Avrupa Bilim ve Teknoloji Dergisi
Özel Sayı 29, S. 377-386, Aralık 2021

Araştırma Makalesi

www.ejosat.com ISSN:2148-2683

European Journal of Science and Technology
Special Issue 29, pp. 377-386, December 2021

Research Article

Analysis and Improvement of Production Planning Processes in a Food Factory

Mehmet Savsar[1], Hasan Çiçek[2]

[1]Üsküdar Üniversitesi, Mühendislik Fakültesi, Endüstri Mühendsiliği Bölümü, İstanbul, Türkiye (ORCID: 0000-0003-4299-8545)
[2]Üsküdar Üniversitesi, Mühendislik Fakültesi, Endüstri Mühendsiliği Bölümü, İstanbul, Türkiye (ORCID: 0000-0003-1956-9750)

(International Symposium on Multidisciplinary Studies and Innovative Technologies (ISMSIT) 2021 – 21-23 October 2021)

(**DOI:** 10.31590/ejosat.1035233)

ATIF/REFERENCE: Savsar, M. & Çiçek, H. (2021). Analysis and Improvement of Production Planning Processes in a Food Factory. *European Journal of Science and Technology*, (29), 377-386.

Abstract

Demand forecasting and production planning are the main planning issues in industry. Poor forecasting and ineffective production planning procedures result in either excess inventories or unmet demand. In either case company faces with excessive losses. Over the past century, scientific management principles have been highly developed and can be used to solve these problems. However, many companies either lack engineering and management knowledge in this respect or are careless in applying already available forecasting and planning tools. This study presents a case application which illustrates the use of available management tools and shows how a significant amount of cost savings can be achieved by just applying basic tools and procedures. The paper can be useful for practicing engineers and production planning managers in future applications.
.

Keywords: Forecasting, production planning, EOQ, inventory management, safety stocks, food production.

Bir Gıda Fabrikasında Üretim Planlama Süreçlerinin Analizi ve İyileştirilmesi

Öz

Talep tahmini ve üretim planlaması, endüstrideki ana planlama konularıdır. Yetersiz tahmin ve etkisiz üretim planlama prosedürleri, ya fazla stokla ya da karşılanmayan taleple sonuçlanır. Her iki durumda da şirket aşırı kayıplarla karşı karşıyadır. Geçen yüzyılda, bilimsel yönetim ilkeleri oldukça gelişmiş olup, bu sorunları çözmek için kullanılabilir. Ancak, birçok şirket bu konuda ya mühendislik ve yönetim bilgisinden yoksundur ya da halihazırda mevcut olan tahmin ve planlama araçlarını uygulamada dikkatsizdir. Bu çalışma, mevcut yönetim araçlarının kullanımını gösteren ve sadece temel araç ve prosedürleri uygulayarak önemli miktarda maliyet tasarrufunun nasıl sağlanabileceğini gösteren bir vaka uygulaması sunmaktadır. Bu makale, gelecekteki uygulamalarda mühendisler ve üretim planlama yöneticileri için yararlı olabilir.

Anahtar Kelimeler: Tahmin, üretim planlama, EOQ, EPQ, envanter yönetimi, gıda üretimi.
.

[1] Corresponding Author: Üsküdar Üniversitesi, Mühendislik Fakültesi, Endüstri Mühendisliği, İstanbul, Türkiye, ORCID: 0000-0003-4299-8545, mehmet.savsar@uskudar.edu.tr

1. Introduction

Companies usually face problems in the planning and control process for raw material, production, and final products. Timely supply and storage of raw material is essential for the continuity of the production; the production department has to make right plans to meet the demand for the final products on time; and the right amount of final product inventories must be held in order to avoid delays in meeting customer demand due to production fluctuations and uncertainties. While control mechanism in a company assures if the plans are being implemented right and the operations are carried out as planned, planning is the most important activity in any industrial setting. In order to make right plans, data and information related to the operational activities must be collected and analyzed. One of the procedures that is utilized by all manufacturing companies is forecasting or predicting the requirements in the future. However, uncertainty and related risks are the most important factors that complicate the decision-making process for managers. Mozelewski and Scheller (2021) stated that forecasts support decision makers in taking right decisions while making plans, preparing for future conditions and using resources in the most effective way. Yenradeea, et al. (2001) presented a demand forecasting and production planning model and analysis for a pressure container factory, where the demand patterns of individual product groups were highly seasonal. Amare, et al. (2021) discussed the forecasting, production planning, and productivity improvement issues for a pulp and paper manufacturing company. The goal of their work was to discover the problems that lead to poor company production planning and control systems. Methods were used to gather and interpret data by observations, which resulted in an in productivity and efficiency in the manufacturing system. Jaipuria and Mahapatra (2014) made a demand forecast with data from three different sectors (automotive, cement, and steel) to make an accurate demand forecast in an uncertain environment and at the same time reduce the bullwhip effect caused by demand variability. Kandananond (2012) forecasted the demand of daily consumer products and Murphy et al. (2014) made a demand forecast of the raw milk production farm using a 3-year data set.

McGarrie (1998) describes the development and application of a production planning framework for small manufacturing companies. The framework has been validated in ten small manufacturing companies in the UK. Rianthong et. al. (2019) presented an aggregate production planning case study in a small-sized company. Savsar and Abdulmalek (2008) developed a model for a pull-push assembly system to minimize inventory and demand delay costs by using simulation techniques. Savsar (2017) studied a food processing assembly system and presented a procedure to improve system efficiency and productivity.

The inventory management system provides information to efficiently manage material flow, use equipment effectively, and communicate with customers. It ensures that stocks are kept at desired levels. Wei et al. (2013) studied the stability and bullwhip effect of a production and inventory control system. According to Shin et al. (2015), inventory management is the technique of managing, controlling, and improving the stock levels of raw materials, semi-finished products, and finished goods so that regular sourcing can be obtained at minimum cost. Ensuring appropriate stock levels is an important issue in the performance of firms. Appropriate stock levels depend on the production schedule as a managerial response to market demand. Excess inventories increase costs, while stock shortages can cause lost sales. It can also be reflected in the efficiency of the company with efficient stock management, lower storage costs, and greater customer loyalty.

Forecasting and production inventory planning are very much related subjects. Research in these directions is countless. Every year thousands of research papers are being published in these areas. However, most of the papers are theoretical and their applications are rather limited. In this paper we present a case application of both demand forecasting and production planning for a company. Several basic procedures, which could be very useful for production and planning engineers, have been applied to case problems and the results are presented.

2. Analysis of the Production and Inventory System

The Canned Food Company considered in this study produces a variety of canned foods based on demand. The lead time between placing an order and receiving it is 21 days. This period is set to ensure the availability of the relevant raw materials. In addition to its factory, the company has a warehouse in another location for packing material, as well as a warehouse for exported goods located near the port. The factory has three raw material inventories. One is for labels (including can labels and special offers labels), spices inventory (for example, sugar and salt) and can plant inventory (such as copper wires and glue). The final product inventory has a capacity of 100,000 cans. Figure 1 shows the material flow structure for the company inventories. Main problems faced by the company related to production, inventory, and material flow in general are listed below.

1. The company cannot meet the demand on time due to poor production plans.
2. Some processes take longer due to poor planning.
3. Excessive inventory is held in the system.
4. Lead time is relatively long for the final product.

The following procedure was used to solve the problems company was facing:

5. 1. Demand was forecasted for all 27 types of goods produced using past data.
6. 2. Production capacity was estimated to determine if demand could be covered.
7. 3. Inventory and production plans developed for raw material and finished products.

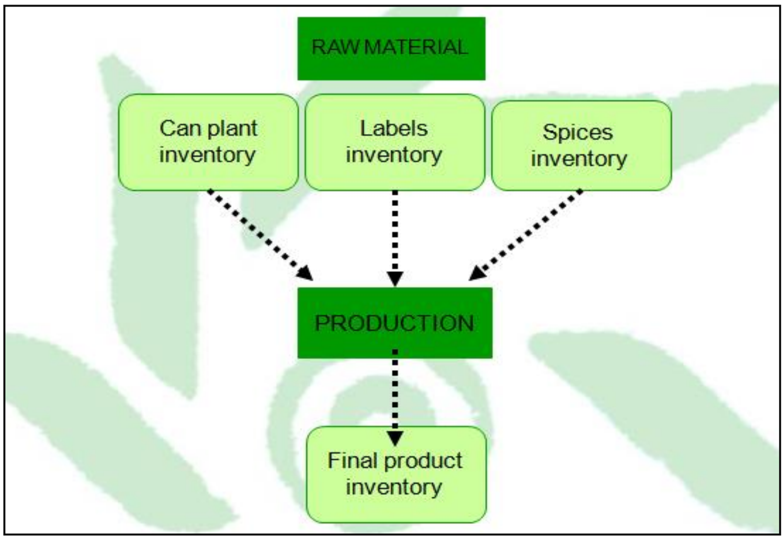

Figure 1. Inventory flow in the factory.

The following step by step methodology was used for solution of the problems:

1. Data was collected for the past three years for all goods.
2. Forecasting methods were applied to determine the demand for the next year.
3. Best forecasting method was selected based on forecasting errors.
4. Current inventory system and order quantities for raw material were analyzed based on forecasted demand.
5. Inventory models were used to determine optimum order quantities, which were compared to current system.
6. Current production plan and lot sizes were analyzed.
7. Production planning models were applied to determined optimum lot sizes.
8. Production capacity was checked if it was matched with the plan.
9. Capacity was adjusted according to the demand.
10. Service level calculations were made to determine safety stocks.

3. Demand Forecasting for the Canned Food

Demand forecasting is the activity of estimating the demand of products that consumers will purchase in the future. It involves techniques such as methods that can be used to predict the future demands or sales. Forecasting depends on the trend of the historical data, and the company's demand of the final products have a trend and seasonality in every September of each year, considering three years back. In this study the demand was forecasted for the next five years for capacity planning and for the next one year for production planning. The appropriated method that will be applied to forecast the demand must be with least error based on the (Mean Absolute Deviation (MAD) for each method. The tested forecasting methods were as follows:

- Moving average method
- Exponential smoothing with trend method
- Regression method
- Winter's method
- Holt's method

Based on the MAD error estimations, it was found that Holt's Method was the most appropriate method for forecasting the demand for 27 food products produced by the company under study. The Holt's method is designed to track time series with linear trend. Two smoothing constant α and β must be specified for two smoothing equations below:

$$S_t^* = (\alpha)^*(D_t^*) + (1-\alpha)^*(S_{t-1}^* + G_{t-1})$$
$$G_t^* = (\beta)^*(S_t^* - S_{t-1}^*) + (1-\beta)^*(G_{t-1}^*)$$
$$S_{t-1}^* = D_{t-1}^*$$
$$G_{t-1}^* = (D_i^* - D_j^*) / (i - j)$$
$$F_{t,t+\tau}^* = S_t^* + \tau G_t^*$$
$$F_t = F_t^* (CQ_t^*) \qquad [1]$$

Where S_t * is the value of the intercept, G_t* is the value of the slope, F_t* symbolizes the forecast of the deseasonalized unit and F_t is the final forecast of the original units. To compute the value of G_{t-1}*, an approximate trend line should be obtained by eyeballing the data. The first point the trend line goes through is the value of (i) and the last point is the value of (j). The forecasting results will not be presented for all 27 products due to space limitations. Only the case for baked beans is shown in Figure 2 for illustration.

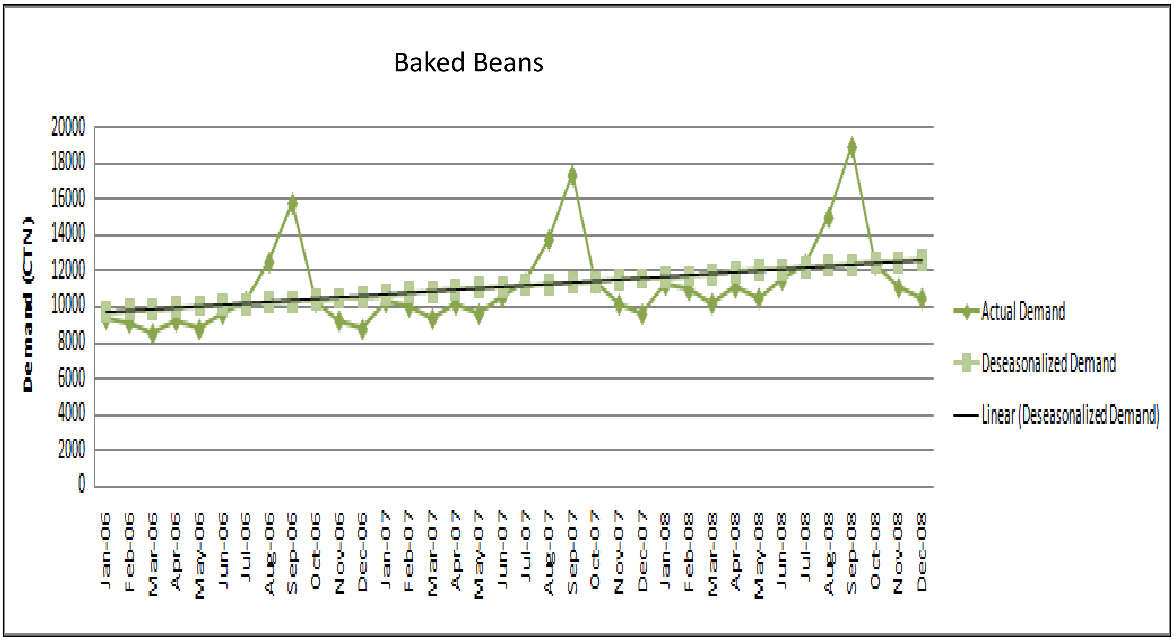

Figure 2. Forecasting model for seasonality & trend for baked beans.

As it is seen in the figure, there is a clear seasonality in every September. As mentioned previously, the value of Gt-1* can only be determined if a trend line passing through the deseasonalized demand is drawn. The trend line passes through D10* and D30* which are the values of (i) and (j) respectively. While it is not possible to present all the results in a tabular form, forecasting results for baked beans are shown in Figure 3. For example, expected demand in period 10, D10* is 10344. Different values of α and β were generated. It happens to be that when α is 0.9 and β is 0.1, the error is at its minimum. From the Figure 3, the forecasted demand is almost overlapping the actual demand. This indicates that the error is very low. After applying Holt's method, the following results were achieved for the baked beans. Mean Absolute Deviation = 12.542; Mean Square Error = 385.972. The same procedure is applied to the rest of the products and the results are summarized in Table 1. Forecasted demand for the next 5-years for baked beans are shown in Figure 4. The same was done for the rest of the 27 products. For all products, the trend line was passing through D10 and D30. The values of these two demand points, Mean Absolute Deviation (MAD), and Mean Square Error (MSE) are given in Table 1. Using the forecasting method presented above, the demand was forecasted for the next 5 years for all 27 products.

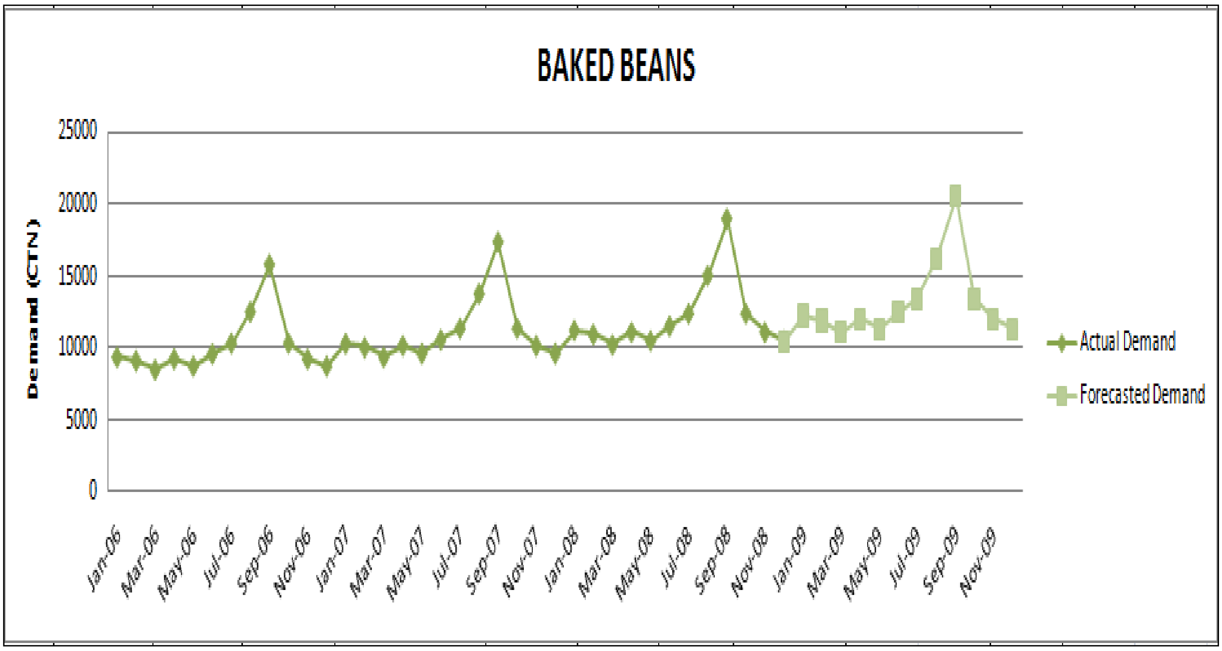

Figure 3. Forecasting results for the demand for baked beans.

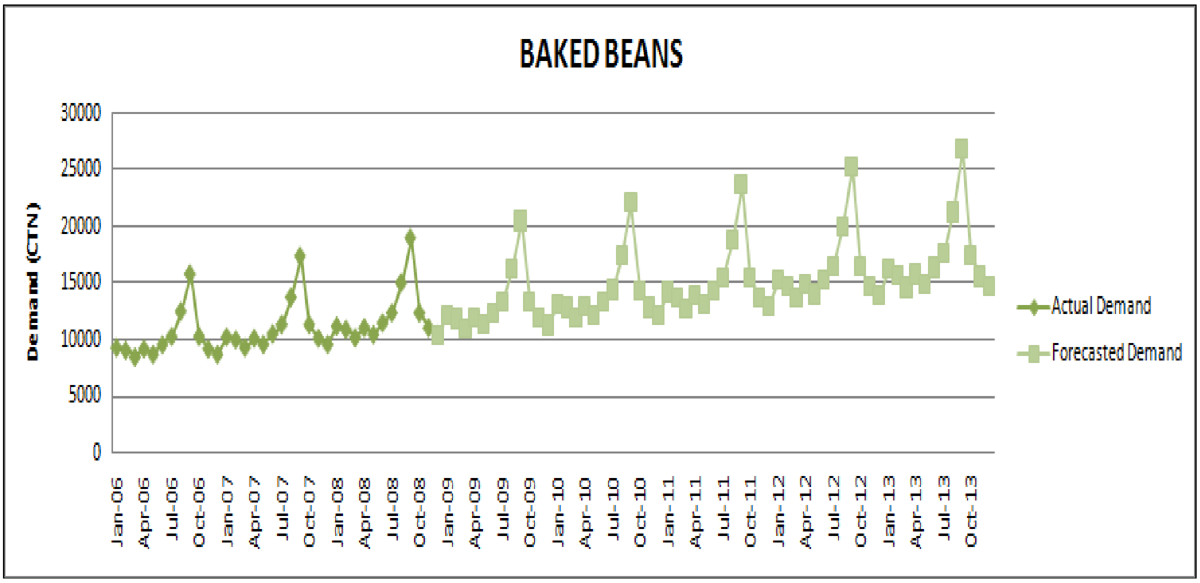

Figure 4. Forecasted demand for the next 5-years for baked beans.

Table 1. Demand forecasting results and related errors for 27 canned foods (partial)

Product Name	D_{10}	D_{30}	MAD	MSE
1. Black Eye Beans	1467	1713	1.779	7.765
2. Broad Beans	14673	17127	17.791	776.660
3. Chick Peas	19508	22771	23.654	1372.860
4. Chick Peas 10mm	2539	1963	3.078	23.251
…	..	..	..	..
…	..	..	..	..
26. Sweet Corn	1871	2184	2.269	12.230
27. White Beans	384	448	4.607	119.103

Figure 5 illustrates the 5-year forecasting for the case of baked-beans. Forecasting for the rest of the 26 products was done similarly. These results are reproduced here, since it is not necessary. The forecasted demand is used in inventory planning for economic order quantity calculations, which is discussed in the next section.

4. The EOQ Calculations for Canned Food Production Planning

The Economic Order Quantity (EOQ) is essentially an accounting formula that determines the point at which the total of two conflicting costs, namely the order costs and inventory carrying costs, is the least. The result is the most cost-effective quantity to order. In purchasing, this is known as the order quantity, whilst in manufacturing it is known as the production lot size. While EOQ may not apply to every inventory situation, most organizations will find it beneficial in at least some aspect of their operation. The EOQ formula, also known as Wilson's formula, as attributed to its developer, has been used since the beginning of 20th century. Thus, it is not a new formula, but its correct application is crucial. The formula is reproduced here and applied to the case of the company under consideration. Related parameters are as follows: Q = Order quantity; Q * = Optimal order quantity; D = Annual demand quantity of the product (average demand for three years was used); Ch is total annual holding cost per unit (also known as carrying cost); Co is the ordering cost per order. Based on these definitions, total cost equation [2] is differentiated with respect to Q and optimum Q* and the minimum total costs are obtained by EOQ model.

$$TC = C_h(Q/2) + C_o(D/Q) \quad [2]$$
$$Q^* = \sqrt{(2C_oD/C_h)} \quad [3]$$
$$TC^* = \sqrt{(2C_oDC_h)} \quad [4]$$

Using the forecasted demand and the cost figures for each raw material with the EOQ formula, the optimum order quantities are obtained for each raw material. Table 2, 3, and 4 compares the optimum order quantities to the current order quantities for the labeling raw material, spices, and the food raw material respectively.

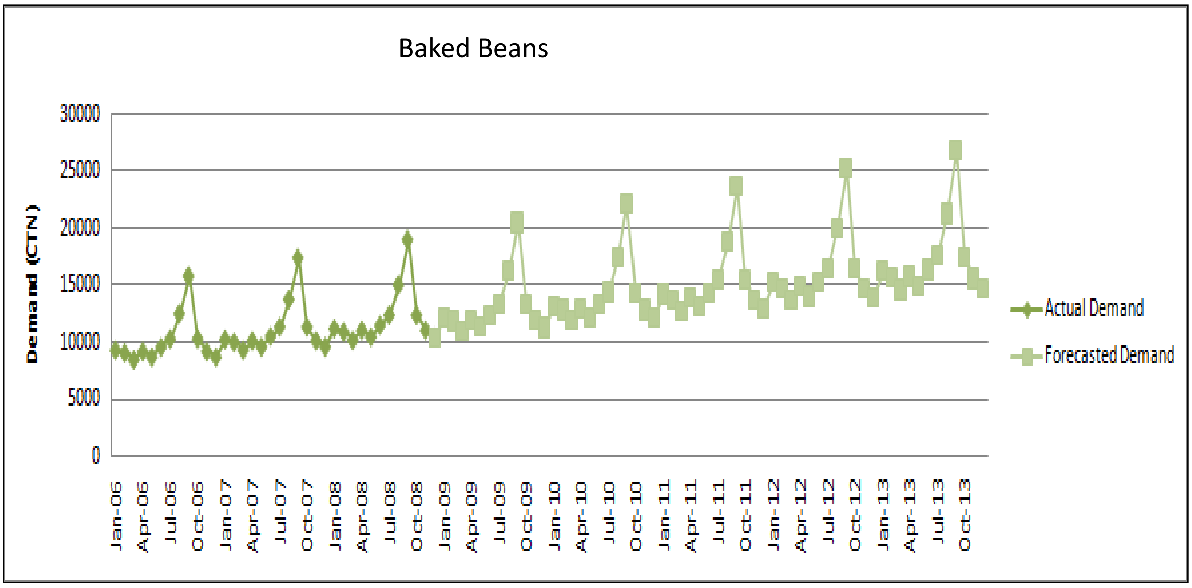

Figure 5. Forecasted demand for baked beans.

As it is seen from these tables, the optimum order quantities deviate much from the current order quantity. Apparently, the company was not using the EOQ in their order process as it is done by most other companies. The benefit of using EOQ is illustrated here by calculating the total inventory costs under the currently practiced ordering policies and the proposed optimum ordering policies for different raw material. (CTN=Counting; PCs=Pieces; Kg=Kilograms). The results are shown in Tables 5, Table 6, and Table 7. As it can be seen from these results, the inventory cos savings was 574.32 dollars for the labeling material, 186.40 dollars for spices raw material, and 12,406.92 dollars for the canned food raw material. The total savings was 13,167.64 dollars per year. This saving could be achieved by just changing the ordering policy based on optimum order quantities calculated and given in Table 3 and 4.

Table 2. The current and optimal quantities for the can plant.

Item	Unit	Q	Q*
Labels	CTN	2000	1474
Copper Wire	Kg	4250	812
Lids	CTN	2000	1266
Tin-sheet	CTN	1000	847
Cartoon	CTN	1500	1030
Shrink Film	PCS	30000	26857
Glue	Kg	6751	3071
Lacquer	Kg	6179	1593

Table 3. The current and optimal quantities for the spices.

Item	Unit	Q	Q*
Tomato Pasta	Kg	6000	3537
Lemon Juice	Liter	500	339
Green Color	Kg	1000	405
Edta	Kg	1000	775
Citric Acid	Kg	3000	1960
Camon Powder	Kg	1000	596
Chick Peas Powder	Kg	2000	1695
Spices	Kg	1000	548
Whole Red Chili	Kg	500	381
Onion Powder	Kg	2000	706
Powder Red Chili	Kg	1200	1014

Table 4. The current and optimal quantities for the beans.

Item	Unit	Q	Q*
Black Eye Beans	Kg	10553	2096
Broad Beans	Kg	132234	17287
Chick Peas 8mm	Kg	101930	18899
Chick Peas 7mm	Kg	27500	4633
Chick Peas 10mm	Kg	46309	6619
Whole Mushrooms	Kg	18750	2972
Mushroom Stems and Pieces	Kg	18750	2412
Green Peas	Kg	61291	2419
Mixed Vegetables	Kg	25811	2013
Navy Beans	Kg	53905	5228
White Beans	Kg	18766	2499
Peeled Fava Beans	Kg	65000	11185
Fava Beans	Kg	71153	7396
Red Kidney	Kg	33869	2070
Sweet Corn	Kg	33572	5806
Lima Beans	Kg	19184	4229
Carrots	Kg	12000	4883

Table 5. Inventory cost comparisons for the labeling raw material.

Item	Unit	TC	TC*	TC-TC*
Labels	CTN	448	424	24
Cooper Wire	Kg	496	180	316
Lids	CTN	80	72	8
Tin-sheet	CTN	32	28	0
Cartoon	CTN	40	36	4
Shrink Film	PCS	32	28	0
Glue	Kg	240	176	64
Lacquer	Kg	300	144	156
			Sum=	574.32

5. Service Level Calculations

The service level expresses the probability that a certain level of safety stock will not lead to a stock-out. Naturally, when safety stocks are increased, the service level increases as well. Three scenarios of service level percentages were applied to the average demand of the raw materials in order to evaluate the safety stock for each item. If the company applies one of the scenarios, it will consider the safety stock and the total cost for it. The following conditions related to the service level hold: The labels, cartons and the spices are locally provided, but the other raw materials are provided from different countries. The local raw materials have an average lead time of one week, while the other materials have an average lead time of three months. The three different service levels tested were 90%, 95%, and 99%. All raw materials follow a normal distribution. Parameters related to the calculations are as follows:

D: Average demand.
Q: Order quantity.
L: Lead time.
DL: Demand during lead time.
SS: Safety stock.
μ: Mean of the demand during lead time (DL)
σ: Standard deviation of the demand during lead time.

Table 6. Inventory cost comparisons for the spices raw material.

Item	Unit	TC	TC*	TC-TC*
Tomato Pasta	Kg	160	137.96	22.04
Lemon Juice	Liter	64	59	5
Green Color	Kg	192	133.48	58.52
Edta	Kg	48	46.48	1.52
Citric Acid	Kg	112	102.04	9.96
Camon Powder	Kg	64	53.68	10.32
Chick Peas Powder	Kg	68	66.08	1.92
Spices	Kg	80	65.72	14.28
Whole Red Chili	Kg	40	37.76	2.24
Onion Powder	Kg	152	95.24	56.56
Powder Red Chili	Kg	60	57.76	2.24
			Sum=	186.4

Table 7. Inventory cost comparisons for the canned food raw material.

Item	Unit	TC	TC*	TC-TC*
Black Eye Beans	Kg	301.76	169.76	132.04
Broad Beans	Kg	3254.96	1244.68	2010.32
Chick Peas 8mm	Kg	2572.48	1360.72	1211.72
Chick Peas 7mm	Kg	974.8	472.6	502.24
Chick Peas 10mm	Kg	1288.64	536.16	752.48
Whole Mushrooms	Kg	1167.4	534.88	632.48
Mushroom Stems and Pieces	Kg	1152.92	434.12	718.8
Green Peas	Kg	1044.4	123.36	921.04
Mixed Vegetables	Kg	963.72	223.4	740.32
Navy Beans	Kg	464.08	133.16	330.96
White Beans	Kg	1078.84	419.8	659.04
Peeled Foul	Kg	2376.04	1174.44	1201.64
Fava Beans	Kg	1590.72	488.16	1102.6
Red Kidney	Kg	1053.68	192.12	861.56
Sweet Corn	Kg	1157.56	574.76	582.84
Lima Beans	Kg	139.8	86.16	53.64
Carrots	Kg	55.84	54.6	1.24
			Sum=	12406.92

The mean and the standard deviation are obtained by fitting the demand during lead time to a distribution using Arena (Kelton, 2012) input analyzer. Safety stock (SS) is calculated by the following formula:

$$SS = \mu + z\,\sigma \quad [5]$$

Total Inventory Cost with safety Stock, $TC(SS) = TC(Q) + C_h(SS)$

$$z = \frac{x-\mu}{\sigma}$$

Table 8 shows the average demand, mean and standard deviation of demand during lead time, optimum order quantity Q, total inventory cost (TC(Q)), and the holding cost for the list of products for which service level were calculated. We did not include sauces, paste, and spice group of products as they were not very crucial. Table 9 shows the safety stock inventory costs at different service levels. After applying the three scenarios of the service levels for the beans, it was found that the 90% service level once again gives the least total cost, which is equal to 36204.92 $/year, according to the safety stock. The total cost of the current order quantity without keeping any safety stock is equal to 20637.36 $/year.

Table 8. Average demand, optimum order quantity and the costs for the beans

Product	Average Demand	Unit	Mean	Stand. dev	Q	TC(Q)	C_h
Black Eye Beans	88936	Kg	1853	794	10553	301.76	0.08
Broad Beans	768446	Kg	15328	7133	132234	3254.96	0.07
Chickpeas 8mm	1168924	Kg	17262	16829	101930	2572.48	0.07
Chickpeas 7mm	608219	Kg	12671	5429	27500	974.80	0.10
Chickpeas 10mm	161314	Kg	3361	1440	46309	1288.64	0.08
Whole Mushrooms	132455	Kg	3356	7122	18750	1167.40	0.18
Mushroom Stems and Pieces	109071	Kg	2272	974	18750	1152.92	0.18
Green Peas	24859	Kg	7392	5614	61291	1044.40	0.05
Mixed Vegetables	37465	Kg	1873	1824	25811	964.00	0.11
Navy Beans	24859	Kg	3760	9203	53905	464.00	0.02
White Beans	37465	Kg	518	222	18766	1080.00	0.17
Peeled Foul	820995	Kg	780.5	334.5	65000	2376.00	0.10
Fava Beans	128946	Kg	15709	8098	71153	1592.00	0.07
Red Kidney	24859	Kg	3096	7061	33869	1052.00	0.09
Sweet Corn	208549	Kg	4345	1861.5	33572	1156.00	0.10
Lima Beans	26026	Kg	542.3	232.5	19184	140.00	0.02
Carrots	16664	Kg	347.3	149	12000	56.00	0.01
SUM						20637.36	

Table 9. Safety stock costs at different service levels the beans

Product	SS For 90%	TC (SS) 90%	SS For 95%	TC (SS) 95%	SS For 99%	TC (SS) 99%
Black Eye Beans	2869	531.28	3154	554.12	3694	597.28
Broad Beans	24458	5015.96	27026	5200.80	31876	5550.04
Chickpeas 8mm	38802	5366.24	44860	5802.40	56304	6626.32
Chickpeas 7mm	19620	3015.28	21574	3218.52	25265	3602.40
Chickpeas 10mm	5204	1704.96	5722	1746.44	6702	1824.76
Whole Mushrooms	12471	3412.16	15035	3873.64	19877	4745.32
Mushroom Stems/pieces	3518	1786.24	3869	1849.32	4531	1968.48
Green Peas	14577	1802.40	16598	1907.48	20415	2105.96
Mixed Vegetables	4208	1435.00	4865	1508.56	6105	1647.48
Navy Beans	15540	837.04	18853	916.56	25111	1066.76
White Beans	802	1213.64	882	1227.04	1033	1252.40
Peeled Foul	1209	2501.76	1329	2514.28	1557	2537.92
Fava Beans	26075	3363.80	28990	3562.04	34497	3936.52
Red Kidney	12134	2170.04	14676	2403.88	19478	2845.60
Sweet Corn	6727	1830.32	7398	1897.32	8663	2023.92
Lima Beans	840	156.60	924	158.28	1082	161.44
Carrots	538	62.28	592	62.92	693	64.16
Sum		36204.92		38403.64		42556.80

The total costs for different service levels are summarized in Table 10. As it is seen in the table, the scenario is to have a 90% service level with a total cost of 36205 dollars per year. As it was mentioned before, if no safety stocks were kept the total inventory costs would be 20637.36 $/year. But, with such a policy, the company would run out of stocks 50% of time, while with the best safety stock policy, the probability or percent of time the company would run out of stocks would be only 10% of time. It is necessary to look into shortage costs to see if the additional cost of 36,205-20,638=15,567 $/year is justified to keep safety stocks. Because, we did not have data for shortage costs, we could not make such an analysis. However, if such analysis could be done, it would be most likely that keeping safety stocks would be justified. If just optimum EOQ model was implemented during the past 3 years, the company would have saved $13,164 per year. In addition to the EOQ and safety stocks analysis, economic production quantity (EPQ) analysis was also performed on all products. The models and procedures are not included in this paper due to excessive amount of material and tables. It was found that if optimum EPQ models were implemented during the past three years, the company would have saved $50,976 per year and if optimum EPQ model were implemented in the coming next year, the company could save $18,912 on total inventory costs.

Table 10. Total costs for the different service levels.

Service Level	TC($/yr.)
Scenario 1: 90%	36204.92
Scenario 2: 95%	38403.64
Scenario 3: 99%	42556.80

6. Conclusions

This study involved with the analysis and improvement of the production planning processes in a canned food factory. After testing several forecasting methods, Holt's method was the most appropriate procedure for forecasting the demand for 27 food products. After forecasting the demand, economic order quantities were calculated using EOQ model for each product, which resulted in optimum order quantity and the minimum cost. Furthermore, the EPQ model was applied to the same products to determine the optimum production quantities for the set up of the line for each product. It was found that the company could have substantial savings if these already available formulas and the procedures were correctly applied. The procedures and the case applications presented in this paper illustrate the importance of the use of production planning tools in reducing the production and inventory costs.

References

Amare, T., Singh, B., Kabata, G., and Bhaskaran J. (2021) “Improvement Analysis of Production Planning and Control System”, Industrial Engineering & Management Vol. 10, No. 3.

Jaipuria, S., & Mahapatra, S. S. (2014). An improved demand forecasting method to reduce bullwhip effect in supply chains. Expert Systems with Applications, 41(5), 2395-2408

Kandananond, K. (2012). Consumer product demand forecasting based on artificial neural network and support vector machine. International Journal of Economics and Management Engineering, 6(3), 313-316.

McGarrie, B. (1998), "Case study: production planning and control - selection, improvement and implementation", Logistics Information Management, Vol. 11 No. 1, pp. 44-52.

Mozelewski, T. G., & Scheller, R. M. (2021). Forecasting for intended consequences. Conservation Science and Practice, 3(4), 370-380.

Murphy, M. D., O’Mahony, M. J., Shalloo, L., French, P., & Upton, J. (2014). Comparison of modelling techniques for milk-production forecasting. Journal of dairy science, 97(6), 3352-3363.

Rianthong, S., Ruekkasaem, L., and Aungkulanon, P. (2019) “Aggregate Production Planning, Case Study in a Small-Sized Company in Thailand”, International Journal of Mechanical Engineering and Technology 10(12): pp.182-187.

Savsar, M. and Abdulmalek, F. (2008), “Modeling of a Pull-Push Assembly Control System to Minimize Inventory and Demand Delay Costs”, *International Journal of Industrial Engineering, Vol. 15, No. 1.*

Savsar, M. “Analysis and Improvement of Efficiency for Food Processing Assembly Lines,” International Conference on Production Engineering and Management, 24-25 April 2017, Boston, USA.

Shin, S., Ennis, K. L., & Spurlin, W. P. (2015). Effect of inventory management efficiency on profitability: Current evidence from the US manufacturing industry. Journal of Economics and Economic Education Research, 16(1), 98.

Wei, Y., Wang, H., & Qi, C. (2013) “On the stability and bullwhip effect of a production and inventory control system”, International Journal of Production Research, 51(1), 154-171.

Yenradeea, P., Pinnoi, A., and Charoenthavornying, A. (2001). “Demand Forecasting and Production Planning for Highly Seasonal Demand Situations: Case Study of a Pressure Container Factory”, Science Asia, Vol. 27, pp. 271-278.