Method selection for demand forecasting: Application in a private hospital

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**ABSTRACT**

On the basis of a productive and peaceful society, the physical and mental health of individuals constituting society lies. The threat for health resulting from the deterioration of environmental conditions, genetic inheritance, etc. leads individuals to receive health care services and thus direct them to hospitals. Hospitals in the service sector are enterprises where there is very intense interaction with customers which is difficult to manage. Competition among the institutions involved in this field, to transfer the best service to our customers with cost-efficient confronts us as a necessity. One of the most important points in providing suitable planning during making a purchase. Particularly in institutions such as hospitals where the purchase of medical supplies is a major cost item, a good demand forecast should be made for the control of inventory costs. In this study, with data taken from a hospital in Istanbul, a demand forecast application was conducted with the actual demand data for the last five years of basic medical materials used. Different forecasting methods were applied to the available data, and it was intended to determine the most appropriate forecasting method.

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**Introduction**

Health services to be effective and efficient are very important for people to maintain prosperity in their lives. The presence of health services fictionalized with a lean approach where waste is reduced, service areas are satisfied is also a great contribution to the development of societies. With the impact of global competition, especially in hospitals located in the central area of health services; employee management, implementation of improvement activities in the supply and installation planning has become an imperative condition (Bendavid and Boeck, 2011).

Hospitals are places which are showing the importance given to health in the country. Therefore, in order for the hospitals in Turkey to operate effectively and efficiently, it is important to provide quality health care (Tasliyan and Gök, 2012). In the health field, materials and equipment are of great importance to offer various services to consumers quickly. While the lack of equipment when needed is causing serious problems, material stocked in large quantities also adversely affect the costs.

Demand forecast is carried out to estimate raw materials, the product or customer demand for a future period of time. The growing popularity of the concept of supply chain, has enabled supply chain members to conduct study on this issue. In this way, the benefits are pronounced particularly for the reduction of inventory levels (Murphy and Klemeyer, 2016). Demand forecasting is very important as business decisions based largely on projections. Decisions regarding which markets will be entered, which products will be produced, how the purchase will be made, how much stock will be achieved and how many staff will be employed need forecasting (Ersoy and Ersoy, 2011). The success of demand forecasting plays an important role in the meeting the demands of targeted cost estimates, to obtain the intended profit and resulting satisfaction of the stakeholders who benefit from the system (Yaman, 2011).

Forecasts can be classified as short, medium and long term. Short-term forecast cover a period of less than six months. It is available for purchasing decisions, job scheduling, labor levels and production levels. Medium term forecasts, which cover the period from six

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months to two years serve for labor, material and inventory planning purposes. The forecasts for over two years or more are long-term. It is intended to provide data on issues such as expansion of facilities, planning of new products, and availability of capital funds and is usually carried out by senior management (Yenersoy, 2011; Yüksel, 2013).

The purpose of this study is the choice of method to use in a private hospital medical services in Istanbul to be used to determine the demand for some of the materials for the next year. As historical data is found on a monthly basis, it is deemed appropriate to make forecasts within the same period using time series. Different methods were compared under various error criteria used, and the most appropriate method was selected. With the study conducted, it was intended to shed light on the company’s stock plans, to contribute to the literature on buying supplies in hospitals where small number of studies are relatively made.

**Literature Review**

**Theoretical and Conceptual Framework**

Various studies exist in the literature available for demand forecasting. Rahman and Hazim (1993) carried out a work on forecasting the temperature of the four states in the United States with a model based on regression applied to categorized data. Tanrtanır (1995), in a demand forecasting study for a furniture factory, has forecasted the value of 1993 by applying the method of regression to the amount of sales in 1990-1992. Akbay, Aktas and Koç in their study (1999) have studied the effects of socio-economic variables that affect consumption of concentrated fruit juice consumption. In research, the data obtained from surveys of household consumption to specify the juices are used. Gavcar, Sen and Aytekin (1999) in their demand forecasting study, made the demand forecast of eight different types of paper among paper and paperboard types used in Turkey. Patır and Yıldız (2003) forecasted the amount of sales of industrial enterprises in 2002 by using Monte Carlo simulation application. Soysal and Ömürşönen (2010) in their study on tourism industry on the demand forecasts have carried out a forecast for the first six months of 2008 by using data on the number of domestic and foreign tourists who come to the facilities with operation certificates between 2000-2007. While making their forecast, they compared the performance of Moving Average, Simple Exponential Smoothing and Holt-Winters method. Sabar and Batukan (2013), made demand forecasting using time series method in textile paint finishing enterprises. While researchers are forecasting demand, they have used exponential smoothing method and Winters model. Solak (2013) in his study used the Box-Jenkins method to estimate the demand for oil in the transport sector and Turkey's total oil demand. In the study he used 42 years of data covering the years 1970 to 2011 and has made forecast for 2012-2020 period. Çuhadar (2014) conducted a study to forecast the external tourism demand in Mugla province. In this study, he used the number of tourists, the number of overnights, tourism revenues, hotel occupancy rate and visitors expenses as the extent of demand. Exponential smoothing and Box-Jenkins method were applied using the data specified. Smith and Agrawal (2015) aims to demonstrate that it may be possible to create technology forecasting models through the use of patent groups. The techniques used are Holt-Winters Exponential Smoothing and ARIMA.

**Forecasting Methods**

When the scope of the literature of demand forecasting studied, it is possible to see numerical and non-numerical methods.

**Delphi Method:** It is a method that can be used when there is no data to develop statistical models of the past. Delphi method can be used in the long-term forecast of product demand and new product sales forecasts (Yüksel, 2013). In this method, first the individual opinions of experts are collected and these views are transferred into experts n a certain order and it is required to reconsider the ideas in the previous round. This decision-making system continues until a compromise is maintained (Okoli and Pawlowski, 2004; Viehland, 2007).

**Market Research:** Hypotheses are tested by using data collected through a survey, the interest of customers for a product or services are determined with a systematic approach (Yüksel, 2013).

**Life Cycle Model:** Product life cycle model is a planning tool developed with the aim to forecast market life of a good or a service. It is used to find solutions to marketing problems of the product that will encounter throughout life and to determine the appropriate marketing strategy. In addition, while making demand forecast, they are able to forecast by looking at the product life cycle of other similar products (Karafakioğlu, 2012).

**Expert Opinions:** Forecasts made by the determination of experts and senior managers opinions.

**Time Series:** Time series; is a series of observations obtained in regular intervals for a certain period (day, week, month, year, etc.) (Özcan, 2009). Number series revealed by the arrangement of observation results with acquisition depending on time is called a time series. Annual import and export values, monthly sales of a company, weekly or daily cash receipts in a company, the price of the exchange, etc. can be expressed as a time series (Turan and Gürüş, 2008; Bozkurt, 2013). There are many methods used in the analysis of time series. Some of those can be expressed as; simple average, moving average methods, exponential smoothing, Holt-Winters method.

**Regression:** Regression is a method that enables to describe the relationship between at least two variables by an equation. If relationships between variables can be expressed by equation, unknown variable values can be estimated with the help of a known variable values (Çil, 2013).
Econometric Models: Econometric models provide opportunities to forecast by solving multiple regression equations about a wide range of economic activities (Yüksel, 2013).

Simulation: is a method that can be used to generate estimates for the future by means of random numbers considering the probability values of the results obtained in the past.

Determination of the Appropriate Forecasting Methods

Forecasting methods to be used can vary according to the length of the period to be forecasted, the desired degree of accuracy, and the budget allocated. After analysis of the data sets by forecasting methods, it is important to assess the scope of error criteria. Error criteria, enables us to interpret the relationship between the forecasted values and the actual behavior of the time series. Error criteria mostly used in demand forecasting; are mean error, mean absolute error, mean square error and error percentage values. Mean error (ME), represents how far the forecasts are below or above the demands as average. If positive errors in some periods are put out with negative error of other period and ME gets a small value or approaches zero. This result is a natural development resulting from normal distribution of error and defines that the forecast is neutral / impartial. In mean absolute error (MAE), whether the magnitude of the error is negative and positive is not taken into account. Average is the difference between average absolute error forecast and actual values. With the value of mean absolute percentage error (MAPE), the absolute error, is not taken into account per period but as a percentage of the actual value. If squaring is preferred as a way positive (+) or negative (-) errors not to influence each other, the error range is defined in large numbers. As the averages of the squared error (MSE) are taken by squared errors the value of errors grow and big errors are punished in a sense. In the evaluation phase of MSE value, lower estimation method is chosen as the most appropriate method for the data set (Barlow, 2005; Ersoy and Ersoy 2011; Yenersoy, 2011).

Application

Today, the health sector in addition having a large share of the economy has become an important service industry in Turkey. Modern health systems are forced to cope with increasing demand (Blume et al., 2015). It is a fact that the numbers of enterprises in our country in health sector do not meet the rapid population growth. Lower ratio of the number of health facilities, the lack of the number of doctors and nurses in hospitals, lack of materials and equipment to meet the needs of consumers require the upgrading of the adoption of corrective measures in the health sector and service quality (Tutar and Kılınç, 2007).

Hospitals, which are one of the cornerstones of the health sector, are important units in which hundreds of patients are treated in a day. The availability of materials used in these units for treatment should be handled carefully. Problems occur due to possession of surplus stocks based costs as well as problems that may arise in the absence of these materials should be considered. The hospital that is used for its data is a hospital with 2600 beds. This hospital has four operating rooms and four intensive care units. Intensive care units are; surgical intensive care units, general intensive care, coronary care, intensive care newborn. Purchasing department of the hospital is divided into three parts as general purchasing, medical purchase and medical drug (pharmacy) purchase. Medical equipment purchase is a section which purchases all medical materials with approximately twenty-five suppliers. Varieties of forecasting methods were applied for purchase data of four different medical materials commonly used in the hospital for five years (monthly). Three and five-month moving average basis, single exponential smoothing method, Holt’s linear method, the term multiplicative Holt-Winters method, additive-term Holt-Winters method and regression methods were applied and comparisons were made. To compare methods, Mean Absolute Error, Mean Absolute Percentage Error and Average Squared Errors were used for error criteria values determination. Only Medical Gloves analyses were presented under study. In Table 1, the amount of demand in 2010-2014 of gloves is shown.

Table 1: Glove Demand Amounts Between years of 2010-2014 (pcs)

|       | 2010   | 2011   | 2012   | 2013   | 2014   |
|-------|--------|--------|--------|--------|--------|
| January | 31055  | 32040  | 32545  | 33540  | 33540  |
| February | 31522  | 32510  | 32560  | 32560  | 32560  |
| March | 31525  | 31520  | 33560  | 31540  | 31540  |
| April | 32055  | 31530  | 32565  | 32540  | 34566  |
| May | 32544  | 32520  | 31560  | 31550  | 34560  |
| June | 32550  | 31526  | 31860  | 32560  | 32560  |
| July | 35580  | 32035  | 33050  | 32056  | 33560  |
| August | 33320  | 33520  | 33565  | 33540  | 34560  |
| September | 32560  | 32052  | 34560  | 34550  | 35560  |
| October | 32560  | 32052  | 31560  | 31450  | 32540  |
| November | 32560  | 32560  | 32560  | 32560  | 35520  |
| December | 31560  | 32540  | 32560  | 34520  | 35460  |

Source: Authors' own work
Most demanding sections for gloves in hospital are laboratory, patient rooms, intensive care, emergency services and general biochemistry unit. Maximum demand for gloves was realized in 2014. 406526 pcs of gloves have been requested during the twelve months in 2014. In the year 2010, 389391 pcs, in the year 2011 386405 pcs, in the year 2012 392505 pcs, and total demand realized in the year 2013 was 392966.

**Forecasting with Moving Average Methods**

By taking into account the amount of specified demand for gloves, it was made moving average estimate primarily for 3-months and 5-months. Tables 2 and 3 shows only the last year of 5 years data. Calculations were made considering 3-months and 5-months moving months average values and the revealed forecast values, forecast errors and error criteria were stated.

![Time Series Plot of Eldiven](image)

**Figure 1**: Demand for Gloves for 60 months

**Table 2**: Forecasting Results with 3-Months Moving Average for Gloves

| Months     | Demand | Moving Average(MOV3) | Forecast | Error |
|------------|--------|----------------------|----------|-------|
| January    | 33540  | 33540                | 32843    | 697   |
| February   | 32560  | 33540                | 33540    | -980  |
| March      | 31540  | 32547                | 33540    | -2000 |
| April      | 34566  | 32889                | 32547    | 2019  |
| May        | 34560  | 33555                | 32889    | 1671  |
| June       | 32560  | 33895                | 33555    | -995  |
| July       | 33560  | 33560                | 33895    | -335  |
| August     | 34560  | 33560                | 33560    | 1000  |
| September  | 35560  | 34560                | 33560    | 2000  |
| October    | 32540  | 34220                | 34560    | -2020 |
| November   | 35520  | 34540                | 34220    | 1300  |
| December   | 35460  | 34507                | 34540    | 920   |

| MAPE       | 3      |
| MAE        | 940    |
| MSE        | 1347325|

**Source**: Authors' own work
Table 3: Forecasting Results with 5-Months Moving Average for Gloves

| Months  | Demand | Moving Average (MOV5) | Forecast | Forecast Error |
|---------|--------|-----------------------|----------|----------------|
| January | 33540  | 33324                 | 33324    | 216            |
| February| 32560  | 32926                 | 33324    | -764           |
| March   | 31540  | 32944                 | 32926    | -1386          |
| April   | 34566  | 33345                 | 32944    | 1622           |
| May     | 34560  | 33353                 | 33345    | 1215           |
| June    | 32560  | 33157                 | 33353    | -793           |
| July    | 33560  | 33357                 | 33157    | 403            |
| August  | 34560  | 33961                 | 33357    | 1203           |
| September| 3560   | 34160                 | 33961    | 1599           |
| October | 35520  | 34348                 | 33756    | -1620          |
| November| 35460  | 34728                 | 34348    | 1112           |

MAPE: 3
MAE: 870
MSE: 1210377

Source: Authors' own work

Forecasting with Exponential Smoothing Method

In the second stage, the forecasting was made with exponential smoothing method which was frequently encountered in the literature. Exponential smoothing methods, required correction factors are chosen as 0.2, 0.5 and 0.8. Information in the literature have been used to determine these values. The results created by using 0.2 value are expressed in Table 4. The values for all results are presented in Table 9 and 10 together.

Forecasting with Holt’s Linear Method

Holt’s linear method is a method that can be used when the average and growth rate of time series change. There may be increased or decreased trend in demand. Exponential smoothing is made in order to create a new basic level to determine the trend in the first stage.

Table 5: Forecast Results with Holt’s Linear Method

| Months   | Demand | Exponential Smoothing | Basic Level | Trend | Forecast Demand | Forecast Error |
|----------|--------|-----------------------|-------------|-------|-----------------|----------------|
| January  | 33540  | 33650                 | 33650       | 60    | 33831           | -291           |
| February | 32560  | 32995                 | 32995       | 19    | 33710           | -1150          |
| March    | 31540  | 32097                 | 32097       | -33   | 33014           | -1747          |
| April    | 34560  | 33620                 | 33620       | 55    | 32064           | 2502           |
| May      | 34560  | 34226                 | 34226       | 87    | 33676           | 884            |
| June     | 32560  | 33223                 | 33223       | 25    | 34313           | -1753          |
| July     | 33560  | 33442                 | 33442       | 36    | 33247           | 313            |
| August   | 34560  | 34151                 | 34151       | 74    | 33478           | 1082           |
| September| 35560  | 35055                 | 35055       | 121   | 34225           | 1335           |
| October  | 32540  | 33537                 | 33537       | 28    | 35177           | -2637          |
| November | 35520  | 34781                 | 34781       | 97    | 33564           | 1956           |
| December | 35460  | 35240                 | 35240       | 118   | 34878           | 582            |

MAPE: 3
MAE: 915
MSE: 1385483

Source: Authors' own work

Equation that will be used to determine the basic trend is as follows (Bulut, 2006; Benli and Yildiz, 2014):

\[
L_t = \alpha Y_t + (1-\alpha)(L_{t-1} + T_{t-1})
\]

\[
F_{t+n} = L_t + nT_t
\]

\[
T_t = \beta (L_t - L_{t-1}) + (1 - \beta)T_{t-1}
\]
\( L_t \): Expected level of the period \( t \)  
\( \alpha \): The smoothing factor of the level  
\( Y_t \): Actual value in the period  
\( T_t \): Trend in period \( t \)  
\( \beta \): The smoothing factor of the trend  
\( n \): The number of periods to be foreseen

The method was applied by using the specified equities. The results are summarized in Table 5 above.

**Forecasting with Holt-Winters methods**

Holt-Winters exponential smoothing methods, consider trend and seasonality which can be found in the series and each component of the series will be forecasted by using separate equations (Sen and Kaba, 2009). The most commonly used methods for seasonal time series; the additive Holt-Winters method for additive seasonality and multiplicative Holt-Winters method recommended for multiplicative seasonality (Irmak et al., 2012). Holt-Winters exponential smoothing methods are based on three equal. The first is to determine the level of \( t \) period, second to determine the trend, and the third is used to determine the seasonal component. The equations for the multiplicative method can be expressed as follows (Çuhadar, 2014):

\[
L_t = a \left( \frac{Y_t}{S_{t-s}} \right) + (1 - a) \left( L_{t-1} + b_{t-1} \right)
\]
\[
b_t = \beta \left( L_t - L_{t-1} \right) + (1 - \beta) b_{t-1}
\]
\[
S_t = \gamma \left( \frac{Y_t}{L_t} \right) + (1 - \gamma) S_{t-1}
\]
\[
F_{t+m} = L_t + b_t m + S_{t-s+m}
\]

\( L_t \): the overall level of the series in period \( t \)  
\( Y_t \): Observation value  
\( S_t \): seasonal component  
\( b_t \): Trend component  
\( \alpha \): Level correction constant  
\( \beta \): Trend correction constant  
\( \gamma \): Season correction constant  
\( F_{t+m} \): Forecast value for future period \( m \)  

In Holt-Winters’ multiplicative exponential smoothing method size of the seasonal fluctuation varies according to the length of the series and is fixed in the additive method. Equations of additive exponential smoothing method are formulated as follows (Çuhadar, 2014):

\[
L_t = a \left( Y_t - S_{t-s} \right) + (1 - a) \left( L_{t-1} + b_{t-1} \right)
\]
\[
b_t = \beta \left( L_t - L_{t-1} \right) + (1 - \beta) b_{t-1}
\]
\[
S_t = \gamma \left( Y_t - L_t \right) + (1 - \gamma) S_{t-1}
\]
\[
F_{t+m} = L_t + b_t m + S_{t-s+m}
\]

By using equations, both methods were applied to data sets separately. In determining the parameters, in light of the data in the literature, statistical software package was utilized.

**Table 6: Multiplicative Holt-Winters Method Results for Gloves**

| Months    | Demand | Exponential Smoothing | Basic Level | Trend | Season Index | Demand Forecast | Forecast Error |
|-----------|--------|-----------------------|-------------|-------|--------------|----------------|---------------|
| January   | 33540  | 32805                 | 33070       | 83    | 1            | 32861          | 679           |
| February  | 32560  | 32787                 | 33091       | 70    | 1            | 32869          | -309          |
| March     | 31540  | 32418                 | 32968       | 32    | 1            | 32487          | -947          |
| April     | 34566  | 32684                 | 33372       | 106   | 1            | 32715          | 1851          |
| May       | 34560  | 32897                 | 33795       | 169   | 1            | 33002          | 1558          |
| June      | 32560  | 33272                 | 33786       | 134   | 1            | 33439          | -879          |
| July      | 33560  | 34207                 | 33765       | 103   | 1            | 34342          | -782          |
| August    | 34560  | 34709                 | 33818       | 93    | 1            | 34815          | -255          |
| September | 35560  | 34874                 | 34026       | 116   | 1            | 34970          | 590           |
| October   | 32540  | 33175                 | 33988       | 85    | 1            | 33288          | -748          |
| November  | 35520  | 34097                 | 34340       | 138   | 1            | 34183          | 1337          |
| December  | 35460  | 34787                 | 34584       | 160   | 1            | 34927          | 533           |
| MAPE      | 2      |                       |             |       |              |                |               |
**Table 7: Holt-Winters Additive Method Results for Gloves**

| Months     | Demand | Exponential Smoothing | Basic Level | Trend | Season Index | Demand Forecast | Forecast Error |
|------------|--------|-----------------------|-------------|-------|--------------|----------------|----------------|
| January    | 33540  | 32880                 | 33094       | 87    | 64,08        | 32943          | 597            |
| February   | 32560  | 32852                 | 33105       | 71    | -302,65      | 32938          | -378           |
| March      | 31540  | 32477                 | 32974       | 31    | -788,91      | 32549          | -1009          |
| April      | 34566  | 32729                 | 33367       | 103   | 43,69        | 32760          | 1806           |
| May        | 34560  | 32929                 | 33776       | 164   | -192,99      | 33033          | 1527           |
| June       | 32560  | 33291                 | 33761       | 129   | -628,11      | 33455          | -895           |
| July       | 33560  | 34184                 | 33739       | 99    | 302,54       | 34313          | -753           |
| August     | 34560  | 34650                 | 33800       | 91    | 880,62       | 34748          | -188           |
| September  | 35560  | 34810                 | 34023       | 117   | 1115,5       | 34901          | 659            |
| October    | 32540  | 33169                 | 33991       | 88    | -973,13      | 33286          | -746           |
| November   | 35520  | 34043                 | 34356       | 143   | 274,78       | 34131          | 1389           |
| December   | 35460  | 34713                 | 34620       | 167   | 453,48       | 34856          | 604            |

**Source:** Authors’ own work

**Table 8: Simple Linear Regression Results for Gloves**

| Months     | Demand | Demand Forecast | Forecast Error |
|------------|--------|----------------|----------------|
| January    | 33540  | 33370          | 170            |
| February   | 32560  | 33401          | -841           |
| March      | 31540  | 33432          | -1892          |
| April      | 34566  | 33463          | 1103           |
| May        | 34560  | 33494          | 1066           |
| June       | 32560  | 33525          | -965           |
| July       | 33560  | 33556          | 4              |
| August     | 34560  | 33587          | 973            |
| September  | 35560  | 33618          | 1942           |
| October    | 32540  | 33649          | -1109          |
| November   | 35520  | 33680          | 1840           |
| December   | 35460  | 33711          | 1749           |

**Source:** Authors’ own work

**Forecasting with Linear Regression**

In regression method, for finding coefficients, observations regarding dependent and independent variables are needed. A linear regression equation between two variables can be expressed as follows (Serper, 2010: Altaş, 2013):

\[
Y = \beta_0 + \beta_1 X + \epsilon \\
\hat{Y} = a + bX + \epsilon_i
\]

Y: Dependent variable
X: Independent variable
\(\hat{Y}\): Forecast value
\(\beta_0, \beta_1, a, b\): Parameters of the regression equation
\(\epsilon, \epsilon_i\): Error term, Forecaster of error term

**Table 8: Simple Linear Regression Results for Gloves**

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|------------|--------|----------------|----------------|
| January    | 33540  | 33370          | 170            |
| February   | 32560  | 33401          | -841           |
| March      | 31540  | 33432          | -1892          |
| April      | 34566  | 33463          | 1103           |
| May        | 34560  | 33494          | 1066           |
| June       | 32560  | 33525          | -965           |
| July       | 33560  | 33556          | 4              |
| August     | 34560  | 33587          | 973            |
| September  | 35560  | 33618          | 1942           |
| October    | 32540  | 33649          | -1109          |
| November   | 35520  | 33680          | 1840           |
| December   | 35460  | 33711          | 1749           |

**Source:** Authors’ own work
In this study, amount of demand of most frequently used four different medical supplies (gloves, syringes, angioket, plaster) will be no interruption of the manufacturing or service process resulting from lack of stock and the cost advantage by providing this service are in a serious race in terms of the quality of service with the businesses operating in the same market sector. Ensuring efficient and effective way of health services is a key indicator of countries’ level of development. The health sector, being a very important area for human life as well as it is a business with an ever-increasing share in the service sector. Ensuring efficient and effective way of health services is a key indicator of countries’ level of development. The companies providing this service are in a serious race in terms of the quality of service with the businesses operating in the same market because of increased competition. In providing quality services, offered opportunities will naturally affect costs. In terms of page limits in this article and the process is similar to the first phase in maintaining the desired level of costs is a well-planned procurement processes.

Demand forecasting has a great importance for businesses in terms of planning supply. If organizations cab foresee how much material they need at a later stage, how much staff will be needed, to what extent device investments must be made, they can provide significant advantages in terms of production planning and supply chain management. The major advantage is that there will be no interruption of the manufacturing or service process resulting from lack of stock and the cost advantage by disappearance of more than a certain amount of stock holding requirements.

In this study, amount of demand of most frequently used four different medical supplies (gloves, syringes, angioket, plaster) in a hospital in Istanbul between 2009-2014 were examined and the method to be used in forecasting demands for the future was made with 60-month data.

When we look at error values obtained for demand forecast of gloves, it is seen that the lowest value is provided by Holt-Winters Additive Method. The resulting findings state that the forecasts in the next year with additive Holt-Winters method will show fewer errors. All calculations that were performed for gloves, were performed for other three medical supplies, error values for the forecasting methods were identified, the most suitable method for each data set was determined. In terms of page limits in this article and the process is similar therefore they are not included in this section.

### Table 9: Demand Realized for Gloves and Values obtained by Forecasting Methods

| Months      | January | February | March | April | May | June | July | August | September | October | November | December |
|-------------|---------|----------|-------|-------|-----|------|------|--------|-----------|---------|-----------|-----------|
| Methods     |         |          |       |       |     |      |      |        |           |         |           |           |
| Linear Reg. | 33370   | 33401    | 33432 | 33463 | 33494 | 33525 | 33556 | 33587  | 33618     | 33649   | 33680     | 33711     |
| Additive Holt-Winters | 32943 | 32938 | 32549 | 32760 | 33033 | 33455 | 34313 | 34748 | 34901 | 33286 | 34131 | 34856 |
| Multiplicative Holt-Winters | 32861 | 32869 | 32487 | 32715 | 33002 | 33419 | 34342 | 34815 | 34970 | 33288 | 34183 | 34927 |
| Holt’s L. M. | 33831 | 33710 | 33014 | 32064 | 33676 | 34313 | 33247 | 34782 | 34225 | 35177 | 33564 | 34878 |
| Exp. Sm. (0,8) | 34106 | 33653 | 32779 | 31788 | 34010 | 34450 | 32938 | 33436 | 34335 | 35315 | 33095 | 35035 |
| Exp. Sm. (0,5) | 33544 | 33542 | 33051 | 32296 | 33431 | 33995 | 33278 | 33419 | 33999 | 34775 | 33657 | 34589 |
| Exp. Sm. (0,2) | 33011 | 33115 | 33006 | 32716 | 33081 | 33373 | 33213 | 33281 | 33533 | 33933 | 33658 | 34026 |
| MOV5        | 33324 | 33324 | 32926 | 32944 | 33345 | 33353 | 33157 | 33557 | 33961 | 34160 | 33756 | 34348 |
| MOV3        | 32843 | 33540 | 33540 | 32547 | 32889 | 33555 | 33895 | 33560 | 33560 | 34560 | 34220 | 34540 |
| Demand      | 33540 | 32560 | 31540 | 34566 | 34560 | 32560 | 33560 | 34560 | 35560 | 32540 | 35520 | 35460 |

**Source:** Authors' own work

Forecast results obtained by the Forecasting methods of the glove over the past 12 months are shown in Table. Calculations were made with 60-month data.

### Table 10: Error Criteria Values

| Forecasting Methods         | MAPE  | MAE   | MSE   |
|-----------------------------|-------|-------|-------|
| 3-Month Moving Average      | 3     | 940   | 1347325 |
| 3-Month Moving Average      | 3     | 870   | 1210377 |
| Single Exponential Smoothing (α =0,2) | 2   | 826   | 1142513 |
| Single Exponential Smoothing (α =0,5) | 3   | 873   | 1257104 |
| Single Exponential Smoothing (α =0,8) | 3   | 951   | 1496826 |
| Holt’s Linear Method        | 3     | 915   | 1385483 |
| Holt-Winters Multiplicative | 2     | 783   | 924887 |
| Holt-Winters Additive       | 2     | 783   | 923660 |
| Linear Regression           | 2     | 806   | 39019378 |

**Source:** Authors' own work

### Conclusion

The health sector, being a very important area for human life as well as it is a business with an ever-increasing share in the service sector. Ensuring efficient and effective way of health services is a key indicator of countries’ level of development. The companies providing this service are in a serious race in terms of the quality of service with the businesses operating in the same market because of increased competition. In providing quality services, offered opportunities will naturally affect costs. The first phase in maintaining the desired level of costs is a well-planned procurement processes.

Demand forecasting has a great importance for businesses in terms of planning supply. If organizations cab foresee how much material they need at a later stage, how much staff will be needed, to what extent device investments must be made, they can provide significant advantages in terms of production planning and supply chain management. The major advantage is that there will be no interruption of the manufacturing or service process resulting from lack of stock and the cost advantage by disappearance of more than a certain amount of stock holding requirements.

In this study, amount of demand of most frequently used four different medical supplies (gloves, syringes, angioket, plaster) in a hospital in Istanbul between 2009-2014 were examined and the method to be used in forecasting demands for the future was made with 60-month data. All calculations that were performed for gloves, were performed for other three medical supplies, error values for the forecasting methods were identified, the most suitable method for each data set was determined.
determined. The process and results for the materials, except gloves, could not be transferred because of page constraints. Different forecasting methods were compared and methods forming minimum errors have been identified under data sets. In light of the findings, the hospital’s purchasing department has the opportunity to quickly update their planning. As it was demanded to make a forecast with spreadsheets in the current office programs, methods such as simulation, artificial neural networks, support vector machines which may require additional programs; were not used in this study. In subsequent studies, the error values can be analyzed by using different forecasting methods in the literature. Also as there are many forecasting methods, by considering criteria such as ease of application, etc; multi-criteria models can be created in selection of a forecasting method.

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