .

TABLE II. SUMMARY RESULTS OF DIFFERENT FITTED MODEL

Model parameters			Overall	
$N$	$\alpha$	$p$	Average Stock-out%	Average Inventory
15	0.20	0.99	6.041	7.968
15	0.25	0.99	6.021	7.975
15	0.30	0.99	6.021	7.621
15	0.35	0.99	6.021	7.979
30	0.20	0.99	2.665	10.293
30	0.25	0.99	2.814	10.221
<b>30</b>	<b>0.30</b>	<b>0.99</b>	<b>2.643</b>	<b>9.814</b>
30	0.35	0.99	2.686	10.143
45	0.20	0.99	4.511	10.329
45	0.25	0.99	4.511	10.329
45	0.30	0.99	4.511	9.836
45	0.35	0.99	4.511	10.329
60	0.20	0.99	3.069	10.600
60	0.25	0.99	3.092	10.571
60	0.30	0.99	3.069	10.286
60	0.35	0.99	2.999	10.729

**C. Validation of The Fitted Model**

Prior to implementing the above best-fitted model for the purpose of determination of requisitioning quantity regularly, it was decided to validate the usefulness of the model on the daily sales data of items of 2<sup>nd</sup> year. For the validation purpose, 15% items were selected randomly. At first, the stock-out% and average inventory that actually occurred with the existing ROL, determined based on the earlier subjective method, was estimated. Then, the stock-out% and average inventory that would have occurred, if the fitted model were used for determination of the requisitioning quantity, were estimated. Further, stock-to-inventory ratio was estimated under each of the two systems of ROL determination. The comparative results on the two methods are displayed in Table III.

It was noted that the average inventory would be reduced by about 31.25% without increase in average stock-out% if the fitted model were used for determination of requisitioning quantities of items from 2<sup>nd</sup> year sales data. Consequently, the sales-to-inventory ratio would have increased by about 75%.

TABLE III. COMPARATIVE RESULTS (15% SAMPLED ITEMS OF 2<sup>ND</sup> YEAR)

Itemcode (coded)	Earlier subjective method			Using fitted model		
	Stock-out%	Inventory	Sales to inventory ratio	Stock-out%	Inventory	Sales to inventory ratio
223052	3.3	21	26.69	5.07	14	48.71
253242	3.14	12	12.1	4.18	10	19.41
270213	3.06	15	20.27	3.58	13	30.33
331042	2.6	15	11.95	2.69	9	25.06
527020	2.76	11	24.36	4.18	12	28.35
583002	2.58	12	16.59	4.48	9	28.5
888002	15.17	41	19.52	9.85	21	39.61
888005	8.37	16	21.9	6.27	14	30.67
888013	4.34	18	24.5	4.89	11.3	47.5
423050	1.03	10	48	0.98	12.63	68.1
721013	1.68	15	25.69	1.97	7.4	63.37
543051	2.71	21	10.99	2.98	9.02	31.15
Average	4.23	17.25	21.88	4.26	11.86	38.40

## V. CONCLUSIONS AND RECOMMENDATIONS

- Determination of requisitioning quantities for the items using the fitted model (shown in eqn. (2), where  $N = 30$  days,  $\alpha = 0.3$  and  $p = 0.99$  were determined empirically) at fixed interval of one month would reduce the average inventory and, thus, holding cost without increasing average stock-out%. It was recommended to modify the ROL quantities at 30 days interval, in general. However, during festive/seasonal period, the interval for ROL modification should not exceed 7 days to absorb the change of demand pattern quickly in the ROL estimation.
- The overall requisitioning quantity for items in outstation outlets is the sum of the requisitioning quantity determined by the fitted model and the lead-time demand which is very important for outlets being in regions different from the location of the central warehouse.
- Determination of the requisitioning quantities manually for so many items in an outlet at regular interval was not feasible. Therefore it was recommended to develop necessary software for calculating the requisitioning quantity of any item at any day in an outlet, using the fitted model. The software has been developed with Visual Basic 6.0 and the Microsoft Access database system has been used. The software reliability should be tested and then it should be integrated within the scope of the supply chain considered. Subsequently, the cost-benefit analysis was done on new sale data and shown in the next section to estimate the gain per year due to savings of interest.

## VI. IMPLEMENTATION AND COST BENEFIT ANALYSIS

The trial implementation of the software was done in two outlets for one month. The ROLs of the item, determined based on the earlier subjective method, were recorded. However, supplies to the outlets, throughout the month, were given based

on the requisitioning quantity determined using the proposed scientific system. At the end of the month, average stock-out% was estimated. It has been found that the average stock-out% was 3.63% only. On the other hand, whereas the total inventory, when ROLs are determined by the earlier subjective method, is 4784 pairs, the total inventory, when requisitioning quantities (i.e. ROLs) are determined by the proposed scientific method, is 3598 only implying about 25% reduction of inventory.

### A. Cost-Benefit Analysis

Expected savings due to reduction of excess stock/outlet  
 $= 1186 \text{ pairs} \times \text{Rs.}300.00 = \text{Rs.}355800.00$

Monthly interest of the value of excess stock  
 $= \text{Rs. } 355800.00 \times 0.01 = \text{Rs.}3558.00$

Expected yearly gain due to savings of interest/year/outlet  
 $= \text{Rs. } 3558.00 \times 12 = \text{Rs.}42696.00$

Expected total gain/year due to savings of interest  
 $= \text{Rs.}42696.00 \times 28 = \text{Rs.}1195488.00$

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