New developed method of demand normalization improves spare part forecasting

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Abstract
Spare part inventory will be forecasted at higher level if historical demand has spike in few of the months. These few months spiked order lines need to be removed or streamline if it is not genuine for better forecasting. But, in spare part inventory forecasting, number of parts & order lines are very high. It is not practical to remove these order lines one by one. These order lines have been generated mainly due to retro fitment, filed fix, one-time order etc. Means these demands are less probable to generate once again.
In this paper, researcher has shown new method of demand normalization which help to streamline the data instead of removing spiked order lines one by one. New method of demand normalization helps to improve the forecasting.
Researcher has applied new method on spare part inventory data which was received from one of the large automobile company & result of it shown improvement in forecast accuracy. Researcher mainly done the experiment on fast and medium mover parts as per company requirement.

Keywords: Spare part, Forecasting, Standard deviation, Average, Spike etc.

Introduction
4.04 million automobiles exported in FY18. Indian automobile industry is focusing on vehicle export sale to increase it by 5 times till 2026. IBEF automobile industry report (Mar 2019), in 2017-18, spare part business is reached to US$ 51.20 billion. By 2020, spare part business turnover is expected to reach up to US$ 100 billion. In 2017-18 Spare part export is reached to US$ 13.50 billion. In 2018-19, there is growth of 14% in it. By 2026, spare part export business is expected to reach at US$ 80 billion. IBEF auto component industry report (Mar 2019).

Above figures shows that, spare part is the focus area in organizations. There are large investments in spare part inventory management. Right part at right quantity to be kept in inventory, else companies will be ended up with large inventory in hand. In spare part inventory management, inventory planning is the main core area. There are various statistical inventory planning methods already available. These methods forecast the demand based on previous demand periods.

It is most important that, demand history provided to these methods should be accurate one, else forecast will not be accurate. But, many times due to large number of part lines and a greater number of orders in spare parts, this activity becomes difficult. Many times, other types of orders routed through spare part to serve the company one time need e.g. field fix issues i.e. retro fitment orders get placed through spare part order. Or many times, there are spikes in order due to design or manufacturing defects which later gets corrected. But, these one times abnormal demand dilute the spare part demand and hence statistical method forecast error increases.

In this research paper, researcher shows how to streamline the abnormal demands periods & it effect on forecasting error percentage. This research is practical oriented as it also shows the impact on inventory and part availability which are the main supporting factor for management decision.

The remaining paper is arranged as below - section 2 refers to literature review. Section 3 focuses on research methodology. It talks about detailed procedure used in current research as well as the overview of selected organization. Section 4 mentioned the result of new demand normalization method against current method. Section 5 refers to conclusion, limitation and future scope.

Literature Review
Even after importance of forecasting in spare part, most researcher gives more focus to inventory modelling Hua H (2006). As per Andrea (2012), recently focus of forecasting method is given more to lumpy demand. There is a need of classifying the demand for forecasting.

Classification of Demand for Forecasting Purpose
Syntetos (2010) develops the framework which classifies the 3 stages of forecasting i.e. pre-processing, processing, post processing. Pre-processing classifies the items. It segregates the items e.g. rules that defines the slow-moving demand. In processing stage, actual forecasting method used to forecast the part. In post processing stage, forecast user makes an adjustment. Most of the research has focused on processing stage.

Kalchschmidt (2003) & (2006) develops the criteria which segregates the irregular demand and stable demand & then he applies the different forecasting method to different demand pattern. Verganti (1997) is collected early information about demand for forecasting from customer. Similarly, Fisher ML (1992) & (1994) collected the orders from customer for longer lead time to forecast the demand. It is called Early Sales method. But these two methods are not suited to durable consumer goods industry. As per Andrea (2012), these two methods unlikely for spare part due to a greater number of customers and items. Also, in

spare part, demand triggers by unexpected product failures. So, these hypothesis of two methods cannot be considered.

Keyes (2009) identified that, classification of spare parts may improve spare part availability & reduces cost of inventory. It significantly improves the decision making & helps to manage inventory in better way.

Mainly previous researcher has classified demand by mix of two ways

1. Coefficient of variance i.e. standard deviation divided by average demand &
2. Average inter demand interval. i.e. average interval between two demand of spare part. These is done for classifying the slow mover demand & use of forecasting method accordingly. Prof. Maurizio Faccio (2010), Ghobbar & Friend (2002), Syntetos & Boylan (2005), Eaves (2004).

Performance assessment of forecasting quantity vs actual demand:

This is very important step as this will finalise the selection of appropriate forecasting method.

Forecasting Error

This is a classical approach used in measuring the forecasting error. This is suitable for the objective of minimising the error. In this, researchers are analysing the tendency of overestimates or underestimates the demand. Mean squared error is a theoretically traceable measure, which is used for analytical investigation & evaluation of two strategies Ali et al., (2015).

Table 1: Forecasting error calculation methods Andrea (2011)

Measures of Distortion- This considered the error sign.	Mean Error (ME)	$\frac{1}{N}\sum_{i=1}^{n} ei$
	Mean Percentage Error (MPE)	$\frac{1}{N}\sum_{i=1}^{n} ei\,/Di * 100$
Measures of dispersion- This is not account the sign of error	Mean Absolute Percentage Error (MAPE)	$\frac{1}{N}\sum_{i=1}^{n} \lvert ei\rvert\,/Di * 100$
	Mean Absolute Deviation (MAD)	$\frac{1}{N}\sum_{i=1}^{n} \lvert ei\rvert$
	Mean Square Error (MSE)	$\frac{1}{N}\sum_{i=1}^{n} (ei) \wedge 2$

Generic indicator of forecasting error is divided into below categories: Error ei = Actual – forecast qty

Christopher (2007) collected the data from 18 spare part managers and he mapped the top 10 critical challenges of spare part inventory management. Out of 10 critical challenges, "inaccuracy of spare parts forecast" is second amongst them. Demand for spare part is highly volatile & it significantly complicate the forecast process. It also affected due to inaccurate maintenance of part data as well as old part to be supplied in spare part.

First Fill Ratio (FFR) / Service level / Part Availability

This is a more common method being used by practitioners as it is directly related to customer satisfaction. The fraction of total demand that can be dispatched from stock. Example, if customers' orders 100 lines and out of which 95 lines delivered in full qty then FFR is 95%.

Inventory Value

This is the management interest to know the investment in inventories. Andrea (2011).

Research Methodology

Objective of this study is to improve forecasting accuracy by streamlining excess demand periods. Mainly by streamlining those demand periods which shows abnormal demand.

First, researcher collected 27 months order lines data from one of the large automobile company. Then, researcher chosen old 24 months data from that & classified the item in fast mover, medium mover, slow mover category. These classifications are done based on order frequencies i.e. order lines received. For fast mover, researcher considered top 60% items, for medium mover researcher considered 60 to 80% items & for slow mover 80 to 100% demand frequencies items.

Researcher chosen fast mover & medium mover category & sorted out the part lines which has abnormal demand. Segregation of these abnormal demand is done based on standard deviation / average quantity value. Researcher finalize the greater than 1.5 value to segregate the abnormal demand. 1.5 value is set based on discussion with company and researcher's 10 years' experience in spare part business.

Now, for segregated line items below procedure is done to streamline the demand from 24 months demand quantity. In this, researcher replaced max demand quantity by average demand quantity & checked the abnormality again. If still demand is abnormal, then this procedure is done again till 3 iteration. 3 iteration is set based on business input as company projects 3 times there is possibility that demand has placed wrongly & due to which abnormality is appeared. Step by step procedure followed as below & example given after it.

1. Chosen fast mover and medium mover category parts as described above.
2. From that, selected abnormal demand parts as described above.
3. 24 months demand quantity is placed in sequence in front of each part number.
4. Out of last 24 months demand quantity, researcher replaced max quantity by average demand quantity.
5. Now, researcher has new 24 months data with him.
6. Checked standard deviation / average quantity value. If it is less than 1.5 then considered those 24 months for further forecasting quantity (24 months demand received from step 5).
7. If standard deviation / average quantity value is more than 1.5, then again researcher replaced max quantity

by average demand quantity in 24 months demand received from step 5. Note, now this is second time researcher replaced max quantity by average quantity. First, it was done in step no.4.

8. Now, again researchers have 24 months data. This is second time.
9. Again, Checked standard deviation / average quantity value. If it is less than 1.5 then considered those 24 months for further forecasting quantity (24 months demand received from step 8).
10. If standard deviation / average quantity value is more than 1.5, then again researcher replaced max quantity by average demand quantity in 24 months demand received from step 8. Note, now this is third time researcher replaced max quantity by average demand on 24 months data. (previously done at step 4 & 7)
11. Now, researcher has 24 months modified data for these abnormal lines.
12. Researcher used weighted average forecasting method to forecast the quantity by using modified 24 months data for abnormal lines. For latest 6 months average quantity weight is given 70% & for previous 18 months average quantity weight is given 30%.
13. Researcher also forecasted the quantity based on original 24 months data.
14. Researcher checked the MSE i.e. mean square error for both the forecasted quantity.
15. Also, researcher checked the inventory value and % availability through simulation method i.e. by applying forecasted quantity on 25th to 27th month demand data.

Example – How demand is normalized in new method:

Below is the consumption of part. Actual order quantity for below part is mentioned in second column below. Standard deviation divided by average quantity value is 3.5 which is more than 1.5, so researcher replaced the average quantity in place of max quantity. Researcher done it for 3 replacement. It is seen from below table that; average order quantity is reduced from 331 to 29 due to max replacement. By seeing data there is abnormal quantity which increases the average demand quantity. It is highlighted in table below.

Table 2: New demand normalization method

Period	Actual order QTY	1st max replaced	2nd max replaced	3rd max replaced
	A) Avg = 331, B) SD = 1148, C) SD/Avg = 3.5	A) Avg = 114, B) SD = 371, C) SD/Avg = 3.3	A) Avg = 41, B) SD = 70, C) SD/Avg = 1.7	A) Avg = 29, B) SD = 35, C) SD/Avg = 1.2
1	5	5	5	5
2	5	5	5	5
3	50	50	50	50
4	0	0	0	0
5	0	0	0	0
6	40	40	40	40
7	0	0	0	0
8	95	95	95	95
9	20	20	20	20
10	50	50	50	50
11	60	60	60	60
12	5	5	5	5
13	5	5	5	5
14	5543	331	331	41
15	20	20	20	20
16	45	45	45	45
17	1865	1865	114	114
18	0	0	0	0
19	25	25	25	25
20	0	0	0	0
21	0	0	0	0
22	0	0	0	0
23	110	110	110	110
24	0	0	0	0

Avg – Average, SD– Standard Deviation

Company Profile
Industry: Automotive.
Vehicle type: 2 & 3-wheeler.
Age of organization: 75 years
Number of distributors place an order: 144
Number of orders receive in year: 2822
Number of order lines receive in year: 635615
Number of parts ordered in last 2 years: 20265
Total spare part business: INR 3690 Cr / annum
Fast & medium mover parts (contributes to 80% of business): 6745
Abnormal parts from fast & medium mover: 1168 (on these lines researcher applied new demand normalization method)
Volume: Very high
Software used for demand normalization & forecast – Microsoft excel office 365.

Result

Mean Square Error

Researcher checked the forecasting accuracy by Mean Square Error method. Also, researcher checked the impact on overall inventory level and availability of spare parts. Researcher calculated the mean square of next 3 periods of forecast and then considered the average of it to arrive final value. It is seen that mean square value is reduced by 29% percentage.

Table 3: Result of mean square error (MSE) is as below

MSE value before demand normalization (Old method)	MSE value after demand normalization (New method)	% reduction in MSE
1441161	1024880	29%

Inventory Value & Spare Part Availability

Forecasting value for both the methods given below. Company has reduced its inventory level by 47%. But reduction in inventory also decreases availability by 14%. But still, as MSE is low, company has reduced the risk of inventory pile up at their end.

Table 4: Inventory value & availability

	Value before demand normalization (Old method)	Value after demand normalization (New method)	% change
Inventory Value	INR 14.63 crore	INR 7.77 crore	47%
Part Availability in %	73%	59%	14%

Conclusion, Limitation & Future Scope

Result shown that, there is significant decrease in mean square error i.e. forecasting error after demand normalization through new method. Also, new method helps to reduce inventory value significantly. Key point in this study is that, selected organization is mainly concern about inventory value than spare part availability. As discussed with company officers, they supply parts to international distributors who mainly responsible for part availability in those countries. So, company doesn't want to increased inventory at company level.

Uniqueness of this research paper is, researcher segregated the abnormal demand lines to streamline it instead of applying different forecasting methods which previous researcher was done. After streamline, forecasting method shows improve performance through reduction in forecasting error.

New demand normalization model segregates the abnormal demand from past consumption and normalize the same. It is more logical that, if there is spike in few months, company should not increase their inventory level. New model reduces the risk of carrying higher inventory.

In this journal, researcher has not emphases only on forecasting error reduction, but also shown the impact on inventory and availability. It helps business to know the monitory effect on their business and impact on availability of spare part. As company main concern is to reduce the unnecessary inventory pile up, new method suits to them.

It is seen that, availability also reduces with reduction in inventory value. Still, it satisfies main objective of company.

Company is using average method for forecasting & they would like to check forecasting effect on this forecasting method only. But in future, this study can be checked on other forecasting methods. Also, effect of demand normalization can be checked in future on normal distribution forecasting method i.e. after addition of standard deviation.

Conflict of Interest: None.

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