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Study on Effective Inventory Management by Determining the Appropriate Safety Stock in an Automobile Manufacturing Industry

D. Sobya[1, a]*, Parthasarathi Chakraborty[2, b]

[1] *Department of Electronics and Communication Engineering, Raja Rajeswari College of Engineering, Bengaluru, Karnataka-560074, India*

[2] *Department of Adult and Continuing Education & Extension, Jadavpur University, Kolkata- 70032, India*

Abstract: *Inventory management mainly focuses on planning and controlling the inventory level of production industries and plays an important role in the production. The revenue and the reputation of the organization depend largely on the service level at which the customers are served. The service level can be improved by reducing the mismatch between the supply and the demand. The methods used to reduce the supply and demand mismatch are forecasting, determining the safety stock required, and determination of the service level required. The optimum forecasting method for the organization is selected based on the Mean Absolute Percentage Error (MAPE) method. Based on the forecast and the error in the forecast on the historical demand, the tracking signal or bias is calculated. Goods are segmented on the volume of the demand, and different service levels for different segments of products are used to calculate the safety stock. The total value of the stock is calculated based on the unit cost of the product and is compared with the actual value of the stock. The results obtained show that an overall savings of about Rs.75000 can be obtained.*

Keywords: *Inventory, Forecasting, MAPE, Tracking Signal, Service Level, Safety Stock*

I. INTRODUCTION

The company manufactures a different variety of springs and oil seal shells. In total, they manufacture about 61 different varieties of finished products. Each product requires a number of processes to get converted into finished goods. The raw material used for the oil seal shell is usually in the form of a sheet. The size of the sheet is 1250mm X 2500mm. The thickness of the sheet varies according to the type of finished goods. The processes which a sheet metal need to undergo before being converted into raw material are shown in Figure 1.Once the manufacturing is completed the products are transferred to the main warehouse and from where it is transported to the respective regional warehouses. The flow of finished goods from the plant to the regional warehouse is shown in Figure 2.

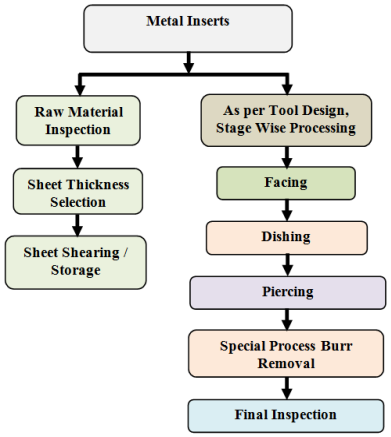

Fig 1: Manufacturing process of oil seal shell

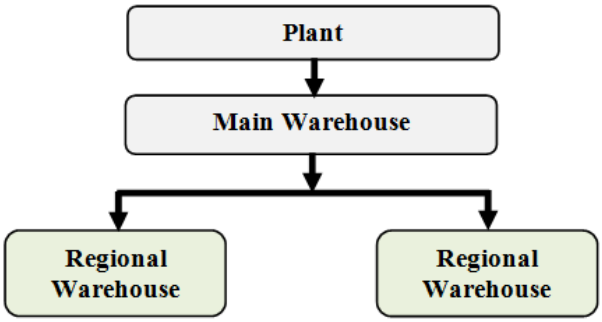

Fig 2: Product flow from plant to warehouse

II. LITERATURE REVIEW

A model for estimating the economic advantage of using a time-phased order point system (TPOP) with time series forecasting rather than a simple reorder point system in an independent demand inventory management is developed [1-3]. A model to manage the inventory was developed. Here, the inventory is managed on the basis of minimizing the variable cost. Value at risk analysis is done to find the optimum

safety stock to be maintained [4-6]. Effective inventory management of automobile parts manufacturing parts has been explained. The concept used for managing the inventory is Multi-Criteria Inventory Classification (MCIC) [7-9]. In addition to that, AHP is used to find the value of inventory. The factors influencing inventory demand are, and the interactions between productions, control, and inventory control are considered and identified [10-12]. Inventory management is one of the important aspects of staying in this competitive market. It concludes this after the evaluation of several drivers associated with inventory management. The management of inventory is obtained by the development of vendor managed inventory model. The vendor takes care of the inventory based on demand and lead time. The importance of managing the inventory was mentioned and discussed [13-15].

III. FORECASTING

Forecasting is done to predict future demand based on historical demand data. There are several methods of forecasting available. The different methods may be suitable for a different organization. In order to find the optimum forecasting method, the comparison is used. The moving average method and the exponential smoothening methods are taken for comparison based on the trend of the data. To find out the moving average method, the following equation has been used.

$$MA = \frac{\sum_i^n D_i}{n} \quad (1)$$

Where, MA - Moving Average

D - Demand

n - Number of months

The simple exponential method is calculated using equation 2, and level and trend are calculated using in equations 3 and 4, respectively.

Forecast=Level (L) + Trend (T) (2)

Level=$\alpha * Demand + 1 - \alpha * (L_{i-1}+T_{i-1})$ (3)

Trend=$\beta * (L_i - L_{i-1}) + (1- \beta) * T_{i-1}$ (4)

Using these formulas, the forecasting is done. The forecasting using the moving average method is done in both 3 months and 5-month averaging method. The best of the two (3 months and 5 months) are selected by comparison of MAPE values. Once the better of the two is selected, the MAPE value of it is compared with the MAPE value of the simple exponential method. Table 1 and Table 2 show the sample forecasted data using the moving average method and simple exponential method, respectively.

Table 1: Forecasting using Moving Average Method

Part Number	Demand	3 Months Moving Average	5 Months Moving Average	F-D (3 Months)	F-D (5 Months)	Abs (3 Months)	Abs (5 Months)	Abs F/d (3 Months)	Abs F/d (5 Months)
128	9000			-9000.0	-9000	9000.0	9000	1.00	1.00
128	10450			-10450.0	-10450	10450.0	10450	1.00	1.00
128	8700			-8700.0	-8700	870.0	8700	1.00	1.00
128	10150	9383.3		-7667	-10150	766.7	10150	0.08	1.00
128	16000	9766.7		-6233.3	-16000	6233.3	16000	0.39	1.00
128	4650	11616.7	10860	6966.7	6210	6966.7	6210	1.50	1.34
128	12000	10266.7	9990	-1733.3	-2010	1733.3	2010	0.14	0.17
128	10499	10883.3	10300	384.3	-199	384.3	199	0.04	0.02
128	6000	9049.7	10659.8	3049.7	4659.8	3049.7	4659.8	0.51	0.78
128	7500	9499.7	9829.8	1999.7	2329.8	1999.7	2329.8	0.27	0.31
128	10000	7999.7	8129.8	8129.8	-1870.2	2000.3	1870.2	0.20	0.19
128	9450	7833.3	9199.8	9199.8	-250.2	1616.7	250.2	0.17	0.03
128	9850	8983.3	8689.8	8689.8	-1160.2	866.7	1160.2	0.09	0.12
128	9000	9766.7	8560	8560	-440	766.7	440	0.09	0.05
128	8450	9433.3	9160	9160	710	983.3	710	0.12	0.08
128	9500	9100.0	9350	9350	-150	400.0	150	0.04	0.02

Table 2: Forecasting using Simple Exponential Method

Month	Demand (D)	Level Estimate	Trend Estimate	Forecast (F)	F-D	Abs (F-D)	Abs (F-D)/D
Jan-16	9000	9000.00	-1800.00	7200	-1800	1800	0.25
Feb-16	10450	7740.00	-1638.00	6102	-4348	4348	0.71
Mar-16	8700	7406.40	-1246.68	6160	-2540	2540	0.41
Apr-16	10150	6922.00	-1018.00	5904	-4246	4246	0.72
May-16	16000	7177.80	-635.86	6542	-9458	9458	1.45
Jun-16	4650	9379.40	215.38	9595	4945	4945	0.52
Jul-16	12000	8111.50	-299.60	7882	-4118	4118	0.52
Aug-16	10499	9117.40	141.05	9258	-1241	1241	0.13
Sep-16	6000	9360.30	252.60	9883	3883	3383	0.39
Oct-16	7500	8718.10	-96.84	8621	1121	1121	0.13
Nov-16	10000	8284.70	-197.81	8087	-1913	1913	0.24
Dec-16	9450	8660.90	-25.60	8635	-815	815	0.09
Jan-17	9850	8879.50	47.66	8927	-923	923	0.10
Feb-17	9000	9203.90	130.68	9335	335	335	0.04
Mar-17	8450	9234.50	100.68	9335	885	885	0.09
Apr-17	9500	9069.50	20.96	9090	-410	410	0.05
May-17	15000	9213.00	57.72	9271	-5729	5729	0.62

Both forecasting methods produce different results. MAPE is used to compare the results of both these methods and concluded that the lesser the value of MAPE, the higher the accuracy of the forecast.

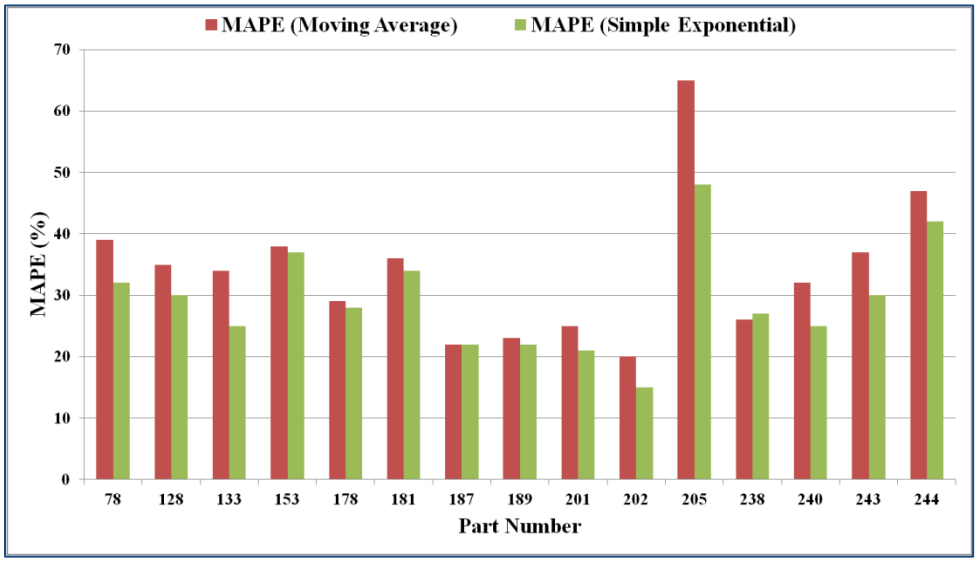

Fig. 3: MAPE for Moving average Vs Simple Exponential

Figure 3 represents the MAPE value comparison of different parts for moving average and simple exponential method. The line on the blue indicates a moving average, whereas the line on the orange indicates a simple exponential. Lower the value of MAPE, the higher the accuracy of the method. Based on the above fact, the simple exponential method is preferred over the moving average method for further calculations.

IV. SAFETY STOCK

Total stock is the sum of both cycle stock and safety stock. Since cycle stock is a constant, the total stock is directly proportional to the safety stock. Safety stock depends on the service factor, lead time, and demand variability. The service factor depends on the percentage of the service level required. The organization is interested in maintaining different service level for a different segment of products, unlike most organization which maintain a constant service level.

A. SEGMENTATION

The segmentation of the products is done based on the volume of the demand for the product. Products with higher demand are classified under A, with moderate demand are classified under B, and with very low demand is classified under C. This segmentation is done based on the historical sales of the respective products. The sample ABC classifications of the parts are shown in Table 3.

Table 3: Segmentation of Products

Part Number	Total Sales	Percentage	Cumulative Percentage	Classification
415	9618509	0.153946217	0.15395	A
391	9244857	0.14796584	0.30191	A
523	490772	0.07027521	0.37219	A
695	2951685	0.047242326	0.41943	A
618	2674475	0.042805523	0.46224	A
381	2464850	0.039450432	0.50169	A
202	2302728	0.0396855636	0.53854	A
503	1859844	0.029767186	0.56831	A
187	1827747	0.029253467	0.59756	A
153	1539360	0.024637774	0.62220	A
591	1467332	0.023484951	0.64568	A
78	1166248	0.018666039	0.66435	A
569	1158835	0.018547393	0.68290	A
181	1134084	0.018151248	0.70105	A
413	1132251	0.0181512191	0.71917	A
436	954366	0.015274824	0.73445	A
178	935306	0.014969765	0.74942	A
265	931277	0.01490528	0.76432	A

B. SERVICE LEVEL AND SERVICE FACTOR

It is not necessary that an organization is needed to serve all the products with a constant service level. Some may concentrate more on products with high demand, and some may give priority to large scale customers. Here, the organization is interested in maintaining a high service level for products with high demand compared with products of low demand. They are also not interested in maintaining a service level of less than 85% for any of the products. Based on the above-mentioned constraints and discussions, different service levels for a different segment of products are set, as shown in Table 4.

Table 4: Service Level for Different Segments

Classification	Service Level
A	95%
B	90%
C	85%

Another fact is that an organization that wishes to serve a product to the customer at a 95% service level does not require serving its warehouse with the same 95% service level. As shown in Figure 4, the goods flow from the plant to the regional warehouse through the main warehouse. It is not necessary that the plant need to maintain a 95% service level to the main warehouse to maintain a service level of 95% for a certain product. This is the area where the concept of local demand and dependent demand comes into existence. Local demand is nothing but demand which is created directly by the customer. Dependent demand is the demand created by

intermediate warehouses. The demand for each product is classified based on its local and dependent demand.

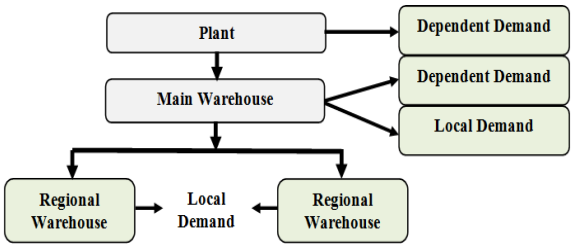

Fig 4: Dependent and local demand

Based on the data of dependent and local demand at various warehouses, the final service level that is needed to be maintained is calculated. The local demand needed to be given the pre-determined service level, whereas for the dependent demand, the operational efficiency is considered. The final service level obtained shows the service level the plant should maintain in order to achieve the pre-determined service level for the respective products. Table 5 shows the final calculated service level for various products.

Table 5: Service Level for Different Products

Part Number	Classification	Total Demand	Local Demand	Department Demand	Service Level
78	A	48594	12148	36445	86.8%
128	C	9362	2341	7022	85.0%
133	B	15360	3840	11520	86.9%
153	A	64140	16035	48105	85.9%
178	A	38971	9743	29228	85.4%
181	A	47254	11813	35440	87.2%
187	A	76156	19039	57117	86.6%
189	B	16133	4033	12100	86.2%
201	B	24334	6083	18250	86.0%
202	A	95947	23987	71960	89.4%
205	C	4556	1139	3417	85.0%
238	C	3324	831	2493	85.0%
239	B	20720	5180	15540	87.1%
240	C	6450	1613	4838	85.0%
243	C	2512	628	1884	85.0%
244	C	2056	514	1542	85.0%
247	C	2589	647	1942	85.0%
252	B	20078	5020	15059	87.3%

C. SAFETY STOCK CALCULATION

Based on the service level, the service factor is identified. Using the service factor, lead time, and demand variability, the safety stock is calculated using, as shown in equation 5.

$$\text{Safety stock} = \text{Service factor} * \text{Demand Variability Error} * \sqrt{\text{lead time}} \quad (5)$$

Table 6: Safety Stock Calculation

Part Number	Service Level (%)	Average Weekly Forecast (Places)	Demand Variability (Places)	Lot Size (Places)	OR Delivery or Production (%)	Cycle Time (Week)	Lead Time (Week)	Service Factor	Model Safety Stock (Places)
78	87.5%	12148	7870.25	24,296.83	85%	2.00	1.00	1.15	9053.54
128	85.0%	2341	8108.5	4,681.23	85%	2.00	1.00	1.04	8403.92
133	86.3%	3840	6675	7,680.23	85%	2.00	1.00	1.09	7286.57
153	87.5%	16035	67223	32,070.00	85%	2.00	1.00	1.15	77329.94
178	87.5%	9743	11181.75	19,485.54	85%	2.00	1.00	1.15	12882.92
181	87.5%	11813	198875.75	23,626.75	85%	2.00	1.00	1.15	228776.60
187	87.5%	19039	219510.25	38,078.06	85%	2.00	1.00	1.15	252513.48
189	86.3%	4033	15817.5	8,066.35	85%	2.00	1.00	1.09	17266.71
201	86.3%	6083	21098.75	12,166.79	85%	2.00	1.00	1.09	23031.83
202	87.5%	23987	362286.25	47,973.50	85%	2.00	1.00	1.15	416755.76
205	85.0%	1139	4132.25	2,278.10	85%	2.00	1.00	1.04	4282.80
238	85.0%	831	1859.25	1,662.00	85%	2.00	1.00	1.04	1926.99
239	86.3%	5180	12873.25	10,359.90	85%	2.00	1.00	1.09	14052.70
240	85.0%	1613	6088	3,225.04	85%	2.00	1.00	1.04	6309.81

The value of the stock to be maintained is identified based on the unit cost of the product. The total value of the suggested stock to be maintained is compared with the value of the stock, which is usually maintained by the organization. The value of the total recommended stock and value of the actual stock is shown in Table 6.

In spite of the fact that the value of the recommended stock for some of the products is more compared to the value of the actual stock when all the products are considered, a considerable amount of savings to found to be present, as shown in Table 7.

Table 7: Value of Recommended Stock Vs. Actual Stock

Total stock (Pieces)	Unit Price (Rupees)	Total Stock Value (Rupees)	Actual Total Stock (Pieces)	Actual Total Stock Value	Savings
20939	20.5	429257.32	20521	420672.17	-8585.15
10745	11.25	120876.02	10530	118458.50	-2417.52
11327	10	113273.05	11441	114405.78	1132.73
88356	2	176712.03	84822	169643.55	-7068.48
21525	6.75	145296.96	22386	151108.84	5811.88
237716	50	11885779.40	230584	11529206.01	-356573.38
262186	60	15731169.91	270052	16203105.01	471935.10
21264	4.5	95687.80	22327	100472.19	4784.39
28829	5	144147.22	27676	138381.33	-5765.89
476151	9.5	4523431.80	495197	4704369.07	180937.27
5422	29	157233.76	5259	152516.75	-4717.01
2758	16	44127.82	2620	41921.43	-2206.39
19741	28	552755.81	18952	530645.57	-22110.23
7922	55	435728.00	7922	435728.00	0.00
1231	100	123052.07	1267	126743.63	3691.56
1952	7.5	14641.17	1972	14787.58	146.41
1671	200	334158.09	1721	344182.84	10024.74
16723	4.5	75253.67	15887	71490.98	-3762.68
29398	14	411567.23	29398	411567.23	0.00
12098	6	72590.78	12703	76220.32	3629.54
3311	7.25	24002.39	3443	24962.48	960.10
11226	9	101032.38	11563	104063.35	3030.97

V. SAFETY STOCK IN CASE OF RAW MATERIAL STORAGE

Here, there are large numbers of products that use only a single raw material. Though savings have been achieved by using the recommended stock level, furthermore savings can be achieved by maintaining the inventory stock as raw material rather than finished goods for some products.

A. SAFETY STOCK CALCULATION

The demand for the product needs to be considered while calculating the safety stock for the raw material. The demand for finished goods needs to be converted into an equivalent amount of raw material required for manufacturing. While considering this, the rejections due to quality and other issues are all considered. Table 8 shows the amount of inventory that needed to be maintained in case of raw material storage. It also shows the value of goods that are recommended.

Table 8: Safety Stock in Case of Raw Material

SKU	Tons Required per Week	Difference in Tons	Std. Dev	Lead Time	Safety Stock	Cost of Safety Stock
78	3.94	-0.10	2.886227639	11	5.596722768	289939.00650
128	0.32	0.05	1.195536428	2	0.480568185	29839.80496
133	0.59	0.04	0.851489948	4	0.799410141	4021.14547
153	0.56	0.10	2.08059549	16	8.525943261	388611.12970
178	0.98	0.05	1.169566624	9	2.26735438	128002.85670
181	7.01	4.93	118.585948	13	331.8885319	22932873.61000
187	15.98	7.53	178.5047369	13	507.535266	27935319.63000
189	0.29	0.05	1.039697784	13	3.085684871	159916.23560
201	0.43	0.06	1.280403806	14	4.494100775	257185.29820
202	3.82	2.41	45.85963004	12	149.8704912	7158294.24700
205	0.43	0.06	1.814915642	3	0.861529216	56061.21375
238	0.21	0.02	0.392510787	11	0.938378152	46086.30344
239	0.29	0.23	6.060138873	12	14.04683575	712882.53320
240	1.49	0.24	5.831519184	7	8.621702337	405412.96350
243	0.94	0.03	1.008431791	7	1.15453252	59529.44005
244	0.06	0.01	0.137543287	4	0.125134914	7007.30488
247	1.64	0.10	2.697608348	10	5.136668843	335826.52250
252	0.28	0.02	0.69545701	2	0.244483853	16028.50567
265	1.60	0.11	3.284397008	13	7.43837343	504779.92240
275	0.60	0.02	0.500856041	11	1.097484284	57598.53237
277	0.17	0.01	0.208352365	11	0.543273789	23047.30397
303	0.70	0.02	0.635465134	8	0.988149885	55306.99610
351	0.63	0.07	1.635995596	12	4.132169956	224204.76510
356	3.91	0.25	4.54551402	7	9.048514564	393343.27140

VI. SELECTION BETWEEN INVENTORY AS RAW MATERIAL OR INVENTORY AS FINISHED GOODS

Though the use of recommended stock level in spite of already used stock level results in savings in cost, further savings can be obtained by maintaining inventory as raw material for some products and as finished goods for some products. For this purpose, the final recommended stock value for finished goods is compared with the stock value of raw material. The value which is lower is selected and considered as optimum. The products with a value of inventory as raw material lower than the value of inventory as finished goods are recommended to use inventory as raw material. The remaining products are recommended to use inventory as finished goods.

Table 9 shows the value of inventory as raw material and the value of inventory as a finished good. It shows that for some products, it would be good to maintain inventory as raw material, and for others, it would be good to maintain inventory as finished goods.

Table 9: Value of Inventory as Raw Material Vs. Finished Goods

Cost of Safety Stock	Finished Goods Value	Difference
289939.0065	429257.32	139318.31
31802.95003	120876.02	89073.07
42300.03614	113273.05	73973.02
418125.8991	176712.03	-241413.87
124995.1696	145296.96	20341.79
22932873.61	11885779.40	-11047094.21
27572523.27	15731169.91	-11841353.36
148356.0258	95687.80	-52668.23
269882.8068	144147.22	-125738.59
7516208.959	4523431.80	-22992777.16
54082.58268	157233.76	103151.18
47299.1009	44127.82	-3171.28
739615.6282	552755.81	-186859.82
400281.1539	432728.00	35446.85
57983.22083	123052.07	65068.84
6677.549363	14641.17	7963.62
331780.4198	334158.09	2377.67
15434.85731	75253.67	59818.81
530018.9185	411567.23	-118451.69
56887.43938	72590.78	15703.34

VII. CONCLUSION AND RESULTS

The objective of the study on effective inventory management by determining the appropriate safety stock in an automobile manufacturing industry was carried out. The value of the total stock obtained using the above method is compared with the value of the actual maintained total stock. It is evident that there is a considerable amount of savings in case of money. The result reveals that the required service level can be obtained with a considerable amount of savings in the money. The total value of the stock is calculated based on the unit cost of the product and is compared with the actual value of the stock. The results obtained show that an overall savings of about Rs.75000 can be obtained.

VIII. REFERENCES

[1] Arthur V. Hill et al, Forecasting the forecastability quotient for inventory Management, International Journal of Forecasting. 25 (2015) 651-663.

[2] S. Nallusamy, R. Balaji and S. Sundar, Proposed model for inventory review policy through ABC analysis in the automotive manufacturing industry, International Journal of Engineering Research in Africa. 29 (2017) 165-174.

[3] Qamar Iqbal, Don Malzahn, and Lawrence E. , Whitman Selecting a multi-criteria inventory classification model to improve customer order fill rate, Advances in Decision Sciences (2017) 01-11.

[4] Philipp Moser, Inventory dynamics in process industries: An empirical investigation, International Journal of Production Economics. 191 (2017) 253–266.

[5] M.B. Jeddou, Multi-criteria ABC inventory classification, a case of vehicles spare parts items, Journal of Advanced Management Science. 2(3) (2014) 181-185.

[6] J. Park, Bae and J. Bae, Cross evaluation based weighted linear optimization for multi-criteria ABC inventory classification, Computers and Industrial Engineering, 76(1) (2014) 40-48.

[7] Camelia Burja and Vasile Burja, Analysis model for inventory management, Annals of the University of Petrosani, 10(1) (2010) 43-50.

[8] A. Bacchetti, F. Plebani, Saccani and Syntetos, Empirically driven hierarchical classification of stock-keeping units, International Journal of Production Economics. 143 (2013) 263-274.

[9] Petropoulos, Wang and Disney, The inventory performance of forecasting methods: Evidence from the M3 competition data, International Journal of Forecasting. 35(1) (2019) 251-265.

[10] Mario Di Nardo, Mariano Clericuzio, Teresa Murino, and Chiara Sepe, An economic order quantity stochastic dynamic optimization model in a logistic 4.0 environment Sustainability, 12 (2020) 01-25.

[11] K. Balakannan et al, Performance evaluation of supply chain and logistics management system using balanced scorecard for efficiency enhancement in Indian automotive industries, Indian Journal of Science and Technology.9(35) (2016) 1-9.

[12] Lalith Goonatilak, Inventory management in the manufacturing sector in developing countries, Engineering Costs and Production Economics.19 (2008) 19-24.

[13] Jianhu Cai et al., Optimal inventory decisions under vendor managed inventory: Substitution effects and replenishment tactics, Applied Mathematical Modelling, 43 (2017) 611-629.

[14] X. Hong, W. Chunyuan, L. Xu and A. Diabat, Multiple-vendor, multiple-retailer-based vendor-managed inventory, Annals of Operations Research, 238(1-2) (2016) 277-297.

[15] Jayalal Wettasinghe and Huynh Trung Luong, A vendor managed inventory policy with emergency orders, Journal of Industrial and Production Engineering, 37(2-3) (2020) 120-133.