ISSN: 0974-5823 Vol. 6 No. 3 October-December, 2021

International Journal of Mechanical Engineering

Improving supply chain performance in an online store using Lean tools

K. Sadesh
Department of Mechanical Engineering, PSG College of Technology
ksh.mech@psgtech.ac.in

A P Senthilkumar
Department of Mechanical Engineering, PSG College of Technology
aps.mech@psgtech.ac.in

ABSTRACT

In today's scenario severe Competitive pressure for Shorter lead time and lower cost in Supply chain Management, So Lean manufacturing have been incorporated into Supply chain approaches. This Paper deals with Reduction of Customer lead time and Transportation cost in an online store. The Customer lead time reduced from 2.5 days to 1.5 days and transportation cost reduced from 1216 to 1136 for 11 orders with 63.9 km through lean supply chain network with vehicle routing (Travelling sales man approach), Inventory classification and Forecasting techniques.

Keywords: Lean Supply chain Network; Travelling sales man approach; ABC analysis; Forecasting techniques

I INTRODUCTION

Supply chain management (SCM) refers to managing the flows of physical products and services, information, and money between the activities or process steps that companies perform, while aiming for customer service as the goal (i.e., get the right product to the right place at the right time for the right cost). Supply chains encompass the companies and the business activities needed to design, make, deliver, and use a product or service. Businesses depend on their supply chains to provide them with what they need to survive and thrive. Every business fits into one or more supply chains and has a role to play in each of them.

A. Lean manufacturing

Lean is a systematic approach to enhancing value to the customer by identifying and eliminating waste (of time, effort and materials) through continuous improvement, by flowing the product at the pull of the customer, in pursuit of perfection.

B. Lean supply chain management

Lean supply chain management represents a new way of thinking about supplier networks Lean principles require cooperative supplier relationships while balancing cooperation and competition Cooperation involves a spectrum of collaborative relationships & coordination mechanisms Supplier partnerships & strategic alliances represent a key feature of lean supply chain management.

II LITERATURE REVIEW

[1]Ram Janm Singh et al., suggested that lead time reduction attained through implementation of LJIT practices and SCI between with-in and between firms

and Lead Time (LT) can be an effective competitive weapon as customers become less patient and less willing to wait for delivery of what they order.

[2]Mahtab Hajghasem et al., discussed web-based system was designed in order to enable the registration of handling requests in the system with the purpose of compensating vehicle shortage. The main purpose was to cover all transportation requests in a manner that it results in a reduced transportation cost, a reduced use of rental vehicles, and a reduced stopping duration of vehicle in destinations.

[3]R.Nallusamy et al., have focused mTSP has been converted into TSP which is simple in computation compared to mTSP. After clustering, an optimized route is generated for each salesman in his allotted cluster and Simulated Annealing generate optimized route covering less distance than Tabu search.

[4]Reem Al Zoubi suggested that Generic Algorithm (GA) in an efficient way to reach optimal solution. Generic Algorithm follows sequence of steps to solve any problem (selection, fitness, crossover and mutation). Each of these steps has types which can be selected according to characteristics of the problem.

[5]M. Karthick et al., discussed that ABC classification is simple to understand and easy to use. Moreover, various inventory items may play quite different roles in the business of the organization. Hence, the managers need to classify these items in order to control each inventory category properly based on its importance rating.

[6]In 2010, an article was presented entitled "The use of techniques based on the artificial intelligence for multiple criteria ABC analysis" by" Maine-Chun-Yu".In this paper, a study has been conducted to compare the classification techniques based on artificial intelligence and traditional classification techniques.

[7]PradeeKumar Sahu et al., discussed few of forecasting models and their application for sales forecasting of sterilized flavored milk in Chhattisgarh. The forecasting method analyzed included: naive model, moving average, double moving average, simple exponential smoothing; and semi average method. The accuracy of the forecasting method was measured using mean Forecast Error (MFE), mean Absolute Deviation (MAD), mean Square Error (MSE), root mean square Error (RMSE).

[8]Rachel J. C. Chen described, are readily transferable to recreation use data sets with seasonal patterns. Moreover, the potential applications of forecasting methods to the broad range of recreational settings may include seasonal use at museums, aquariums, outdoor recreational areas, campgrounds, historical sites, trails, and so on

[9]Paul Myerson discussed in Lean logistics and supply chain management about Supply chain network design in order to optimize the Procurement, Manufacturing, Transportation and Distribution.

From the literature review Lean supply chain management provide way to maintain stability in market through cut down the operation cost and inventory level, when implementing lean in supply chain approaches in online stores which is viable to reduce Customer lead time and transportation cost effectively.

III. PROBLEM STATEMENT

Company has more distributors for Electronic gadgets from various Locations. If a customer is placing an order, for him/her to procure the item and store it in inventory which includes packaging and labelling accounts for high customer lead time which is 2.5 days and involves high transportation cost. As demand and Price uncertainty varying day by day, managing inventory and faster service level are difficult (i.e. Customer lead time).

IV. OBJECTIVES

1. To develop lean supply chain network design in order to Reduce Customer lead time
2. To reduce the transportation cost of vehicle route by using Travelling salesman approach.
3. To analyze the inventory through ABC Classification
4. To implement forecasting techniques in order to predict the future forecast.

V. METHODOLOGY

The Figure 1 shows the developing lean supply chain network design in order to reduce high customer lead time and Transportation cost.

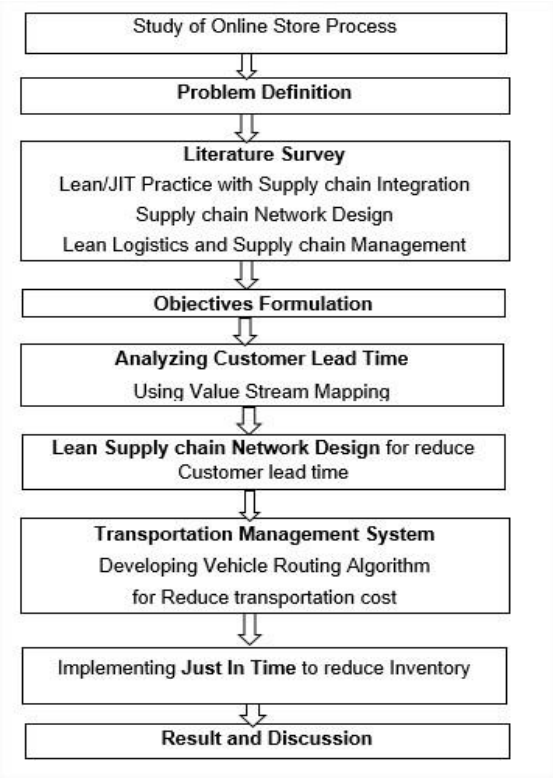

Figure 1. Methodology

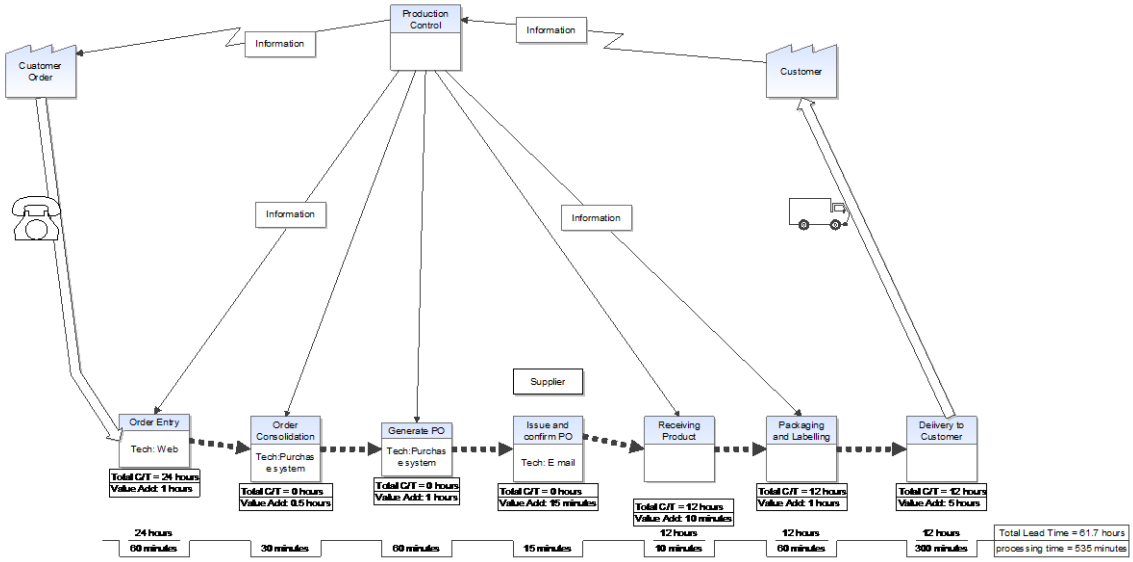

Figure 2. Current State VSM for High Customer lead time

VI. CUSTOMER LEAD TIME

It is a time or period ranging from the time when a customer orders some of goods from a store or a sales person to the time when they are deliver to the customer, here the customer lead time is 2.5 days. The following figure 2 shows current customer lead time

VII. LEAN SUPPLY CHAIN NETWORK

Lean supply chain network essential for make the supply chain decisions. Figure 3 shows frame work for lean supply chain Network design

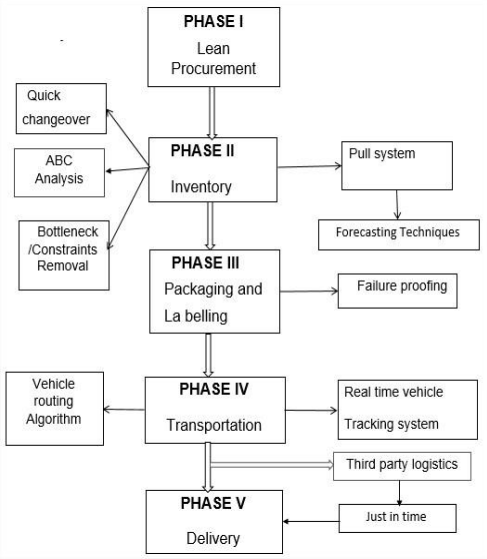

Figure 3. Lean supply chain network

A. Logistics Management

Transportation refers to the movement of product from one location to another as it makes its way from the beginning of a supply chain to the customer. Following figure 4 shows route cause for high transportation cost.

For 11 orders total travelling distance is 77 KM including service charge Rs 600 and Rs 8 per km total transportation cost was Rs 1216.

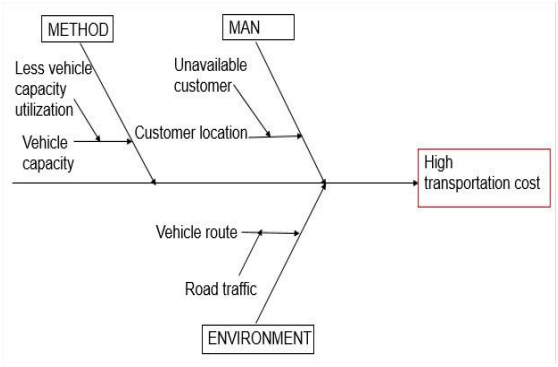

Figure 4. Route Cause Analysis

B. Mathematical model

Mathematical model is developed for Travelling Sales man approach which used to find out the minimum the Travelling Distance

4	5	7	6	10	3	9	2	8	1

$$MinZ = \sum_{i=1}^{n}\sum_{j=1}^{n} D_{ij}\, x_{ij} \qquad (1)$$

Subjected to,

$$\sum_{i=1}^{n} x_{ij} = 1, \qquad j = 1, 2, \ldots, n \qquad (2)$$

$$\sum_{j=1}^{n} x_{ij} = 1, \qquad i = 1, 2, \ldots, n \qquad (3)$$

$$y_i - y_j + n x_{ij} \le n - 1 \qquad \forall i \ne j \qquad (4)$$

$$x_{ij} = 0 \text{ or } 1 \qquad \forall i, j. \qquad (5)$$

Where ,

n = Number of customers

D_{ij}= Distance of customer from i to j

x_{ij} = { 1 Sales man travels from i to j; 0 otherwise

y = Sub tour avoiding variable for i^{th} and j^{th} customer

The variables y_i, y_j are arbitrary real numbers which satisfy the constrain (4) which helps to avoid the sub tours.

C. Travelling Salesman Approach

TSP a number of cities have to be visited by a salesman who must return to the same city where he started. In solving the problem one tries to construct the route so that the total distance traveled is minimized. The following table 1 shows distance between each customer.

Table 1. D_{ij}Distance Matrix

	1	2	3	4	5	6	7	8	9	10
1	0	4.7	16.5	13.1	10.4	6.8	6.8	7	10.1	13.4
2	4.7	0	11.5	15	12.8	4.7	6.3	4.3	6.1	12
3	16.5	11.5	0	23	19.2	12	14.2	18.7	9.7	12.3
4	13.1	15	23	0	10.4	13	13.3	17.8	16.6	19.6
5	10.4	12.8	19.2	10.4	0	7	6	13.8	11.7	8.9
6	6.8	4.7	12	13	7	0	1.8	9	4.7	6.3
7	6.8	6.3	14.2	13.3	6	1.8	0	8.5	6.3	7.3
8	7	4.3	18.7	17.8	13.8	9	8.5	0	9.4	15.4
9	10.1	6.1	9.7	16.6	11.7	4.7	6.3	9.4	0	8.6
10	13.4	12	12.3	19.6	8.9	6.3	7.3	15.4	8.6	0

Using travelling salesman approach with evolutionary method shortest path and the total distance are calculated.

Optimized path

Distance

10.4+6+1.8+6.3+12.3+9.7+6.7+4.3+7+0

Total travelling distance =63.9 KM

D. Vehicle routing Algorithm

Vehicle Routing Algorithms are used to solve the Capacitated Vehicle Routing Problem. The problem involves optimizing a fleet of vehicles that are to serve a number n of customers from a central depot. Each vehicle has limited capacity and each customer has a certain demand (or) orders.

Terminology:

Number of Order = n1
Optimized Distance = do
Total service charge = cs
Cost per KM = ckm
Number of customer = nc
Number of vehicle = v1
Capacity of vehicle = cv
Number of delivery person = d1
Rental vehicle cost = rc
Transportation cost = tc

E. Algorithm to Calculate Transportation cost in Vehicle Routing

Step 0. Initialize and store n1, do, cs, ckm, nc, cv, d1, v1 and rc.

Step 1. Compute Number of customer nc.

Step 2. Compute do and tc

Step 3. Compute tc using various n values. Choose the n1* that gives minimum tc

Step 4 . Stop

The simulation was done in mat lab and result is shown in following figure 5.

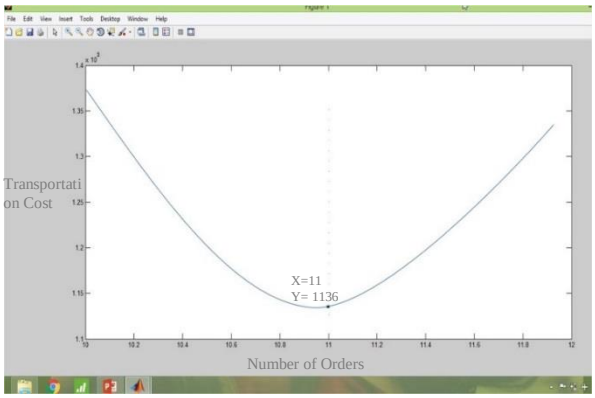

Figure 5.Mat lab result for Transportation Cost

VIII. INVENTORY CLASSIFICATION

Today the Effective Inventory Management plays an important role in the success of the organizations in the new business environment

A.ABC Analysis

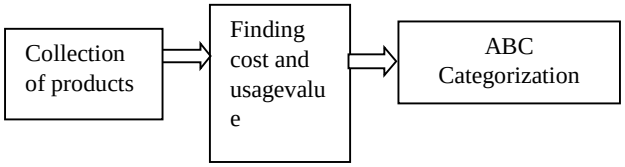

Figure 6. Process flow of ABC analysis

Table 2 shows ABC Classification based on the Cost and Usage value of the product.

Table 2. Inventory classification

Category	% of item	Description
A	5-30	Fast moving
B	30 - 70	Medium moving
C	70- 100	Slow moving

The following Figure 7 shows moving range of inventory items 0.3 to 30 % Headphones, Pen drives, Memory cards A items and 30 to 67% Mother boards, PC ram, Laptop Ram. B items and 70 to 100% Graphics card, Cables, Speakers, SMPS, Monitors, Processor C items.

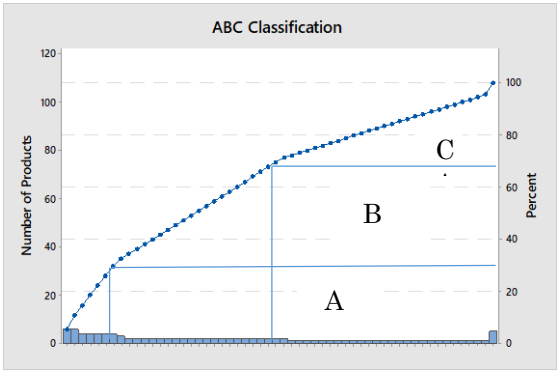

Figure 7. ABC Classification

IX. FORECASTING TECHNIQUES

Forecast of future demand are essential for making supply chain decisions. Following forecasting techniques helps to predict the forecasting accuracy.

1. Simple Moving Average Method.

The Simple moving average method involves calculating the average of observations and then employing that average as the predictor for the next period.

$$F_t = A_{t-1} + A_{t-2} + \ldots + A_{t-p} / P$$

2. Exponential Smoothing

The exponential smoothing method is a technique that uses a weighted moving average of past data as the basis for a forecast.

$$F_{t+1} = \alpha A_{t-1} + (1-\alpha) F_{t-1}$$

3. Weighted Moving Average

This forecasting method is calculated by the previous forecast.

$$F_t = W_1 A_{t-1} + W_2 A_{t-2} + W_3 A_{t-3}$$

4. Trend Adjusted Exponential smoothing

It is updated from simple exponential smoothing method. The level is smoothened at the end of the period

$$F_{lt} = F_t + T_t$$

5. Linear trend

Essential method to obtain the future forecast with the help of linearplot

$$F_{t} = mt + b$$

Where ,

m = Slope; b = intercept

Mean Absolute deviation (MAD)

A common method for Measuring overall forecast error is the mean absolute deviation (MAD).

$$MAD = \sum_{t-1}^{n} \frac{Ft - At}{n}$$

Where,

Y_t= the actual value in time period t

F_t = the forecast value in time period t

n = the number of periods

Mean Square Error (MSE)

Jarrett (1991) stated that the mean square error (MSE) is a generally accepted technique for evaluating exponential smoothing and other methods.

$$MSE = 1/n \sum_{t-1}^{n} (Y_t - F_t)$$

Where,

Yt = the actual value in time period t

Ft = the forecast value in time period t

n = the number of periods

Table 3 shows demand data about 18 weeks from December 2017 to February 2018.

A. Simple moving Average

Using theSimple moving Forecast formula Average error rate is calculated Average period 9, MAD 7, MSE 85. Figure 8 shows demand and Forecast range

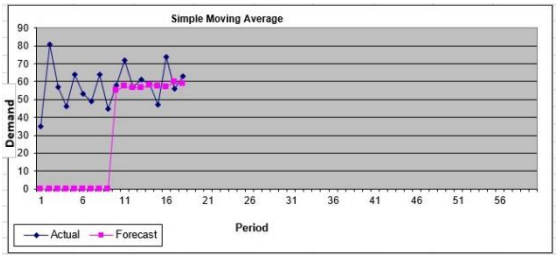

Figure 8.Simple Moving Average

Table 3. Demand data

Week No	Demand
1	35
2	81
3	57
4	46
5	64
6	53
7	49
8	64
9	45
10	58
11	72
12	57
13	61
14	59
15	47
16	74
17	56
18	63

B. Simple Exponential smoothing method

Using the Simple Exponential smoothing Forecast formula Average error rate is calculated Smoothing Constant α = 0.2, MAD = 13, MSE = 295. Figure 9 shows Demand and Forecast range.

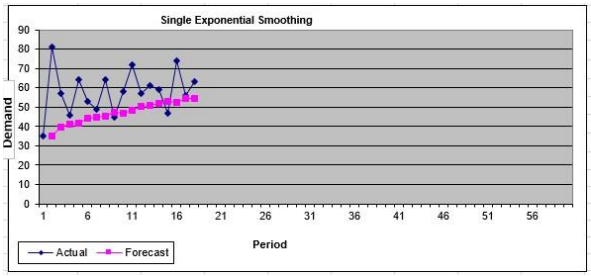

Figure 9. Simple Exponential smoothing

C. Weighted Moving Average

Using the Weighted moving Forecast formula Average error rate is calculated MAD 6, MSE 67. Figure 10 shows Demand and Forecast range.

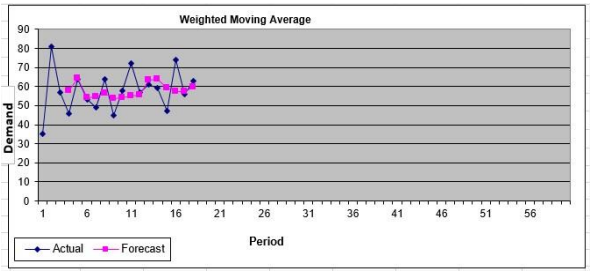

Figure 10. Weighted Moving Average

D. Trend Adjusted Exponential Smoothing

Using the Trend Adjusted Exponential Smoothing Forecst formula Average error rate is

calculated Smoothing costant α 0.2, Smoothing constant δ 0.5, MAD 11, MSE 246. Figure 11 shows Demand and Forecast range.

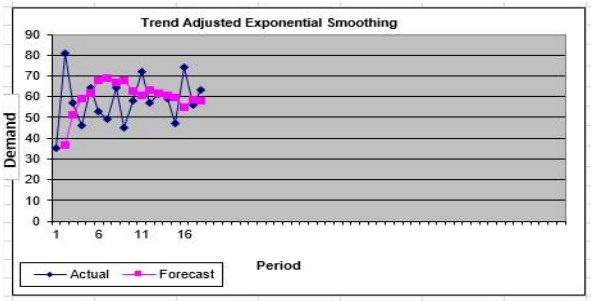

Figure 11. Trend Adjusted Exponential Smoothing

E. Linear Trend

Using the Linear Trend Forecast formula Average error rate is calculated **slope** m 0.43, Intercept y 53.71, MAD 7, MSE 70. Figure 12 shows Demand and Forecast range.

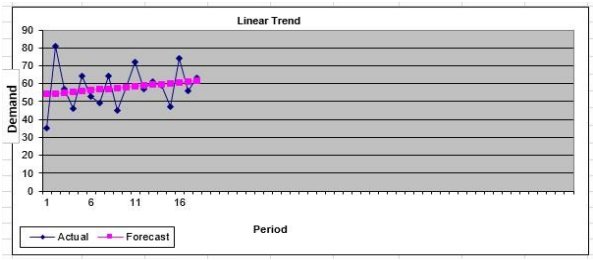

Figure 12. Linear Trend

The following table 4 shows overall error rate of the forecasting techniques

Table 4. Average Error rate

Method	**Error rate**	
Simple Moving Average	MAD	7
	MSE	80
Exponential Smoothing	MAD	6
	MSE	73
Weighted Moving Average	MAD	13
	MSE	295
Trend Adjusted Exponential Smoothing	MAD	11
	MSE	246
Linear Trend	MAD	7
	MSE	70

IX. RESULTS AND DISCUSSION

A. Transportation Cost

Transportation cost for 11 orders and 63.9 km

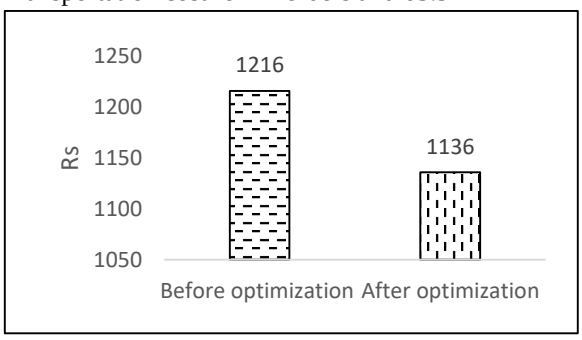

Figure 13. Transportation cost

B. ABC Classified Items

The categorized item shows that item which we can kept on minimal Inventory Table 5 results ABC categorized items

Table 5. ABC Classification

Sequence	**Products**	**Category**
0.3 to 30 %	Headphones, Monitors, Memorycards	A
30 to 67 %	Mother boards, PC ram, Laptop, Ram	B
70 to 100 %	Graphics card, Cables, Speakers, SMPS, Pendrives, Processor	C

C. Future state VSM for customer lead time

Inventory classification, vehicle routing and third party logistics are used to in lean supply chain network to reduce customer lead time; the following figure 14 shows Future state VSM for customer lead time.

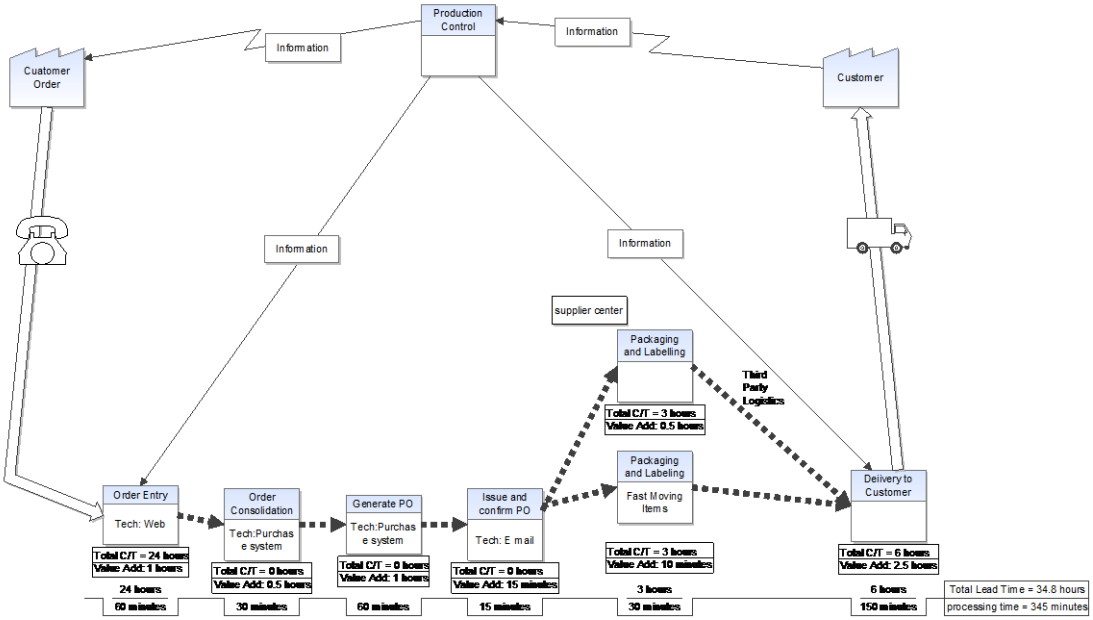

Figure 14.Future State VSM for Reduction of High lead time

D. Forecasting demand

Single Exponential Smoothing and linear trend more confident and also lowest error rate which will helps to put Sales discount on Seasonal period and Manage forecasting accuracy following figure 11 shows Error range of forecasting techniques.

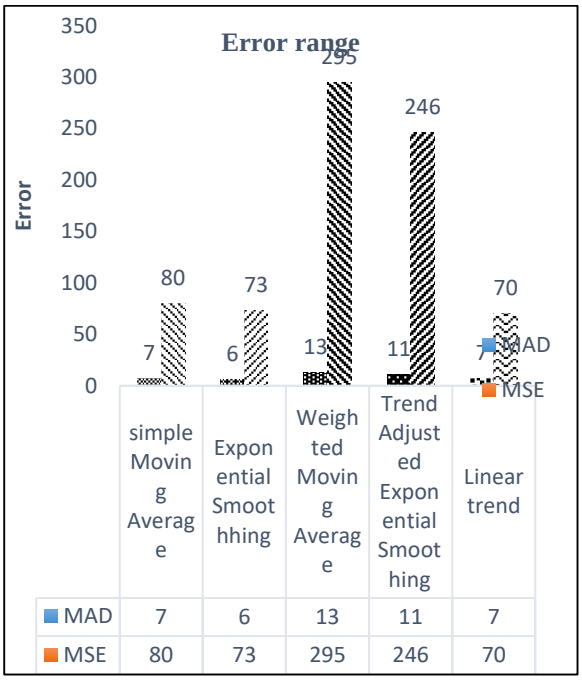

Figure 11. Error range

X. CONCLUSION

Lean and supply chain has most significant objectives of profit, customer satisfaction, and quality of the product including timely delivery to customer hand. These are three drivers behind the application of a lean supply chain in the industry. Thus the Customer Lead time was reduced from 2.5 days to 1.5 days and also the transportation cost also reduced for 11 orders with 63.9 km from Rs 1216 to Rs1136 .The inventory classification help us to keep minimal inventory for Fast moving items. The forecasting method helps to predict the forecasting accuracy for the future demand. Moreover, the present output has encouraged the entrepreneur to expand the business by taking additional orders for the same products and adopting few more new product orders.

REFERENCES

[1] Ram janm sigh, Nagendra, Hemant Marmat., "Effect of lean /JIT practices and supply chain Integration on lead time performance" Journal of supply chain management system, volume 2. pp 345-352, Mar 2013.

[2] MahtabHajghasema, Amir Abbas shojaie., "Optimal Routing in Supply Chain Aimed at Minimizing Vehicle Cost and Supply" Procedia Economics and Finance .pp 353 – 362, 2016.

[3] R.Nallusamy, K.Duraiswamy, R.Dhanalaksmi, P. Parthiban.," Optimization of Non-Linear Multiple Traveling Salesman Problem Using"K-Means Clustering, Shrink Wrap Algorithm and Meta-Heuristics" International Journal of Nonlinear ScienceVol.8 No.4,pp.480-487, 2009.

[4] Recon A, Zoubia., "Travelling sales man approach" International journal of computer application".Volume 94, 2014.

[5]M. Karthick, S. Karthikeyan and M.C. Pravin.,"A Model for Managing and Controlling the Inventory of Stores Items based on ABC Analysis" Global Journal of Researches in Engineering. Volume 14, 2014.

[6] Maine-Chun-Yu., "The artificial intelligence for multiple criteria ABC analysis", Global Journal of Researches in Engineering. Volume 9, 2010.

[7] Pradeep Kumar Sahu, Rajesh Kumar ,"The Evaluation of Forecasting Methods for Sales Of Sterilized Flavoured Milk in Chhattisgarh". International Journal of Engineering Trends and Technology (IJETT).Volume no.8, 2014.

[8] Rachel J. C. Chen.,"Evaluation of alternative forecasting methods to recreation", International Journal of Engineering Trends and Technology (IJETT).Volume no9, 2015.

[9] Paul Myerson "Lean logistics and supply chain management" McGrawhill books, 2012.