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Development of Inventory Model for Public Distribution System by Using BPSO

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Abstract: *The proposed work is to deal with the distribution of rice to people through this distribution system. Usually FCI procures rice from millers or organizations constituted by farmers situated at some convenient central places. Then FCI supplies to some distribution centers referred to as MLSP's. Each MLSP, in turn supplies materials to some associated FPS's. Thus in a distribution system we have (i) FCI go downs, (ii) a small number of Mandal Level Service Poins (iii) a large number of FPS which are, in sets, associated with each Mandal Level Service Point (MLSP). This is the structure of a multi echelon PDS. The procurement of rice by FCI, its storage, supply to MLSP's, ordering/reordering by MLSP's for their respective demands, their storage and supplies to FPS's, all involve considérable expenditure. The multi echelon PDS system consists of: (i) procurement, (ii) inventory, (iii) reordering at FCI, (iv) supply, (v) storage, (vi) maintenance of the safety stock, and (vii) accounting for perishability of items. All these are to be looked into and the integrated cost of PDS is to be minimized scientifically. Variable cost minimization in a public distribution system (PDS) allowing for perishability of the product by implimention of BPSO (Binary Particle Swarm Optimization) using with C++ coding. BPSO technique have been successfully employed to model and simulate of lot sizing problem such as single item multi-level, capacitated problems under consideration to minimize total cost. The total cost obtained for the PDS problem under consideration by BPSO method it is observed that reduced cost is nearly two cores compared to the total cost of real existing system.*

Keywords: *Inventory Models;Public Distribution System; Lot Sizing: BPSO.*

I. Introduction

The importance of the public distribution system lies in situation where there is a shortage of foodgrains in the market rather than real shortages, for prices are not left to be determined by the market forces alone but are to an extent controlled by the government. The unrealistic approach of the government, while pursuing a policy of controls and regulations often results in hoarding by traders and speculators and consequently the prices are very high. Distribution through government agencies is precisely significant in the context of overcoming shortages in the market and ensuring an equitable distribution of foodgrains at reasonable price (Shafi and Aziz, 1989, Page 269).The national objective of growth with social justice and progressive improvements in the living standards of the population make it imperative to ensure that food grains is made available at reasonable prices. Public Distribution of food grains has always been an integral part of India's overall food policy. It has been evolved to reach the urban as well as the rural population, in order to protect the consumers from the fluctuating and escalating price syndrome. Continuous availability of food grains is ensured through about 4.5 lakhs fair price shops spread throughout the country. A steady availability of food grains at fixed prices is assured, which is lower than actual costs due to Govt. policy of providing subsidy that absorbs a part of the economic cost (about 45%).Under the Targeted Public Distribution Scheme effective from June, 1997, stocks are issued in the following two categories:

1. Below Poverty Line: Determination of the families under this category in various states is based on the recommendation of the Planning Commission. A fixed quantity of 35 Kg. food grains per family per month is issued under this category. The stocks are issued at highly subsidized Price of Rs.4.15 per Kg. of wheat and Rs. 5.65 per Kg. of rice. During the year 2000-2001, Govt. of India decided to release food grains under Antyodaya Anna Yojana. Under this scheme, the poorest section of population, out of earlier identified BPL population, is covered. Food grains are being provided to 1.5 crores poorest of the poor families, out of the BPL families, at highly subsidized rates of Rs.2/- per kg of wheat and Rs.1/- per kg of rice by FCI. This is the biggest food security scheme in the world.

2. Above Poverty Line– Families, which are not covered under BPL, areplaced under this category. The stocks are issued at Central Issue Price ofRs. 6.10 per kg of wheat and Rs. 8.30 per kg of rice.

II. Public Distribution System Of Warangal District

2.1 Introduction

Public Distribution System includes the procurement (from the producer i.e. farmers) and distribution (to the customers i.e. common people) of essential commodities. As far as distribution is concerned, the whole transportation model is divided in two stages.

Stage 1: Movement of commodities from FCI owned go downs to intermediate ware houses, also known as Mandal Level Service Points (MLSP).

Stage 2: Transportation of material from MLSP to Fair Price Shops (FPS)

2.2 Working System Of Pds

FPS owner placed there order to Civil Supplies Department (CSD) before 20th of every month. After receiving the order CSD send releasing order (R/O) to respected mandal level service points (MLSP) to release specific amount of material to particular FPS.

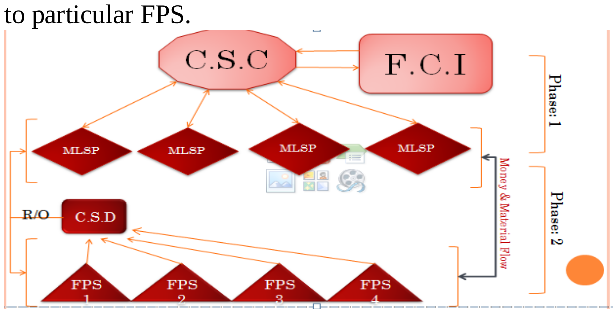


Fig.1 Working System Of PDS

Demand Draft for the material is directly sent to the MLSP and order is dispatched after receiving R/O. All the MLSP have buffer of amount of 300MT -600MT depending upon the region and the number of FPS in that mandal. There are 18 mandal level service points (MLSP) which serve the total of 51 mandals. In 51 mandals there are 2011 FPS. The monthly demand of the MLSP is served between 20th-1st of every month. The rotation of material is cyclic, MLSP received material from FCI owned go downs. There are 7 FCI owned go downs, located at different locations. These FCI owned have huge amount of buffer as procurement of the material (i.e. rice) from the millers is cyclic and throughout the year status of total BPL cards and rice allotment of various divisions taken from the previous exsisting data. All mandals and MLSP are divided into five divisions due to administration.

III. Problem Statement

The objective of the research is usually to solve the inventory control problem for Public Distribution System. The procurement quantity and incurring cost is almost always tremendously high if only when without estimation of optimum quantity at several stages. It has been suggested that the best way to meet this problem is to set up district MLSP's which enable the reduction of wastage and holding cost. In this work, the present PDS uses several FCI owned go downs MLSP's and which are incurring cost of holding and ordering/reordering for the shipping demands of all points, all of which are required to meet the necessary demand.

3.1 Project Objectives

The present system is fraught with many difficulties such as inefficiency, deterioration of food grains, unsatisfactory quality of commodities, malpractices in weights and measures, mismatch of demand and supply, long waiting times, exorbitant corruption, rude behavior of shopkeepers and poor service delivery.

Objectives of present work are given below:

a. Development of integrated mathematical model for efficient management of such PDS Supply Chain at District level.
b. To ensure food security through better management of food stocks for PDS disasters like drought during as well.
c. Optimization of models for optimum quantity estimation of food items at different levels of Supply Chain for overall quantity estimation and there by estimation of variable cost.

In this chapter, the available data is taken into account in which the possibility of a portion of a commodity being perishable before it goes from FCI to MLSP. In a way, the formulation here is more general and the proposed model is used to determine, for each time period the optimum procurement quantity for FCI, the total variable cost estimation.

IV. Methodology

The main objective of the work is to minimize the overall inventory carrying cost by estimating optimum quantity estimation and the reordering time period.

The procedure consists of the following steps:

Step 1: Calculate the overall demand.

- Demand of one MLSP is the summation of demands of all the mandalas under that MLSP
- Demand of one Mandal is the summation of demands of all FPS in that mandal.
- Demand of one FPS is the summation of demands of all the below poverty line(BPL) cards attached with that FPS.

Step 2: Define objective function.

The objective of this research is to minimize the inventory holding costs, reordering costs, fixed costs and setup costs.

Model parameters:

I= {1}= set of FCI go downs;

J= set of Mandal Level Service Points (MLSP);

T= set of time periods in the planning horizon;

N(v) = maximum number of trips made by transporter *v* during each period;

a(t) = procurement cost at FCI during time t;

h(t)= inventory holding cost at FCI during time t;

$h_j(t)$= inventory holding cost at MLSP*j* during time t;

$C^c_{i,j}$= shipping rate (per unit load) for chartered transporters to go from location *i* to location *j*;

C_v= maximum loading capacity for transporter *v*;

$D_j(t)$ = demand of MLSP*j* in time period tthat must be satisfied by either the inventory at MLSP*j*, or bythe shipment that arrives duringt, or by both(allowing for no backlogs);

P^{max}= maximum procurement capacity of FCI;

S^{max} ,S^{min} = maximum ending inventory capacity and safety stock (i.e., the minimum inventory) requirement, respectively, at FCI in a time period.

Z_i^{max} ,Z_i^{min} = maximum ending inventory capacity and safety stock (i.e., the minimum inventory) requirement, respectively, at MLSP*i* in a time period.

Variables

P(t) = procurement quantity by FCI during timet ;

S(t)= ending inventory of FCI at time t.

$Z_i(t)$= ending inventory of MLSP*j* at time t.

$q^{v,n}_j$ (t)= quantity delivered by transporter *v*, *v* ∈*V*(*i*),to MLSP*j* from FCI during its *n*th trip in period t;

$Q_{,j}$ (t)= quantity shipped from FCI to MLSP*j* by chartered transporters in period t.

4.1 Problem Formulation and Constraints

$$R:\min\sum_{t\in T}\sum_{j\in J}C^c_jQ_j(t)+\sum_{t\in T}a(t)P(t)+\sum_{t\in T}h(t)\{P(t)+(1-\alpha)S(t)\}+\sum_{t\in T}\sum_{j\in J}h_jZ_j(t)\cdots(1)$$

Subject to

FCI inventory balance constraints:

$$S(t)=S(t-1)+P(t)-\sum_{t\in T}\sum_{n\in N}\sum_{j\in J}q^{v,n}_j(t)\forall i\in I,t\in T\cdots\cdots\cdots(2)$$

Customer inventory balance constraints:

$$Z_j(t)=Z_j(t-1)+\sum_{t\in T}\sum_{n\in N}\sum_{j\in J}q^{v,n}_j(t)-D_j(t)\forall j\in J,t\in T\cdots\cdots\cdots(3)$$

Storage capacity and safety stock requirement constraints:

$$S^{min}\le S(t)\le S^{max}\forall i\in I,t\in T\cdots\cdots\cdots\cdots\cdots\cdots\cdots(4)$$

$$Z_j^{min}\le Z_j(t)\le Z_j^{max}\forall j\in J,t\in T\cdots\cdots\cdots\cdots\cdots\cdots(5)$$

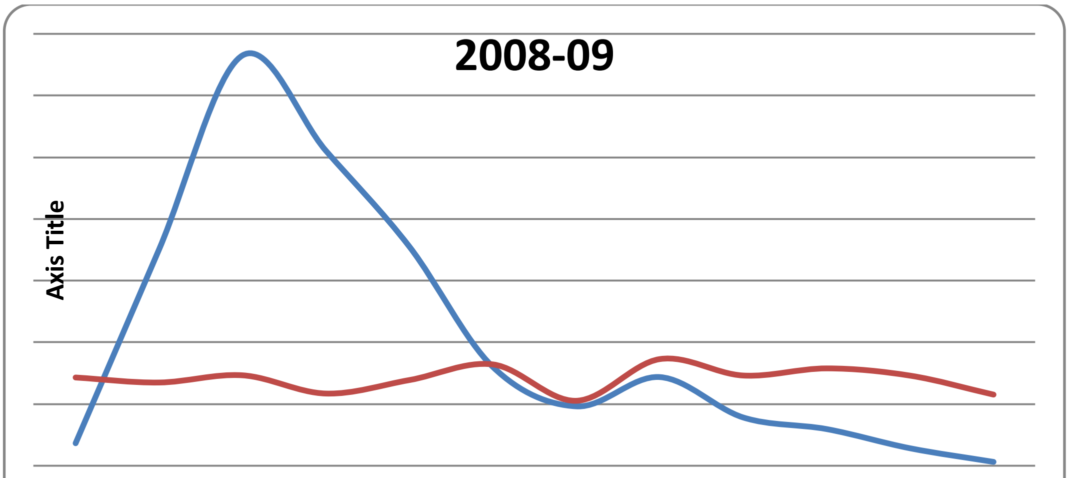
Production capacity constraints:

$$0\le P(t)\le P^{max}\forall i\in I,t\in T\cdots\cdots\cdots\cdots\cdots\cdots\cdots(6)$$

Non-negatively constraint: and

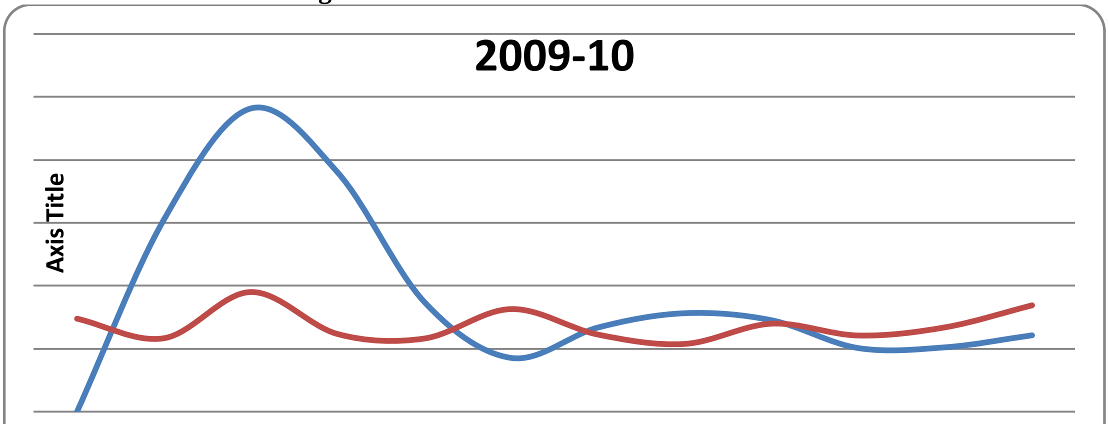
$$Q_j(t)\ge 0\forall j\in J\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots(7)$$

The first term of Equation (4.1) represents the shipping cost due to hiring chartered transporters, where $C_j^c Q_j(t)$ defines the resulting cost if quantity $Q_j(t)$ is delivered by a chartered transporter from FCI to MLSP*j*. The second term denotes the total procurement cost by the FCI over T periods. The last two terms denote the FCI inventory cost charged against average inventory level and the distributor inventory cost charged against ending inventory, in each time period. While here the inventory cost structures are different, they could be the same in a model, depending on the assumptions.



	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09	Mar-09	Apr-09	May-09	Jun-09	Jul-09	Aug-09	Sep-09
Procurement	3642	35067	66524	51063	35526	16020	9624	14374	7822	5941	2828	620
Used	14270	13459	14628	11672	13855	16393	10498	17257	14591	15749	14574	11496

Fig. 4.1: Procurement levels at different months.



	Oct-09	Nov-09	Dec-09	Jan-10	Feb-10	Mar-10	Apr-10	May-10	Jun-10	Jul-10	Aug-10	Sep-10
Procurement	0	30493	48170	38033	17432	8540	13369	15640	14520	10100	10225	12130
Used	14781	11665	19028	12342	11622	16312	12252	10765	13988	12102	13413	16913

Figure.4.2: Procurement levels at different months

V. Results Of Parametric Studies

As mentioned in the previous chapter, a full-fledged computer code in C++ is written for obtaining the solution to the present problem. The present chapter gives details of parametric studies executed making use of the above code.

5.1 Results and Discussion

5.1.1 Study of Variation of Total Variable Cost and Inventory Levels

It would be interesting to investigate the nature of total variable cost at different perishability rates and at different demands, at different months, while working in various independent parametric configurations.

5 .1.1.1 Variation with Time (in months) and supply

The table 5.1 shows the variable cost profiles for different inventory levels at different months. It also reveals the study of variable cost on supply variations over time period during the planned year. The variable costs are generated after giving input cost parameters like, SC, HC on left over stocks in each month in the period of planned year.

Table 5.1: Variable costs (holding, setup) at various supplies

Months	Variable Cost
1	153180
2	359540
3	629080
4	825440
5	1094980
6	1470880
7	1856780
8	1936780
9	2555400
10	2708580
11	3127660
12	3344020

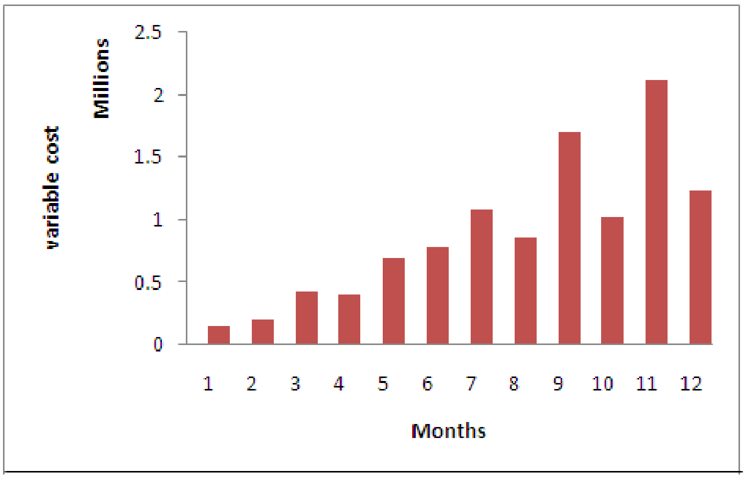
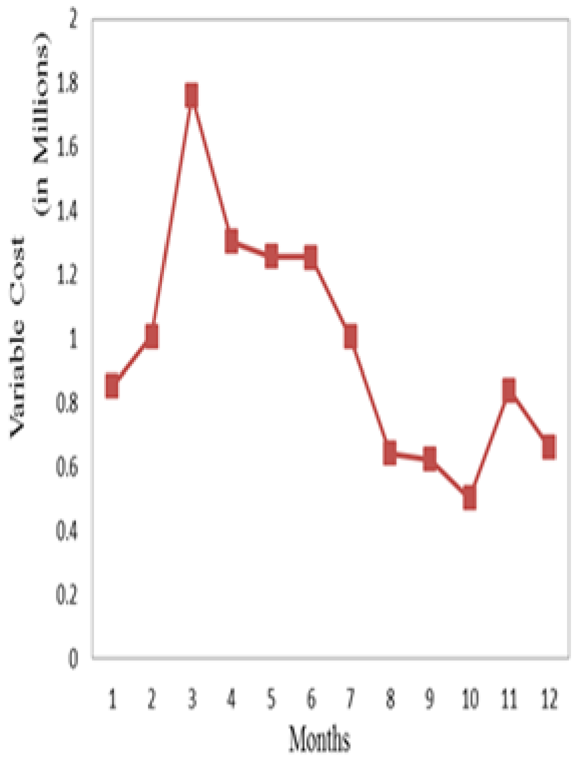


Fig. 5.1: Variable cost at different months.

Table 5.2: Optimized Variable costs at various supplies



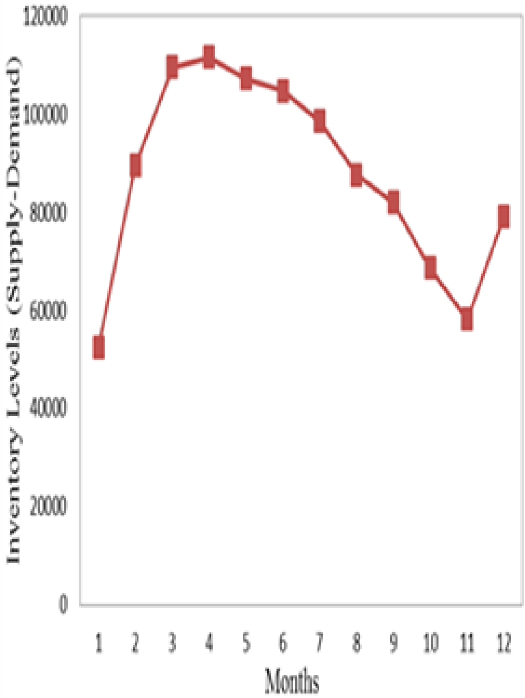
Months	Variable Cost	optimized inventory levels based (08-09)&(09-10) data
1	853180	28080
2	1008860	32155
3	1759540	59625
4	1303860	44325
5	1257040	39542
6	1255900	35261
7	1005900	20886
8	642000	22533
9	624050	21658
10	503180	14040
11	840430	16854
12	663735	17895

Fig. 5.2: Variable cost at different months.

for a given variable costs, there are increasing and decreasing values noticed with the increase and decrease of holding inventory i'e, depending on their supplies with respect to corresponding months. The

increasing values are noticed where ever holding inventory is high for satisfying the next month's demand and the decreasing values are noticed where ever the holding inventory is less compare to the higher inventory months. It is to be further noted that the cost values are depends on the holding inventory at that particular month.
The below figures5.3-5.10, shows the inventory level profiles plotted for different procurements at different months. The value of input parameter is levels at different months.

Table 5.3: Various inventory levels at different supplies in a year (08-09)

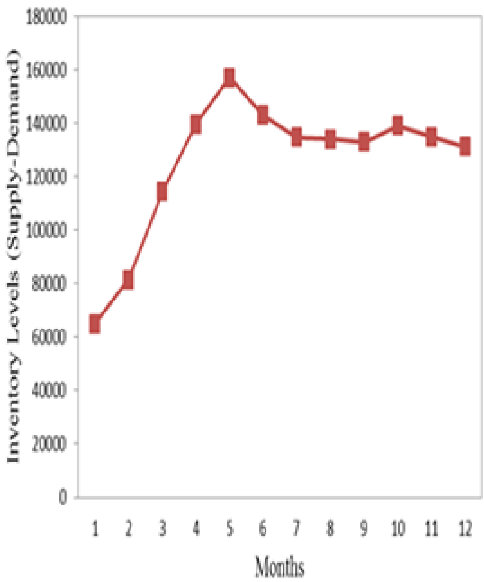


Months	Inventory Levels (Supply-demand)
1	52484
2	89507
3	109589
4	111589
5	107153
6	104679
7	98461
8	87554
9	81957
10	68537
11	58139
12	79166

Fig.5.3: Various inventory levels at different months.

The below table 5.3, shows the inventory level profiles plotted for different procurements at different months. The value of input parameter is procurement levels at different months.

Table 5.4: Various inventory levels at different supplies in a year (09-10)

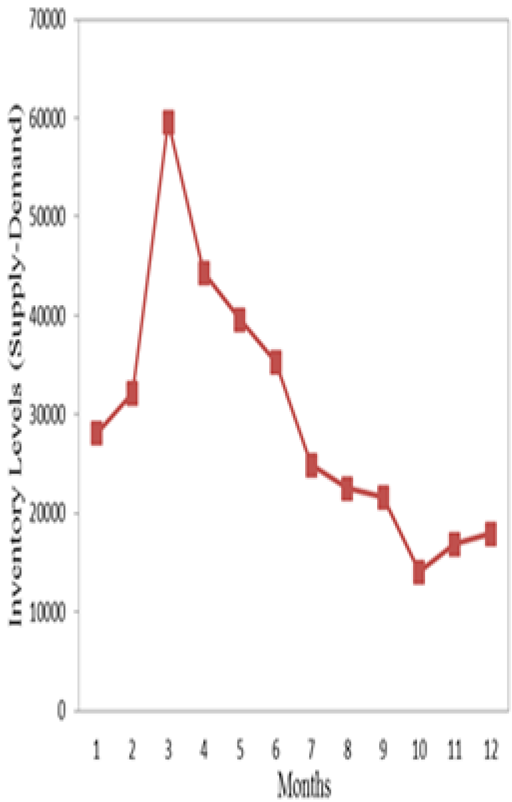


Months	Inventory Levels (Supply-demand)
1	65126
2	81579
3	114305
4	139701
5	157134
6	143094
7	134786
8	134115
9	132927
10	139003
11	135063
12	131248

Fig. 5.4: Various inventory levels at different months.

The table 5.4, shows the optimized inventory level profiles plotted for different procurements at different months. The value of input parameter is procurement levels at different months taken as per the past two years data and demand taken as per the previous two years usage.

Table 5.5: Optimized inventory levels based on (08-09) & (09-10) data.



Months	Inventory Levels (Supply-demand)
1	28080
2	32155
3	59625
4	44325
5	39542
6	35261
7	24886
8	22533
9	21658
10	14040
11	16854
12	17895

Fig.5.5: Optimized inventory levels at different months.

From the figure 5.5 observed that maximum inventory and minimum optimum inventory levels for the reduction of wastage and total variable cost.

The table 5.6, shows Comparison between optimized inventory levels based on past years data and presently used inventory levels**.** The value of input parameter is procurement levels at different months taken as per the past two year data and the demand taken as usage in the previous years.

Table 5.6: Comparison between optimized inventory levels based on (08-09) & (09-10) data and presently used inventory levels.

Months	optimized inventory levels based on (08-09) & (09-10) data	Presently used inventory levels
1	28080	54000
2	32155	82565
3	59625	112000
4	44325	125635
5	39542	137310
6	35261	122420
7	20886	105320
8	22533	101235
9	21658	97253
10	14040	102652
11	16854	95634
12	17895	102562

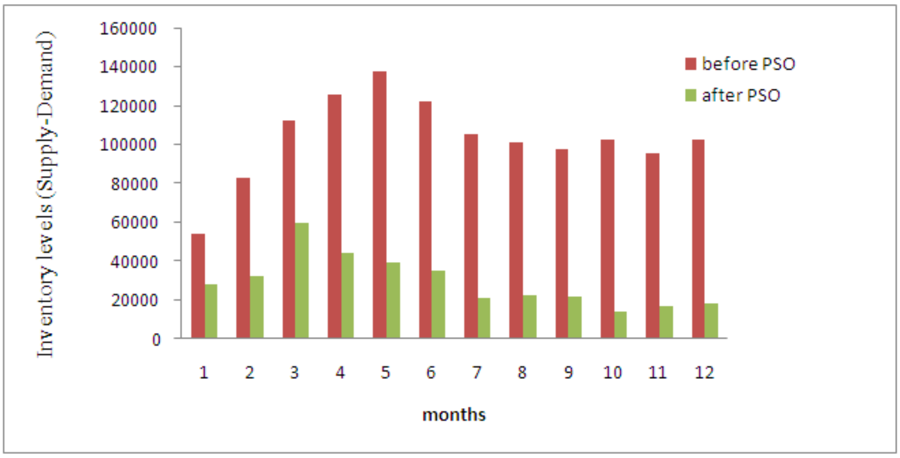


Fig. 5.6: Comparison between optimized inventory levels based on (08-09) & (09-10) and presently used inventory levels.

Table 5.7.Comparison between optimized inventory levels for exact requirement and presently used inventory levels.

Months	optimized inventory levels for Exact requirement	Presently used inventory levels
1	27527.09	54000
2	31539.1	82565
3	52706.91	112000
4	43514.86	125635
5	38820.96	137310
6	34592.5	122420
7	16383.1	105320
8	22082.92	101235
9	21214.596	97253
10	13614.69	102652
11	16414.05	95634
12	17457.97	102562

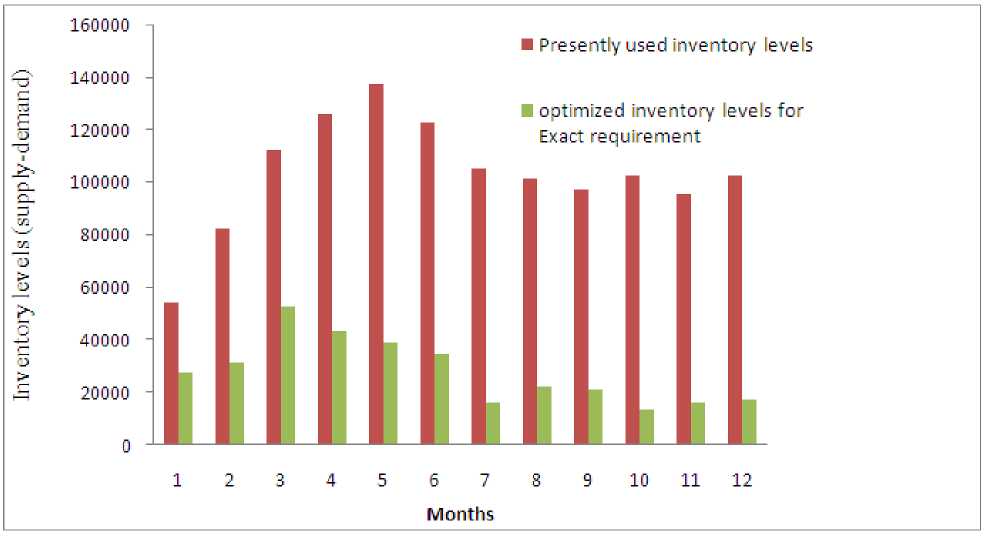


Fig.5.8: Comparison between optimized inventory levels for exact requirement and presently used inventory levels.

VI. Conclusion

The total expenditure has been minimized through determination of optimum holding inventory at FCI taking into account the inventory holding cost, setup costs and perishability effects. The proposed model has determined at FCI, the optimum ending inventory at the end of each time period, total variable cost estimate for FCI by taking into account realistic available data by implementation of BPSO technique with using C++ coding.

1.BPSO technique have been successfully employed to model and simulate of lot sizing problem such as single item multi-level, capacitated problems under consideration to minimize total cost.

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