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Analysis of an Economic Order Quantity and Forecasting Models for Transmission Plant

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Abstract

This report focuses on research done at XYZ Transmission Plant case lines. The study was conducted in order to develop a methodology for improving the manufacturer's ability to forecast and predict the variation of demand throughout the year. The current forecasting model is to simply look at historical data to determine how much demand for the 8 speed and 9 speed transmission case will be required on an annual basis. The current forecasting model in placed at XYZ transmission plant has brought problems due to ineffective forecasting that has resulted in product stock outs and loss of sales. Economic order quantity and forecasting guide to control and reduce the product stock outs. The forecasting method used is the rolling average method, which takes previous historical demand and calculates the average for the next forecasting period. CNC is a computer numerical control machine tool which uses a programmed control system of an automatic machine tool. This control system is able to handle with the programs which have logic control code or other symbols in accordance with procedures prescribed by the instruction. The purpose of this research is to develop the capability to integrate seasonality and other variation into a model, which will allow for more rigorous and accurate forecasting. The 8-speed case was less expensive to purchase and had a lower calculated EOQ, which could be due to the increased volumes of the 8-speed, which may lower total cost by producing in (greater) "bulk" quantities. The calculation for forecasting methods in order to reduce the company's products stock outs. The forecasting methods that calculated will help to determine the amount of products in the previous two years.

Keywords:
Moving Average, Forecasting, Order Quantity.

1. Introduction

Manufacturing is a methodology that focuses on reducing waste, increasing productivity, and improving quality and safety in a systematic and organized way. WCM engages the workforce to provide and implement suggestions on how to... Transmission plant completed and production began in 1956. FCA announced in May 2010 that it would invest $43 million to adapt the plant for production of the World Engine and improve processes for the 62TE transmission program. Then in June 2010, the Company announced that it would invest $300 million to produce a new, fuel-efficient eight-speed automatic transmission for future vehicles. An investment of an additional $85 million was announced in December 2010. In February 2013, the Company announced an investment of $212 million at the XYZ Transmission, Tomo Casting and Indiana Transmission I Plants for additional tooling and equipment to produce the eight- and nine-speed transmissions, which would add up to 400 new jobs. Production of the eight-speed transmission began in September 2012. FCA confirmed in December 2014 that it will invest an additional $266 million to increase capacity of the fuel-efficient Torque Flite eight-speed transmission. Production of the 42RLE ended in early 2012. Since 1974, XYZ has built more than 67 million transmissions. The 17-million four-speed milestone was achieved over a 25-year period from 1988 to December 2013. The plant began building the six-speed in 2006 and reached the three million mark in April 2014. In December 2014, XYZ achieved the

Bronze award level in World Class Manufacturing after demonstrating clear know-how and competence in the manufacturing methodology. World Class improve their jobs and their plants.

2. Literature Review

Bill Roach explains how the origin of the Economic Order Quantity began in his article, "Origin of the Economic Order Quantity formula; transcription or transformation?" published in 2005. Roach explains that the Economic Order Quantity (EOQ) has been a well-known formula that calculates the optimal economic order quantity. On the other hand, business disciplines study the EOQ in both operational and financial courses. In both disciplines, EOQ formulas have practical and specific applications in illustrating concepts of cost tradeoffs; as well as specific application in inventory (Roach 2005). (Piasecki 2001) As a result of bad data, companies have had bad experience with some inventory models, and that is one of the reasons they do not take advantage of the EOQ model.

3. CNC Background

In recent years, computer numerical control technology (CNC), is the key to automation of mechanical manufacturing and the core power factor of the development of automation and intellectualization of machinery manufacturing. So numerical control technology has a direct impact on national industrial development and the strengthening of comprehensive national strength. Therefore, to enhance the automation of the process of development of the traditional machinery manufacturing industry, and promote the core competitiveness of the industry, market and improve the standard of our industrial base, leaving open the effective application of numerical control technology in the machinery manufacturing.
CNC is a computer numerical control machine tool which uses a programmed control system of an automatic machine tool. This control system is able to handle with the programs which have logic control code or other symbols in accordance with procedures prescribed by the instruction. Decoding then allows the machine to operate by machining material. Compared with the ordinary machine tool, CNC machine tool has the following features:

- High machining precision, has the stable machining quality
- Can do multi-axis linkage, producing the parts with complex shape section;
- When machining parts change, generally only need to change the CNC program, which may save the production preparation time;
- The machine tool itself is under high precision and big rigidity, which can choose favorable processing amount and high productivity (usually 3 ~ 5 times of ordinary machine tool);
- The automation degree of machine tool is high, which can reduce labor intensity.

4. Problem Statement

The current forecasting model in placed at XYZ transmission plant has brought problems due to ineffective forecasting that has resulted in product stock outs and loss of sales. The forecasting method used is the rolling average method, which takes previous historical demand and calculates the average for the next forecasting period. By doing this method, variability is not taken into consideration due to the historical demand which can cause inaccurate forecasting results.

5. Methodology

In this project, we used EOQ calculation, forecasting and cost estimates to determine the best possible order quantity cost for the transmission plant.

5.1. EOQ Description

The formula for EOQ and description of all variables is listed below in Equation 1:

$$q = \sqrt{\frac{(2 * K * D)}{H}}$$

q= EOQ order quantity. An unfixed value that we are seeking to optimize.
D= annual demand of product in quantity per unit time.
K= product order cost.
H= Holding cost per unit as a fraction of product cost.
The relationship between the "q" value and the various costs which affect EOQ are show below in Figure 1, where the ideal EOQ (x-axis) and purchasing price (y-axis) is found by the intercept point between all associated total, ordering and carrying (holding) costs.

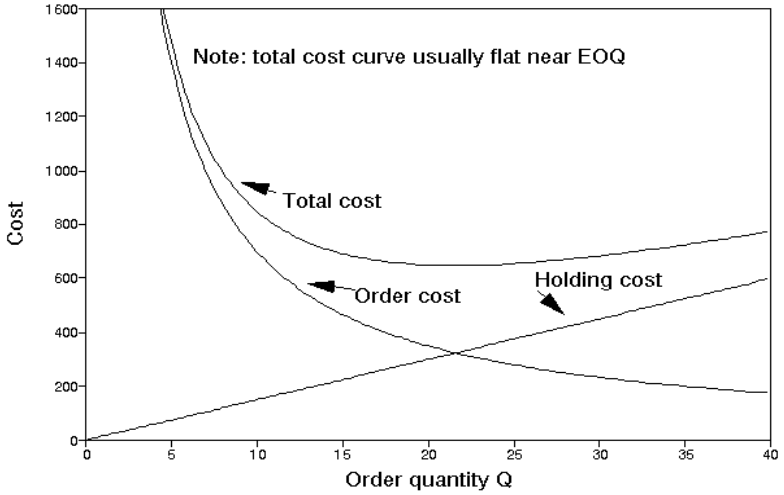

Figure 1: EOQ and Cost Relationship

5.2.Calculation of EOQ

Calculating EOQ reveals the optimal amount of costs that are affected both by the amount of inventories held and the number of orders made. Ordering in bulk at the same time will increase the costs of maintaining a small business, because that will increase the number of stocks in the warehouse, while ordering costs will be lowered. Increasing the number of orders reduces holding costs but increases the costs of ordering. The EOQ model finds the value that minimizes the amount of these costs.

5.3. Forecasting Description

Forecasting is the activity of estimating the quantity of a product or service that consumers will purchase. There are different forecasting methods that can assist in predicting the quantity of a product a consumer will purchase. Choosing what forecasting method to use from an organization's historical demand data can be quite challenging. The average demand of two periods can provide a better forecast than that of a single moving averages, known as the simplest forecasting method. A more detailed explanation of this simple method will be explained during the execution of this project. Extensive topic research was conducted to gain knowledge of the concepts used to complete the project. The essential material used was the forecasting techniques along with the economic order quantity methods. The methods used ensured that appropriate steps were taken to fully understand the concept in order to build an inventory control model for XYZ Transmission Plant. Moving averages consist of two simple techniques that involve simple moving average and weighted moving averages. For both moving averages, if the periods increase then the forecast becomes more stable in the calculations. *Simple moving Average:* in simple moving average, you are calculating the demand of the product base on the time period required (Quarter, weekly, daily). This is the average value of previous periods (period is a fixed amount. Ex. N=3) calculated over the periods length. For example: If you want to calculate the amount of product you will need in the Nth day then you could simply use equation 4 to calculate the amount.

$$F = \frac{\sum_{i=1}^{n} W * S_{i-1}}{n}$$

Where,
F= the forecast of the period you are trying to calculate.
S= the sales of the periods.
i= the periods.
n= the fix period amount.
W= the weighted percent in the period.
Seasonal Index: This forecasting technique makes seasonal adjustments. It determines if there is any forecasting trend that might have been labeled by the seasonality pattern. Once a pattern is determined, a single order polynomial equation called the "y-trend" (yt) is calculated to assist in determining the forecast for the desired quarter. Equation 3 is used to calculate the seasonal index forecasting model:
yt= axi+b
Equation 3: y-trend
Where,
yt= y-trend equation.
a=the steepness between units and demand (x-axis).
xi= quarter number we wish to calculate.
b= the average demand (y-axis).
Seasonal Index=demand/forecast
Equation 4: Seasonal Index
Expected Forecast= yt*(average seasonal index)
Equation 5: Expected Forecast

6. Data Collection

Two final assembled products were chosen from XYZ Transmission Plant software database that were considered to be high revenue level items. Two years' worth of historical data was obtain in order to see the products sales behavior due to its demand to help with establishing a forecasting trend for each product. Along with the products historical data, the product's ordering cost, purchasing cost and unit cost was collected to calculate the products total annual cost. The data also was used to establish the economic order quantity of each product. Tables 1 and 2 show data for demand through 24 months.

Table 1: Transmission Case Period (Monthly) Demand

Product #1		Actual			Actual
8 speed case					
Period	Months	Demand	Period	Months	Demand
1	Jan	6833	13	Jan	6884
2	Feb	6712	14	Feb	6593
3	Mar	6707	15	Mar	6866
4	Apr	6715	16	Apr	6839
5	May	6872	17	May	6774
6	Jan	6835	18	Jan	6761
7	Jul	6797	19	Jul	6622
8	Aug	6888	20	Aug	6888
9	Sep	6882	21	Sep	6848
10	Oct	6775	22	Oct	6770
11	Now	6819	23	Now	6683
12	Dec	6614	24	Dec	6839

Table 2: Transmission Case Period (Monthly) Demand

Product #2		Actual			Actual
9 speed case					
Period	Months	Demand	Period	Period	Demand
1	Jan	4111	13	Jan	4077
2	Feb	4175	14	Feb	4120
3	Mar	4201	15	Mar	4206
4	Apr	4084	16	Apr	4206
5	May	4139	17	May	4277
6	Jan	4222	18	Jan	4158
7	Jul	4151	19	Jul	4104
8	Aug	4280	20	Aug	4149
9	Sep	4074	21	Sep	4117
10	Oct	4241	22	Oct	4070
11	Now	4166	23	Now	4255
12	Dec	4079	24	Dec	4080

7. **Determination of EOQ**

In order to determine the EOQ, we need the annual demand data, the cost of purchasing a part and the cost of holding a part. For our study, we analyzed two transmission case CNC machines for the transmission plant which produce two different products, eight- and nine-speed transmission cases for vehicles. The data and results are shown below in Table 6.

Table 3: Variable

Variable	Meaning
K	Order cost
D	Annual demand
H	Holding cost
q	Economic order quantity
Type of cost	Meaning
Purchase COST	Qty* cost unit
Holding Cost	20%* unit cost
Ordering cost	K*(#annual order/# ordered at a

Table 4: Assumption

Number	Assumption
1	Daily shifts encompass an entire 24-hour period
2	Production of 2 machines from entire assembly plant Chosen
3	One machine produces 8spd trans case, other produces 9spd Trans cases
4	Factory report production period from one month in 2016
5	Each machine runs at the same efficiency level with identical availability
6	Price of each transmission unit is fixed ,$800
7	Holding cost uses 20% of purchase cost
8	Setup cost estimated
9	All cost and monetary values in USD (us Dollar $)

Machine 1 (8Speed)	CAS-010A1-40160-0
Machine 2 (9Speed)	CAS-010A1-40170-0

Table 5: Machine Production Counts

Machine	# produced in 1 Month
1 (8spd)	6953
2 (9spd)	4287
Machine	# Produced Annually
1 (8spd)	83436
2 (9spd)	51444

Table 6: EOQ Calculation

EOQ Machine one	
K	800
D	6953
H	160
q	26369
Purchasing Cost	5562400
Holding Cost	160
Ordering Cost	9600
Orders Per Year	12
EOQ Machine Two	
k	800
D	4287
H	160
q	20705
Purchasing Cost	3429600
Holding Cost	160
Ordering Cost	9600
Orders Per Year	12

8. **Forecasting Methods**

The calculation for forecasting methods that did in order to reduce the company's products stock outs. The forecasting methods that calculated will help to determine the amount of products in the previous two years. Based on that, then we can determine the amount of products in the next year. I used two kind of forecasting which are Moving Average Demand and the other one is Seasonal Index. Tables 7 and 8 illustrates the moving average for 8 and 9 speed transmission case.

Table 7: Moving average for 8 speed transmission case

Period (Quarter)	1	2	3	4	5	6	7	8	Forecast	MAD
Unit Demands	20252	20422	20567	20208	20343	20374	20358	20292		
Forecast (n=2)			20337	20494	20387	20275	20358	20366	20325	122
Forecast(n=3)				20413	20399	20372	20308	20358	20341	75

Forecast(n =4)					20362	20385	20373	20320	20341	18
Forecast(n =5)						20358	20382	20370	20315	39
Forecast(n =6)							20361	20378	20357	44
Forecast(n =7)								20360	20366	68
Forecast(n =8)									20352	

From table 7, the company needs to order 20341 units to meet the demand for the next quarter. The minimum MAD that we got is 18 for 4 quarters. Figure 1 illustrates the product behavior over 8 quarters.

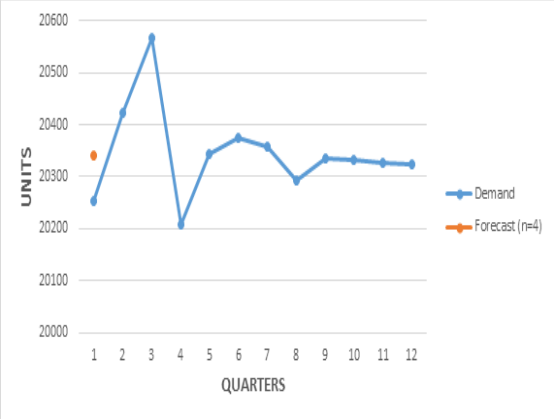

Figure 2: Moving Average Demand for 8 speed

Table 8: Moving average for 9 speed transmission case

Period (Quarter)	1	2	3	4	5	6	7	8	Forecast	MAD
Unit Demands	12487	12445	12505	12486	12403	12641	12370	12405		
Forecast (n=2)			12466	12475	12495	12444	12522	12505	12387	98
Forecast(n=3)				12479	12478	12464	12510	12471	12472	93
Forecast(n=4)					12480	12459	12508	12475	12454	117
Forecast(n=5)						12465	12496	12481	12461	126
Forecast(n=6)							12494	12475	12468	97
Forecast(n=7)								12476	12465	71
Forecast(n=8)									12467	

From table 8, the company needs to order 12465 units to meet the demand for the next quarter. The minimum MAD that got is 71 for 7 quarters. Figure 2 illustrates the product behavior over 8 quarters.

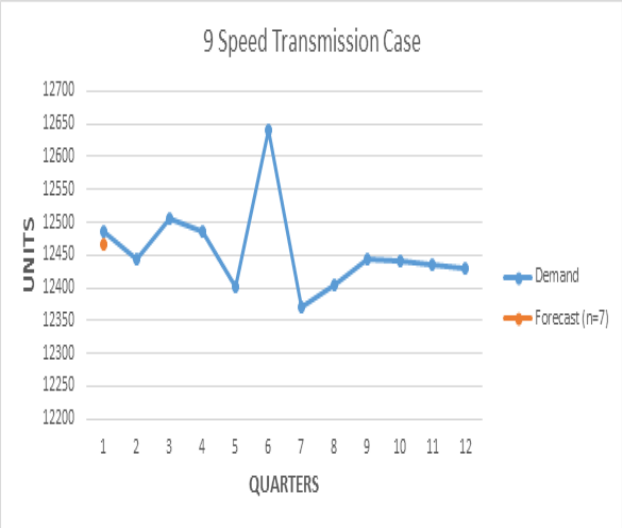

Figure 3: Moving Average Demand for 9 speed

Seasonal Index:

Table 9: Seasonal Index for 8 Speed Transmission Case

Year	Quarters	Demands	Forecast	Seasonal Index	Average Seasonal Index
2014	1	20252	20365.35	0.99	Quarter 1= 1.00
	2	20422	20361.54	1.00	Quarter 2= 1.00
	3	20567	20357.72	1.01	Quarter 3= 1.01
	4	20208	20353.91	0.99	Quarter 4= 0.99
2015	1	20343	20350.09	1.00	
	2	20374	20346.28	1.00	
	3	20358	20342.46	1.00	
	4	20292	20338.65	1.00	
2016			20334.83		

From table 9, it was obvious that the forecasting for the next year which is 2016 for 8 speed transmission product to avoid the company's products stock outs and can manage the amount of products every month. So, the forecasting for 2016 is about 20335.

Seasonal Index = Demands / Forecast …….(Equation 1)
Average Seasonal Index = Seasonal Average / Overall Average…….(Equation 2)

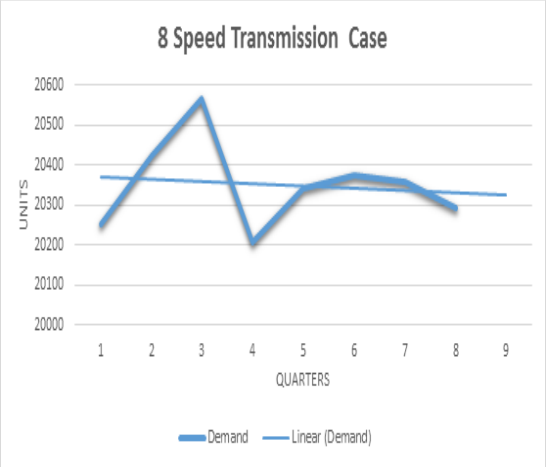

Figure 4: Seasonal Index for 8 Speed Transmission Case

Table 10: Seasonal Index for 9 Speed Transmission Case

Year	Quarters	Demands	Forecast	Seasonal Index	Average Seasonal Index
2014	1	12487	12485.38	1.00	Quarter 1= 1.00
	2	12445	12480.35	1.00	Quarter 2= 1.01
	3	12505	12475.31	1.00	Quarter 3= 1.00
	4	12486	12470.27	1.00	Quarter 4= 1.00
2015	1	12403	12465.23	1.00	
	2	12641	12460.19	1.01	
	3	12370	12455.15	0.99	
	4	12405	12450.12	1.00	
2016			12445.08		

From table 10, it was obvious that the forecasting for the next year which is 2016 for 9 speed transmission product to avoid the company's products stock outs and can manage the amount of products every month. So, the forecasting for 2016 is about 12446.

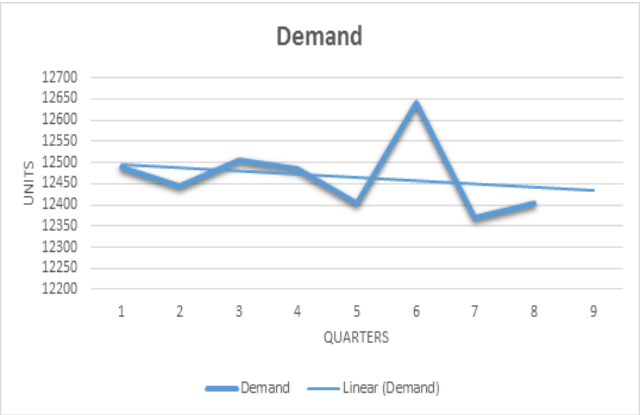

Figure 5: Seasonal Index for 9 Speed Transmission Case

9. Cost Estimates

Holding, ordering and purchasing cost were all based on several assumptions: price of each transmission case unit is fixed at $800, holding cost is based on 20% of the purchase cost, ordering cost is based on twelve orders per year, as the annual production value was determined by extrapolating the monthly production data for another eleven months to complete a year.

10. **Results and Discussion**

From the calculations, the optimal purchasing cost for the 8-speed transmission case from Machine 1 was approximately $5,562,400 for one year. For the 9-speed case from Machine 2, the optimal purchasing cost was $3,429,600. The optimal EOQ for Machine 1 was $263.69, while Machine 2 was $207.05. The 8-speed case was less expensive to purchase and had a lower calculated EOQ, which could be due to the increased volumes of the 8-speed, which may lower total cost by producing in (greater) "bulk" quantities. The calculation for forecasting methods in order to reduce the company's products stock outs. The forecasting methods that calculated will help to determine the amount of products in the previous two years. Based on that, it can determine the amount of products in the next year. It used two kind of forecasting which are Moving Average Demand and the other one is Seasonal Index. From table 4, the company needs to order 20341 units to meet the demand for the next quarter. The minimum MAD that got is 18 for 4 quarters. Figure 1 illustrates the product behaviour over 8 quarters. From table 5, the company needs to order 12465 units to meet the demand for the next quarter. The minimum MAD that got is 71 for 7 quarters. Figure 2 illustrates the product behavior over 8 quarters.

11. **Conclusion**

Understanding economic order quantity and the forecasting model will help company to reduce their stock outs. The recommended model provides two different forecasting techniques which will be more accurate in forecasting the end result for different product. The optimized order quantity for each transmission case will reduce the company's product stock out issue.

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Biography

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