Available online at www.ijpe-online.com

International Journal of Performability Engineering

vol. 17, no. 2, February 2021, pp. 216-228
DOI: 10.23940/ijpe.21.02.p6. 216228

Performance Measurement on Inventory Management and Logistics Through Various Forecasting Techniques

S. Nallusamy*

Department of Mechanical Engineering, Dr. M.G.R. Educational and Research Institute, Chennai - 600095, Tamil Nadu, India

Abstract

Currently, inventory and logistics performance play a significant role for the efficiency augmentation and competitiveness of the manufacturing industry. The objective of this research study focuses on inventory management and measurement of logistics performance metrics of on-time in full and vehicle capacity utilization. The problem of maintaining inventory due to the dynamic fluctuating schedule of the customer results in stock-outs due to fluctuating demand and poor performance of on-time in full. Primarily, annual sales data were collected and classified based on ABC-FSN analysis. Then, the outcome of the analysis was used to classify about 123 parts into three classes such as fast, slow, and non-moving categories. Demand forecasting was carried out using various forecasting techniques, followed by ordering policy by economic order quantity. Reorder point model and safety stock were also analyzed. Logistics performance metrics, on-time in full, and vehicle capacity utilization were studied and measured. From the final observed results, it was found that vehicle capacity utilization was poor and all vehicles had an average utilization of 52.61%. Further suggestions were made to demand and adopt the maintaining inventory safety stock and proper packaging of goods to improve the overall performance.

Keywords: performance; inventory; ABC-FSN analysis; ordering policy; on-time-in full; logistics; VCU

1. Introduction

Inventory management mainly deals with planning and controlling the inventory level of an industry and plays a vital role in production and supply chain. Effective inventory management requires the correct level of inventory at the right place at the right time to minimize the system costs and satisfy the customers' needs. It plays a huge role in supply chain objectives such as cost and responsiveness. There are three major type of inventories used in manufacturing firms: raw material, work in progress, and finished goods. An enhanced control in inventory results in productivity enrichment. Generally, the inventory can be raw materials, finished products, work in progress items, stores materials, etc. Classifying these inventories is a challenging task. Traditionally, ABC classification is used to classify the inventory with the support of Pareto chart. In recent days, researchers have focused more on multi criteria inventory classification. Also, many articles proved that multi criteria classification has many advantages compared to the traditional ABC classification. In some of the multi criteria classifications, optimization methods are used to classify the inventory. In this study, ABC-FSN analysis was carried out to classify the items and logistics performance metrics were used to measure the average utilization of the vehicles.

2. Literature Review

Most of the previous literatures concentrate on classifying inventory with the help of ABC classification and some optimization techniques like genetic algorithm and artificial neural network. Some literatures used heuristic methods and programming models to classify the inventory by considering multiple criteria. The inventory in a manufacturing industry was classified using FSN analysis and inventory management in electric multiple unit coach manufacturing, which was carried out in a study with the components classification of F, S, and N [1-3]. The gap between research and classroom in ABC analysis was bridged. The large body of research was summarized based on multiple criteria ABC analysis that has accumulated since the 1980s. Traditional and multi-criteria ABC analysis was compared in this literature. The status of research on ABC analysis was discussed broadly [4-6]. The models of inventory management under uncertainty were reviewed. The article was analysed for possible parameters of existing models of inventory control and up-to-date existing

* Corresponding author.
E-mail address: ksnallu@gmail.com

literatures were reviewed [7-9]. Ordering policy based on multiple inventory classification schemes was established. Weightage was given to criteria like cost, customer satisfaction, innovation and analysis of various inventory classification systems like ABC, HML, SDE and FSN. The proposed system has been used to develop the inventory control policies applicable for input materials such as raw, packing, and other components [10-13].

Multi criteria inventory ABC classification for an automobile rubber manufacturing industry was developed. Multiple criteria such as annual usage, unit price, demand, unit weight and shape were taken into account and analytic hierarchy process matrix was formed [14-16]. Analysis model for inventory management was developed. The model provides information about the factors that influence the efficient inventory management. Results showed that factors such as turnover, average inventory, and average daily sales affects the inventory [17]. Stock keeping units were classified with the help of empirically driven hierarchical classification. It is always a challenge for any industry to reduce the inventory cost and to manage inventory levels effectively. For controlling inventory that involves large number of products, it is very essential to have an inventory model that depends on control variables. By fixing the control variables, it is possible to fix Economic Order Quantity (EOQ) [18-19]. The factors influencing inventory demand were identified and the interactions between production, control, and inventory control were considered [20]. The management of inventory was obtained by the development of the vendor managed inventory model. The vendor takes care of the inventory based on the demand and lead time [21-24]. Based on the above literature study, an attempt was made to study inventory and logistics performance metrics in the automobile component manufacturing industry by different forecasting techniques.

3. Methodology

The methodology of the study is shown in Figure 1. Initially, the problem of the company was identified based on the existing process and the objectives were made according to the research needed. Data collection was done for inventory and On-Time in Full (OTIF) with Vehicle Capacity Utilization (VCU). Then, ABC-FSN classification was done and demand forecasting and inventory ordering policies such as EOQ and Reorder Point (ROP) were found. Next, logistics performance measurement was done and the final report was prepared.

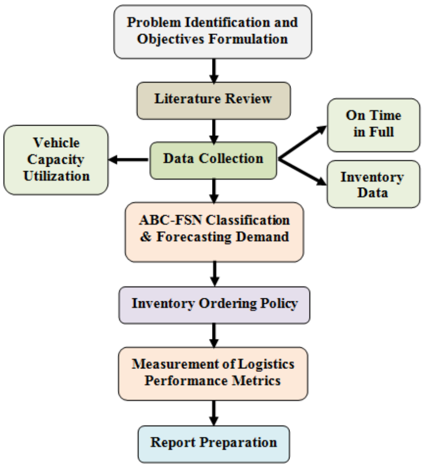


Figure 1. Methodology flow chart

4. ABC-FSN Analysis

In the ABC analysis, the part items were classified according to the number of usage and total expenditure as shown in Figure 2. Table 1 shows the parts classification for ABC classification. Table 2 shows the ABC-FSN matrix where each A, B, and C are grouped with fast, slow and non-moving items. Table 3 shows the combined classification into category classification.

5. Demand Forecasting

Demand forecasting is a technique that uses patterns to predict future company demand. The different techniques used in this study are as follows.

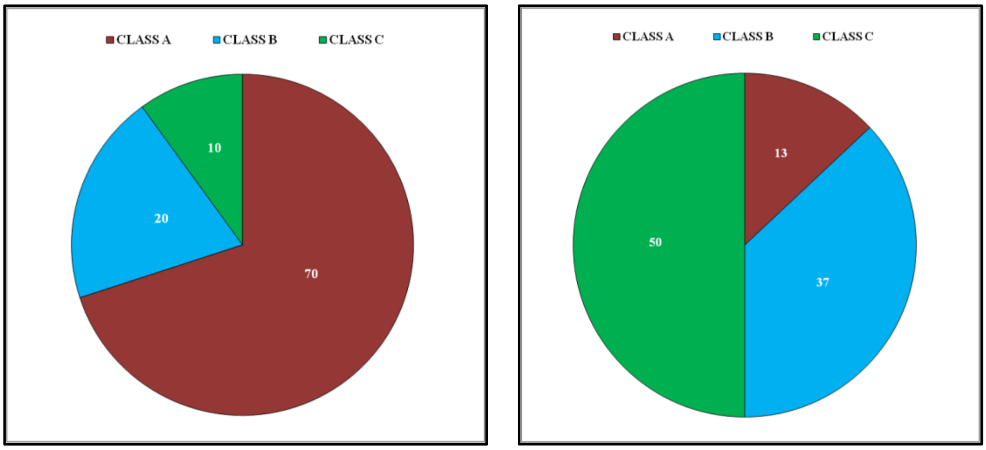


Figure 2. Pictorial results of part items under ABC classification

Table 1. Parts class classification for ABC classification

Parts	Cost
13% of parts (15 out of 123)	% of total cost catered by class A = 70%
37% of parts (35 out of 123)	% of total cost catered by class B = 20%
50% of parts (73 out of 123)	% of total cost catered by class C = 70%

Table 2. ABC-FSN matrix

Category	F		S		N		Total No. of parts	% of the parts
	Combined category	No. of parts	Combined category	No. of parts	Combined category	No. of parts		
A	AF	14	AS	0	AN	1	15	12
B	BF	32	BS	1	BN	2	35	28
C	CF	31	CS	15	CN	27	73	59

Table 3. Combined category

Category	Combined category	Total No. of parts
I	AF+BF+CF+AS+AN	78
II	BS+CS+BN	18
III	CN	27

5.1. Moving Average

In this study, both three months and six months moving average were studied. The results are shown in Figure 3 for six months moving average and Figure 4 for three months moving average. The moving average was calculated by using the following equation:

$$MA_n = \frac{\sum_{i=1}^{n} D_i}{n} \tag{1}$$

Where D_i is Demand and n is Period.

5.2. Weighted Moving Average

In this method, weights were assigned to the data to be forecasted. The recent data has a higher weight compared to others. The sum of all weights in total is equal to 1. Three months and six months forecasting were done.

$$WMA_n = \frac{\sum_{i=1}^{n} W_i D_i}{n} \tag{2}$$

Where W_i is Weights assigned and D_i is Demand.

Weights assigned for three months forecasting were 0.5, 0.33 and 0.17 and for six months forecasting 0.3, 0.2, 0.17, 0.13, 0.1 and 0.1. The observed results for three months and six months forecasting are shown in Figure 5 and Figure 6, respectively.

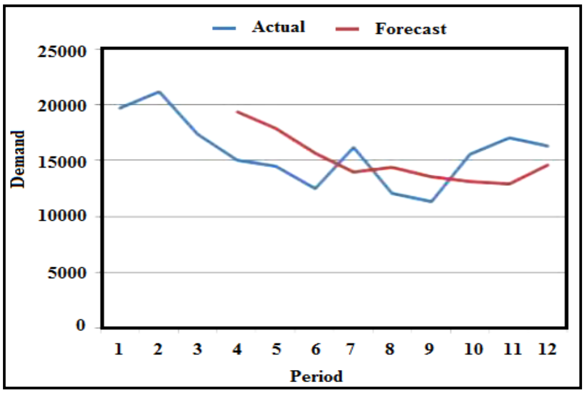


Figure 3. Moving average - 3 months

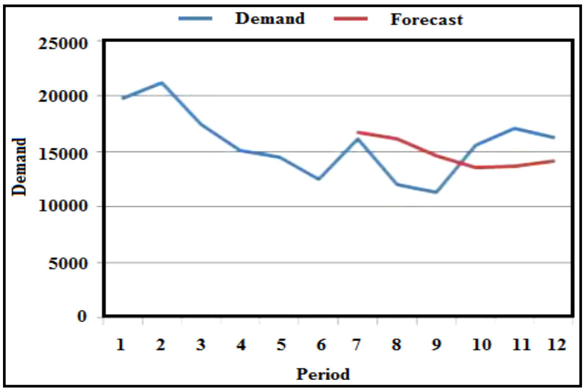


Figure 4. Moving average - 6 months

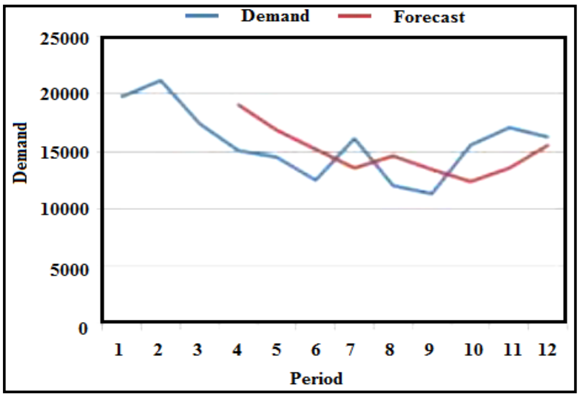


Figure 5. Weighted moving average - 3 months

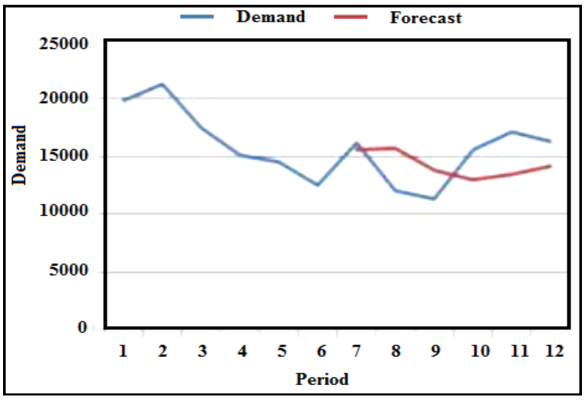


Figure 6. Weighted moving average - 6 months

5.3. Exponential Smoothing

Exponential smoothing is the most commonly used averaging method. The smoothing constant is between 0.0 and 1.0. It reflects the weight given to the most recent demand data. In this study, smoothing constant α = 0.5. The calculated results for exponential smoothing technique are shown in Figure 7.

$$F_t + 1 = \alpha D_t + (1 - \alpha)F_t \tag{3}$$

Where D_t is Demand, F_t is Forecast and α is Smoothing constant.

5.4. Adjusted Exponential Smoothing

This method consists of the exponential smoothing forecast with a trend adjustment factor added to it with α = 0.5 and β = 0.3. Results are shown in Figure 8 for the adjusted exponential smoothing technique.

$$T_t + 1 = \beta(F_t + 1 - F_t) + (1 - \beta)T_t \tag{4}$$

Where β is Smoothing constant for trend, F_t is Forecast and T_t is Trend.

Also,

$$AF_t + 1 = F_t + 1 + T_t + 1 \tag{5}$$

5.5. Summary

The overall forecasting values are shown in Figure 9. The Mean Absolute Deviation (MAD) was calculated for all forecasting techniques. The results show that the MAD for the adjusted exponential smoothing with α = 0.5 and β = 0.3 is smaller compared to others and hence, this method was finalized for demand forecasting.

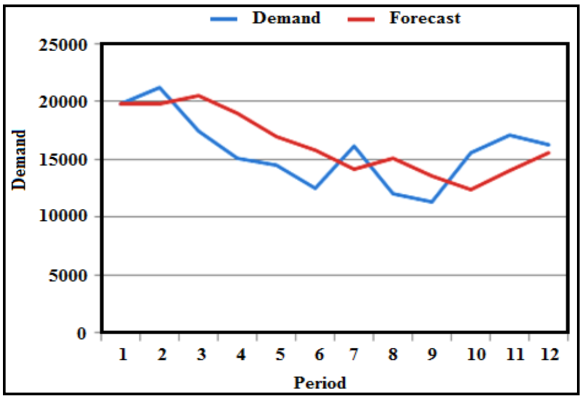


Figure 7. Exponential smoothing

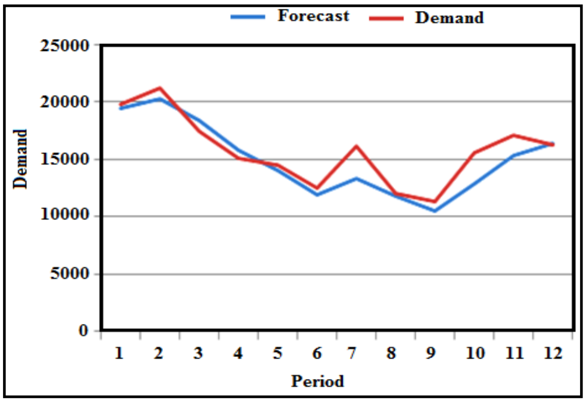


Figure 8. Adjusted exponential smoothing

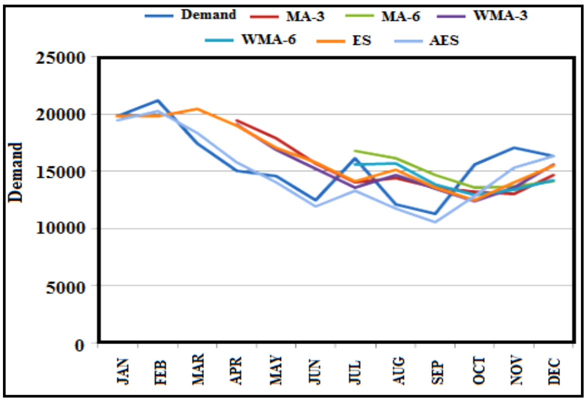


Figure 9. Overall comparison of forecast values

6. Ordering Policy

6.1. Economic Order Quantity

The EOQ model is one of the independent demand models, which minimizes the total of ordering and holding costs. When the quantity order increases, the total number of placed orders per year will decreases. Hence, the ordering cost or annual setup cost will be decreased when the quantity increases. But, the holding cost may also be increased when the quantity of order increases due to more inventory average maintained. In this study, EOQ was done for two raw materials BSK 46 and ISO 2026 to be procured.

$$Q_{opt} = \sqrt{\frac{2C_o D}{C_c}} \tag{6}$$

Where C_o is Ordering cost/Setup cost, C_c is Carrying cost/Holding cost and D is Demand.

BSK 46 EOQ = √ (2 × 2804140.0 × 21, 79,637.61)/4.3
= 17, 73,493.86 kg/Order = 1773.49 Tones/Order

ISO 2026 EOQ = √ (2 × 2759034.94 × 21, 79,637.61)/3.95
= 17, 44,966.91 kg/Order = 1744.96 Tones/Order

6.2. Total Inventory Cost

It is cost incurred for the product and calculated by:

$$TC = \frac{C_o D}{Q} + \frac{C_c Q}{2} \tag{7}$$

The total inventory cost for BSK 46 TC is Rs. 76, 26, 023.50, and the total inventory cost for ISO 2026 is Rs. 68, 92, 619.31.

6.3. Reorder Point

The lead time or delivery time is the duration between placement of an order and receipt of material. Hence, ROP is expressed by the decision of when-to-order. The reorder point is the level of inventory where a respective order could be placed to top off the item available in the stock. In this study, demand varys with constant lead time and hence, the following formula is used to find out ROP.

$$ROP = (\text{Average daily demand} \times \text{Lead time in days}) + Z\sigma_{dLT} \tag{8}$$

Where,

σ_{dLT} = Standard deviation of demand during lead time = σ_d √ (Lead time)

σ_d = Standard deviation of demand per day

In this analysis, we keep the lead time as 3 days and Z is 1.04. Based on these values, ROP was found for the selected two raw materials as follows.

For BSK 46, ROP = (6.96 × 3) + (1.04 × (1.6) √ (3)) = 24.48 ≈ 24 days.

For ISO 2026, ROP = (7.64 × 3) + (1.04 × (2.3) √ (3)) = 26.5 ≈ 26 days.

6.4. Safety Stock

This type of inventory is more often added to the expected demand for the period of lead time. The safety stock for the raw materials was calculated as follows.

For BSK 46, Safety stock = (1.04 × (1.6) √ (3)) = 2.88 Tones.

For ISO 2026, Safety stock = (1.04 × (2.3) √ (3)) = 2.52 Tones.

Inventory record accuracy = (Physical counts) - (Deviated counts) / Physical counts.

Inventory record accuracy = (531) - (41) / (531) = 0.923 × 100 = 92.3%.

6.5. Inventory Turnover Ratio

Based on the data collection, the inventory turnover ratio was calculated and the results are as follows. Similarly, the average days to sell inventory and average inventory were calculated.

$$\text{Inventory turns} = \frac{\text{Cost of goods sold}}{\text{Average aggregate value of inventory}}$$
$$= (26{,}77{,}73{,}001.58)/((3{,}82{,}21{,}433.99 + 2{,}52{,}74{,}437.35 + 5{,}61{,}27{,}989.52)/3) = 6.72 \tag{9}$$

$$\text{Average days to sell inventory} = 360/(\text{Inventory turns}) = 360/6.72 = 53.57 \text{ days}$$
$$\text{Average inventory} = \frac{FG + WIP + RM}{3} = \frac{4826 + 23227 + 7476}{3} = 11843 \text{ items} \tag{10}$$

6.6. Inventory Record Accuracy

The accuracy of inventory record was calculated using the following formula for different items and the results of audit inventory is given in Table 4.

7. Logistics Performance Metrics

The performance metrics of on-time in full and vehicle capacity utilization were identified and evaluated. OTIF is logistics or performance measurement of delivery inside a supply chain network and also measures the ability of the supply chain for delivery. OTIF was calculated based on the dispatched lines Vs schedule line to be dispatched with the following formula

$$OTIF\ (\%) = \frac{\text{Number of deliveries OTIF}}{\text{Total number of deliveries}} \times 100 \tag{11}$$

The customers of an automobile manufacturing company are focused for the following plants: Alwar, Ennore and Hosur. The OTIF report was done daily to identify the causes of failure that affect the OTIF performance. The internal and external failures and reasons for it were accounted for in the report.

Table 4. Inventory record accuracy

Audit on : 27.01.2020					
Item code	**Description**	**System quantity**	**Physical quantity**	**Diff in quantity**	**Accuracy**
FG-FL0004-AA-TU	Internal Flitch Front LH-Turret Punching	100	113	13	88.5
FG-FL0003-AA-TU	Internal Flitch Front RH-Turret Punching	100	102	2	98.0
FG-FL0045-AA-NP	Flitch RH-Part Number Punching	90	70	-20	128.6
RM-BL0055-AA	BL-L:3215xW:0292xT:05.80MM HR IS2062A	25	57	32	43.9
FG-FL0069-AA-NP	Flitch LH-Part Number Punching	26	51	25	51.0
FG-FL0035-AA-FO	External Flitch LH at Rear SP-Folding	17	30	13	56.7
RM-BL0078-AA	BL-L:5000xW:0292xT:05.80MM BSK46	26	26	0	100.0
RM-BL0026-AA	BL-L:2690.00xW:318.00xT:4.80MM IS2062A	27	24	-3	87.5
FG-FL0081-AA-NP	Internal Flitch RH Rear-Part Number Punching	22	22	0	10.0
RM-BL0074-AA	BL-L:4543xW:0292xT:05.80MM BSK46	11	10	-1	90.0
RM-BL0071-AA	BL-L:4157.00xW:282.00xT:5.80MM IS2092 A	26	6	-20	-233.3
FG-FL0123-AA-NP	External Flitch LH-Part Number Punching	5	5	0	100.0
FG-FL0080-AA-FO	External Flitch LH Rear-Folding	3	3	0	100.0
RM-BL0299-AA	BL-L:804.00xW:460.00xT:3.80MM IS2062 A	3	3	0	100.0
FG-FL0014-AA-FO	Flitch LH Front- Folding	3	3	0	100.0
FG-FL0039-AA-TU	Flitch LH for 135KW LT with-Turret Punching	2	2	0	100.0
FG-FL0015-AA-FO	Flitch RH Front-Folding	2	2	0	100.0
FG-FL0023-AA-NP	External Flitch Front LH-Part Number Punching	1	1	0	100.0
FG-FL0106-AA-TU	ENG MFG Flitch RH-Turret Punching	1	1	0	100.0
		490	**531**	**41**	**92.3**

7.1. Past Trend Analysis

The previous historical data on OTIF were analysed and studied to identify the previous failures. The OTIF from April 2019 to Dec 2019 are shown in Figure 10.

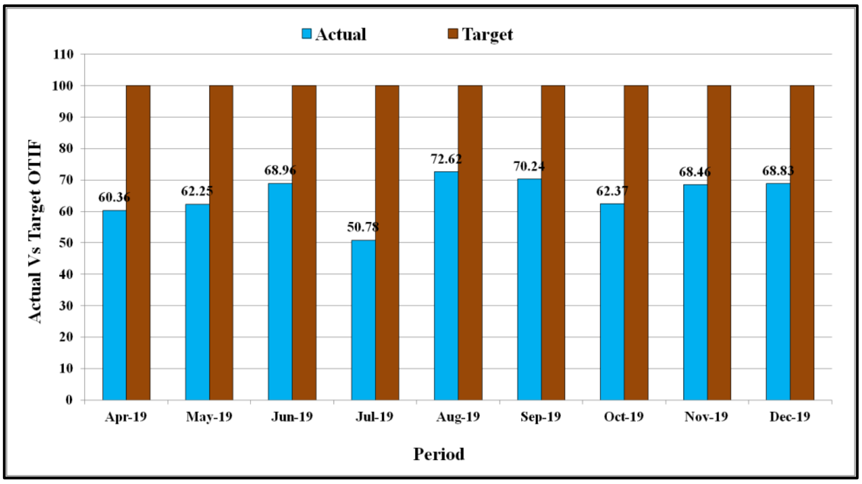


Figure 10. OTIF trend analysis

7.2. OTIF Monitoring

Monitoring of OTIF was carried out on a daily basis from January 2020 to February 2020, and the failures of the OTIF were noted. The OTIF monitoring process is shown in Figure 11. The duration given for dispatch of part items after the daily schedule notification consists of 24 hours for Ennore and 48 hours for Hosur, which is critical to the OTIF and affects the overall performance. Figure 12 shows the average results of OTIF was 54.50% as well as the variation results from 1st February 2020 to 19th February 2020. The OTIF failure reason is conveyed to management through e-mail daily. Also, monitoring of the next three days tentative schedule plan is taken from the customer SAP portal and is informed in prior to the concerned business verticals about the required items to be produced from the available stock.

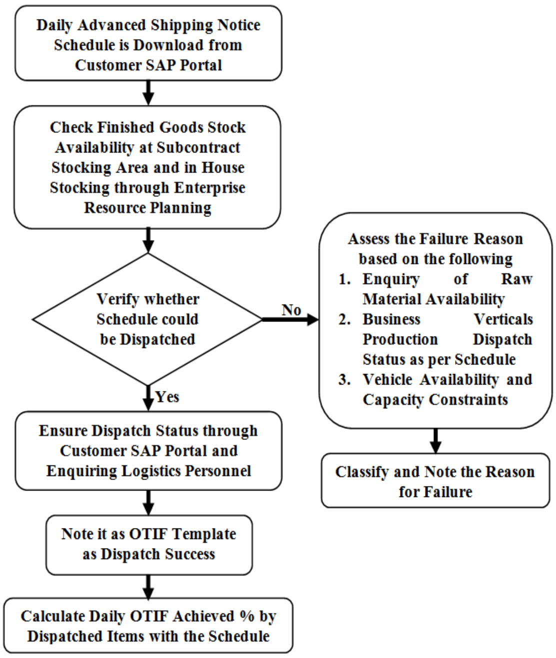


Figure 11. Daily OTIF monitoring

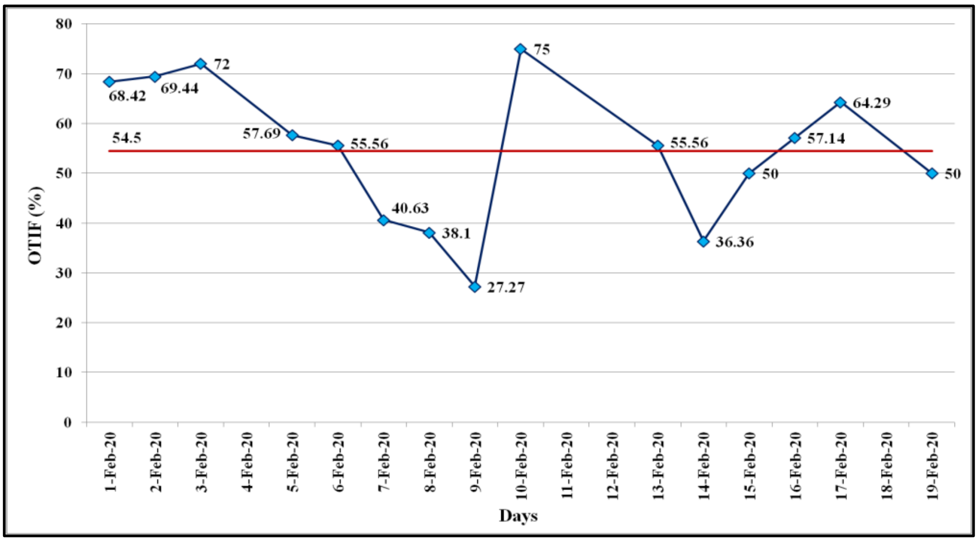


Figure 12. Results of OTIF chart

7.3. OTIF Failures

OTIF failures are classified into internal and external failures. Some internal failures are production delay, quality issues, availability of raw material, vehicle availability. External failures include bulk schedule, customer vehicle not placed, etc. The failure results of OTIF for the month of Jan 2020 and Feb 2020 are shown in Figure 13 with different failure parameters.

Root cause analysis was done to uncover root causes of problems and to further eliminate them. A fishbone diagram was used to arrive at the various causes contributing to the OTIF failure. The fishbone diagram for each department is shown from Figures 14 to Figure 18. Figure 14 shows the various causes affecting OTIF performance from the materials department perspective and Figure 15 shows causes from the press operation section. Similarly, Figure 16 shows the various causes affecting OTIF performance from the production line 1 and Figure 17 illustrates the different causes affecting OTIF performance from production line 2.

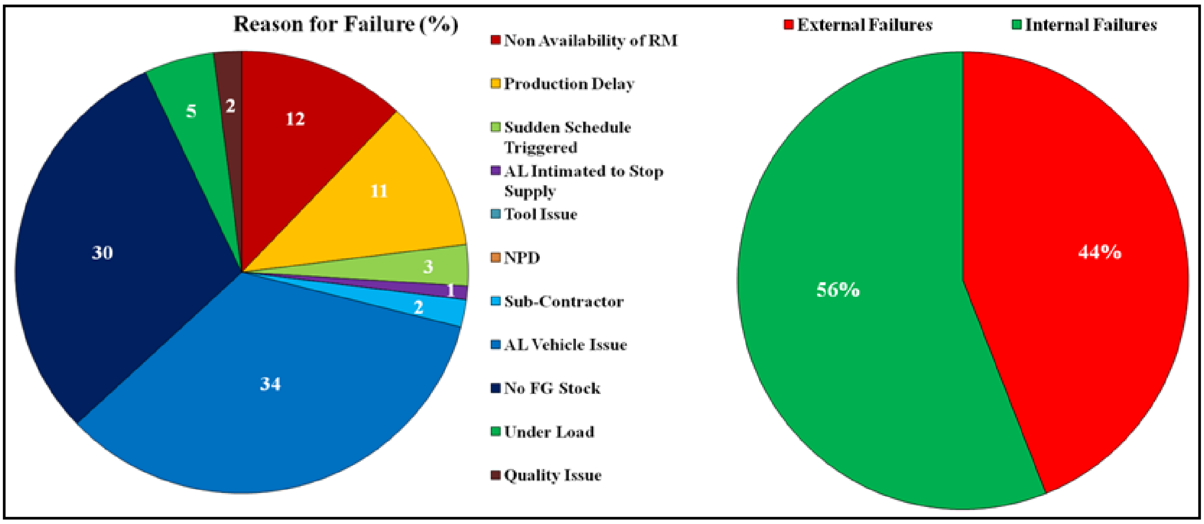


Figure 13. OTIF failure and failure distribution

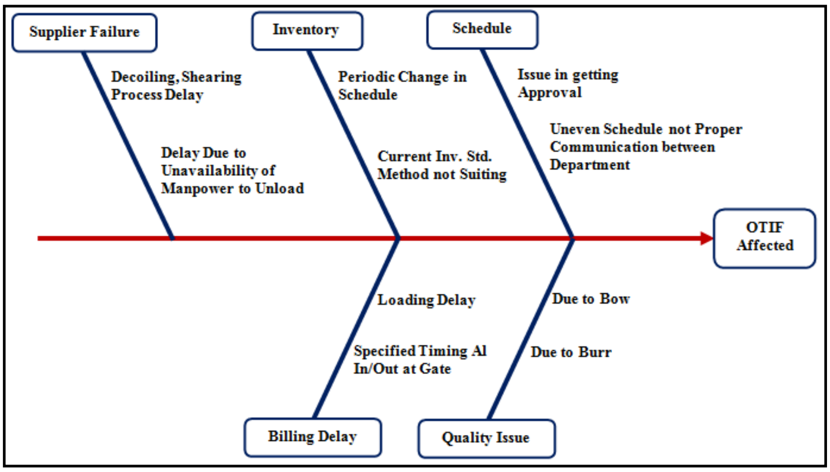


Figure 14. Overall causes affecting OTIF - Materials department

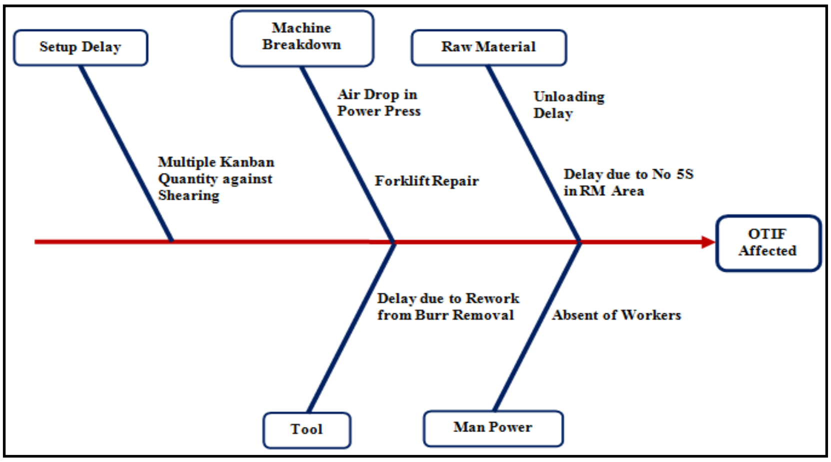


Figure 15. Overall causes affecting OTIF - Press operations

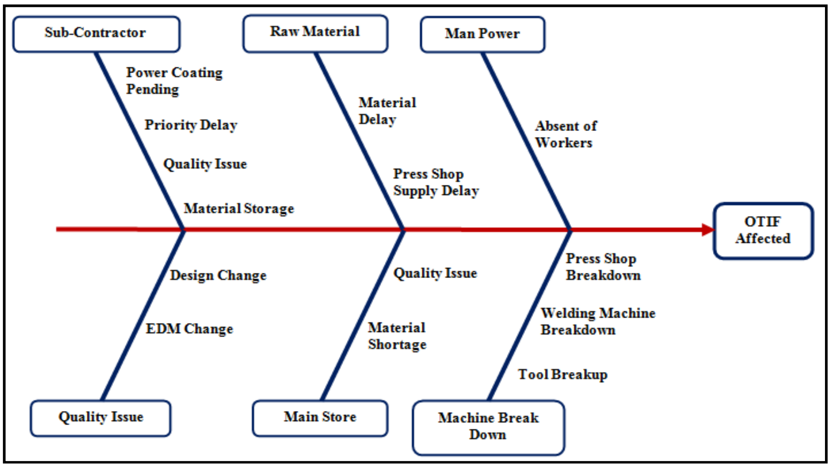


Figure 16. Overall causes affecting OTIF performance - Production line 1

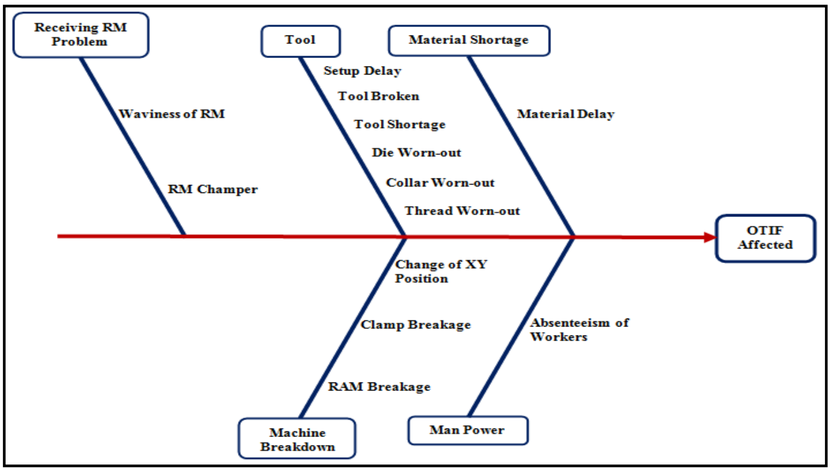


Figure 17. Overall causes affecting OTIF performance - Production line 2

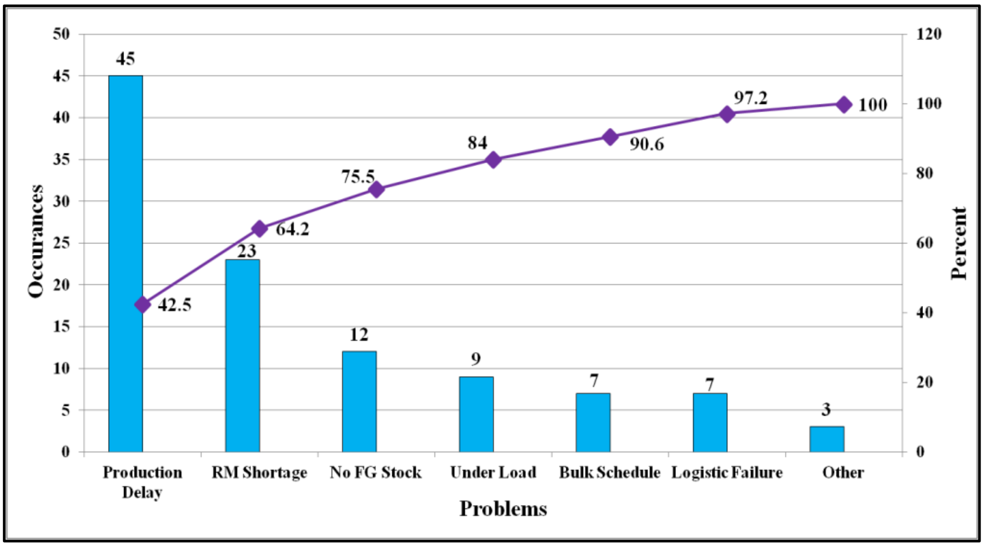


Figure 18. Pareto analysis - Failures affecting OTIF

The critical failures were classified based on a Pareto analysis with data inputted through daily OTIF monitoring as shown in Figure 18. 5 why analysis was then carried out to drill down to root cause of the critical failure. The analysis was done for activities causing major issues. Figure 19 shows the Why-Why analysis for OTIF Failures.

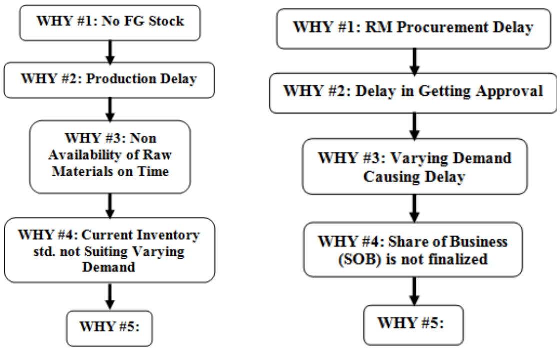


Figure 19. Why-why analysis for OTIF failures

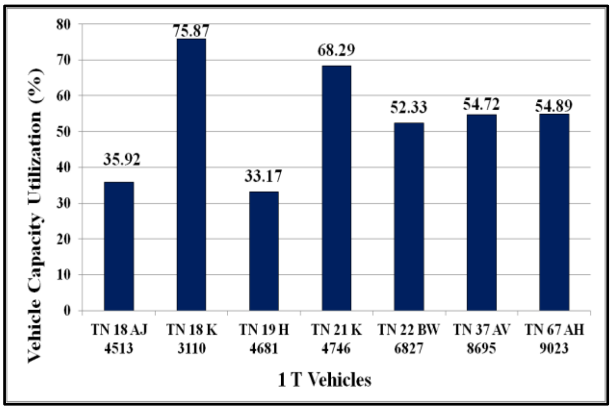
7.4. Action Plan for OTIF

The following steps should be taken to eliminate the failures and to improve OTIF.

- Finalize the Share of Business (SOB) with the customer.
- Maintain the following inventory safety stock levels based on the tentative monthly schedule.
- ➢ FG (Fast moving Items) - 15 days stock
- ➢ FG (Slow moving Items) - 7 days stock.
- ➢ For BSK 46 - 2.52 T & ISO 2026 - 2.52 T.
- Continue monitoring the performance of OTIF on a daily basis by the operational teams and focus on continuous improvement and follow-up of the inventory standards set.

7.5. Vehicle Capacity Utilization (*VCU*)

Vehicle capacity utilization is an aggregate measure of utilization of capacity that transports the product from warehouse to the customer location. VCU was done in order to identify the proper utilization of vehicles and also to identify the correct vehicle capacity through routes. VCU includes factors such as loading and unloading at different stations, distance travelled from one station to another, fuel consumption, time utilization, and deviations from schedules. In this study, the capacity utilization of hired vehicles was studied. The objective was to improve vehicle capacity utilization and the vehicle tonnages used were 1T, 6T, 7T and 9T. Vehicle capacity utilization could be determined by using the below formula by considering tonnage, distance covered, capacity of the vehicle and route distance of the vehicle as determining factors. The results of vehicle capacity utilization for 1, 6, 7 and 9 Tones are shown in Figures 20 and Figure 21.



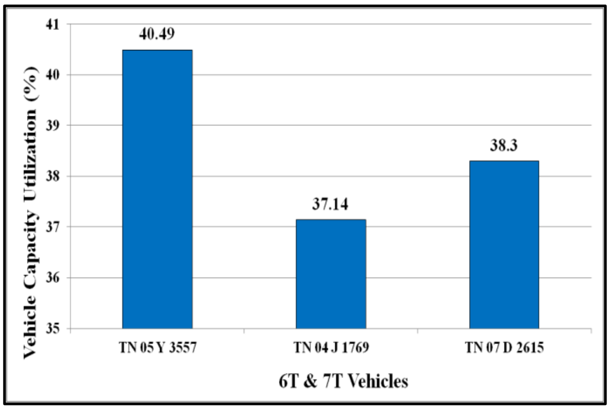


Figure 20. Vehicle capacity utilization - 1T, 6T and 7T

Vehicle No = TN 23AA 4236

Capacity = 9 Tones

From/To - MF-II to Sree Devi powder coating = 18 Km

Sree Devi powder coating to AL (Ennore) = 7 Km

Loading at MF-II = 1772.5 Kg

Loading & unloading at Sree Devi Powder coating = 700 Kg and 260.5 Kg

$$\text{Vehicle capacity utilization rate} = \sum \frac{(\text{Net Weight Distance Covered between Stations})}{(\text{Capacity of the Vehicle x Total ROute Distance})} \tag{12}$$
$$= \sum \{[(0 + 1772.5 - 0) \times 18] + [(1772.2 + 700 - 260.5) \times 7]\}/(9000 \times 25) = 21.06\%$$

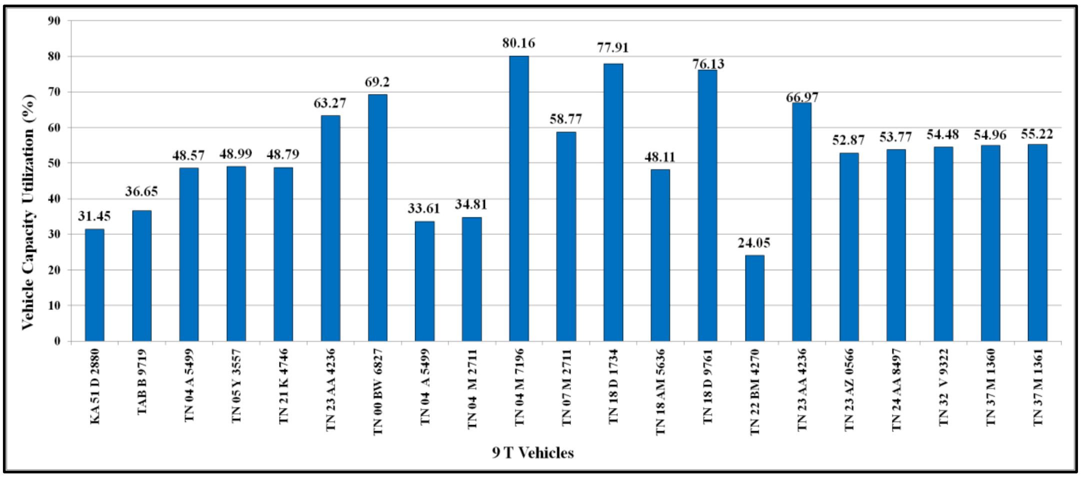


Figure 21. Vehicle capacity utilization - 9T

7.6. Suggestions

- Proper packaging of goods can improve the fill rate of the vehicles.
- Effective use of material handling also increases the capacity utilization.
- Another important factor is the proper loading of standard and non-standard goods into the deck space.

8. Conclusion

The objective of inventory management and performance measurement of logistics metrics with different techniques were carried out. Based on the final observed results, the following conclusions were drawn.

- ABC-FSN classification of items were classified into fast, slow, and non-moving parts, which helps to identify and prioritize more critical items.
- Demand forecasting helps to understand on required quantity for the next month and helps to reduce variation of supply and demand.
- The adjusted exponential method is preferred as it has a smaller mean absolute deviation of 71.92 compared to others.
- The EOQ, ROP and SS were found and suggests the company follow the systematic procedure for improving performance and productivity and avoid stock-outs.
- It is suggested that SOB be finalized from the customer to avoid fluctuations in demand and adopt the maintaining inventory safety stock suggested to avoid failure in OTIF.
- Since the VCU was poor and all vehicles have on average of 52.61%, it is suggested that proper packaging of goods and proper loading into deck space will improve performance.

References

1. S. Mitra, S. Reddy, and K. Prince, “Inventory Control using FSN Analysis - A Case Study on a Manufacturing Industry,” *International Journal of Innovative Science, Engineering and Technology*, Vol. 2, No. 4, pp. 322-325, 2015
2. S. A. Khan, “Implementation of Inventory Management System in a Furniture Company: A Real Case Study,” *Journal of Engineering Technology*, Vol. 2, No. 8, pp. 1457-1474, 2012

3. H. Shen, Q. Deng, R. Lao, and S. Wu, “A Case Study of Inventory Management in a Manufacturing Company in China,” *Nang Yan Business Journal*, Vol. 5, No. 1, pp. 20-40, 2017
4. H. Ravinder and R. Misra, “ABC Analysis for Inventory Management: Bridging the Gap Between Research and Classroom,” *American Journal of Business Education*, Vol. 7, No. 3, pp. 51-58, 2014
5. G. Majumdar and S. Nallusamy, “ABC Analysis and Diminution of Inventory Level Through Forecasting Technique in a Medium Scale Manufacturing Industry,” in *Proceedings of the International Conference on Industrial Engineering and Operations Management*, pp. 23-26, Pilsen, Czech Republic, 2019
6. R. Kampf, et al., “The Application of ABC Analysis to Inventories in the Automatic Industry Utilizing the Cost Saving Effect,” *Journal of Marine Sciences*, Vol. 63, No. 3, pp. 120-125, 2016
7. S. Ziukov, “A Literature Review on Models of Inventory Management under Uncertainty,” *Business Systems and Economics*, Vol. 5, No. 1, pp. 35-48, 2015
8. I. Ahmed and I. Sultana, “A Literature Review on Inventory Modeling with Reliability Considerations,” *International Journal of Industrial Engineering Computations*, Vol. 5, pp. 169-178, 2014
9. R.S. Angel, S. N. Gomathi, and G. Chitra, “Inventory Management - A Case Study,” *International Journal of Emerging Research in Management and Technology*, Vol. 3, No. 3, pp. 36-42, 2014
10. M. Ketkar and O. S. Vaidya, “Developing Ordering Policy based on Multiple Inventory Classification Schemes,” *Social and Behavioural Sciences*, Vol. 133, pp. 180-188, 2014
11. S. Nallusamy, R. Balaji, and S. Sundar, “Proposed Model for Inventory Review Policy through ABC Analysis in an Automotive Manufacturing Industry,” *International Journal of Engineering Research in Africa*, Vol. 29, pp. 165-174, 2017
12. Q. Iqbal, D. Malzahn, and L. E. Whitman, “Selecting a Multi Criteria Inventory Classification Model to Improve Customer Order Fill Rate,” *Advances in Decision Sciences*, Vol. 2017, pp. 1-11, 2017
13. Q. Iqbal and D. Malzahn, “Evaluating Discriminating Power of Single Criteria and Multi Criteria Models Towards Inventory Classification,” *Computers and Industrial Engineering*, Vol. 104, pp. 219-223, 2017
14. M. B. Jeddou, “Multi-Criteria ABC Inventory Classification a Case of Vehicles Spare Parts Items,” *Journal of Advanced Management Science*, Vol. 2, No. 3, pp. 181-185, 2014
15. J. Park, H. Bae and J. Bae, “Cross Evaluation based Weighted Linear Optimization for Multi-Criteria ABC Inventory Classification, ” *Computers and Industrial Engineering*, Vol. 76, No. 1, pp. 40-48, 2014
16. C. Burja and V. Burja, “Analysis Model for Inventory Management,” *Annals of the University of Petrosani*, Vol. 10, No. 1, pp. 43-50, 2010
17. A. Bacchetti, F. Plebani, N. Saccani, and A. A. Syntetos, “Empirically Driven Hierarchical Classification of Stock Keeping Units,” *International Journal of Production Economics*, Vol. 143, pp. 263-274, 2013
18. F. Petropoulos, X. Wang, and S. M. Disney, “The Inventory Performance of Forecasting Methods: Evidence from the M3 Competition Data,” *International Journal of Forecasting*, Vol. 35, No. 1, pp. 251-265, 2019
19. M. D. Nardo, M. Clericuzio, T. Murino, and C. Sepe, “An Economic Order Quantity Stochastic Dynamic Optimization Model in a Logistic 4.0 Environment,” *Sustainability*, Vol. 12, pp. 1-25, 2020
20. K. Balakannan, et al., “Performance Evaluation of Supply Chain and Logistics Management System using Balanced Score Card for Efficiency Enhancement in Indian Automotive Industries,” *Indian Journal of Science and Technology*, Vol. 9, No. 35, pp. 1-9, 2016
21. L. Goonatilak, “Inventory Management in the Manufacturing Sector in Developing Countries,” *Engineering Costs and Production Economics*, Vol. 19, pp. 19-24, 2008
22. J. H. Cai, et al., “Optimal Inventory Decisions under Vendor Managed Inventory: Substitution Effects and Replenishment Tactics,” *Applied Mathematical Modelling*, Vol. 43, pp. 611-629, 2017
23. X. Hong, W. Chunyuan, L. Xu, and A. Diabat, “Multiple-Vendor, Multiple-Retailer based Vendor-Managed Inventory,” *Annals of Operations Research*, Vol. 238, No. 1-2, pp. 277-297, 2016
24. J. Wettasinghe and H. T. Luong, “A Vendor Managed Inventory Policy with Emergency Orders,” https://www.tandfonline.com/toc/tjci21/currentVol. 37, No. 2-3, pp. 120-133, 2020

Dr. S. Nallusamy is currently a Professor and Dean of the Department of Mechanical Engineering at Dr. M.G.R. Educational and Research Institute, Chennai 600095, Tamilnadu, India. His research areas of interest are Lean Manufacturing, Optimization, Composite Materials, Nano Materials and Material Science.