Analysis of an Economic Order Quantity and Reorder Point Inventory Control Model for Company XYZ

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Abstract

As a result to today's uncertain economy, companies are searching for alternative ways to stay competitive. In which, Company XYZ has been faced with an ineffective forecasting method that has lead to multiple product stock outs. The issue faced has caused sales loss as well as profit loss, which companies can not afford to lose if they want to stay competitive. This project goes through the process of analyzing the company's current forecasting model and recommending an inventory control model to help them solve their current issue. As a result, an Economic Order Quantity (EOQ) and a Reorder Point was recommended along with two forecasting techniques to help them reduce their product stock outs.

In addition, a cost estimate was done to compare both their current and the recommended models. As a result, Company XYZ would able to reduce their overall total cost from $13,654 to $5,366. This was a cost reduction of approximately 61%, which summed to a total saving of about $8,300 per quarter.

It is highly recommended that Company XYZ implements the inventory control model provided in order to reduce stock out and back orders. By doing so, the company could also reduce the total cost associated with their inventory. If the methods are used effectively, the company could remain competitive among their industry.

Introduction

With today's uncertain economy, companies are searching for alternative methods to keep ahead of their competitors by effectively driving sales and by cost reduction. Big retail companies do not stand a chance in today's environment if they do not have an appropriate inventory control model intact. The Economic Order Quantity and a Reorder Point (EOQ/ROP) model have been used for many years, but yet some companies have not taken advantage of it. An Economic order quantity could assist in deciding what would be the best optimal order quantity at the company's lowest price. Similar to EOQ, the reorder point will advise when to place an order for specific products based on there historical demand. The reorder point also allows sufficient stock at hand to satisfy demand while the next order arrives due to the lead time.

Since retail can be unpredictable and competitive, the interest of seeing how forecasting can affect the economic order quantity (EOQ) and reorder point led to assist Company XYZ in finding alternative methods to solved their forecasting issues.

Topic

The topic of this project was to recommend an Analysis of an Economic Order Quantity and Reorder Point Inventory Control Model for Company XYZ.

Problem

The current forecasting model in placed at Company XYZs 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.

Essentially, the purpose of this project was to recommend alternative ways to help reduce the Company's stock outs by providing a more effective forecasting method along with an Economic Order Quantity and Reorder Point model. In the approach of doing so, only thirteen top selling products that range from seasonal to annual sales will be analyze from their previous 2 years or 8 quarters. In addition, a cost estimate would be calculated to see the significance between both current model and recommended model.

Literature Review

Economic Order Quantity History

"Origin of the Economic Order Quantity formula; transcription or transformation?"

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. He also mentions how Ford W. Harris contribution to the EOQ formula was significant. Harris was always a self taught individual that only received formal schooling that extended throughout high school. He managed to write and publish the economic order quantity formula in 1915 as an undergraduate student. (Roach 2005)

The Economic Order Quantity (EOQ) formula has been used in both engineering and business disciplines. Engineers study the EOQ formula in engineering economics and industrial engineering courses. 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).

"Optimizing Economic Order Quantity"

In the article, "Optimizing Economic Order Quantity," published by Dave Piasecki in 2001, focused on the economic order quantity. Piasecki mentions that in today's leading technology, many companies are not taking advantage of the fundamental inventory models. There are various software packages in aiding companies with inventory control, but if the data inputted are inaccurate, it may lead to poor results. (Piasecki 2001) In order to have suitable results for any inventory model, accurate product costs, activity costs, forecasts, history, and lead times need to be in place. (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.

Piasecki also explains that another reason why a company does not take advantage of the EOQ model is because management does not know how it works. (Piasecki 2001) Even if a company has implemented a leading software package to help them, if they do not know how the system works it could cost more harm than good. Many times the users do not understand how the data is calculated and how the system is set up. They simply rely on the system built-in default software calculations, which in most cases, the system is "out of whack". (Piasecki 2001) In order to prevent the system from going "out of whack," management as well as the user, need to obtain proper knowledge of the EOQ concepts and how they are derived. The software is only design to aid and not replace the traditional way of running a business.

"The EOQ Inventory Formula"

At times, people in the retail business or in the manufacturing industry do not know or do not understand what EOQ stands for and how it is used? In this article, "The EOQ Inventory Formula," written by James A. Cargal clearly explains the fundamental theory of the Economic Order Quantity. Cargal published this article from Troy State University Montgomery. The article is straight forward and easy to understand. Cargal does a great job explaining each variable and how it's used accordingly. The formula is written as illustrated in equation 1 and described as the following,

$$\mathbf{Q} = \sqrt{\frac{\mathbf{2 * D * S}}{\mathbf{H * C}}} \text{ Where,} \qquad \text{(EQ: 1)}$$

Q= the EOQ order quantity. This is the variable we want to optimize. All the other variables are fixed quantities.

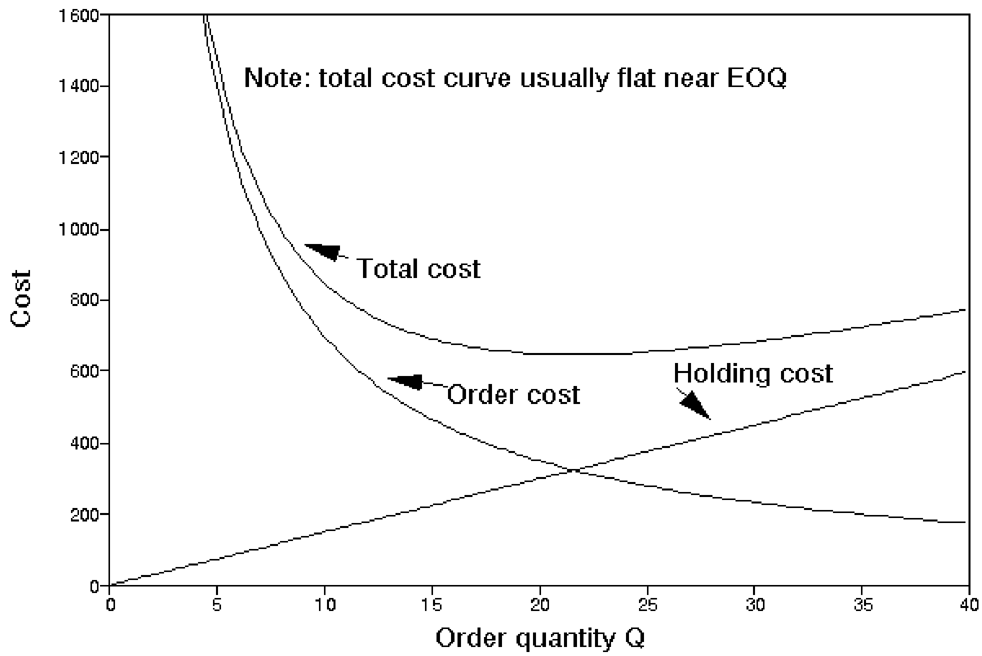
D= the annual demand of product in quantity per unit time. This can also be known as a rate.

S= the product order cost. This is the flat fee charged for making any order and is independent of Q.

C=Unit cost.

H= Holding cost per unit as a fraction of product cost.

Figure 1: EOQ Process Graph [3]



An Example by Cargal:

It is useful at this point to consider a numerical example. The demand for Klabitz's is 50 per week. The order cost is $30 (regardless of the size of the order), and the holding cost is $6 per Klabitz per week. Plugging in these figures into equation 1; the EOQ formula we get:

$$\mathbf{Q} = \sqrt{\frac{\mathbf{2 * 30 * 50}}{\mathbf{6}}} = \mathbf{22.36\ units}$$

In summary, Cargal, describes the Economic Order Quantity as, "Determining the order quantity "Q", that balances the order cost "C" and the holding costs "H", to minimize total costs as shown in figure 1. The greater the Q, the order cost would decrease due to less orders placed. On the other hand, if Q increases, the holding cost would increase due to higher inventory levels.” (Cargal)

This is an excellent illustration of how the EOQ is used and how it benefits a company.

"Stack Them High, Let 'em Fly": Lot-Sizing Policies When Inventories Stimulate Demand”

In this article, “Stack Them High, Let ‘em Fly” by Anantaram Balakrishnan, Michael S Pangburn, and Euthemia Stavrulaki, introduced a revised EOQ model to help increase profit in retail. It mentions how some retails stock large quantities of inventory to drive sales and stimulate demand. By having high inventory level of a certain product, the company could create side stacks or distribute the products in different locations within the store in hence promotes impulse buying. As a result to stimulating demand, the standard economic order quantity model had to be modified in order to incorporate the demand parameter from prior cycles. They show how their new method could increase profit even though it may not be the optimal result.

> “Using an extension of a standard inventory-dependent demand model from the literature, we first provide a convenient characterization of products that require early replenishment. We demonstrate that the optimal cycle time is largely governed by the conventional trade-off between ordering and holding costs, whereas the reorder point relates to a promotions-oriented cost-benefit perspective. We show that the optimal policy yields significantly higher profits than cost-based inventory policies, underscoring the importance of profit-driven inventory management.”(Balakrishnan, Pangburn, Stavrulaki 2004)

"A Technique for Applying EOQ Models to Retail Cycle Stock Inventories"

The focus of this article was to apply the EOQ model to small business in order to calculate the order quantity in dollar amount for each vendor. William Bassin illustrated how the EOQ model minimized the total cost of ordering and carrying stock in small businesses. Bassin calculates the order quantities based on existing data in an easy to use Microsoft Excel spreadsheet. As a result for using an EOQ system, small businesses could:

1. Yield cost savings by reducing inventory investments
2. Not requiring measurements of or assumptions about ordering and carrying costs
3. Keying the technique to the current mode of doing business.

Reorder Point and Safety Stock

Another important technique used along with the Economic Order Quantity is the Reorder Point (ROP) and Safety Stock. According to Fangruo Chen, the ROP quantity reflects the level of inventory that triggers the placement of an order for additional units**.** Where as, the quantity associated with safety stock protects the company from stock outs or backorders. Safety stock is also known as a "buffer". In Figure 2, the graph illustrates how the reorder point is connected with the lead time and the order quantity as a function of time.

In determining the reorder point the following three factors need to be at hand:

1. Demand **-** Quantity of inventory used or sold each day
2. Lead Time **-** Time (in days) it takes for an order to arrive when an order is placed
3. Safety Stock **-** The quantity of inventory kept on hand incase there is a unpredictable event like delays in lead time or unexpected demand.

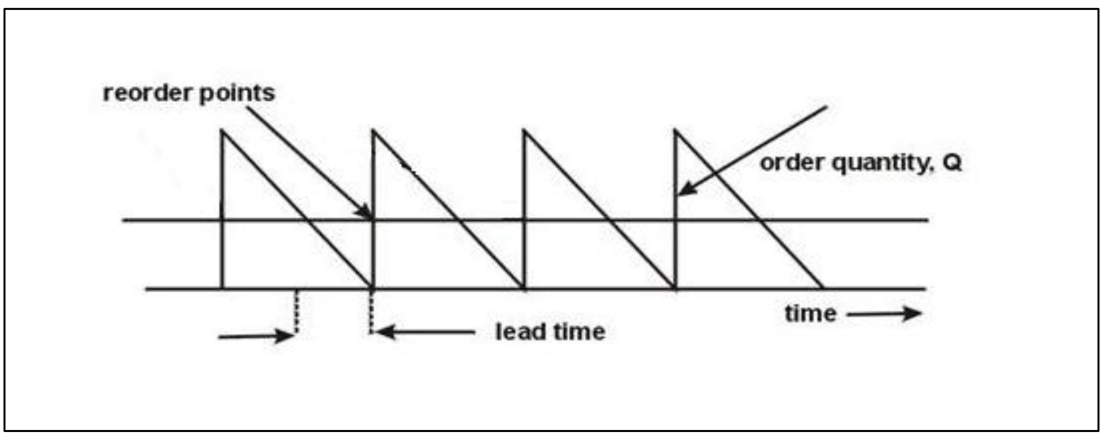
If the demand is constant and the lead time is known, then the reorder point is written as the following:

Reorder Point= Daily usage*Lead time (in days)   (EQ:2)

When a safety stock is maintained, then the reorder point is written as the following:

Reorder Point= [Daily usage*Lead time (in days)] +safety stock   (EQ:3)

Figure 2: Reorder Point [3]



Forecasting

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 a Company's historical sales data can be quite challenging.

The article, "Using Composite Moving Averages to Forecast Sales" by DJ Rob and EA Silver, states that the demand average of two periods can provide a better forecast than that of a single moving averages. (Rob, Silver 2002) This method is 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 authors researched have done an excellent job conveying their material and how each variable can affect different scenarios due to demand variability. 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 Company XYZ.

Design

Although the EOQ system has been around for many years and it is a quite simple formula to understand, companies seem to be fading away from this method. New alternatives have been introduced like Material Requirement Planning (MRP), which deals more with manufacturing process, but can also be used in retail. MRP has an important forecasting method that deals with forecasting conditions which were essential in order to calculate the products seasonal trends. Therefore, in order to recommend an EOQ analysis model for Company XYZ, several MRP methods were incorporated in the calculations.

Collecting Data

Thirteen final assembled products were chosen from Company XYZ software database that were considered to be high revenue level items. Two year's 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 and the reorder point of each product. Once the data was collected, analyzing it was the first initial step.

Analyzing Data

In the analysis portion of the project, there were several methods used in conjunction with the EOQ and ROP model. One method, as mention earlier in the report, was demand forecasting which included seasonal and annual trends. These techniques used to calculate the annual trends involved moving averages and exponential smoothing. Furthermore, the annual trend was used in the EOQ model as the annual demand in order to manipulate the fix order cost or the holding cost of each product.

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 N^{th} day then you could simply used equation 4 to calculate the amount.

$$\mathrm{F} = \frac{\sum_{i=1}^{n} S_{i-1}}{n} \text{ Where, } \quad \text{(EQ: 4)}$$

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.

Weighted moving average: this technique is similar to the simple moving average, but each sale period is multiplied by a different weight. The weight is represented in percent which will total to 100 percent for the nth amount of periods.

$$F = \frac{\sum_{i=1}^{n} W * S_{i-1}}{n} \text{ Where,} \qquad \text{(EQ: 5)}$$

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" (y_t) is calculated to assist in determining the forecast for the desired quarter. Equation 6 is used to calculate the seasonal index forecasting model:

$$y_t = ax_i + b \text{ where,} \qquad \text{(EQ: 6)}$$

$y_{t=}$ y-trend equation

a=the steepness between units and demand (x-axis)

x_i= quarter number we wish to calculate

b= the average demand (y-axis)

Seasonal Index=demand/forecast

Expected Forecast= y_t*(average seasonal index)

EOQ and Reorder Point

Based on the forecasting techniques mention earlier in the report, only the seasonal index and simple moving average was used. Once the demand was establish for all products for quarters 1 thru 9, the forecast value for quarter 9 was used as the "demand" in the economic order quantity equation. By having the forecasted demand as being constant as well as for seasonal products, the ability to use the EOQ formula was possible. Recall that the EOQ formula is calculated by using equation 1:

$$\mathbf{Q} = \sqrt{\frac{\mathbf{2} * \mathbf{D} * \mathbf{S}}{\mathbf{H} * \mathbf{C}}}$$

Reorder point is calculated by:

Reorder Point= Demand usage*Lead time (in days)

Methodology

Once the design was established, it was used as the projects guideline to ensure proper steps were taken to complete the project. In this portion, the processes of each method used as well as assumptions taken are explained in order to show how the results were obtained.

Data

The data collected was provided by the company which included the products sales, holding cost, ordering cost and unit price for their previous two years. Only two years worth of data was provided because the company's database only retains that amount. The first step taken was to sort out the 13 products and insert their historical demand into an excel spreadsheet to see the products behavior. Once the data was organized, the demand was plotted for each of the 13 products which showed their previous demand behavior. Figure 3 illustrates the products behavior over 8 quarters. The graphs helped categorize each product accordingly based on their demand. Please see Appendix B and C for all product demand graph.

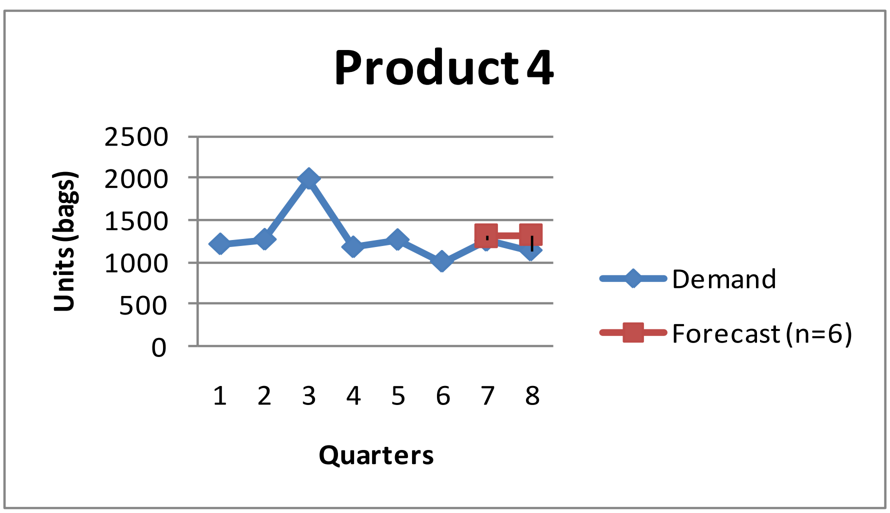


Figure 3: moving average demand example

Forecasting method

A forecasting method was used to aid the company reduce stock outs as well as to help them understand alternative ways for forecasting due products behaviors. For this particular reason, plotting the demand in excel was essential to see the forecasting trends. The products were sorted into two categories, seasonal index and moving averages due to the products demand behavior which was shown in the excel graphs. By separating each product in two categories, it would ensure we use the correct method of forecasting to get the most accurate result. This process was extremely important because it would be the use as the constant demand when calculating the economic order quantity as well as the reorder point for the recommended analysis.

Simple moving Average: There were six out of the thirteen products that were considered to be simple moving average. These products had constant demand from quarter to quarter, but there was still some noise (unexpected demand) in some quarters. Moving average was used for these products since they have the least variability, which would give a more accurate forecasting result. As mention earlier in the design process, moving average is the average value of previous periods calculated over the period's length. The data obtain was in months, but since there was a lot of variability from month to month in each product, picking quarter demand was more useful in the calculation. As a result of choosing quarters as the time period, the variability was reduced.

The next step was to forecast for the next quarter using different time periods. So, forecasting was done using 2-8 periods and looked at how each forecasting period varied due to the amount of periods used. Ideally, using more periods would give you the best results since you have more historical data, but it's not always true. In moving average, one of the most important factors to take into consideration is calculating the mean average deviation (MAD) of the demand. So, if you don't calculate the MAD value for each period used, then the forecasting would have more variability. The MAD value provides the least variability in each period, so the lower the MAD value, the more accurate the forecasting. An example of a product forecast is shown in table 1 to illustrate the difference in forecasting and the difference in the MAD value. In table 1, the highlighted portion indicates how many periods gave the best forecasting results with the least variability.

Table 1: Moving average for product 4

Product 4									**Forecast**	
Period (Qtr)	1	2	3	4	5	6	7	8	**Qtr-1 (10)**	**MAD**
Unit Sales	**1204**	**1260**	**1992**	**1168**	**1256**	**994**	**1247**	**1129**		
Forecast (n=2)			1232.0	1626.0	1580.0	1212.0	1125.0	1120.5	1188.0	315.1
Forecast (n=3)				1485.3	1473.3	1472.0	1139.3	1165.7	1123.3	231.4
Forecast (n=4)					1406.0	1419.0	1352.5	1166.3	1156.5	179.4
Forecast (n=5)						1376.0	1334.0	1331.4	1158.8	223.8
Forecast (n=6)							1312.3	1319.5	1297.7	127.9
Forecast (n=7)								1303.0	1292.3	174.0
Forecast (n=8)									1281.3	

In this case, using more periods would not be beneficial since the MAD value increased when using seven periods. As a result to the moving average method, the company would need to order about 1298 units to meet the demand for the next quarter. The forecasting unit was later used as the constant demand for the economic order quantity. Please see Appendix B for the all the moving average product tables and graphs.

Seasonal Index: There were seven products that fit the seasonal index category. In this method the demand is not considered to be constant from quarter to quarter. Due to this unpredictable demand, seasonal index is used to make any seasonal adjustments through out the year. This behavior is when the product goes through a demand cycle that imitates or is similar to a sinusoidal trend. Figure 4 shows the behavior of product 3, which shows the demand throughout the year. Product 3 goes through a seasonal cycle since it tends to peak during the spring and summer. This indicates that in order to forecast more accurately there needs to be some form of seasonal adjustment.

For this method (seasonal index), each product went through the same process for a more accurate forecasting. Once the data was plotted for each product a linear regression line was fitted to the product demand as shown in figure 4.

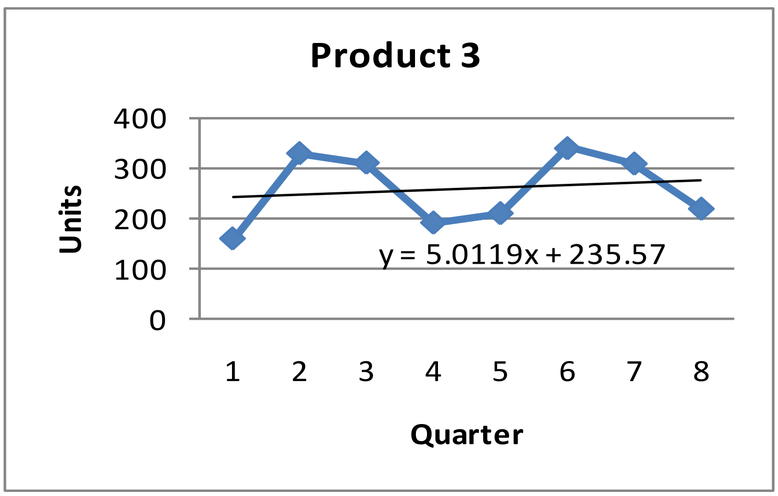


Figure 4: Seasonal Index with Y-Trend equation

The trend line was then utilized to calculate the forecast for each quarter up to nine quarters (The calculations for the forecast was explained earlier in the design section). Since there was two years worth of data as mention earlier, an average seasonal index was calculated to get a more accurate result as well as to reduce variability. For example, in table 2, to calculate the forecast for quarter 9, Y-trend equation was used. Quarter 9 was used for the x variable, but then it was multiplied by the 1st quarter of the average seasonal index to get 204.65 units. The 1st quarter average index was used since the forecast was for the 1st quarter of 2010. If there was a need to calculate for quarter 3 of 2010, the average seasonal index for quarter 3 would be used to calculate the forecast.

Table 2: Seasonal index for product 3

Product 3						
Year	**Qtr's**	**Units (tanks)**	**Forecast**	**Seasonal Index**	**Avg Seasonal Index**	
2008	1	158	240.58	0.66	Qtr's 1	0.73
	2	330	245.59	1.34	Qtr's 2	1.31
	3	311	250.61	1.24	Qtr's 3	1.19
	4	190	255.62	0.74	Qtr's 4	0.77
2009	5	209	260.63	0.80		
	6	340	265.64	1.28		
	7	309	270.65	1.14		
	8	218	275.67	0.79		
2010	9		**204.65**			

The forecast for the remaining products were calculated and are shown in Appendix C. Once the forecasting was determined for both moving average and seasonal index, another closed look at the results was done to ensure the forecast made sense for each product. The equations were double checked and any mistakes were fixed. The next step was to calculate the EOQ and ROP for each product.

Economic Order Quantity

Most of the data was provided by the company to calculate the economic order quantity for each product. In the data gathered, as mention in our literature review, an EOQ is used to minimize stock outs and find the optimal order quantity while minimize total cost associated with each product. The holding cost and order cost are equal when the optimal order quantity is obtained. As mention in the literature review, all the variables needed in order to calculate the optimal order quantity are illustrated in the Appendix D.

For their current method, to calculate the ordering cost for each product additional data was collected. The additional data collected was the number of orders placed per year, quarter and monthly. Only the orders placed per quarter were useful since all the calculations were done in based on quarter demand. With this data, the holding cost and the ordering cost was determined in order to compare the cost estimates from their current method and the recommended method. This portion of the project was the most challenging to complete because there was some reverse engineering involved to get the total cost for each product. This data is shown in Appendix D.

Before proceeding in calculating the EOQ some assumptions needed to be established;

- The calculated forecast would be the Demand
- The calculated forecast would be different for each product due to trend demand
- Fix order cost was provided by the company
- Holding cost was provided by the company
- Unit price was different for each product

Once the assumptions were satisfied, the calculations of the economic order quantity were done for each product. The results are shown in the Appendix D. The EOQ indicates that in order for the holding cost and the ordering cost to equal, the recommended amount should be order every time and order is placed to minimize the cost.

In the recommended results, the optimal order quantity for each product was high which meant that their holding cost would increase. One advantage was that the fix order cost was reduced since there would be less orders placed through out the quarter.

Reorder Point

Along with the economic order quantity, a reorder point was provided. The reorder point took in consideration the annual demand and the lead time. The lead time is the number of days it takes to receive the product when an order is placed. The reorder point states that an order needs to be placed once the product falls below a certain amount of units as indicated in the tables in Appendix D. Furthermore, the reorder point maintains enough stock to satisfy the demand between orders.

Cost Estimates

Once the total cost was produced for all thirteen products for both, the company's current method and the recommended EOQ, the cost estimates was calculated. There were two parts in the total quarter cost that was looked at closely in the calculations which were the holding cost and order cost. As shown in table 3, both current and the recommended methods show that both holding cost and order cost are associated to the thirteen products analyzed. The results looked reasonable, for instance, in their current method their holding cost was low compared to the recommended results. This illustrates that in the recommended method, the company would have to store more inventory in their warehouse which would increase their holding cost. But when the order cost associated with the thirteen products was compared, there was a significant difference in cost. This was because the company would order more frequently since they would have low inventory levels which created a high order cost. In the recommended method, both the holding cost and the order cost were equal due to the economic order quantity calculations. As mention earlier, the EOQ would give the optimal order quantity when both the holding cost and order cost are minimized. As shown in table 3, Company XYZ could save a significant amount of money by simply utilizing the EOQ method effectively. Please see Appendix E for a more detail cost estimate for all thirteen products.

Table 3: Total Quarter Cost

Cost Estimate: Total Cost					
Old Method			Recommended Method		
Holding ($)	Order ($)	Total Cost ($)	Holding ($)	Order ($)	Total Cost ($)
591.7	13062.3	13654.0	2683.4	2683.4	5366.9
	Overall Cost	13654.0		Overall Cost	5366.9
		Total Savings	$8,287.16		
		Percent (%)	60.69		

Results and Discussion

After analyzing the results, the recommended inventory model showed improvements in the overall total cost. With their current forecasting model, the results showed that the company's order cost was high due to frequent ordering. If the company was to reduce the total orders placed each quarter, their ordering cost would decrease. For instance, in the cost estimate table of appendix E, the results show the total cost savings associated with each product. If the company proceeds in implementing the recommended forecasting model along with the economic order quantity, it would help them save approximately 61% of their total cost which adds up to about $8,300 in saving per quarter.

The recommended model aids the company in forecasting more accurately according to each product and their demand behaviors. Along with the forecasting model, the economic order quantity allows the company to optimize each order and reduce the total cost. As a result, the company would ensure enough products are in stock to satisfy customers demand and save money.

Conclusion

The current forecasting model in place at Company XYZs has brought problems due to ineffective forecasting that resulted in product stock outs and loss of sales. In order to help them reduce their stock outs, a forecasting model was provided along with an economic order quantity and reorder point. The recommended model provides two different forecasting techniques that allow a more accurate forecasting result for different product behaviors. Finally, the economic order quantity and the reorder point, optimized the order quantity for each product when an order is placed, reducing the companies product stock out issue.

By providing and recommending the inventory control model, the results have shown improvements in forecasting as well as in cost reduction. So, if the company follows through and implements the recommended inventory model, they would be able to reduce the total cost by approximately 61% which is a cost reduction of $8,300 per quarter for their 13 top selling products.

In the end, the issues the company faces would be reduced by implementing the recommended inventory model. The model will ensure the product is in stock, which would drive product sales and would allow the company to increase profit by forecasting accordingly. The recommended analysis showed that simple, yet complex techniques are the key for retail success which could give them the competitive edge.

Project Experiences

During the course of the project, there were many obstacles along the way. Through hard work, dedication and guidance, it was possible to overcome all the obstacles faced. Most of the knowledge gained was due to intense research and from previous courses taken. The most important concept retained was forecasting and how it affected the economic order quantity. The concepts learned are essential for someone who would want to pursue a career in supply chain management and logistics.

The process of completing a senior project allows the author to be able to apply concepts learned and put them to practice. Along the way, there are struggles in finding a feasible solution to the problems faced, but when solved, the feeling is rewarding. As a recommendation for anyone starting a senior project, it is critical that sufficient time is allocated for the completion of the project. This could be done by effectively using project management skills to ensure everything goes according to plan. Overall, the experience and knowledge gain from completing a senior project was rewarding.

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Appendices

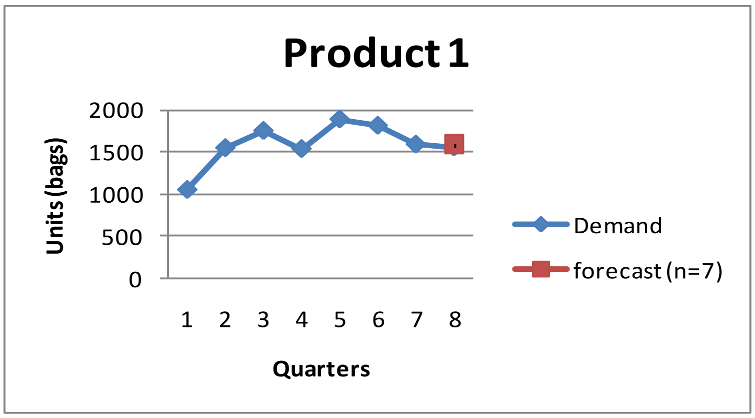
Appendix A: Historical Data for 13 products in months and quarters

Item Description	Product 1	Product 2	Product 3	Product 4	Product 5	Product 6	Product 7	Product 8	Product 9	Product 10	Product 11	Product 12	Product 13
Date(MM/YY)	**Units**	**Units**	**Units**	**Units**	**Units**	**Units**	**Units**	**Units**	**Units**	***Units***	***Units***	***Units***	***Units***
Jan-2008	0	0	0	0	0	0	0	0	0	0	0	0	0
Feb-2008	390	0	69	455	786	5.34	279	4	47	94	162	150	129
Mar-2008	654	0	89	749	900	3.84	649	6	108	174	677	202	1312
Apr-2008	420	0	76	494	782	0.54	535	2	99	872	458	403	167
May-2008	421	0	100	279	1488	1.38	1907	2	102	158	655	582	707
Jun-2008	704	0	154	487	1310	3.58	553	4	188	1449	334	145	160
Jul-2008	686	2	96	1102	934	0.28	418	5	394	215	282	320	1482
Aug-2008	441	4	112	432	1078	0.22	358	2	201	94	392	224	788
Sep-2008	624	10	103	458	1273	4.94	337	2	179	116	1061	406	471
Oct-2008	453	3	65	437	835	3	318	3	106	70	178	158	76
Nov-2008	573	6	69	352	817	3.9	207	1	70	41	327	199	38
Dec-2008	508	12	56	379	373	2.82	124	3	74	55	316	132	226
Jan-2009	602	10	61	463	348	4.82	243	0	54	67	265	44	1153
Feb-2009	485	2	55	294	575	12.08	235	3	30	34	203	143	63
Mar-2009	801	5	93	499	812	5.62	746	1	128	144	496	438	662
Apr-2009	527	14	100	328	730	0	588	3	125	2031	140	28	200
May-2009	607	2	88	344	403	2	440	6	176	637	292	411	502
Jun-2009	679	8	152	322	916	0.14	300	2	314	214	361	415	658
Jul-2009	511	8	88	305	686	2.9	260	2	361	318	1342	1323	595
Aug-2009	501	6	105	471	534	2.16	290	6	382	352	824	682	431
Sep-2009	576	5	116	471	716	5.4	545	6	268	168	711	384	439
Oct-2009	523	2	72	358	442	11.86	260	5	83	204	90	73	215
Nov-2009	514	6	77	413	535	5.52	186	0	88	162	361	84	76
Dec-2009	516	9	69	358	288	15.24	100	2	70	46	416	43	70

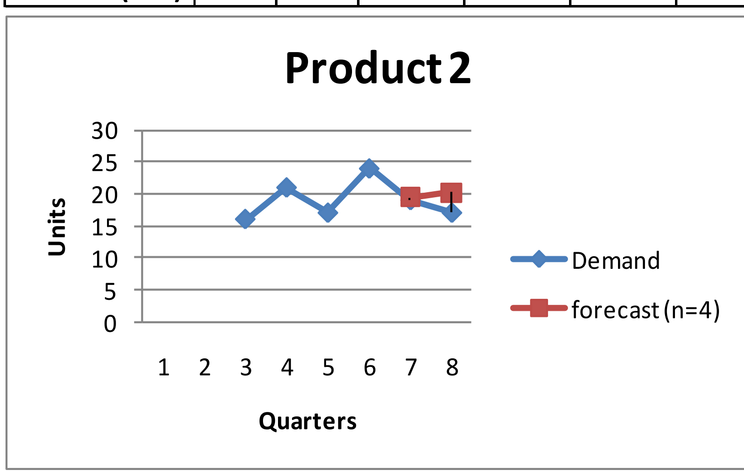
Item Description	Product 1	Product 2	Product 3	Product 4	Product 5	Product 6	Product 7	Product 8	Product 9	Product 10	Product 11	Product 12	Product 13
Quarters	**Units**	**Units**	**Units**	**Units**	**Units**	**Units**	**Units**	**Units**	**Units**	**Units**	**Units**	**Units**	**Units**
Qtr 1 (2008)	1044	0	158	1204	1686	9.18	928	10	155	268	839	352	1441
Qtr 2 (2008)	1545	0	330	1260	3580	5.5	2995	8	389	2479	1447	1130	1034
Qtr 3 (2008)	1751	16	311	1992	3285	5.44	1113	9	774	425	1735	950	2741
Qtr 4 (2008)	1534	21	190	1168	2025	9.72	649	7	250	166	821	489	340
Qtr 1 (2009)	1888	17	209	1256	1735	22.52	1224	4	212	245	964	625	1878
Qtr 2 (2009)	1813	24	340	994	2049	2.14	1328	11	615	2882	793	854	1360
Qtr 3 (2009)	1588	19	309	1247	1936	10.46	1095	14	1011	838	2877	2389	1465
Qtr 4 (2009)	1553	17	218	1129	1265	32.62	546	7	241	412	867	200	361

Appendix B: Moving Average Tables with Graphs (to show demand behavior)

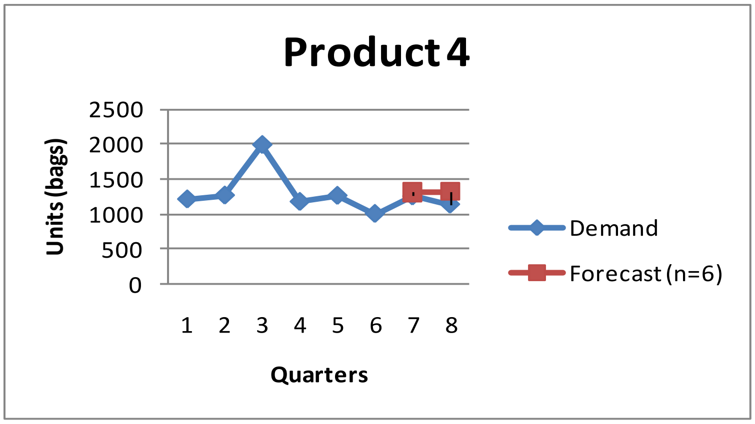
Product 1									Forecast	
Period (Qtr)	1	2	3	4	5	6	7	8	Qtr-1 (10)	MAD
Unit Sales	1044	1545	1751	1534	1888	1813	1588	1553		
Forecast (n=2)			1294.5	1648.0	1642.5	1711.0	1850.5	1700.5	1570.5	221.3
Forecast (n=3)				1446.7	1610.0	1724.3	1745.0	1763.0	1651.3	164.2
Forecast (n=4)					1468.5	1679.5	1746.5	1705.8	1710.5	216.1
Forecast (n=5)						1552.4	1706.2	1714.8	1675.2	180.2
Forecast (n=6)							1595.8	1686.5	1687.8	70.7
Forecast (n=7)								1594.7	1667.4	41.7
Forecast (n=8)									1589.5	



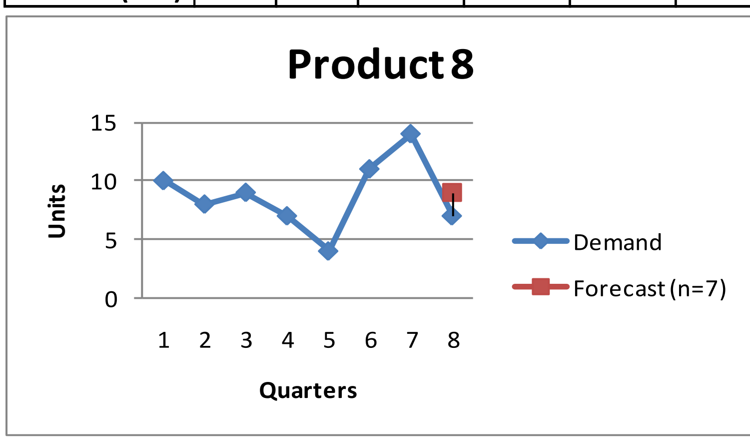
Product 2									Forecast	
Period (Qtr)	1	2	3	4	5	6	7	8	Qtr-1 (10)	MAD
Unit Sales			16	21	17	24	19	17		
Forecast (n=2)					18.5	19.0	20.5	21.5	18.0	2.9
Forecast (n=3)						18.0	20.7	20.0	20.0	3.6
Forecast (n=4)							19.5	20.3	19.3	1.9
Forecast (n=5)								19.4	19.6	2.4



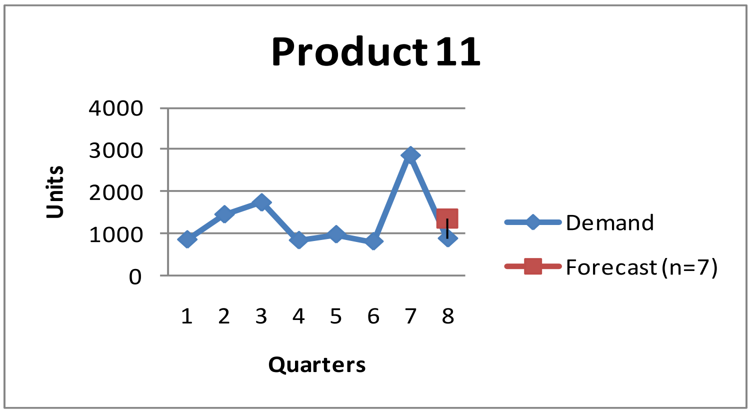
Product 4									Forecast	
Period (Qtr)	1	2	3	4	5	6	7	8	Qtr-1 (10)	MAD
Unit Sales	1204	1260	1992	1168	1256	994	1247	1129		
Forecast (n=2)			1232.0	1626.0	1580.0	1212.0	1125.0	1120.5	1188.0	315.1
Forecast (n=3)				1485.3	1473.3	1472.0	1139.3	1165.7	1123.3	231.4
Forecast (n=4)					1406.0	1419.0	1352.5	1166.3	1156.5	179.4
Forecast (n=5)						1376.0	1334.0	1331.4	1158.8	223.8
Forecast (n=6)							1312.3	1319.5	1297.7	127.9
Forecast (n=7)								1303.0	1292.3	174.0
Forecast (n=8)									1281.3	



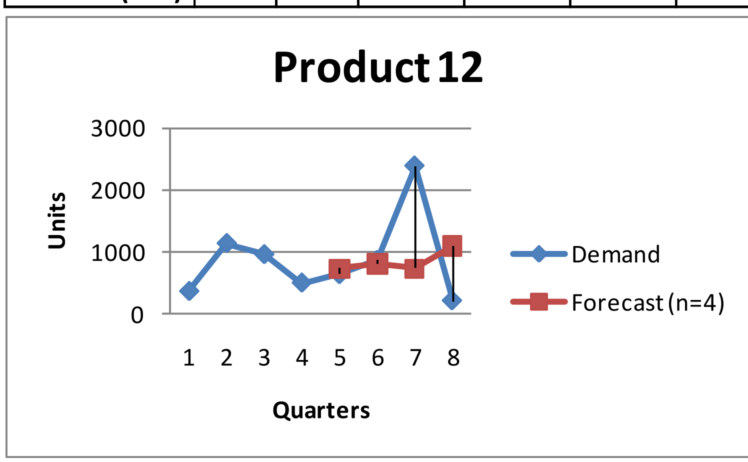
Product 8									Forecast	
Period (Qtr)	1	2	3	4	5	6	7	8	Qtr-1 (10)	MAD
Unit Sales	10	8	9	7	4	11	14	7		
Forecast (n=2)			9.0	8.5	8.0	5.5	7.5	12.5	10.5	3.8
Forecast (n=3)				9.0	8.0	6.7	7.3	9.7	10.7	3.9
Forecast (n=4)					8.5	7.0	7.8	9.0	9.0	4.2
Forecast (n=5)						7.6	7.8	9.0	8.6	3.9
Forecast (n=6)							8.2	8.8	8.7	3.8
Forecast (n=7)								9.0	8.6	2.0
Forecast (n=8)									8.8	



produt 11									Forecast	
Period (Qtr)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Qtr-1 (10)**	**MAD**
Unit Sales	**839**	**1447**	**1735**	**821**	**964**	**793**	**2877**	**867**		
Forecast (n=2)			1143.0	1591.0	1278.0	892.5	878.5	1835.0	1872.0	790.3
Forecast (n=3)				1340.3	1334.3	1173.3	859.3	1544.7	1512.3	793.1
Forecast (n=4)					1210.5	1241.8	1078.3	1363.8	1375.3	747.7
Forecast (n=5)						1161.2	1152.0	1438.0	1264.4	888.1
Forecast (n=6)							1099.8	1439.5	1342.8	1174.8
Forecast (n=7)								1353.7	1357.7	486.7
Forecast (n=8)									1292.9	

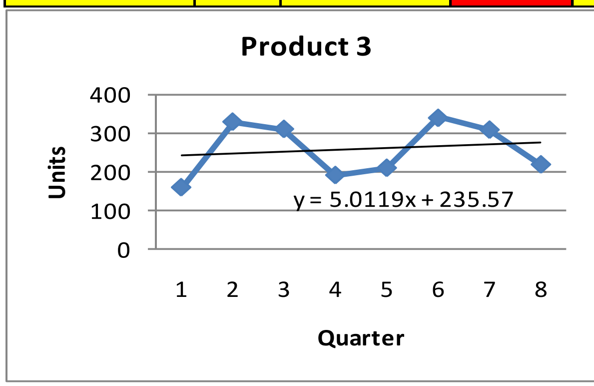


Product 12									Forecast	
Period (Qtr)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Qtr-1 (10)**	**MAD**
Unit Sales	**352**	**1130**	**950**	**489**	**625**	**854**	**2389**	**200**		
Forecast (n=2)			741.0	1040.0	719.5	557.0	739.5	1621.5	1294.5	703.8
Forecast (n=3)				810.7	856.3	688.0	656.0	1289.3	1147.7	708.3
Forecast (n=4)					730.3	798.5	729.5	1089.3	1017.0	677.4
Forecast (n=5)						709.2	809.6	1061.4	911.4	861.9
Forecast (n=6)							733.3	1072.8	917.8	1264.3
Forecast (n=7)								969.9	948.1	769.9
Forecast (n=8)									873.6	

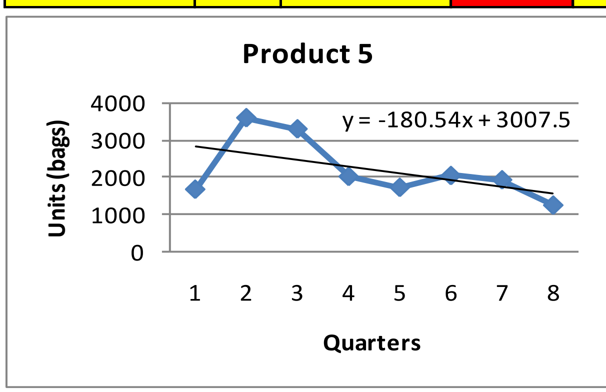


Appendix C: Seasonal Index Tables with Graphs (to show demand behavior)

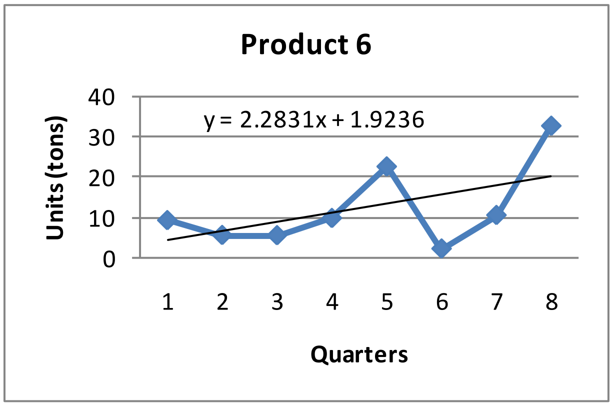
Product 3						
Year	Qtr's	Units (tanks)	Forecast	Seasonal Index	Avg Seasonal Index	
2008	1	158	240.58	0.66	Qtr's 1	0.73
	2	330	245.59	1.34	Qtr's 2	1.31
	3	311	250.61	1.24	Qtr's 3	1.19
	4	190	255.62	0.74	Qtr's 4	0.77
2009	5	209	260.63	0.80		
	6	340	265.64	1.28		
	7	309	270.65	1.14		
	8	218	275.67	0.79		
2010	9		204.65			



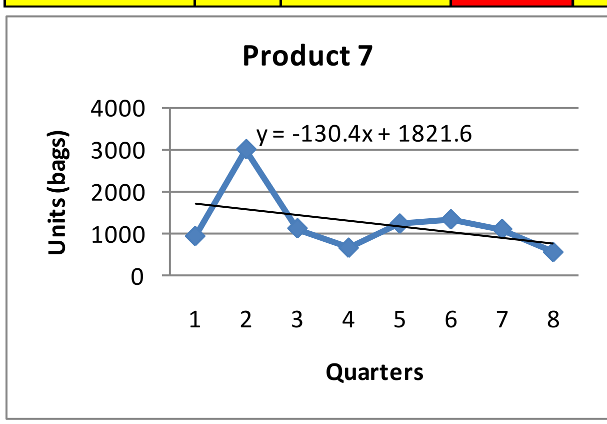
Product 5						
Year	Qtr's	Units (Bags)	Forecast	Seasonal Index	Avg Seasonal Index	
2008	1	1686	2826.96	0.60	Qtr's 1	0.71
	2	3580	2646.42	1.35	Qtr's 2	1.21
	3	3285	2465.88	1.33	Qtr's 3	1.22
	4	2025	2285.34	0.89	Qtr's 4	0.85
2009	5	1735	2104.80	0.82		
	6	2049	1924.26	1.06		
	7	1936	1743.72	1.11		
	8	1265	1563.18	0.81		
2010	9		982.16			



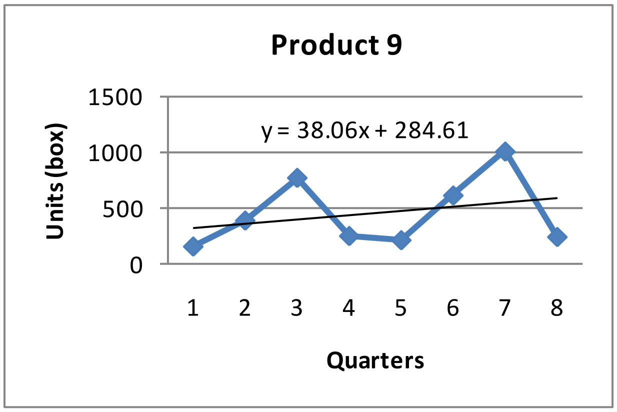
Product 6						
Year	**Qtr's**	**Units (tons)**	**Forecast**	**Seasonal Index**	**Avg Seasonal Index**	
2008	1	9.18	4.21	2.18	Qtr's 1	1.94
	2	5.5	6.49	0.85	Qtr's 2	0.49
	3	5.44	8.77	0.62	Qtr's 3	0.60
	4	9.72	11.06	0.88	Qtr's 4	1.25
2009	5	22.52	13.34	1.69		
	6	2.14	15.62	0.14		
	7	10.46	17.91	0.58		
	8	32.62	20.19	1.62		
2010	9		**43.49**			



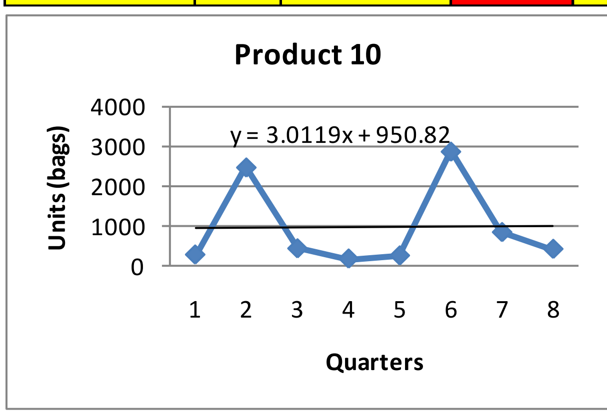
Product 7						
Year	**Qtr's**	**Units (bags)**	**Forecast**	**Seasonal Index**	**Avg Seasonal Index**	
2008	1	928	1691.20	0.55	Qtr's 1	0.80
	2	2995	1560.80	1.92	Qtr's 2	1.60
	3	1113	1430.40	0.78	Qtr's 3	0.99
	4	649	1300.00	0.50	Qtr's 4	0.60
2009	5	1224	1169.60	1.05		
	6	1328	1039.20	1.28		
	7	1095	908.80	1.20		
	8	546	778.40	0.70		
2010	9		**516.86**			



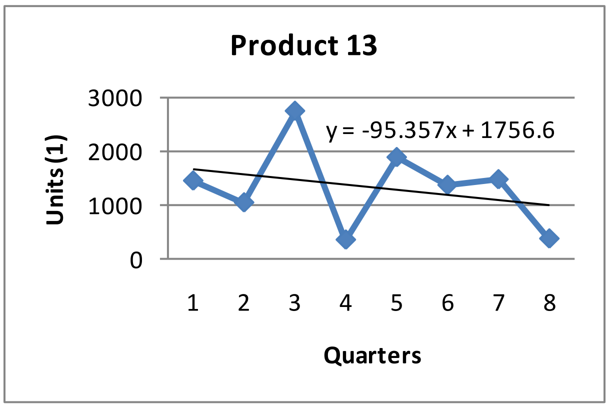
Product 9						
Year	Qtr's	Units (box)	Forecast	Seasonal Index	Avg Seasonal Index	
2008	1	155	322.67	0.48	Qtr's 1	0.46
	2	389	360.73	1.08	Qtr's 2	1.14
	3	774	398.79	1.94	Qtr's 3	1.89
	4	250	436.85	0.57	Qtr's 4	0.49
2009	5	212	474.91	0.45		
	6	615	512.97	1.20		
	7	1011	551.03	1.83		
	8	241	589.09	0.41		
2010	9		290.61			



Product 10						
Year	Qtr's	Units (bags)	Forecast	Seasonal Index	Avg Seasonal Index	
2008	1	268	953.83	0.28	Qtr's 1	0.27
	2	2479	956.84	2.59	Qtr's 2	2.78
	3	425	959.86	0.44	Qtr's 3	0.65
	4	166	962.87	0.17	Qtr's 4	0.30
2009	5	245	965.88	0.25		
	6	2882	968.89	2.97		
	7	838	971.90	0.86		
	8	412	974.92	0.42		
2010	9		261.41			



Product 13						
Year	**Qtr's**	**Units**	**Forecast**	**Seasonal Index**	**Avg Seasonal Index**	
2008	1	1441	1661.24	0.87	Qtr's 1	1.17
	2	1034	1565.89	0.66	Qtr's 2	0.90
	3	2741	1470.53	1.86	Qtr's 3	1.60
	4	340	1375.17	0.25	Qtr's 4	0.31
2009	5	1878	1279.82	1.47		
	6	1360	1184.46	1.15		
	7	1465	1089.10	1.35		
	8	361	993.74	0.36		
2010	9		**1048.79**			



Appendix D: Current Method and Recommended Method (EOQ)

Current method

	Product 1	Product 2	Product 3	Product 4	Product 5	Product 6	Product 7	Product 8	Product 9	Product 10	Product 11	Product 12	Product 13
Times ordered(Qtr)	5	9	13	5	6	4	10	6	5	7	6	6	4
Ave.Demand (Qrt 1)	1466	17	183.5	1230	1710.5	15.85	1076	7	183.5	256.5	901.5	488.5	1659.5
Unit cost Price	3.55	208.38	13.00	3.00	2.18	160.00	2.19	280.07	5.25	3.48	0.73	0.73	0.17
Holding Cost	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Fix order cost	304.71	160.35	181.20	207.56	258.41	105.39	146.02	132.33	129.24	181.23	50.97	34.44	12.19
Lead Time (days)	10	14	5	10	7	7	4	7	6	4	10	10	10
Note: Q=(demand/times ordered)													
Q: (EOQ)	293.2	1.9	14.1	246.0	285.1	4.0	107.6	1.2	36.7	36.6	150.3	81.4	414.9
Qtr Holding cost	130.11	49.20	22.94	92.25	77.69	79.25	29.46	40.84	24.08	15.94	13.71	7.43	8.82
Qtr order cost	1523.54	1443.14	2355.65	1037.81	1550.46	421.55	1460.22	794.00	646.20	1268.58	305.79	206.63	48.75
Total Qtr Cost($)	**1653.64**	**1492.34**	**2378.59**	**1130.06**	**1628.15**	**500.80**	**1489.67**	**834.84**	**670.29**	**1284.52**	**319.50**	**214.06**	**57.56**

Recommended method

	Product 1	Product 2	Product 3	Product 4	Product 5	Product 6	Product 7	Product 8	Product 9	Product 10	Product 11	Product 12	Product 13
Forecast (Qtr 1)	1667.4	19.3	204.7	1297.7	982.2	43.5	516.9	8.6	290.6	261.4	1357.7	1017.0	1048.8
Unit cost Price	3.55	208.38	13	3	2.18	160	2.19	280.07	5.25	3.48	0.73	0.73	0.17
Holding Cost	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
Fix order cost	304.71	160.35	181.20	207.56	258.41	105.39	146.02	132.33	129.24	181.23	50.97	34.44	12.19
Lead Time (days)	10	14	5	10	7	7	4	7	6	4	10	10	10
EOQ	**1070.0**	**10.9**	**151.1**	**847.5**	**965.1**	**15.1**	**525.1**	**5.7**	**239.2**	**330.0**	**870.8**	**619.5**	**775.5**
ROP	**45.9**	**0.7**	**2.8**	**35.7**	**18.9**	**0.8**	**5.7**	**0.2**	**4.8**	**2.9**	**37.4**	**28.0**	**28.9**
Optimal Orders (n*)	**1.6**	**1.8**	**1.4**	**1.5**	**1.0**	**2.9**	**1.0**	**1.5**	**1.2**	**0.8**	**1.6**	**1.6**	**1.4**
Qtr Holding cost	474.83	283.55	245.48	317.81	262.98	302.76	143.74	199.27	157.00	143.55	79.46	56.53	16.48
Qtr order cost	474.83	283.55	245.48	317.81	262.98	302.76	143.74	199.27	157.00	143.55	79.46	56.53	16.48
Total Qtr Cost($)	**949.65**	**567.10**	**490.96**	**635.63**	**525.97**	**605.51**	**287.48**	**398.55**	**313.99**	**287.11**	**158.92**	**113.06**	**32.96**

Appendix E: Cost Estimate

	Cost Estimate: Total Cost					
	Old Method			Recommended Method		
Products:	**Holding ($)**	**Order ($)**	**Total Cost ($)**	**Holding ($)**	**Order ($)**	**Total Cost ($)**
Product 1	130.11	1523.54	1653.65	474.83	474.83	949.66
Product 2	49.20	1443.14	1492.34	283.55	283.55	567.10
Product 3	22.94	2355.65	2378.59	245.48	245.48	490.96
Product 4	92.25	1037.81	1130.06	317.81	317.81	635.62
Product 5	77.69	1550.46	1628.15	262.98	262.98	525.96
Product 6	79.25	421.55	500.80	302.76	302.76	605.52
Product 7	29.46	1460.22	1489.68	143.74	143.74	287.48
Product 8	40.84	794.00	834.84	199.27	199.27	398.54
Product 9	24.08	646.20	670.28	157.00	157.00	314.00
Product 10	15.94	1268.58	1284.52	143.55	143.55	287.10
Product 11	13.71	305.79	319.50	79.46	79.46	158.92
Product 12	7.43	206.63	214.06	56.53	56.53	113.06
Product 13	8.82	48.75	57.57	16.48	16.48	32.96
Total cost	**591.72**	**13062.32**	**13654.04**	**2683.44**	**2683.44**	**5366.88**
		Overall Cost	**13654.04**		**Overall Cost**	**5366.88**
			Total Savings	**$8,287.16**		
			Percent (%)	**60.69**		