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TÍTULO: Modelización de series de tiempo de la producción de trigo y compartir la tasa de autosuficiencia en el futuro, utilizando un modelo de suavizado exponencial doble.

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RESUMEN: El documento propone un modelo de series de tiempo para pronosticar la producción y el consumo anuales de trigo en Egipto a partir de datos e indicadores económicos durante el período (1995-2016) para que la organización pueda realizar una mejor planificación y toma de decisiones en el futuro. El estudio se realizó para encontrar un modelo adecuado para el método de pronóstico a saber: el modelo de media móvil, el modelo de crecimiento exponencial y el modelo de suavizado exponencial doble, y se encontró que el modelo de suavizado exponencial doble es el más apropiado para predecir la tendencia futura del trigo sobre la base de valores más pequeños de errores de pronóstico. Se formularon y sugieren políticas para mejorar la seguridad alimentaria hasta el año 2030.

PALABRAS CLAVES: Media móvil, Análisis de tendencias, modelo de suavizado exponencial doble, series de tiempo, consumo del trigo.

TITLE: Time series modeling of Wheat production and share the self-sufficient rate in the future, using double exponential smoothing model.

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ABSTRACT: The document proposes a time series model to forecast the annual production and consumption of wheat in Egypt based on data and economic indicators during the period (1995-2016) so that the organization can carry out better planning and decision-making in the future. The study was conducted to find a suitable model for the forecasting method, namely the moving average model, the exponential growth model and double exponential smoothing model, and it was found that the double exponential smoothing model is the most appropriate to predict the trend future of wheat based on smaller values of forecast errors. Policies were formulated and suggested to improve food security until the year 2030.

KEY WORDS: Moving average, Trend Analysis, Double Exponential Smoothing model, time series, Wheat consumption.

INTRODUCTION.

Egypt, like other countries, is facing a shortage of food and experiencing food security problems. For a long period, Egypt sought to achieve self-sufficiency in key food products, which included grain (wheat, and others). However, achieving self-sufficiency does not automatically mean that household food security has been achieved (Gaber, A., 2017), indicating that wheat demand has not yet been satisfied which suffers from the gap between the production and consumption. The situation may worsen in the near future due to current demographic trends with the Egyptian population likely to reach 117-120 million persons by 2030 (Negm M.M, et al., 2018), and limited possibilities for increasing the cultivable land area.

According to the economic logic, this increasing demand can be satisfied by expanding cultivated areas, but the ecological and social conditions have been a hindrance to more land expansion; furthermore, the inability of agricultural resources into adequate production of wheat. Thus, most future increases in agricultural production are therefore likely to be generated by increasing the output per unit of land, that's from high land productivity. There are many difficulties that prevent the attainment of the highest possible efficiency; the most important is the increase in the exchange rate of the Egyptian pound against the U.S Dollar [Dawoud, S. D.Z., 2017], as well as many of the conflicting policies such pricing policy, subsidy policy and rationalizing consumption policy.

It is because of this situation that agricultural policy is aimed at encouraging farmers to grow this crop, especially given the steady growth in population and the demand for food. However, due to a lack of production capacity, local production does not cover the needs of all consumers, so it is necessary to rely on imports to cover the food deficit of wheat, and adversely affects the rate of economic growth. All this emphasizes the importance of studying the supply and demand of wheat.

The article considers the lack of domestic supply of wheat in Egypt, which consists in the inability of local production to meet growing demand.

The reason for this situation is a number of factors, the most important of which are limited land resources, limited water resources, population growth, high consumption. Thus, there is a need to import wheat, which in turn has a significant impact on government spending. This article will develop a model for forecasting of wheat in Egypt. The model is developed on the basis of statistical data and a time-series model with certain indicators for improving production to meet the demand of wheat in Egypt. The main objective of this article was to forecast the future trends of wheat production and consumption and apply several forecasting methods for evaluating crop wheat forecasting models in Egypt until 2030, using suitable forecasting model, which provides information to decision makers.

Material and Methods.

For the implementation of the forecast, the relevant time series data are used. Forecasts are used in computational procedures to estimate the parameters of a model being used to allocated limited resources or to describe random processes such. A time series is a sequence of observations of a random variable. Hence, it is a stochastic process and assumes that observations vary according to some probability distribution about an underlying function of time.

Forecasting Models.

First of all, it should be noted that considering mathematical prediction models, we will always keep in mind short- and medium-term forecasts. The formation of long-term forecasts requires the involvement of expert assessment methods. Time series data sets on annual production, consumption and self- sufficiency from 1995 to 2016 period was published by (MALR)* database in order to forecast harvest area for the next 2017-2030 years. Comparing between models namely Linear trend model: Moving Average model, Exponential growth model, and double exponential smoothing model were used to find the best-fitted model for wheat in Egypt. These predictive models can be ranked by R-square and other model performance criteria; general forms of model were analyzed in statistical software Minitab (Version17) as given below: The form of the double exponential smoothing model can be expressed as follows: Let S' denotes the singly smoothed series obtained by applying simple exponential smoothing to series Y (Abid, F. et al., 2014), (Negm, M., 2018). Then, the value of S' at period t is given by:

$$S'(t) = \alpha Y(t) + (1-\alpha)\, S'(t-1) \qquad (1)$$

Let **S''** denote the doubly smoothed series obtained by applying simple exponential smoothing

$$S''(t) = \alpha S'(t) + (1-\alpha)\, S''(t-1) \qquad (2)$$

Finally, the forecast **Y(t+1)** is given by:

$$Y(t+1) = a(t) + b(t) \qquad (3)$$

Where.

a(t) = 2S'(t) - S''(t) the estimated level at period of (t).

b(t) = (a/(1-α)) (S'(t) - S''(t)) the estimated trend at period of (t).

For evaluating the adequacy of the forecasting methods processes based on three accuracy measures, mean absolute percentage error (MAPE), mean absolute deviation (MAD) and mean squared deviation (MSD). The reliability statistics and selected the best-fitted model were computed and calculated as follows:

1. $\text{MAPE} = \frac{100}{N} \sum_{i=1}^{N} |x_i - \check{x}_i|$
2. $\text{MAD} = \frac{1}{N} \sum_{i=1}^{N} |x_i - \check{x}_i|$
3. $\text{MSD} = \frac{1}{N} \sum_{i=1}^{N} |x_i - \check{x}_i|^2$

Where:

- x_i is the actual observations.
- $\check{x}_i$ is the estimated or forecasted observations.
- N is the number of non-missing data points.

The model which has the smaller values of the error term indicates the best-fitted model for forecasting (Karim, et al., 2010). Difference between the actual and fitted value with respect to time series data is known as forecasting error or measure of accuracy. MAPE is relative measures which express the error in terms of percentage.

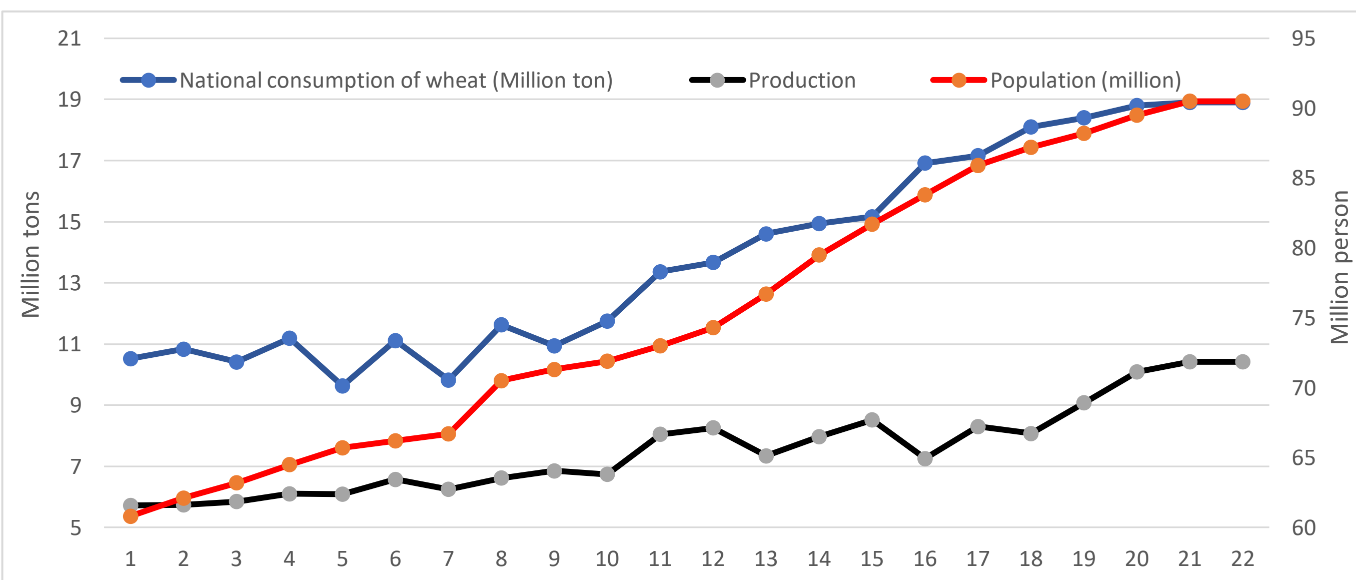
Results and Discussion.

Looking at the original series.

The wheat production in Egypt had a long-term upward fluctuate trend during the period from 1995 to 2016. The wheat production grew increased from 5.27 million tons in 1995 to 10.42 million tons in 2016, with an increase of approximately 97.7%. Under the rising impact of the cultivated area of wheat crop, the consumption of wheat increased from a minimum of 10.52 million tons in 1995 to a maximum of 18.9 million tons in 2016 with an increase of about 79.6 %.

Despite the observed increase in wheat production in Egypt during the period (1995-2016), there is a wide gap between the domestic production and consumption of wheat; this gap is covered through wheat imports which negatively affect Egypt's agricultural trade balance. So, the growth of wheat production is not significant to meet increasing food requirement of the country. The government has to continue filling the food gap caused by the possible failure of wheat crop.

Figure 1. Time series trend, fulfilling the needs of wheat for the population during the period (1995-2016 [Box, G.E.P., Jenkins, G.M. and Reinsel, G.C. (2008):22]).



In view of the prevailing situation, time series analysis provides tools for selecting a model that can be used to forecast of the future events. Thus, time series models were fitted on wheat production and consumption data in Egypt. The objective of fitting multiple time series models on this data is to obtained reliable forecasts on the basis of statistical measures.

Results of ordinary least square (OLS).

One of the main objectives of the study is to determine a model that explains the observed data and allows extrapolation into the future to provide a forecast. The simplest model suggests that the time series is a constant value b with variations about b determined by a random variable $\boldsymbol{\varepsilon_t}$. To estimate parameters form of the ordinary least square (OLS), the model can be expressed as follows:

$$\mathbf{Y = \propto \sum_{j=1} B_j \; X \, e_j^u}$$

The form of the model is the same as below with a single response variable (Y), but this time Y is predicted by multiple explanatory variables (X1, X2, …. to X n).

$$Y = \alpha + \beta_1X_1 + \beta_2X_2 + \ldots\ldots\ldots\ldots + \beta_nX_n.$$

Wheat production in Egypt.

The estimated parameters of wheat production model had a significant at 1%, significant level are marked by a double star. It means that the time trend had a significant and positive effect at 1% level. The estimated parameters have been presented in equation (1), it is observed that coefficients of the quantity of domestic production in the last year ($Y1_{t-1}$), Price farm in the last year ($X1_{t-1}$) and Net return acre of wheat (X3). Those had a positive and statistically significant at one percent level, while the climate variable (D_{01}) was negatively significant.

This explains that increase domestic production last year by 1 %, will increase the domestic product in current year by 0.57%, and the increasing the agricultural Price farm last year by 1 %, leading to increase the price in the current year by 0.0037%, encouraging farmers to expand the cultivation of new areas in the current.

The increase in Net return of wheat by acres about 1% leads to an increase in the quantity of production in the current year by 0.0005% while the climate variable was reduced by 1.14%; the result is in consistency with the Economic logic.

$$\mathbf{Y_{1t} = 1.98 + 0.57_{Y1t-1} + 0.0005x_3 + 0.0037x_{1t-1} - 1.14D_{01}}$$

(3.46) (5.40)** (5.50)** (3.02)** (-3.64)****

R^{-2}=0.94 F=(81.7)**

The analysis revealed that the coefficients of all models are highly significant as given in table 1. Since all coefficients are significant for OLS model, it seems that the assumption of a constant annual rate of growth in percent that lies behind the use of compound or exponential is not true for the growth pattern of wheat production in Egypt.

In interpreting the criteria, value of R2 has been (0.94), F (81.7) during the period (1995-2016). Overall, the result of the model was significant as the probability of the probe (F statistic) was approximately zero, the adjusted R-square quite high, and the Durbin-Watson statistics showed no evidence of first degree autocorrelation.

Table 1.Time series result of the Egyptian wheat production and consumption during the period of 1995 to 2016.

		OLS					parameter's	
Variable	Coefficient	SE	t value	p			Models	
Y_{1t} Production model								
Constant	1.976685	0.571354	3.459647	0.0032	R-squared	0.95331	Mean dependent var	7.399524
$Y1_{t-1}$	0.56146	0.103977	5.399873	0.0001	Adjusted R2	0.94164	S.D. dependent var	1.339711
X3	0.000488	8.89E-05	5.491448	0.000	S.E. of regression	0.32364	Sum squared resid	1.675895
$X1_{t-1}$	0.003696	0.001225	3.016695	0.0082	Durbin-Watson	2.83365		
D -01	-1.1366	0.312909	-3.63236	0.0022				
Y2t Consumption model								
Constant	-30.1694	3.93997	-7.65726	0.000	R-squared	0.97435	Mean dependent var	13.51038
$Y2_{t-1}$	-1.0591	0.30475	-3.47531	0.0034	Adjusted R2	0.9658	S.D. dependent var	2.908062
Y3T1	0.001106	0.00027	4.092259	0.001	S.E. of regression	0.53777	Sum squared resid	4.337917
X2	0.000539	6.46E-05	8.342013	0.000	Durbin-Watson	1.61066		
X4	-0.00772	0.002176	-3.54934	0.0029				
X5	0.085251	0.015205	5.606885	0.0001				

Source: statistical analysis results based on the secondary data, using. Eviews.

Wheat consumption in Egypt.

Table 1 indicates the estimated parameters results of wheat consumption represent had a significant statistically at 1%. Since the P-value for this test is greater than or equal to 0.01, we cannot reject the hypothesis that the series is random at the 95.0% or higher confidence level. The model fitted for wheat consumption has the highest R^2 (0.97) F (114) (see Table1), which indicated that about 97% of changes in the dependent variable are due to independent variables.

Time series models fitted and results are presented with model selection and validity criteria. On the basis of the parameter in this table, we also summarize the results of OLS equation (2). Therefore, our research results show that coefficients of the imported quantity of wheat in the previous year ($Y3_{t-1}$), the total of population (X_2) and per capita wheat consumption by kg/year(X6) had significant and positive effect at 1% level, which indicates that with 1% increase in the imported quantity of wheat in the previous year, the consumption increased by 0.0011%, due to the imports are aimed to raising the level of the strategic stock of the crop, which affects on consumption through the current year.

Population growth was also found to be positively related to the share of wheat consumption and highly significant; it’s certainly and doubtless the increase in the population by about 1%, it leads to an increase of the quantity available of consumption in current year by 0.0005 percent; this also reversed to rising to share of wheat consumption per capita to 0.085 percent, indicating that increase the per capita share by1% and will increase in consumption by 0.85%.

$$\mathbf{Y_{2t}=-30.17-1.06_{y1t-1}+0.0011_{y3t-1}+0.0005_{x2}-0.0077x_5+0.085_{x6}}$$

(7.66) ** (3.48) ** (4.09) ** (8.34) (3.55)** (5.61)****

R^{-2}=0.97 F= (114) **

On the other hand, according, the estimates in table 1, the parameter of domestic consumption in previous year (Y2t-1) and import price from Russian (X5) variables has a negative sign, where an increase of those variables by 1% results in a decrease in wheat consumption by about 1.06%, 0.0077%, respectively, which may indicate that the availability of consumption in the previous year is closely related to the stock of wheat, indicating that the quantity of imports was decreasing when the import prices were increasing, which is consistent with economic logic.

Double Exponential Smoothing Method [DES].

In this section, a double exponential smoothing method was chosen as a suitable model for forecasting to determine the trends in the production and consumption of wheat in the future; through this method, each observation in a series is assumed to consist of two components, level or smoothing. Figure 1 and 2 reveals that the data used had non-stationary in mean.

The best-fitted forecasting method as compared to the trend of Linear model and on the basis of the smaller values of the forecasting errors, based on Moving average model, Exponential smoothing model and double exponential model depend on the values of three accuracy measures (MAPE, MAD, and MSD).

To enable a forecast comparison, each of the time series, the results of the forecasts along with 95% prediction intervals revealed that the wheat production and consumption tend to rise gradually from 2016-17 to 2029-2030 (Table 2). The prediction intervals associated with the forecasts values depict that there is 95% chance that these forecast values will lay within the lower and upper limits. So that the double exponential model is the most appropriate model for predicting the future trend of wheat on the basis of smaller values of forecasting errors.

Table 2. Diagnostic measures for accuracy measures model for wheat consumption and production in Egypt.

Million tons

Criteria for selection of best fitted model						
Forecasting Model	MAPE		MAD		MSD	
	consumption	Production	consumption	Production	consumption	Production
Moving average	7.41	7.16	1.06	0.56	1.88	0.43
Double exponential smoothing	**5.85**	**4.38**	**0.77**	**0.32**	**1.04**	**0.22**
Single exponential smoothing	6.78	6.45	0.91	0.48	1.29	0.32

Source- Result of forecasting model by Eviews.

Figure 2. Double exponential smoothing Plot for wheat production during 2016-17 to 2030.

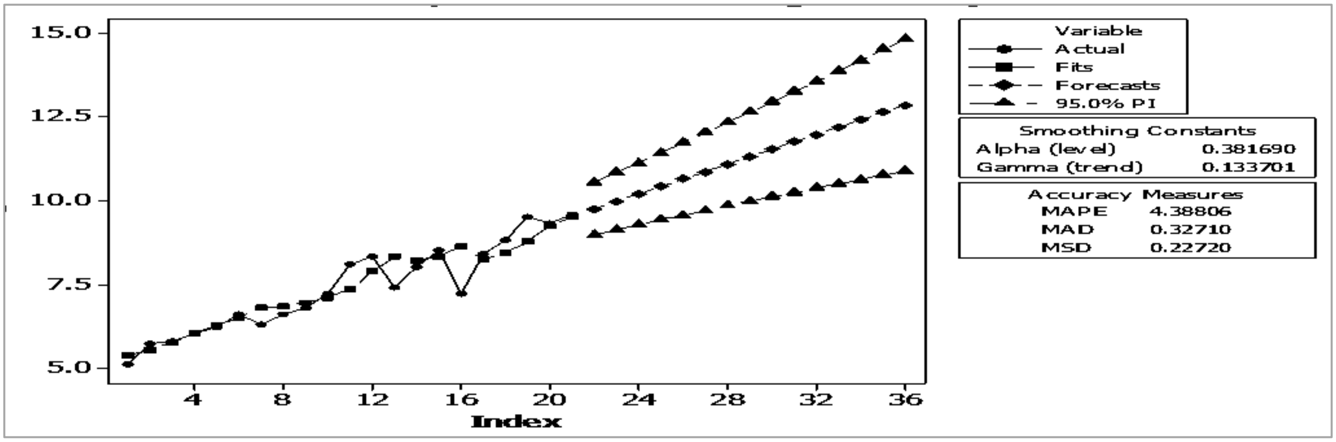
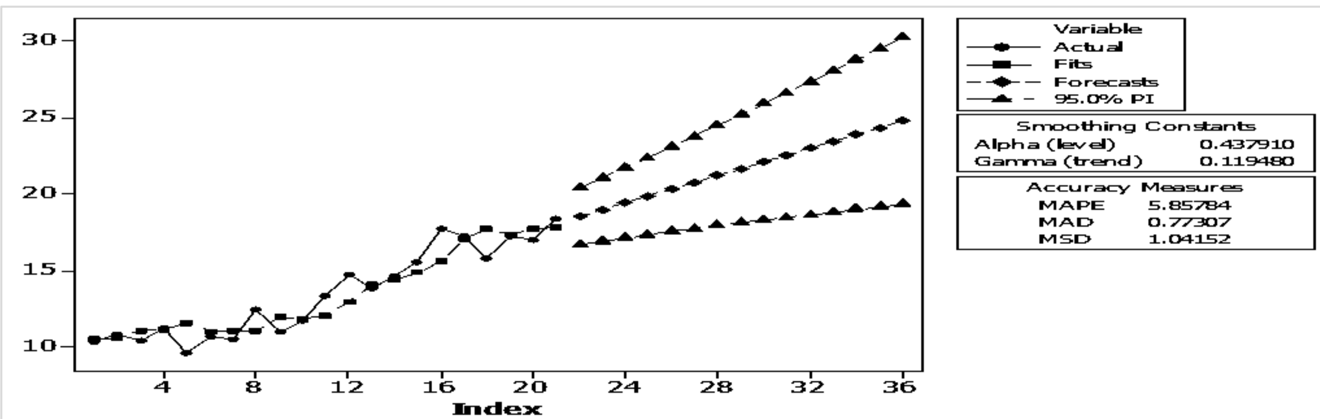


Figure 3. Double exponential smoothing Plot for wheat consumption during 2016-17 to 2030



Forecasting using double exponential forecast method.

This section presents the projections of future consumption, production, quantity of imported, food gap, and self-sufficient of wheat in Egypt, building on existing analysis.

The projections are made for the years in the future using the Double Exponential Smoothing (DES) as known as Holt-Winters method. Diagnostic checking on residual terms is made applying the values of three accuracy measures (MAPE, MAD, and MSD). By using best-fitted model, the details of the estimation and forecasting process are discussed above. The forecasted values obtained from DES model with 95 percent confidence level (lower and upper prediction intervals) for five to ten years are reported in Table 3.

To overcome the challenges already mentioned before and reach the best possible self-sufficiency ratio of wheat needs, analysis and policies are carried out for the next 15 years until 2030 to forecast and project the future demand, supply, production, and imports.

The model predicted overall an increase in wheat consumption (Y2). The prediction for 2030 is resulted in approximately **24.7853** million tons at confidence interval 95%, representing about 34.60 % over the consumption value in 2015. The lower and upper limits show an increase in production levels which may reach up to **19.3270** and **30.2435** million tons, respectively, by the year 2030. The DES model projects that wheat production (Y1) will increase from **9.7548** in 2016 to **12.8671** in 2030, with an increased ratio of about 33.91% more than its value in 2015. With 95% confidence interval, the upper limit of production would increase from **10.5562** million tons in 2016 to **14.8385** million tons in 2030, as follow in figure (4 and 5). Also, the model predicted that the self-sufficient of wheat (figure 5) would decrease to 49.1214 % in 2030; the value of upper limit would increase from 61.6922 % in 2016 to 89.0799% in 2030 if the country adopts new policies that promote self-sufficiency (see. figure 6).

Figure 4. Prediction result for wheat production until 2030.

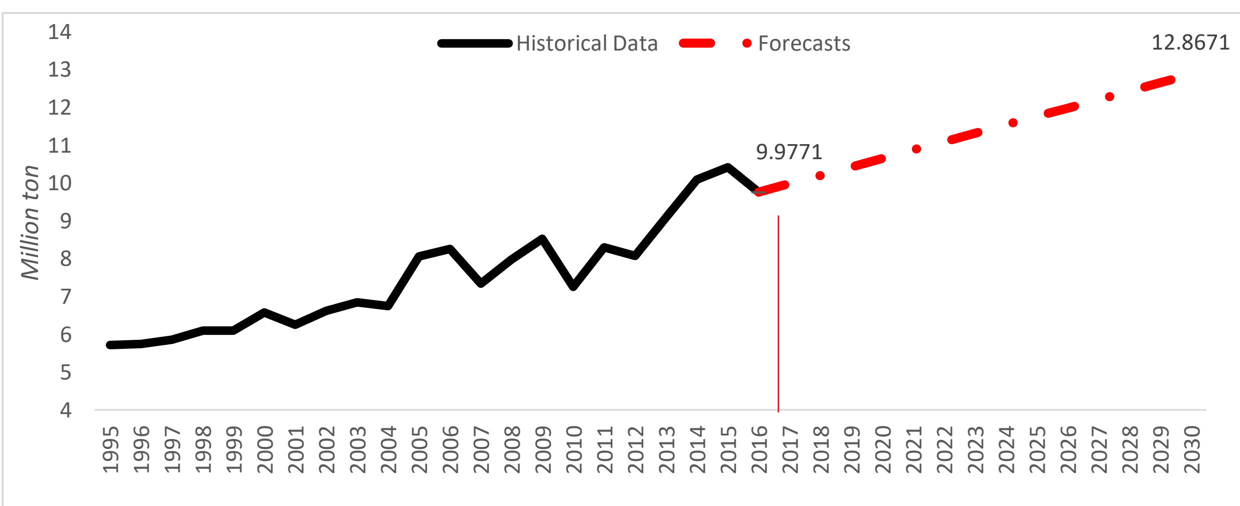


Figure 5. Prediction result for wheat consumption until 2030.

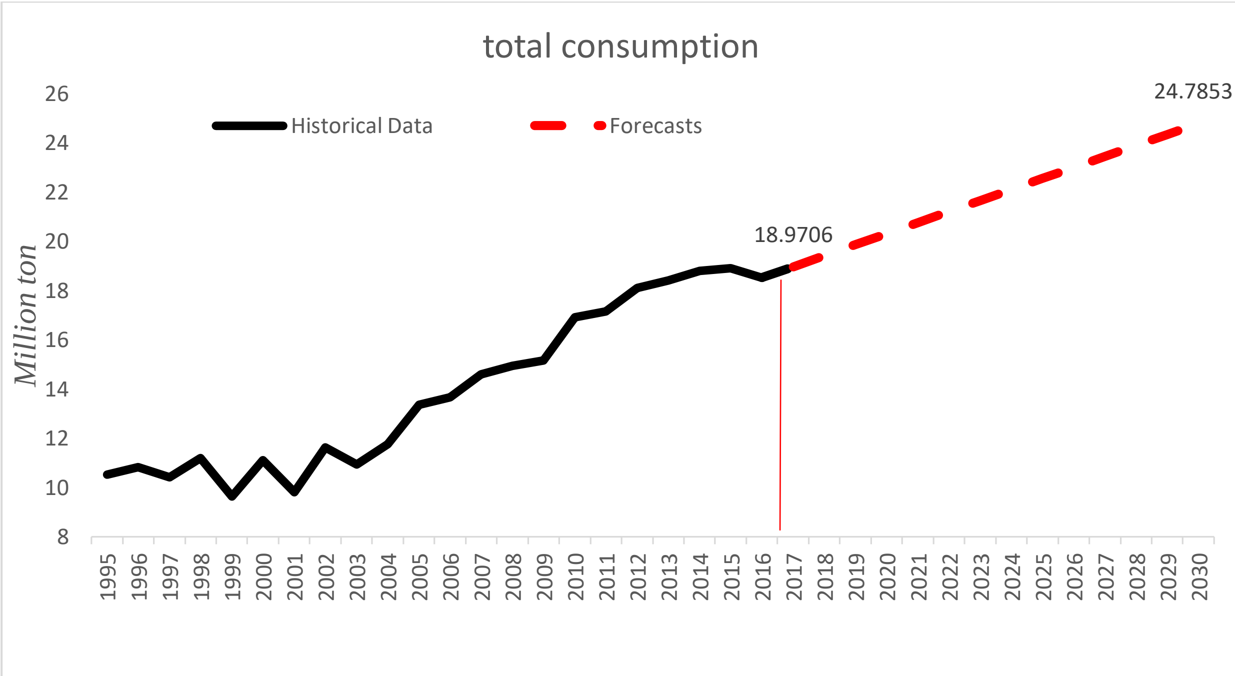


Figure 6. Prediction result of self- sufficient until 2030.

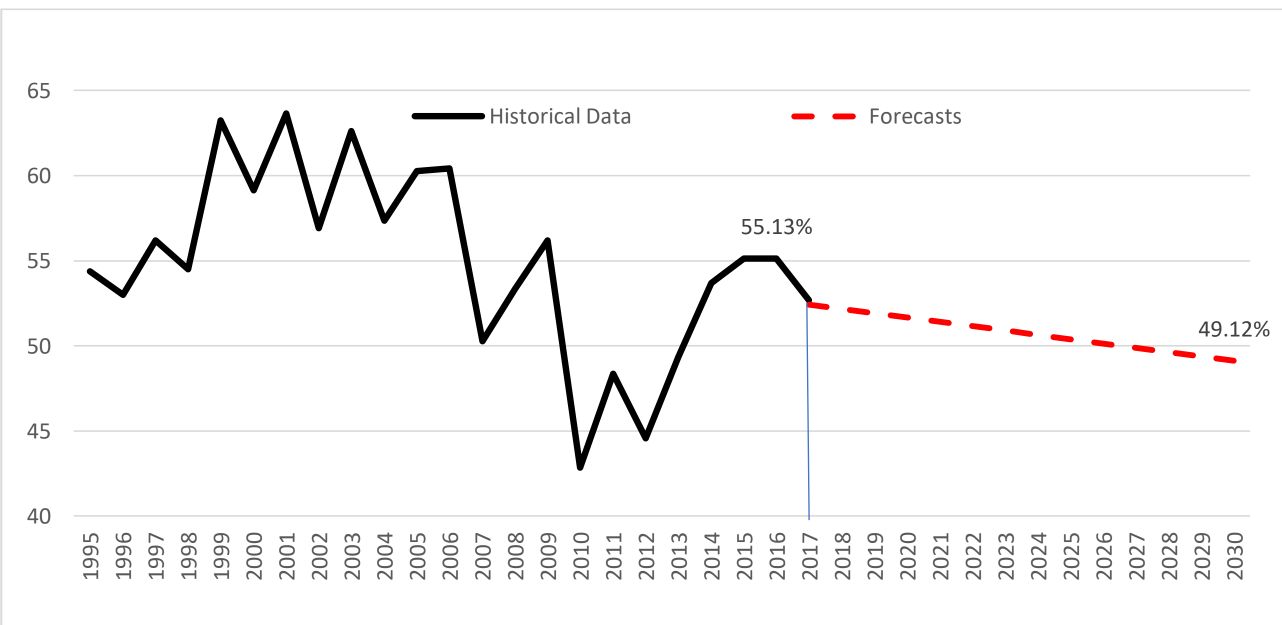


Table 3. Forecasted Values for the Wheat Production, Consumption, self-sufficient in Egypt, with 95% Confidence Interval.

Years	consumption			Production			self-sufficient		
Period	**Forecast**	**Lower**	**Upper**	**Forecast**	**Lower**	**Upper**	**Forecast**	**Lower**	**Upper**
2016	**18.5234**	**16.6294**	**20.4173**	**9.7548**	**8.9534**	**10.5562**	**52.6819**	**43.6715**	**61.6922**
2017	**18.9706**	**16.8827**	**21.0586**	**9.9771**	**9.1136**	**10.8406**	**52.4276**	**41.5957**	**63.2594**
2018	**19.4179**	**17.1155**	**21.7204**	**10.1994**	**9.2673**	**11.1315**	**52.1732**	**39.3450**	**65.0015**
2019	**19.8652**	**17.3330**	**22.3974**	**10.4217**	**9.4159**	**11.4275**	**51.9189**	**36.9893**	**66.8485**
2020	**20.3125**	**17.5391**	**23.0859**	**10.6440**	**9.5603**	**11.7277**	**51.6646**	**34.5674**	**68.7618**
2021	**20.7598**	**17.7364**	**23.7831**	**10.8663**	**9.7015**	**12.0311**	**51.4103**	**32.1015**	**70.7191**
2022	**21.2070**	**17.9270**	**24.4871**	**11.0886**	**9.8401**	**12.3372**	**51.1560**	**29.6051**	**72.7068**
2023	**21.6543**	**18.1122**	**25.1964**	**11.3109**	**9.9765**	**12.6454**	**50.9016**	**27.0869**	**74.7164**
2024	**22.1016**	**18.2934**	**25.9098**	**11.5332**	**10.1111**	**12.9553**	**50.6473**	**24.5525**	**76.7421**
2025	**22.5489**	**18.4711**	**26.6266**	**11.7555**	**10.2444**	**13.2667**	**50.3930**	**22.0059**	**78.7801**
2026	**22.9961**	**18.6461**	**27.3462**	**11.9778**	**10.3764**	**13.5793**	**50.1387**	**19.4497**	**80.8276**
2027	**23.4434**	**18.8189**	**28.0680**	**12.2002**	**10.5073**	**13.8930**	**49.8844**	**16.8861**	**82.8827**
2028	**23.8907**	**18.9897**	**28.7917**	**12.4225**	**10.6375**	**14.2074**	**49.6301**	**14.3164**	**84.9438**
2029	**24.3380**	**19.1590**	**29.5169**	**12.6448**	**10.7669**	**14.5227**	**49.3757**	**11.7417**	**87.0098**
2030	**24.7853**	**19.3270**	**30.2435**	**12.8671**	**10.8956**	**14.8385**	**49.1214**	**9.1630**	**89.0799**

Source: Calculated Based on Data from MALR.

CONCLUSIONS.

This paper has shed light of the current situation of the economics of wheat in Egypt, including the evolution of the pattern of consumption and production, and the consequent development of the volume of the imports of wheat and the impact on the national economy.

As the population increases over time regularly; therefore, it is necessary to plan to meet the requirements of nation. For this purpose, forecasting is the key tool to alarm about the need of nation in advance.

Wheat is the basic need of any country all over the world. In this study, we developed time series models to forecasts wheat production and consumption in Egypt on the basis of historical data; i.e., 1995 to 2016.

The main interest of developing time series model is the prediction of the situation in the future in order to help the decision makers while developing policies and plans that ultimately aim to solve the problem of food security, which will contribute to the formation of food security in Egypt, taking into account the following points that have been studied in the model.

The end of the study makes it possible to develop recommendations for the state, which consists in adopting policies to create an attractive and favorable climate for investment in agriculture, the most important factor of which it is to help investors in newly developed lands by providing the necessary infrastructure.

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