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SELECTION OF PRODUCTION PLANNING FORECASTING METHOD FOR V-BELT DRIVE MANUFACTURING COMPANY USING TOPSIS : CASE STUDY

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ABSTRACT

In Present days, supply chain, forecasting is captious for organizations to ensure the availability of the proper quantity of inventory to satisfy customers with minimum paucity. Without proper forecasting, it is very difficult to plan effectively and efficiently. After going through the literature, it is to be noted that there is no recommendation of a specific method that is best for forecasting. This is also owed to the availability of many alternative forecasting methods and criteria of preferences. Therefore, this paper proposes a ranking of forecasting methods for production planning in a supply chain. The proposed model is based on the TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) since it has been proven useful in multi-criteria decision-making in many industrial and real life applications. It considers seven popular methods such as Decomposition(D), Winter Exponential(WE), Double Exponential(DE), Single Exponential(SE), Trend Analysis(TA), Five Months Moving Average(FMMA) and 12 months moving average and three preference criteria (MAD, MSD and MAPE). The model is tested using a real case study. Finally the ranking of forecasting methods are determined.

Keywords *– forecasting methods; production planning; supply chain management (SCM); Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)*

INTRODUCTION

Proper production planning and control is quite arduous in present days due to high competition in the business environment, customer expectations and proliferation. Furthermore, due to globalization, new customers have more preferences as compared to the past. Monroe et al. (2014) [13] mentioned that within the broader supply chain risk management research, supply chain management disruptions have become a matter of interest for academic researchers since the last decade. This interest has been motivated by real world events which have caused major disruptions around the world in global supply chains for many major companies. If your commodity will not conform to customer demands in terms of Service, availability, quality and price, you will lose customers and market stake. Business success relays primarily on proper planning, quick response due to market change and intuition of the upcoming changes in customer demand. To effectuate all these requirements, adequate forecasting will play a crucial role. Moreover, quite often companies escape the emanation of wrong forecasting. Pertinent forecasting method will allow executive to remain competitive in market and maintain adequate market stake.

LITERATURE REVIEW

In accede to Acar and Gardner (2012)[1], in supply chain management, forecasting is an important tool of operational performance if the forecasting is up to the mark and were able to predict the change in advance, the product and organization will be remain competitive and keep an required market stake.

Forecasting models for product forecasting poses several challenges to computer-human interaction research, from the difficulties of issues in the supply chain context and the organizational aspects of using forecasting information and knowledge, to the more common user interface aspects of designing effective visualizations and embedding relevant knowledge into designs [6]. As supply chain management for high technology products escalates in complexity, and as the attainment expectations of these supply chains also increase, forecasting of parts demands have become imperative to effective operations planning management in these markets [14]. This shows that forecasting and forecasting method selection is decisive in any operations management.

PROBLEM STATEMENT

In every forecasting method, errors sport a vital role on the output of the forecast. We considered widely used forecasting errors in our paper as our dominant criteria and according to that, we rank the forecasting methods. In forecasting, error accuracy is decisive. The major criteria to be considered in these paper are the most common measures of forecasting accuracy that are mean absolute percentage error (MAPE), mean absolute deviation (MAD) and mean square deviation (MSD)(Stevenson, 2012). Consequently, we believe that this study will be the origin in the field of production planning forecasting methods. The forecast data of 72 months is collected from a V-belt manufacturing industry as shown in table- 3.1 in a supply chain management *F. Dweiri et al.*[12]Earlier, where the best forecast method is determined using Analytical Hierarchical Process (AHP) and sensitivity analysis is performed. This paper implements TOPSIS to find the best forecasting methods with respect to its errors as shown in table -5.1 .

Year 1	***Sales***	***Year 2***	***Sales***	***Year 3***	***Sales***	***Year 4***	***Sales***	***Year 5***	***Sales***	***Year 6***	***Sales***
1	1800	13	1850	25	2400	37	1700	49	2200	61	1900
2	1300	14	1800	26	2500	38	1850	50	1800	62	1900
3	1700	15	1900	27	1800	39	2100	51	2100	63	2000
4	1750	16	1950	28	1700	40	2150	52	1750	64	2400
5	2000	17	2000	29	1850	41	2800	53	2300	65	2800
6	220	18	2400	30	2100	42	2900	54	2550	66	2600

	0										
7	2400	19	2800	31	2150	43	2800	55	3100	67	3500
8	2350	20	2650	32	2800	44	2700	56	3150	68	3200
9	2100	21	2500	33	2600	45	2750	57	2800	69	2900
10	2400	22	2600	34	2400	46	2600	58	3000	70	3250
11	2450	23	2500	35	2500	47	2650	59	3100	71	2800
12	2200	24	2600	36	1800	48	2250	60	2850	72	3000

Table-3.1: SALES DATA

TOPSIS METHODOLOGY

TOPSIS Method TOPSIS was first introduced by Yoon (1980) and Hwang and Yoon (1981), for solving Multiple Criteria Decision Making (MCDM) problems based on the concept that the chosen alternative should have the shortest Euclidian distance from the Positive Ideal Solution (PIS) and the farthest from the Negative Ideal Solution (NIS). For instance, PIS maximizes the benefit and minimizes the cost, whereas the NIS maximizes the cost and minimizes the benefit. It assumes that each criterion require to be maximized or minimized. TOPSIS is a simple and useful technique for ranking a number of possible alternatives according to closeness to the ideal solution. The TOPSIS procedure is based on an intuitive and simple idea, which is that the optimal ideal solution, having the maximum benefit, is obtained by selecting the best alternative which is far from the most unsuitable alternative, having minimal benefits [3]. The ideal solution should have a rank of =1‘ (one), while the worst alternative should have a rank approaching =0‘ (zero). Mathematically the application of the TOPSIS method involves the following steps. TOPSIS (technique for order preference by similarity to ideal solution) method was firstly developed by Hwang and Yoon in 1981. The basic approach of this method is choosing an alternative that should have the shortest distance from the positive ideal solution and the farthest distance from negative ideal solution. The positive ideal solution maximizes the benefit criteria and minimizes conflicting criteria, whereas the negative ideal solution maximizes the conflicting criteria and minimizes the benefit criteria. For the calculation of TOPSIS values, we have to go through the following steps

Step 1: In the first step, we have to determine the objective and to identify the attribute values for each alternative.

Step 2: This step involves the development of matrix formats. The row of this matrix is allocated to one alternative and each column to one attribute. The decision making matrix can be expressed as:

$$D = \begin{vmatrix} X_{11} & X_{12} & X_{13} & X_{14} & X_{15} \\ X_{21} & X_{22} & X_{23} & X_{24} & X_{25} \\ X_{31} & X_{32} & X_{33} & X_{34} & X_{35} \\ : & : & : & : & : \\ X_{m1} & X_{m2} & X_{m3} & X_{m4} & X_{mn} \end{vmatrix}$$

Step 3: Then using the above matrix to develop the normalized decision matrix with the help of the formula given below:

$V_{ij}^* = x_{ij} / (\Sigma x_{ij})$ for i = 1, …, m; j = 1, …n

Step 4: Depending upon the relative importance of different attributes obtain weight for each attributes using the formula given below and the sum of the weights should be 1. Where V_i, W_{ij} are the variance and weight of each attribute which can be calculated by the formula given as

$V_i = (V_{ij}^* / V_{ij}^*{}_{\mathbf{mean}})$

Weights of alternatives $W_{ij} = V_i / TW$

Step-5: Weighted Normalized Matrix **V**= $W_{ij} * V_{ij}$

Step 6 : This step determines the ideal (best) and negative ideal (worst) solutions. The ideal and negative ideal solution given as:

(a) The Ideal solution $A^+=\{V_1^+,\ldots\ldots, V_m^+\} = \{(\max V_{ij} \setminus J \in I'),(\min V_{ij} \setminus J \in I'')\}$

(b) The negative ideal solution $A^-=\{V_1^-,\ldots\ldots, V_m^-\}$

$= \{(\min V_{ij} \setminus J \in I'),(\max V_{ij} \setminus J \in I'')\}$ Here, I'={j=1,2,…n|j }: Associated with the beneficial attributes $I^{''}$= {j=1,2,…n|j }: Associated with non-beneficial adverse attributes

Step 7: Obtain separation (distance) of each alternative from the ideal solution and negative ideal Solution which is given by the Euclidean distance given by the equations.

$$D_i^* = \sqrt{\sum_{j=1}^{m}(V_{ij} - V_j^*)^2}, \quad i=1,\ldots\ldots,n.$$

$$D_j' = \sqrt{\sum_{j=1}^{m}(V_{ij} - V_j')^2}, \quad i=1,\ldots\ldots,n.$$

Step 8: Calculate the relative closeness to the ideal solution of each alternative which is given by the formula :

$$C_i^* = \left[\frac{\mathbf{Di'}}{(\mathbf{Di*}+\mathbf{Di'})}\right], \quad i=1,\ldots\ldots\ldots, n$$

Step 9: A set of value is generated for each alternative. Choose the best alternative having largest closeness to ideal solution. Arrange the alternative as an increasing order of C_i^*.

NUMERICAL EXAMPLE

For a company that wants to select the Production Planning Forecasting Method, suppose the following criteria and alternatives are the most important parameters to focus: Mean Absolute Deviation (MAD), Mean Square Deviation (MSD), Mean Absolute Percentage Error (MAPE), and Decomposition(D), Winter Exponential(WE), Double Exponential(DE), Single Exponential(SE), Trend Analysis(TA), Five Months Moving Average(FMMA) and 12 months moving average) are the criteria. After consideration following decision matrix is obtained table 5.1.

Step 1, 2: Establish the Decision Matrix

Table-5.1: The performance criteria values for the alternative forecasting methods

	ALTERNATIVES							
S.NO	**ATTRIBUTES**	**TA**	**5MMA**	**12MMA**	**SES**	**DES**	**WES**	**DM**
1	MAPE	15	17	16	11	11	6.1	4.6
2	MAD	342	393	376	253	261	150.4	105.4
3	MSD	16102	238668	182492	102579	113097	33701	19238.5
	SUM	16459	239078	182884	102843	113369	33857.5	19348.5

Step 3: Normalized Decision Matrix $V_{ij}^{*} = x_{ij} / (\Sigma x_{ij})$ for i = 1, …, m; j = 1, …n

$X_{ij}*_{\mathbf{mean}} = 0.333333$

Normalized Decision Matrix								
S. N O	**ATTRIB-UTES**	**TA**	**5MMA**	**12MMA**	**SES**	**DES**	**WES**	**DM**
1	MAPE	0.0009	7.1106E-05	8.7487E-05	0.00016	9.7028E-05	0.0018	0.0002
2	MAD	0.0207	0.0016	0.0020	0.0024	0.0023	0.0044	0.0054
3	MSD	0.9783	0.9982	0.9978	0.9975	0.9976	0.9953	0.9943
	Xij*mean	0.3333	0.3333	0.3333	0.3333	0.3333	0.3333	0.3333

Table-5.2: : Normalization Matrix (V_{ij}*)

Step-4: Variance (V_j) , V_i= (V_{ij}*/ $V_{ij}*_{mean}$)

VARIANCE (Vj)								
S.NO	**ATTRIBUTES**	**TA**	**5MMA**	**12MMA**	**SES**	**DES**	**WES**	**DM**
1	MAPE	0.1105	0.1110	0.1110	0.1110	0.1110	0.1109	0.1109
2	MAD	0.0976	2.702E-06	0.1097	0.1094	0.1095	0.1081	0.1075
3	MSD	0.4159	0.9965	0.4415	0.4410	0.4412	0.4383	0.4368
AVERAGE		0.2080	0.3692	0.2207	0.2051	0.2206	0.2191	0.2184

Table-5.3:Variance of each Attribute

Total Weight (TW) = Sum of Averages = 1.676821

Weights (W_{ij}) = V_i / TW

TA	**5MMA**	**12MMA**	**SES**	**DES**	**WES**	**DM**
0.124082	0.220186379	0.131675469	0.13150782	0.1315742	0.130696	0.130278

Table-5.4: Weightages of individual Alternatives

Step-5: Weighted Normalized Matrix **V**= W_{ij}* V_{ij}

S.NO	**ATTRIBUTES**	**TA**	**5MMA**	**12MMA**	**SES**	**DES**	**WES**	**DM**
1	MAPE	0.0137	0.02445	0.01462	0.0146	0.01461	0.01450	0.0144
2	MAD	0.0121	5.949E-07	0.01445	0.0143	0.01441	0.01413	0.0140
3	MSD	0.0516	0.21943	0.05814	0.0579	0.05805	0.05728	0.0569
MAX		0.0516	0.21943	0.05814	0.0579	0.05805	0.05728	0.0569
MIN		0.0121	5.949E-07	0.01445	0.0143	0.01441	0.01413	0.0140

Table-5.5: Weighted Normalized Matrix

Step-6 : Positive and Negative Ideal Solution

Positive Ideal solution $D_i^* = \sqrt{\sum_{j=1}^{m} (V_{ij} - V_j^{*})^2}$, i=1,…….,n.

Negative ideal solution. $D_j^{'} = \sqrt{\sum_{j=1}^{m} (V_{ij} - V_j^{'})^2}$, i=1,…….,n.

	TA	**5MMA**	**12MMA**	**SES**	**DES**	**WES**	**DM**
D^*_i (POSITIVE)	0.0547	0.29354	0.06167	0.06151	0.061578	0.06075	0.0603
D'_J(NEGATIVE)	0.0395	0.22078	0.04369	0.04360	0.043639	0.04314	0.0429

Table-5.6: Positive and Negative Ideal Solution

Step-7: Relative Closeness to the Ideal Solution

$$C_i^* = D'_J / (D_i^* + D'_J) \ , \qquad 0 < C_i^* < 1$$

C_i^*	0.4193	0.4292	0.4146	0.4147	0.4147	0.4152	0.4154
RANKING	**6**	**7**	**1**	**3**	**2**	**4**	**5**

Table-5.7: Relative Closeness to the Ideal Solution

Step-8: Ranking of Forecasting Methods

Forecasting Method according to Preference ranking	**Ranking**
Trend Analysis	6
5 Months Moving Average	7
12Months Moving Average	1
Single Exponential Smoothing	3
Double Exponential Smoothing	2
Winters Exponential Smoothing	4
Decomposition Method	5

Table-5.8: Final Rankings of Forecasting Methods

CONCLUSION

Usually the administrators face difficulties in electing the suitable forecasting method due to the availability of many methods and multiple decision criteria methods. Companies cannot incur to plan their business based on awry forecasting. The selection of the appropriate forecasting method is of considerable importance for any business particularly in production. This paper applied the proposed model via a real case study. Where multi-criteria decision making method (TOPSIS) is applied to evaluate the best forecasting method and the ranking of forecasting methods are enlisted in table 5.8. The elaborative conclusion of present analysis after conducting and analyzing the resulting data is

1) 12MMA method is the suggested as best forecast method with minimum forecast error
2) 5 MMA method is the least preferred forecast method beside with Maximum forecast error
3) If the data available is less than the 12 months then the priority is opted to its succeeding Forecasting methods.

FUTURE SCOPE

For future work, it is suggested to integrate TOPSIS with the fuzzy decision-making in tools or any multi criteria decision making methods to select the appropriate forecasting method. Moreover, similar approach can be used in different manufacturing sector to validate the results obtained in this study. This Method is proven to be efficient and effective in V-Belts manufacturing company.

Therefore, it is suggested that similar approach can be implemented in different manufacturing companies such as automotive, food industry etc. for completeness, consistency and accuracy of the prospective method. Also, using the ranking of production planning forecasting method obtain in this study can be used to develop an integrated forecasting method

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