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Building a Computerized System to Measure the Forecasting Methods and Evaluate the Efficiency for an Industrial Product

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Abstract: A forecasting is defined as an attempt to estimate the market need of a particular product or service or a combination of goods over a future period of time. The demand forecasting process is one of the important activities that precede the planning process for capacity and production. The importance of this activity requires determining what to forecast how it is being forecast and the time period covered by the forecast. The desired accuracy in forecasting results depends primarily on the value of the physical product because forecasting error slightly burdens production system. The objective of this study is to build a computerized system using visual basic with access database and integrate the system with Excel program to analyze the data and represent it graphically to calculate the different forecasting methods to forecast the demand of a particular product for a future period of time and evaluate the efficiency the solution using the evaluation criteria which are: Mean Squared Error (MSE), Mean Absolute Deviation (MAD), Mean Absolute Percent Error (MAPE), Largest Absolute Deviation (LAD). This study will use data collected from one of the main companies in Iraq. The data include the order unit of the product. Data analysis will be held using three individual forecasting methods. Due to the limitation of the time, the study will focus on one of the series of the product of the company only.

Key words: Demand forecasting, evaluation criteria, CAD, MSE, MAD, MAPE

INTRODUCTION

Forecasting product demand is vital to any dealer, manufacturer or seller. Forecasts of future demand can verify the quantities that ought to be produced, purchased and shipped. Demand forecasts are essential as the essential operations method, moving from the dealer's raw materials to finished merchandises in the consumer's hands, takes time. Most companies cannot merely wait for demand to rise and then respond to it. As an alternative they need to anticipate and plan for future demand, so they will react directly to client orders as they occur (Nyabwari, 2016).

Demand forecasting is expecting future demand for the merchandise. In alternative words, it denotes to the guess of possible demand for merchandise or a service depends upon the previous events and existing trends at a present time (Reddy, 2016). Forecasting approaches can be categorized into two collections: Qualitative approaches which contain official estimates sales; market research and Delphi style and quantitative approaches which contain time series forecasting and causal approaches or it is identified as a linear regression analysis (Ghobbar and Friend, 2003; Hyndman and Koehler, 2006; Jacobs *et al*., 2010).

Additionally, several efforts have also focused on demand forecasting, according to Armstrong (2006), combining forecasts demands for evolving forecasts from diverse approaches or information and after that averaging the forecasts from these approaches, usually using a simple average. He had recaps what has been educated over the previous quarter century about the precision of forecasting technique and finished that over the previous quarter century, proof from comparative studies has resulted in seven well-propped forecasting approaches. One of these approaches applies to all kinds of information: combined forecasts with an estimated 12% error decline. Nevertheless in the research done by Chandra and Grabis (2005) concerning the influence of the forecasting technique choice on inventory performance, the outcomes displayed that the application of simple moving average with averaging over 5 prior observations didn't result in enhanced inventory performance for the downstream unit calculated by the average inventory size at the constant service level compared to further forecasting approaches considered.

By Kerkkanen *et al*. (2009), demand forecasting is usually applied in firms that work in consumer markets. When demand patterns are comparatively smooth and

continuous, demand forecasts depends upon historical demand are commonly relatively accurate. Demand forecasting success stories typically record lower inventory levels and enhanced customer service. According to Lam *et al.* (2001), Mean Absolute Percentage Error (MAPE) had come to be widespread as a performance measure in forecasting. One among the foremost reasons for its quality is that it's simple to interpret and understand. Bon and Leng (2009) used the simple exponential smoothing technique in a telecommunications trade supply chain producing Digital Subscriber Line (DSL) concentrators, wherever element manufacture had been outsourced. The outcome demonstrations that the simple exponential smoothing technique that does not take any trends or seasonality under consideration consistently gave more precise forecasts than existing forecast technique used by the firm that forecasts depend largely upon the managerial judgment.

As specified in the research of comparing the precision of six univariate approaches for short-term electricity demand forecasting for lead times equal to a day ahead by Taylor *et al.* (2006) they computed the Root Mean Squared Percentage Error (RMSE) and Root Mean Squared Error (RMSE). They discovered that the comparative performances of the approaches for these measures were very comparable to those for the MAPE. Tiacci and Saetta (2009) used a real case of a firm that markets canned food for the hotel and restaurant. The forecasting technique which used in this research is the three-month moving average technique. The outcome discovered that the precision of the moving average technique is higher in term of MAPE and MAD. Nevertheless, Willemain *et al.* (2004) shared the conflicting view concerning the performance of the exponential smoothing. Willemain used several forecasting models to estimate the demand for inventory management scheme and exponential smoothing is one of the techniques used in this study. During this study, the outcome displayed that exponential smoothing did not give an overall development when the task was to predict the whole distribution of lead time demand.

Croston (1972) suggested a technique for forecasting intermittent demand by adapting the Simple Moving Average (SEA). In Croston's technique, intermittent demand is prediction by determining both the demand size and the inter demand interval. By Cheng *et al.* (2016) the study was conducted with the aim of evolving a tertiary pediatric intensive care unit's efforts to accomplish a high level of precision in its predicting of the demand for medical supplies. Around this point, numerous demand forecasting approaches were compared in terms of the forecast precision. The outcomes approve that applying Croston's technique integrated with a single exponential smoothing technique leads to the most precise outcomes for forecasting slow-moving demand, lumpy and erratic, while the Simple Moving Average (SMA) technique is the most appropriate for forecasting smooth demand. Additionally, when the categorization of demand consuming patterns was integrated with the demand forecasting models, the forecasting errors were reduced, demonstrating that this classification structure can play a role in developing patient safety and decreasing inventory management costs.

The first objective of this study is to build a computerized system using visual basic with an access database and integrate the system with Excel program to analyze the data and represent it graphically to calculate the different forecasting methods to anticipate demand for a particular product for some time to come. The second objective is to evaluate the efficiency of the solution using the evaluation criteria which are: Mean Squared Error (MSE), Mean Absolute Percent Error (MAPE), Mean Absolute Deviation (MAD), Largest Absolute Deviation (LAD). This study will use data collected from one of the main companies in Iraq. The data include the order unit of the product. Due to the limitation of the time, the study will focus on one of the series of the product of the company only.

MATERIALS AND METHODS

Data preparation: The necessary information of our system are shows in Fig. 1 which are (actual demand, problem type, problem title, number of time units (periods) and weighted moving average).

The developed system: Our system is developed specifically to select the suitable demand forecasting methods that give a suitable solution. The developed system can perform several functions as depicted in Fig. 1. Each function is interfaced with other functions.

User interface: The user interfaces main module plays a key role in various activities of our system by providing the possibility of accessing any part of the system. The user interface is the communication mechanism between the user and other modules of the system. When the user enters the needed inputs through the user interface, the

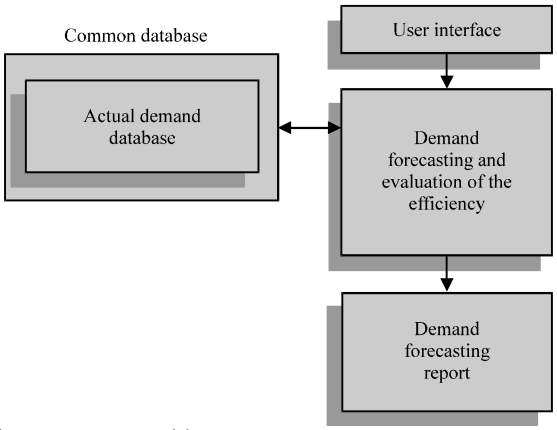


Fig. 1: System architectuer

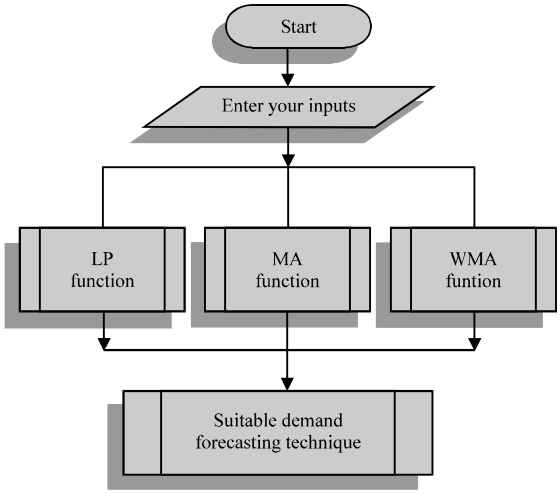


Fig. 2: Flowchart of the demand forecasting module

system calculates and graph the demand forecasting methods then evaluate the suitable methods relative to the input.

Demand forecasting module: Demand forecasting function is the process of determining the forecasting quantities in which order are placed. This module consists of several demand forecasting methods. Therefore, depending on the type of inputs that the user enter, the system has been designed and developed to suggest the best demand forecasting method that corresponds to these inputs as shows in Fig. 2-5.

Time series forecasting: Time series is a set of actual views for earlier periods of time, for example, monthly sales of a product for the two previous years. It can be represented as shows in Fig. 6.

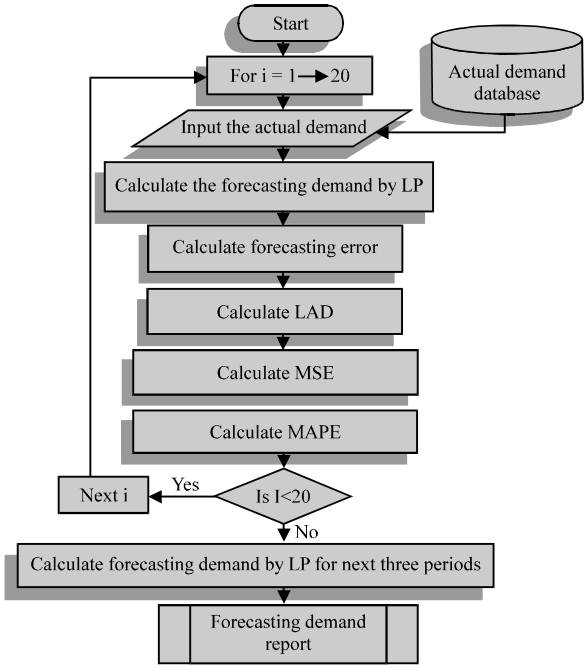


Fig. 3: Flowchart of the LP function

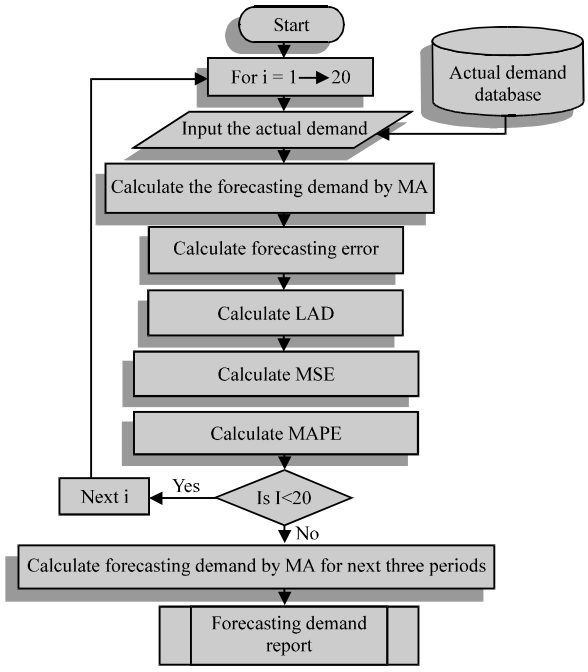


Fig. 4: Flowchart of the MA function

Last period forecasting: In this method, the estimated demand for the subsequent period equal to the actual demand for the previous periodas shows in Table 1:

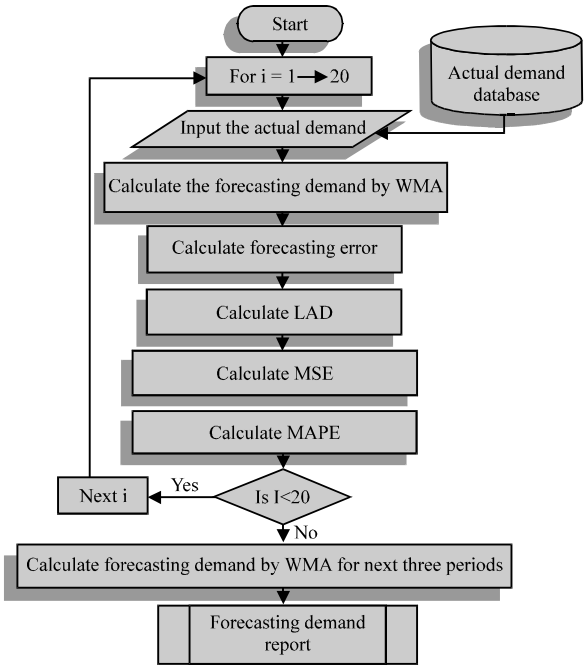


Fig. 5: Flowchart of the WMA function

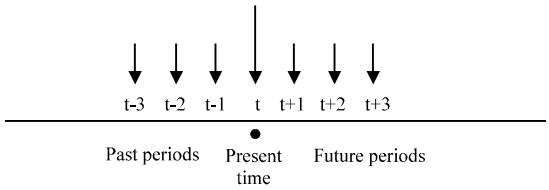


Fig. 6: Time series forecasting

Table 1: Last period forecasting

Time	Actual data (y)	Forecasting (f)
1	398	
2	395	398
3	290	395

$$F_{(t+1)} = y_{(t)}$$
$$F_{(2)} = y_{(1)} = 398 \quad (1)$$

Where:

t = Time period

$Y_{(t)}$ = The value of the actual demand in period t

$F_{(t+1)}$ = The forecasted value for a single subsequent t+1

Simple Average (SA): It takes the average of all previous periods.

Moving Average (MA): In this method, forecasting demand for a subsequent period equal to the total demand for a certain number of previous periods divided by the length of the period, for example, forecasting using four periods ago is imperative that we find the total demand for those periods and dividing the total by four:

$$f_{(t+1)} = \sum_{t=1}^{n} \frac{X}{n} = (X_t + X_{t-1} + X_{t-2} + X_{t-3})/4 \quad (2)$$

Where:

n = Length of the moving average (time period)

X = Values for prior periods of the current period (t) to (n)

Then move values: Delete the old value and add new value.

Weighted Moving Average (WMA): In this method, different weights are giving for each previous value, the given weight depends upon the importance of the time period prior to forecast and the person expertise in charge of forecasting:

$$f(t) = w_1 y_{(t-1)} + w_2 y_{(t-2)} +, \ldots, w_n y_{(t-i)} \quad (3)$$

where, W_1, W_2, W_n = importance weights determined by the beneficiary.

$$\sum W_n = 1, W_1 \geq W_2 \geq W_3, \ldots, \geq W_n$$

Forecasting errors: Each of the previous forecasting methods gives different forecasting value but the question is which of these forecasting methods gives better forecasting of demand? So, it must be able to assess these methods to choose the lowest mistakes method. Forecasting error for a period of time (t) denoted by (Δt) and represents the difference between the actual value of the time series for the period (y_t) and the forecasted value for the same period (f_t), i.e.:

$$\text{Error} = e = \Delta t = y_t - f_t \quad (4)$$

The most common criteria which used in evaluating forecasting errors are MAPE, MAD, MSE or LAD as shows in Table 2 and the method that gives lowest values of MAPE, MAD, MSE or LAD is the best method to forecasting.

Table 2: Criteria for evaluating the forecasting errors

Measure	Description	Formula
Mean Squared Error (MSE)	Average squared differences of forecasted value from the actual values	$\Sigma\Delta t^2/n = \Sigma (y_t-f_t)^2/n$
Mean Absolute Deviation (MAD)	Average the absolute values of differences forecasted values from actual values	$\Sigma\|\Delta_t\|/n = \Sigma\|y_t-f_t\|/n$
Mean Absolute Percent Error (MAPE)	Average absolute percentage differences forecasted values from actual values	$\Sigma((\|\Delta_t\|/y_t)*100\%)/n = \Sigma((\|y_t-f_t\|/y_t)*100\%)/n$
Largest Absolute Deviation (LAD)	Find the largest absolute difference between the forecasting and actual values	$Max\|\Delta_t\| = Max\|1/t-f_t$

Table 3: Forecasting evaluation

Forecasting methods	Proposal	MSE	MAD	MAPE	LAD
Simple average	First				
4 period moving average	Second				
4 period weight moving average	Third				

Table 4: Weekly demand of soap to (21) prior period

Weeks	Demand
1	415
2	236
3	348
4	272
5	280
6	395
7	438
8	431
9	446
10	354
11	529
12	241
13	262
14	365
15	471
16	402
17	429
18	376
19	363
20	315
21	197

RESULTS AND DISCUSSION

To show the validity of our approach and for the purpose of completeness an illustrative case study is introduced here:

Iraqi vegetable oil company interested in predicting the weekly demand for their product soap for the purpose of preparing the requirements of production scheduling. The company proposed that the size of the annual demand for the next year will be somewhat similar to the annual demand for this year. Accordingly, the company decided to forecast the demand on the basis of the previous (21) weeks and previous (21) demands are given in Table 3 and 4.

The researcher proposes and uses three methods of forecasting in the company as follows:

- Using simple average forecasting method
- Using four periods moving average forecasting method
- Using weighted moving average forecasting method

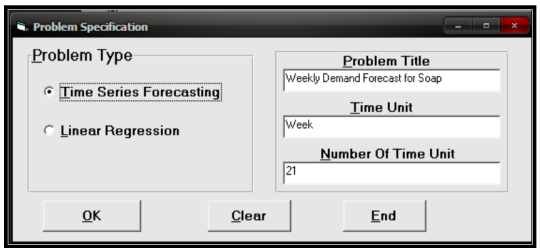


Fig. 7: Main input frame

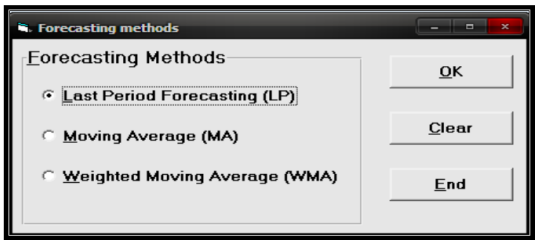


Fig. 8: Forecasting methods frame

Note that, the proposed weights for prior periods are (0.1, 0.2, 0.3, 0.4). The system will calculate the forecasting demand for the next three weeks periods (week 22-24) and then compare the results that will get from the above proposed forecasting methods. After that, the system selects the best forecasting method using the evaluation methods of efficiency measuring methods as shown in Table 3 and Fig. 7 and 8.

In order to study this problem, we can estimate the demand of the period 22-24 using forecasting methods as follows:

Forecasting using last period:

$$F_{22}=y_{21}=197=f_{23}=f_{24}$$

Forecasting by using four period moving average:

$$F_{22}=(y_{21}+y_{20}+y_{19}+y_{18})/4$$
$$F_{53}=(197+315+363+376)/4=313=f_{23}=f_{24}$$

Forecasting using four period weighted moving average:

$$F_{22}=0.4y_{21}+0.3y_{20}+0.2y_{19}+0.1y_{18}=283.5\approx 284=f_{23}=f_{24}$$

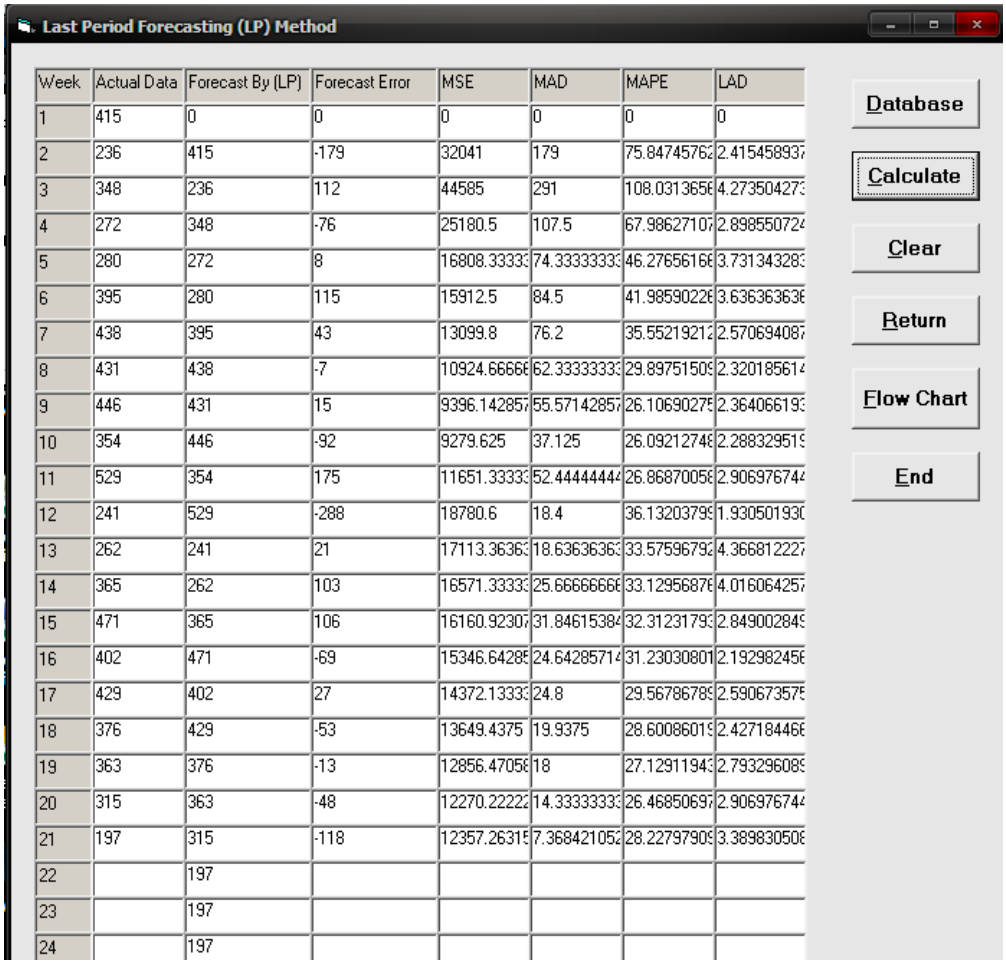


Fig. 9: Computational output frame using the last period methods

The problem can be solved by using a visual basic program with an access database and integrating it with Excel program to analyze and graphically draw the data in the following procedures:

Calling the main program interface Fig. 7 and the user selects the method that used in the forecasting. Here, the user selected time series forecasting and then the name of the problem required to reach a decision, number of the previous real demands which equal to 21 previous real demands in this problem and the time period for each demand is a week.

By clicking OK, the system moves to the interface of the forecasting methods and the user chooses the forecasting method that used to determine the number of periods required to forecast future demand and here was forecasted for three coming periods (3 weeks) using the simple average method (Fig. 8).

Figure 9 shows the output calculations frame using the last period method. The forecasting error value and evaluation criteria are also calculated in addition to the value of the forecasted demand for the next three periods.

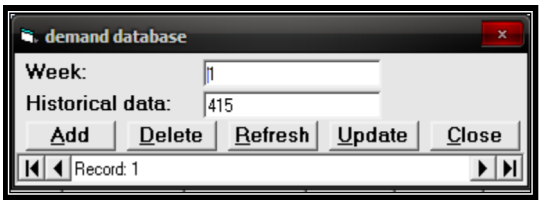


Fig. 10: Demand database frame

When the user presses on the database icon, the database frame will appear (Fig. 10) which contains the actual demand data of the previous 21 periods depends on the input of the main interface.

Figure 11 shows the graphical relationship between the actual demand and forecasting demand of prior periods and the subsequent three periods by using last period method.

Figure 12 represents the output calculations frame using MA forecasting method which was adopted that the length of time = 4 and the number of periods required for forecasting = 3.

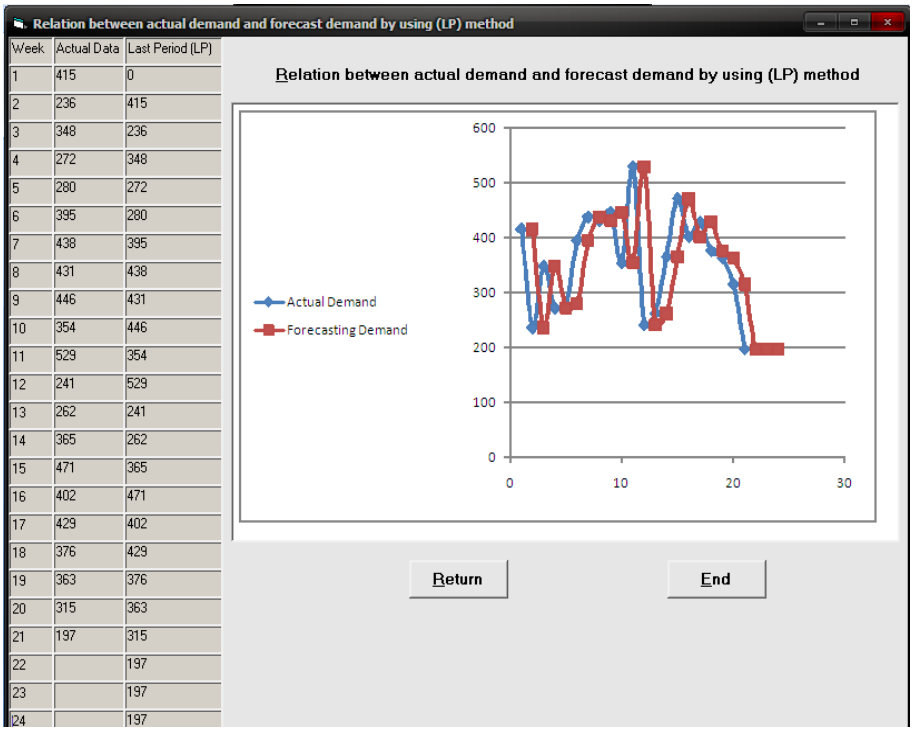


Fig. 11: Graphical relationship frame between actual demand and forecasting demand (last period)

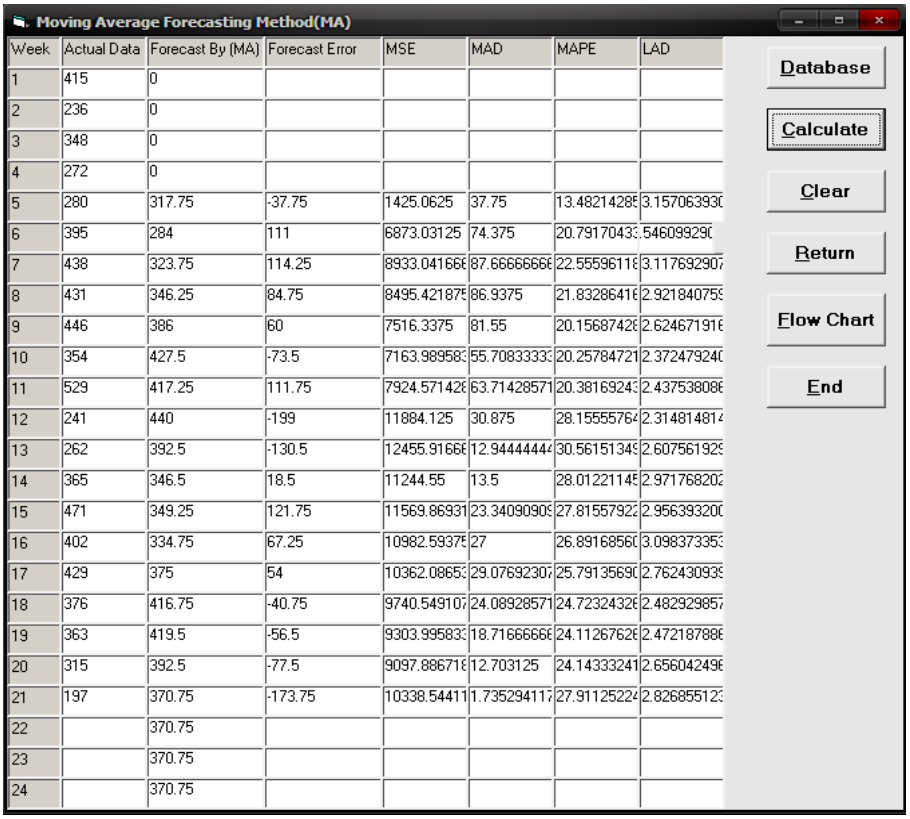


Fig. 12: Output calculation frame by using MA method

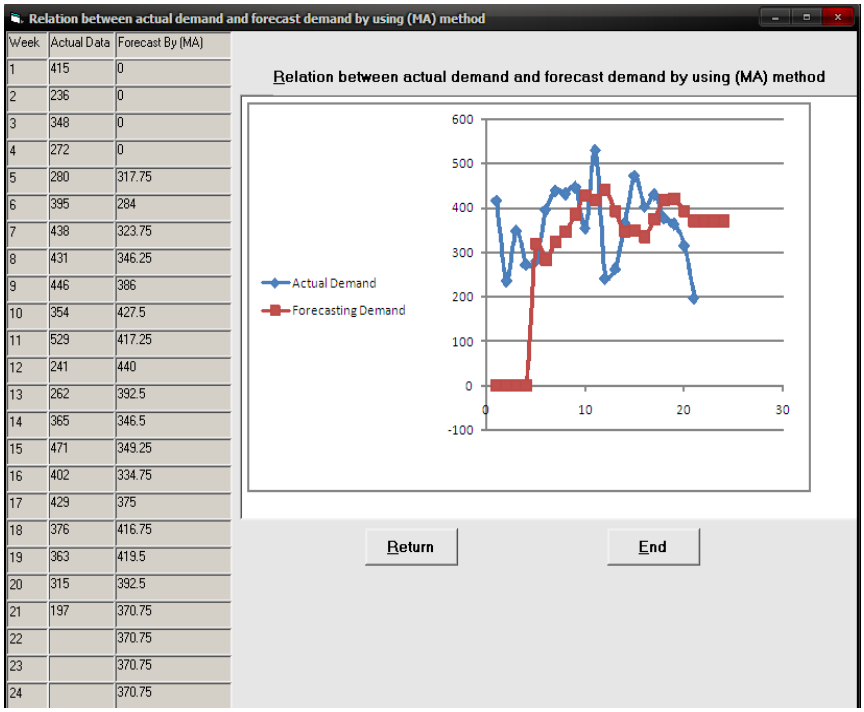


Fig. 13: Graphical relationship frame between the actual demand and forecasting demand (moving average)

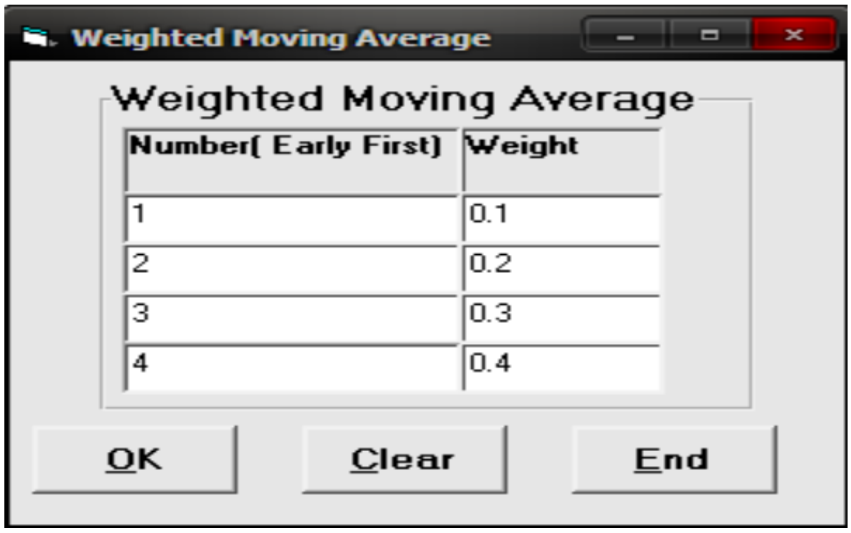


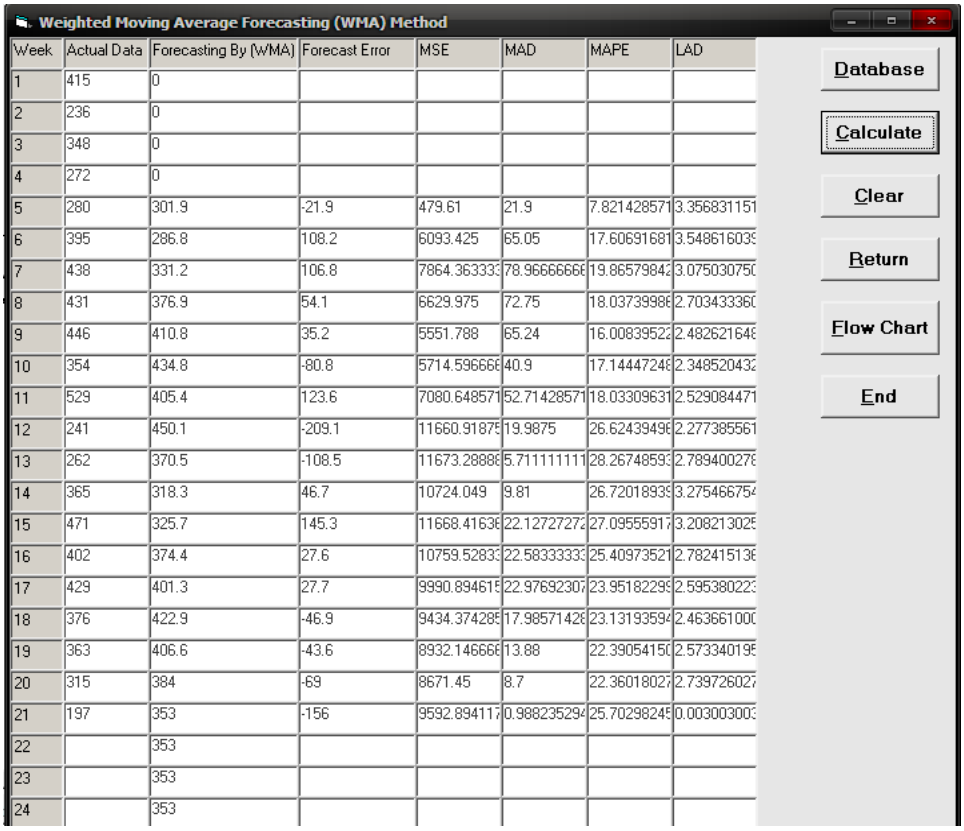
Fig. 14: Given weights frame by using WMA method

Figure 13 shows the graphical relationship between the actual demand and forecasting demand of prior periods and the subsequent three periods by using moving average method.

Figure 14 is the forecasting of the next three months using the weighted moving average. In this method, weights of previous demands are given which equal to 4. The importance and value of these weights are arranged as shows in Fig. 14.

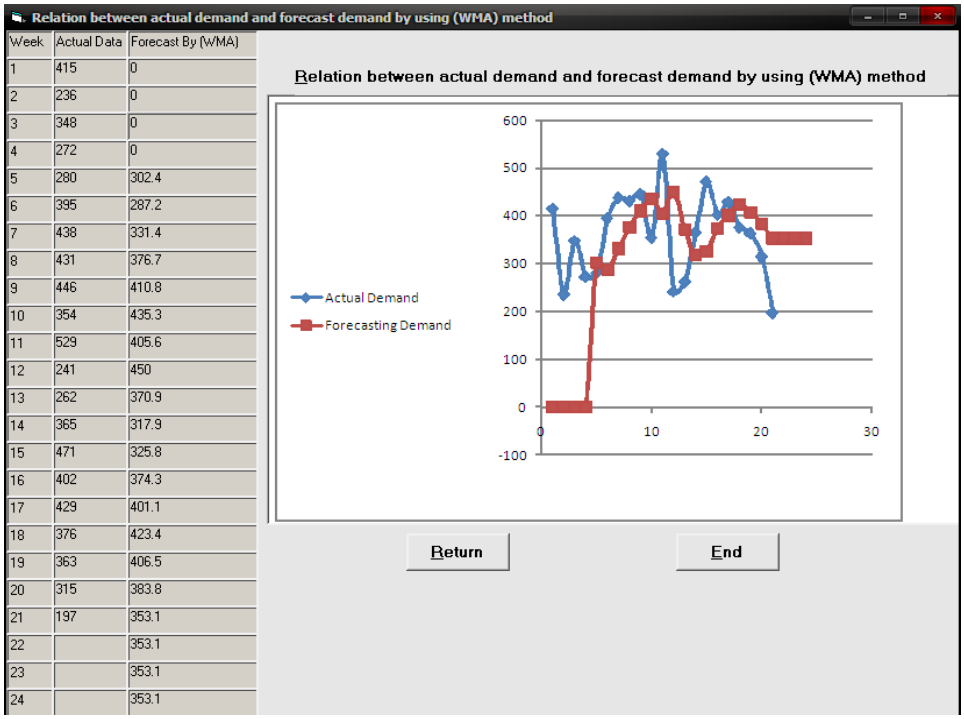
Figure 15 represents the output calculations frame using WMA forecasting method. The forecasting error value and evaluation criteria are also calculated in addition to the value of the forecasted demand for the next three periods.

Figure 16 shows the graphical relationship between the actual demand and forecasting demand for prior periods and the subsequent three periods by using the weighted moving average method.



Week	Actual Data	Forecasting By (WMA)	Forecast Error	MSE	MAD	MAPE	LAD
1	415	0					
2	236	0					
3	348	0					
4	272	0					
5	280	301.9	-21.9	479.61	21.9	7.821428571	3.356831151
6	395	286.8	108.2	6093.425	65.05	17.60691681	3.548616039
7	438	331.2	106.8	7864.363333	78.96666666	19.86579842	3.075030750
8	431	376.9	54.1	6629.975	72.75	18.03739986	2.703433360
9	446	410.8	35.2	5551.788	65.24	16.00839522	2.482621648
10	354	434.8	-80.8	5714.596666	40.9	17.14447248	2.348520432
11	529	405.4	123.6	7080.648571	52.71428571	18.03309631	2.529084471
12	241	450.1	-209.1	11660.91875	19.9875	26.62439496	2.277385561
13	262	370.5	-108.5	11673.28888	5.711111111	28.26748593	2.789400278
14	365	318.3	46.7	10724.049	9.81	26.72018939	3.275466754
15	471	325.7	145.3	11668.41636	22.12727272	27.09555917	3.208213025
16	402	374.4	27.6	10759.52833	22.58333333	25.40973521	2.782415136
17	429	401.3	27.7	9990.894615	22.97692307	23.95182295	2.595380223
18	376	422.9	-46.9	9434.374285	17.98571428	23.13193594	2.463661000
19	363	406.6	-43.6	8932.146666	13.88	22.39054150	2.573340195
20	315	384	-69	8671.45	8.7	22.36018027	2.739726027
21	197	353	-156	9592.894117	0.988235294	25.70298245	0.003003003
22		353					
23		353					
24		353					

Fig. 15: Output calculations frame by using WMA method



Week	Actual Data	Forecast By (WMA)
1	415	0
2	236	0
3	348	0
4	272	0
5	280	302.4
6	395	287.2
7	438	331.4
8	431	376.7
9	446	410.8
10	354	435.3
11	529	405.6
12	241	450
13	262	370.9
14	365	317.9
15	471	325.8
16	402	374.3
17	429	401.1
18	376	423.4
19	363	406.5
20	315	383.8
21	197	353.1
22		353.1
23		353.1
24		353.1

Fig. 16: Graphical relationship frame between the actual demand and forecasting demand (weighted moving average)

other methods (MA and WMA) because it gave the minimum error. This demonstrates the success of this method in forecasting demand.

CONCLUSION

Traditionally, computerized forecasting has involved the development of demand forecasting using one of the quantitative techniques which discussed in this study. By using computers, calculations and processing which often incorporate a wide range of variables can be run off accurately and in a short time. The effects of any alteration can also be explored by changing variable data. The application of computerized systems provides a framework in which the knowledge required to select an appropriate technique can be embodied.

The purpose of this study was to build a computerized system to measure forecasting methods with the efficiency of a product in an industrial engineering. The system model was built using visual basic with database and integrated with the program Excel to analyze the data and represent it graphically to calculate the different forecasting methods to anticipate demand for a particular product and evaluate the solution efficiency using the previous evaluation criteria.

The program is composed of the user interface which is composed of visual basic 6.0 with access database for actual demand, includes the forms of data input and results in output procedures. It is a user-friendly and yet a powerful tool for calculating graph and analysis of demand forecasting.

With such a broad field of application, it would be expected that any company as well as design engineers will find this system to be a powerful tool that facilitates analyzing the data and representing graphically to calculate and evaluate the different forecasting methods.

NOMENCLATURE

f = Forecasting
LAD = Largest Absolute Deviation
MA = Moving Average
MAD = Mean Absolute Deviation
MAPE = Mean Absolute Percent Error
MSE = Mean Squared Error
n = Number of time period
SA = Simple Average
T = Time
Δt = Forecasting error
W = Weighted values b77y
WMA = Weighted Moving Average
X = Values of demand
y = Actual data

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