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USING A DYNAMIC TIME SERIES MODEL (ARIMA) FOR FORECASTING OF EGYPTIAN COTTON CROP VARIABLES

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ABSTRACT

The Egyptian cotton crop is considered one of the important strategic crops, as it is one of the main pillars of the Egyptian national economic structure, and is used in many local industries, such as the textile industry, oil and soap industry, animal feed etc. Also, the cultivation of this crop employs more than one million workers and earns the Country a lot of foreign exchange from the export of this crop. In the past period, there has been a steady decline in the cultivation; in terms of land area and quantity produced of the crop. To achieve the Aims of this study Used ARIMA models because these models combine the method of Autoregression, the moving average of the time series to the forecasting of the cultivated area, Productivity, and Production of the cotton crop where these models are characterized by high accuracy in the analysis of Time series. We found from the results the cultivated area of that crop reached 230.30 thousand acres in 2018 then decreased to 27.85 thousand acres in 2024. After that the Production of the cotton crop in Egypt will cease because there is no area planted of cotton crop in Egypt after the year 2024. Also, the results of the productivity forecast were 7.06 quintals in 2018 then dropped to 6.61 quintals in 2025. Also, the results of the forecast of Production of the cotton crop reached 1173.61 thousand quintals in 2018 then reduced to 128.33 thousand quintals in 2024. Then after 2024, the Production of Egyptian cotton crop ceased permanently.

Keywords: forecasting, ARIMA model, Moving average model, Cotton crop. Auto-regressive model. Egypt, Auto-correlation function, Partial Auto-correlation Function.

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INTRODUCTION

The Egyptian cotton crop is considered one of the important strategic crops, as it is one of the main pillars of the Egyptian national economic structure, and participates in many local industries, such as the textile industry, oil and soap industry, animal feed, etc. Also, the cultivation of this crop employs more than one million people. Export of this crop is important to the Egyptian economy because of its comparative advantage and competitiveness in the foreign markets. Besides, the Egyptian cotton crop has an important place in Egyptian history since its emergence in the early 19th century. During Muhammad Ali's rule of the Arab Republic of Egypt, the cultivated of the cotton crop was expanded, and textile factories developed *(Elsamie et al. 2020).* Where the Egyptian cotton crop competed with the British cotton crop at that time. Foreign exchange earnings of the cotton crop was used in the economic and agriculture development of the country. During the British occupation of Egypt, the important role of the cotton crop declined. Talat Herb, the founder of Bank Masr, re-established the important role of the cotton crop once again affecting Egyptian life *(Salam 2009)*. This strategy continued until 1980 when the cultivated varieties of the cotton crop were developed and improved, Productivity increased, and the industrialization of the crop expanded. The Egyptian textile industry during this period achieved significant development at the international level, as well as at the local level. Also, a 20% increase of the cultivated area of the cotton crop was achieved *(Tolpa 2015).*

In 1980 the cultivated area of the cotton crop decreased, as that area reached less than a million acres in 1990. from then, there has been a continuous decline in cultivated area. The decline in the cultivated area continued to reach 1,245 thousand acres in 1980, then 993 thousand acres in 1990, 518 thousand acres in 2000, 369 thousand acres in 2010, then 217 thousand acres in 2017 *(MALR 2017).*

Besides, the Egyptian government did not pay attention to improving the varieties of the cotton crop during that period, which led to a decrease in the productivity. This led to a decrease in the comparative advantage and competitive advantage of Egyptian exports of this crop. The continuous decrease in the cultivated area of the cotton crop due to some internal and external factors, as well as technological and economic reasons, such as growing cotton in climatic conditions not suitable for its cultivation, no application of technical recommendations, no pest control, decrease in the production requirements, etc. The main focus of this study includes looking at the developments of the cultivated area, productivity and production of the Egyptian Cotton crop in the future and making proposals and recommendations that will contribute to setting planning and production policies in the future. In this study, the use of different methods for forecasting the economic variables in the future for this crop is ascertained. We used a dynamic time series (ARIMA) model, a combination of the Autoregressive model and moving average model to forecast the cultivated area and productivity and production of the cotton crop in the future. Again, secondary data issued by the Egyptian Government Agencies for both the cultivated area and the productivity and production of the Egyptian cotton crop during the period 1980-2017 were used *(Al-Ani 2005).*

The Economic Feasibility of Studying the Egyptian Cotton Crop:

i. Egyptian Cotton is of great economic importance as it contributes to agricultural, industrial, internal, and external trade.
ii. Cotton is considered a cash crop, as it contributes to the national economy.
iii. The cotton crop needs many agricultural workers; therefore, more than a million workers are into the Production and marketing of the crop.
iv. The cotton crop provides raw material needed for the textile industry in Egypt.
v. The cotton crop consumes very little irrigation water compared to other crops.
vi. Growing cotton crops on salt intensity lands increases soil fertility.
vii. The Cotton crop residues is used in the Production of wood and fuel and the cottonseed can be used in oil extraction, *(Al-Zenati et al. 2014)*

The problem of this study arises because of the marked decrease in the area planted with the cotton crop, especially in recent years. This decrease in productivity and production led to a decrease in the natural characteristics of the Egyptian cotton crop, such as length, softness, and maturity. Also, the quantity of cotton staple imports increased to meet the needs of local consumption. The Egyptian export of cotton crops was also affected by this decline, and the international position of those exports declined. The study aims to predict the cultivated area, productivity and production of the Egyptian cotton crop. ARIMA models were used to contribute to the design of production policies for this crop based on accurate predictive information.

MATERIALS AND METHODS

The study based on the quantitative and descriptive method for the cultivated area, productivity, and production of Egyptian cotton crop during the period (1980-2017) and based on estimating the forecast of the main variables mentioned earlier, through the application of the (ARIMA) model. The (ARIMA) model can provide a short-run estimate for a sufficiently large amount of data on the concerned variables very precisely. The ARIMA model is a combination of three processes:

I. Autoregressive (AR) process.
II. Differencing process
III. Moving-Average (MA) process.

These processes are known in statistical literature as main univariate time series models and are commonly used in many applications *(Abdulrahim and Namaky 2018).*

Autoregressive (AR) Model

An autoregressive model can be expressed as:

$$Y_T = B_0 + B_1Y_{T-1} + B_2Y_{T-2} + \dots\dots + B_PY_{T-P} + e_T \qquad (1)$$

Where:

e_T: is the error term in the equation

Y_T: Represent variable values Y Predicted.

Y_{T-1}, Y_{T-2}, Y_{T-} :Represent variable values **Y** Time-delayed during the **T** period.

B_0 ,B_1 ,B_2 ,B_P : Slope equation coefficients.

The Autoregressive model indicates that the current values of the $Y_{.T.}$ variable depend on the previous variable values Y_{T-1}, Y_{T-2}, Y_{T-P}.

Moving average (MA) model

The Moving average model can be expressed as:

$$Y_T = W_0 + e_T - W_1e_{T-1} - W_2e_{T-2} + \dots\dots - W_qe_{T-q} \qquad (2)$$

Where

Y_T: Represent variable values Y predicted.

e_{T-1}, e_{T-2}, e_{T-q}: Represents the lateness of the Y_T variable estimate.

W_0,W_1,W_2,W_q : Represent weights.

e_T: represents the random variable.

From the model, current $Y_{.T.}$ values are based on the previous values of e_{T-1}, e_{T-2}, e_{T-q}

Autoregressive integrated moving average model (ARIMA)

The two previous forms can be grouped into one form called ARIMA.

The new model can be formulated in the following formula:

$$Y_T = B_0 + B_1Y_{T-1} + B_2Y_{T-2} + \dots\dots + B_PY_{T-P} + eT + W0 + eT - W1eT-1 - W2eT-2 + \dots\dots - WqeT-q \qquad (3)$$

This form is referred to as ARIMA of the rank (p, q).

Where

P: Refers to the rank of Autoregressive.

q: Refers to the rank of the moving average.

Before applying the above equation to the time series data, we made sure that this series is stable. This means that the dependent variable has an average and constant variation during the study period. If the time series is signed and found to be unstable, it must be converted to a stable series by finding the first difference for this variable as follows:

$$Y^*_t = \Delta Y \; Y_t = Y_{t-1} \quad (4)$$

If the first difference does not result in a stable chain, the first difference to this difference can be taken as follows:

$$Y^{**}_t = \Delta Y^*_t = Y^*_t - Y^*_{t-1} = \Delta Y - Y_{t-1} \quad (5)$$

In general, this difference process can be repeated several times until we have a stable chain. So, the ARIMA model is determined by both p d q. ARIMA model (2.1.1) It means it is an Autoregressive model from the Second degree and One difference and one moving average.

Box-Jenkins Models: The time series analysis Approach of the Box - Jenkins Named, after the statisticians George Box and Gwilym Jenkins, applies ARIMA models to find the best fit of a time series model to past values of a time series *(Ahmadzai et al. 2019).*

Identification Stage: Ensured that the variables stationary and identifying seasonality in the series, using the Auto-correlation Function and Partial Auto-Correlation Function of the series, to identify Auto-regressive or moving average.

Estimation Stage: Using computation algorithms to arrive at coefficients that best fit the selected ARIMA model.

Diagnostic Stage: By testing whether the estimated model conforms to the specifications of a stationary univariate process the residuals should be independent of each other and constant in mean and variance over time. If the estimation is inadequate, we must return to step one and attempt to build a better model.

Forecasting Stage: Forecasting: When the selected ARIMA model conforms to the specifications of a stationary univariate process, then we can use this model for predicting.

Sources of –Data: The study was based on statistical data published by the Egyptian government agencies issued by the Central Department of Agricultural Economics in the Ministry of Agriculture and Land Reclamation, the Central Authority for Public Mobilization and Statistics and Data of Food and Agriculture Organization (FAO), some References and related studies to the subject of the study *(Ahmed and Elsayed 2020).*

RESULTS AND DISCUSSION

Cultivated Area

Identification: The cultivated area for the cotton crop, deduced from the original data, is shown in Figure (1). It is evident that the data series is not static, due to a decreasing of a general trend, which means that the instability of the average by using Auto-correlation function (ACF) and Partial Correlation function (PCF), to detect the stability of the time series. The results indicate in Table (1) the significance of Autocorrelation and partial correlation coefficient values, which indicates that the time series is not static *(Al Shuwaikh et al. 2015).*

Table 1. Autocorrelation and Partial Correlation of cultivated area of the Cotton crop

<table>
<tr><th>Autocorrelation</th><th>Partial Correlation</th><th></th><th>AC</th><th>P.A.C.</th><th>Q-Stat</th><th>Prob</th></tr>
<tr><td>. |******|</td><td>. |******|</td><td>1</td><td>0.850</td><td>0.850</td><td>29.660</td><td>0.000</td></tr>
<tr><td>. |***** |</td><td>. | . |</td><td>2</td><td>0.716</td><td>-0.021</td><td>51.308</td><td>0.000</td></tr>
<tr><td>. |***** |</td><td>. |** |</td><td>3</td><td>0.668</td><td>0.231</td><td>70.658</td><td>0.000</td></tr>
<tr><td>. |**** |</td><td>. | . |</td><td>4</td><td>0.612</td><td>-0.031</td><td>87.403</td><td>0.000</td></tr>
<tr><td>. |**** |</td><td>. | . |</td><td>5</td><td>0.555</td><td>0.039</td><td>101.57</td><td>0.000</td></tr>
<tr><td>. |**** |</td><td>.*| . |</td><td>6</td><td>0.489</td><td>-0.068</td><td>112.94</td><td>0.000</td></tr>
<tr><td>. |*** |</td><td>. | . |</td><td>7</td><td>0.441</td><td>0.041</td><td>122.50</td><td>0.000</td></tr>
<tr><td>. |*** |</td><td>. | . |</td><td>8</td><td>0.392</td><td>-0.055</td><td>130.28</td><td>0.000</td></tr>
<tr><td>. |** |</td><td>.*| . |</td><td>9</td><td>0.298</td><td>-0.169</td><td>134.92</td><td>0.000</td></tr>
<tr><td>. |*. |</td><td>.*| . |</td><td>10</td><td>0.184</td><td>-0.166</td><td>136.76</td><td>0.000</td></tr>
<tr><td>. |*. |</td><td>. | . |</td><td>11</td><td>0.108</td><td>-0.030</td><td>137.42</td><td>0.000</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>12</td><td>0.059</td><td>-0.011</td><td>137.63</td><td>0.000</td></tr>
<tr><td>. | . |</td><td>. |*. |</td><td>13</td><td>0.035</td><td>0.096</td><td>137.70</td><td>0.000</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>14</td><td>-0.002</td><td>-0.030</td><td>137.70</td><td>0.000</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>15</td><td>-0.035</td><td>0.041</td><td>137.78</td><td>0.000</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>16</td><td>-0.045</td><td>0.044</td><td>137.92</td><td>0.000</td></tr>
</table>

Source: calculated from Table (1) in the Annex.

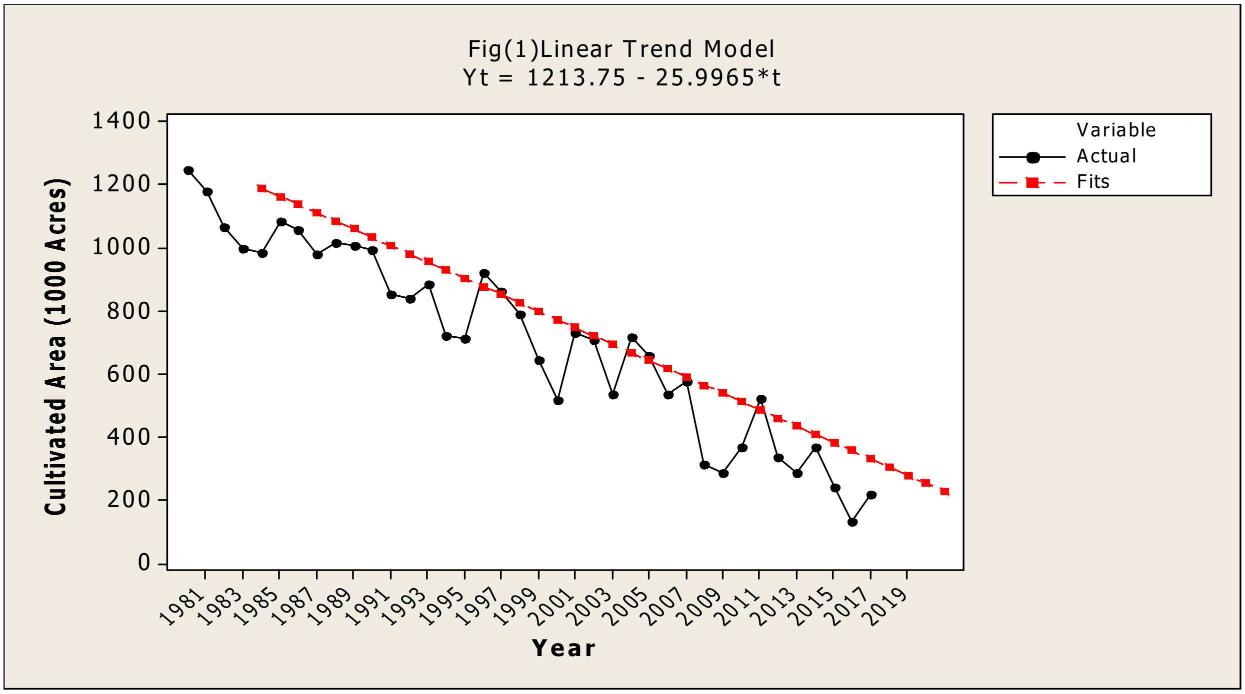
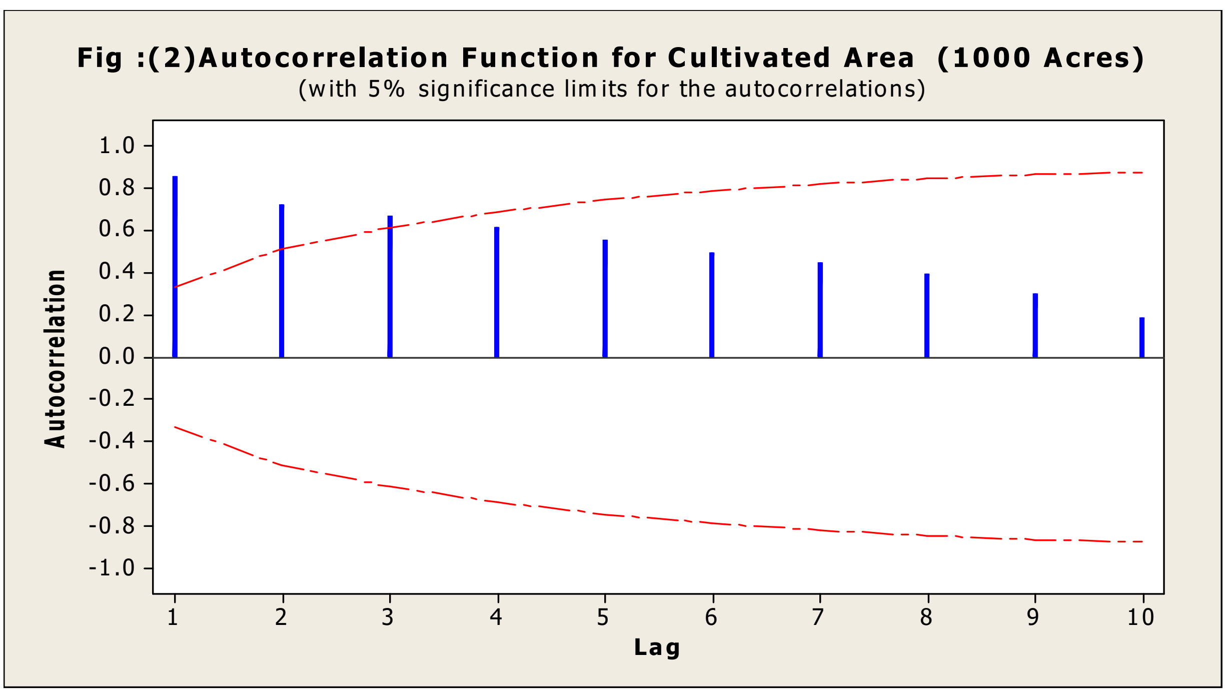


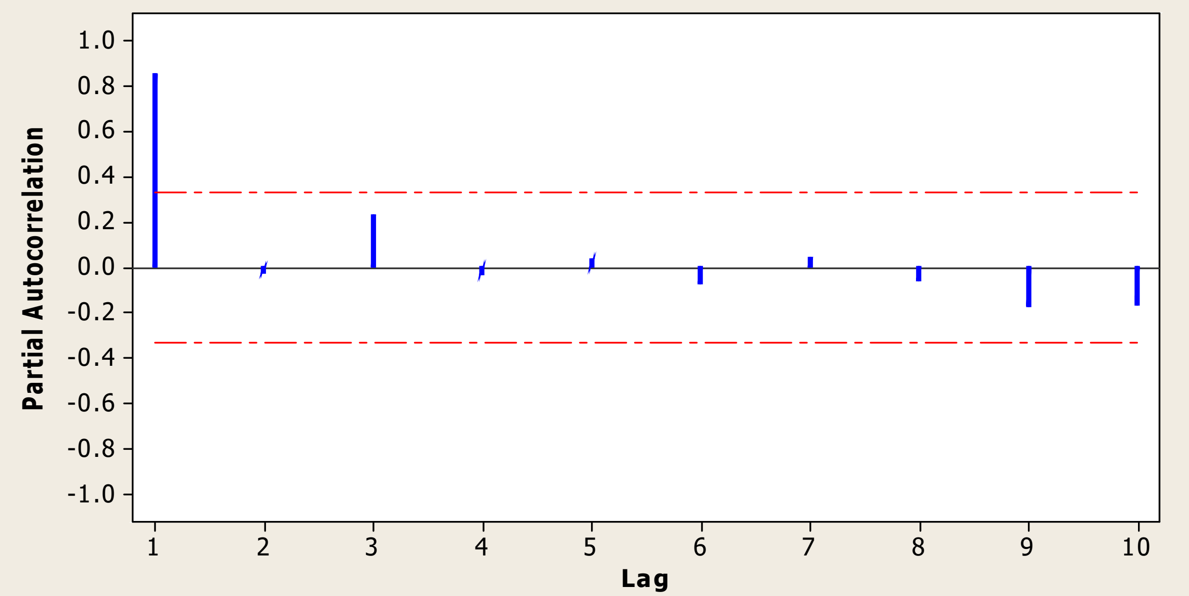
Fig. 1. Time Series Plot of the cotton area

Source: calculated from Table (1) in the Annex.

Also, by the drawing of the original data of the Auto-correlation function (ACF), we get figure (2). by making the drawing of the original data of the Partial Auto-correlation Function (PACF) for the cultivated area of the cotton crop we get figure (3), The results showed the significance of the Partial Auto-correlation Coefficient, Function., which means rejecting the basic assumption that "the sum of the squares of single correlation coefficients are significant", it means there are correlations Known as full test *(Nejm 2015).*



Source: calculated from Table (1) in the Annex.



Fig(3):Partial Autocorrelation Function for Cultivated Area (1000 Acres)
(with 5% significance limits for the partial autocorrelations)

Source: calculated from Table (1) in the Annex.

Estimation: By examining the Partial Auto-correlation function with the original series as in Figure (3), we find that this parameter falls outside the boundaries of the confidence interval at one gap, Therefore the Auto-regression model (AR) and Moving Average model (MA) must be applied. Finally, the best model is shown in Table (2)

Table 2. Final Estimates of Parameters for cultivated area of the cotton crop (2-1-1).

Type	Coef	SE Coef	T-value	P-value
AR 1	0.3349	0.1648	2.03	0.050
AR 2	-0.4056	0.1663	-2.44	0.020
MA 1	1.0923	0.0298	36.68	0.000
Constant	-28.23415	0.09971	-283.16	0.000

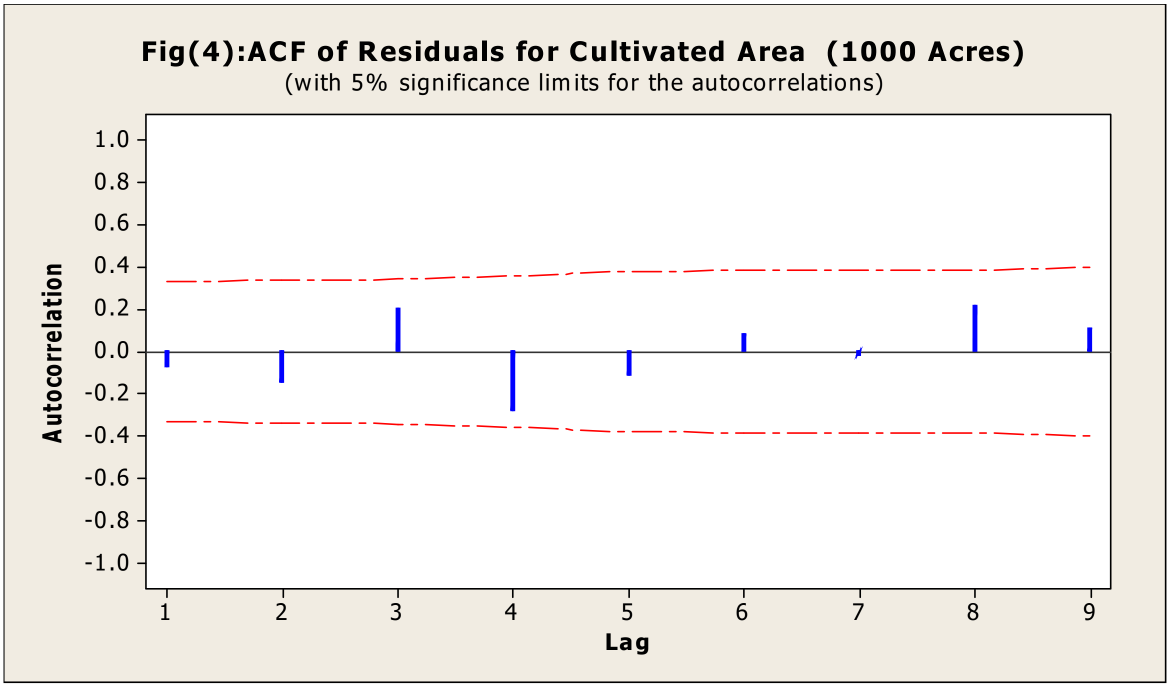
Source: calculated from Table (1) in the Annex.

Diagnostic checking: By estimating Auto-correlation function (ACF) and Partial Auto-correlation Function (PACF) of Residuals estimated models (ei), it was found that they are within confidence limits, where it is clear from the two Figures (4) and (5), that there is no specific behavioral pattern for the Auto-correlation function and Partial Auto-correlation function of the Residuals and this indicates the quality of the model.

Forecasting: Table (3) shows the results of the forecast of the cultivated area of the cotton crop. The cultivated area reached 230.30 thousand acres in 2018, then decreased to 27.85 thousand acres in 2024, After that the production of the cotton crop in Egypt ceased. The figure shows no area planted of the cotton crop in Egypt after the year 2024.

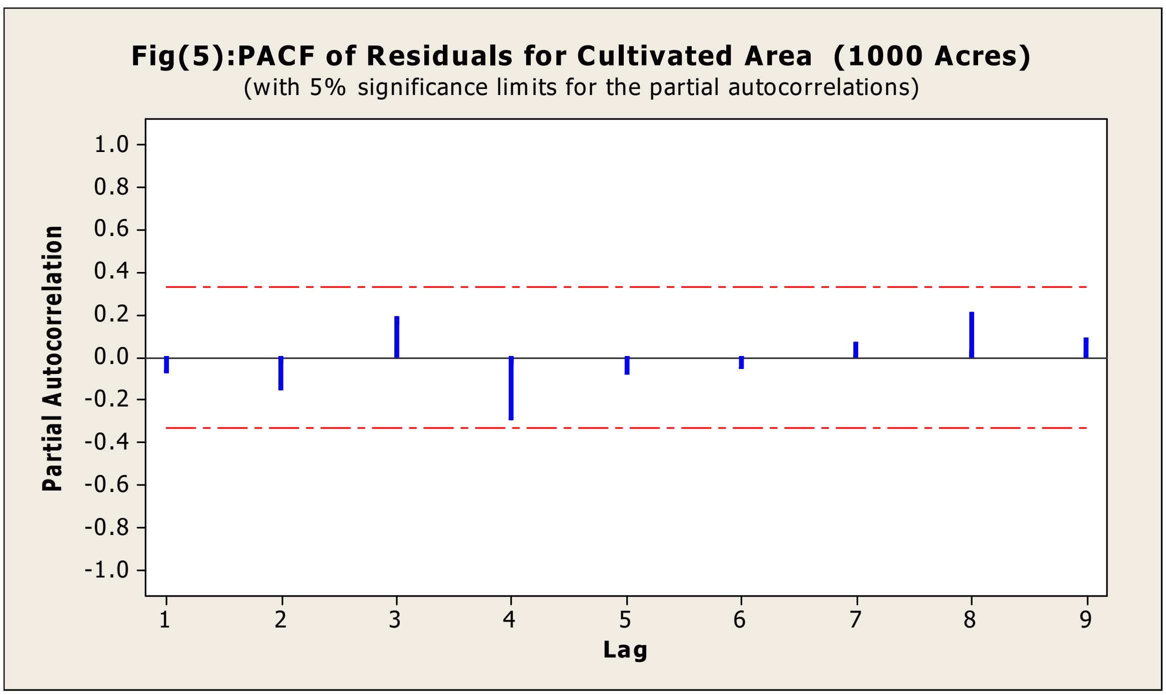
Productivity

Identification: The Productivity for the cotton crop, deduced from the original data, is shown in Figure (6). It is evident that the data series is not static, due to a decreasing of a general trend, which means that the instability of the average by using Auto-correlation function (ACF) and Partial Correlation function (PCF), to detect the stability of the time series. The results indicate in Table (4) the significance of Autocorrelation and partial correlation coefficient values, which indicates that the time series is not static.



Fig(4):ACF of Residuals for Cultivated Area (1000 Acres)
(with 5% significance limits for the autocorrelations)

Source: calculated from Table (1) in the Annex.



Fig(5):PACF of Residuals for Cultivated Area (1000 Acres)
(with 5% significance limits for the partial autocorrelations)

Source: calculated from Table (1) in the Annex.

Table 3. Results of the forecasting for the best dynamic models using Box-Jenkins Models.

Year	2018	2019	2020	2021	2022	2023	2024	2025
Forecast (1000 acres)	230.30	171.98	118.80	96.40	82.24	58.34	27.85	—

Source: calculated from Table (1) in the Annex.

Table 4. Autocorrelation and Partial Correlation of Productivity of the Cotton crop

<table>
<tr><th>Autocorrelation</th><th>Partial Correlation</th><th></th><th>AC</th><th>P.A.C.</th><th>Q-Stat</th><th>Prob</th></tr>
<tr><td>****|. |</td><td>****|. |</td><td>1</td><td>-0.495</td><td>-0.495</td><td>9.5785</td><td>0.002</td></tr>
<tr><td>.*|. |</td><td>***|. |</td><td>2</td><td>-0.079</td><td>-0.430</td><td>9.8316</td><td>0.007</td></tr>
<tr><td>. |*. |</td><td>**|. |</td><td>3</td><td>0.131</td><td>-0.225</td><td>10.539</td><td>0.014</td></tr>
<tr><td>.*|. |</td><td>**|. |</td><td>4</td><td>-0.120</td><td>-0.295</td><td>11.153</td><td>0.025</td></tr>
<tr><td>. |*. |</td><td>.*|. |</td><td>5</td><td>0.135</td><td>-0.098</td><td>11.958</td><td>0.035</td></tr>
<tr><td>.*|. |</td><td>**|. |</td><td>6</td><td>-0.184</td><td>-0.317</td><td>13.494</td><td>0.036</td></tr>
<tr><td>. |*. |</td><td>.*|. |</td><td>7</td><td>0.198</td><td>-0.077</td><td>15.339</td><td>0.032</td></tr>
<tr><td>.*|. |</td><td>.*|. |</td><td>8</td><td>-0.074</td><td>-0.108</td><td>15.606</td><td>0.048</td></tr>
<tr><td>.*|. |</td><td>**|. |</td><td>9</td><td>-0.138</td><td>-0.264</td><td>16.568</td><td>0.056</td></tr>
<tr><td>. |** |</td><td>.*|. |</td><td>10</td><td>0.230</td><td>-0.120</td><td>19.346</td><td>0.036</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>11</td><td>-0.044</td><td>0.069</td><td>19.453</td><td>0.053</td></tr>
<tr><td>. | . |</td><td>. |*. |</td><td>12</td><td>-0.049</td><td>0.114</td><td>19.589</td><td>0.075</td></tr>
<tr><td>.*|. |</td><td>.*|. |</td><td>13</td><td>-0.136</td><td>-0.143</td><td>20.685</td><td>0.079</td></tr>
<tr><td>. |*. |</td><td>. | . |</td><td>14</td><td>0.181</td><td>-0.021</td><td>22.716</td><td>0.065</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>15</td><td>-0.032</td><td>-0.050</td><td>22.783</td><td>0.089</td></tr>
<tr><td>.*|. |</td><td>. | . |</td><td>16</td><td>-0.087</td><td>-0.058</td><td>23.299</td><td>0.106</td></tr>
</table>

Source: calculated from Table (1) in the Annex

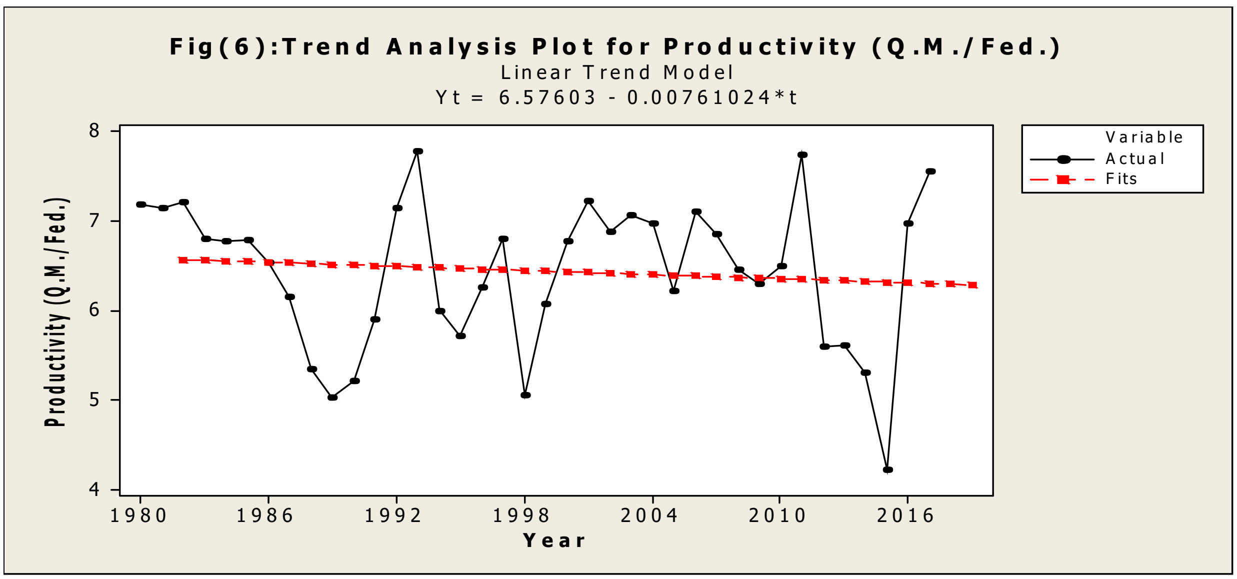
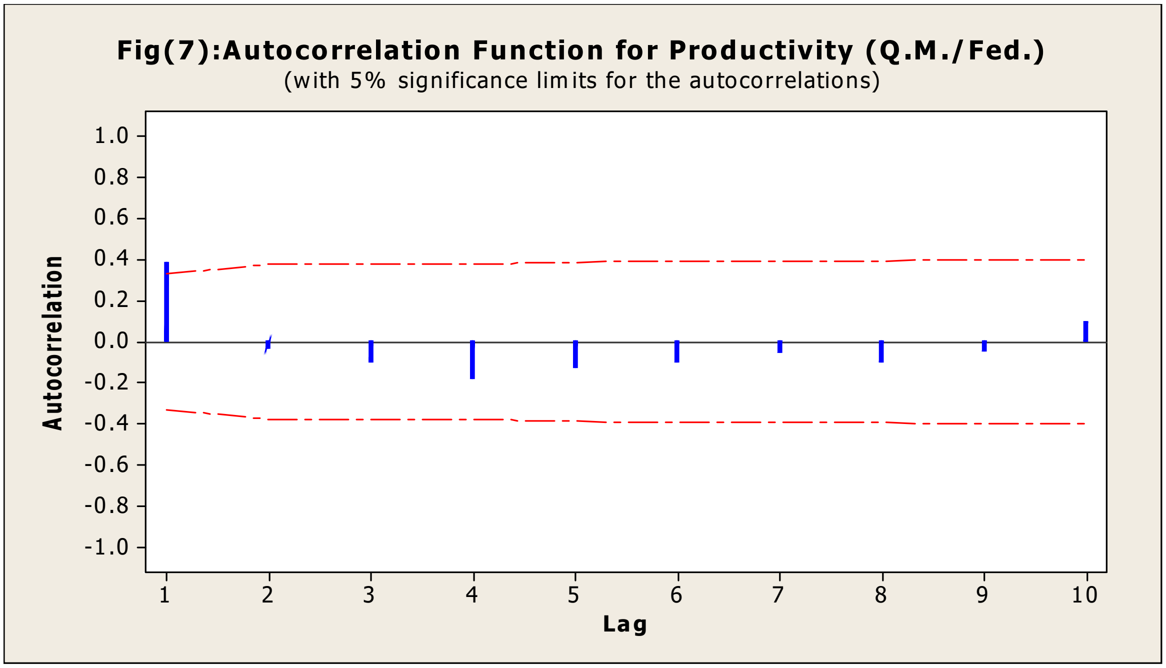


Fig. 6. Time Series Plot of Productivity of the Cotton crop.
Source: calculated from Table (1) in the Annex

Also, by the drawing of the original data of the Auto-correlation function (ACF), we get figure (7). Making the drawing of the original data of the Partial Auto-correlation Function (PACF) for Productivity of the cotton crop we get figure (8), The results showed the significance of the Partial Auto-correlation Coefficient, Function., which means rejecting the basic assumption that "the sum of the squares of single correlation coefficients are significant", it means there are correlations known as full test *(Youssef, 2001).*

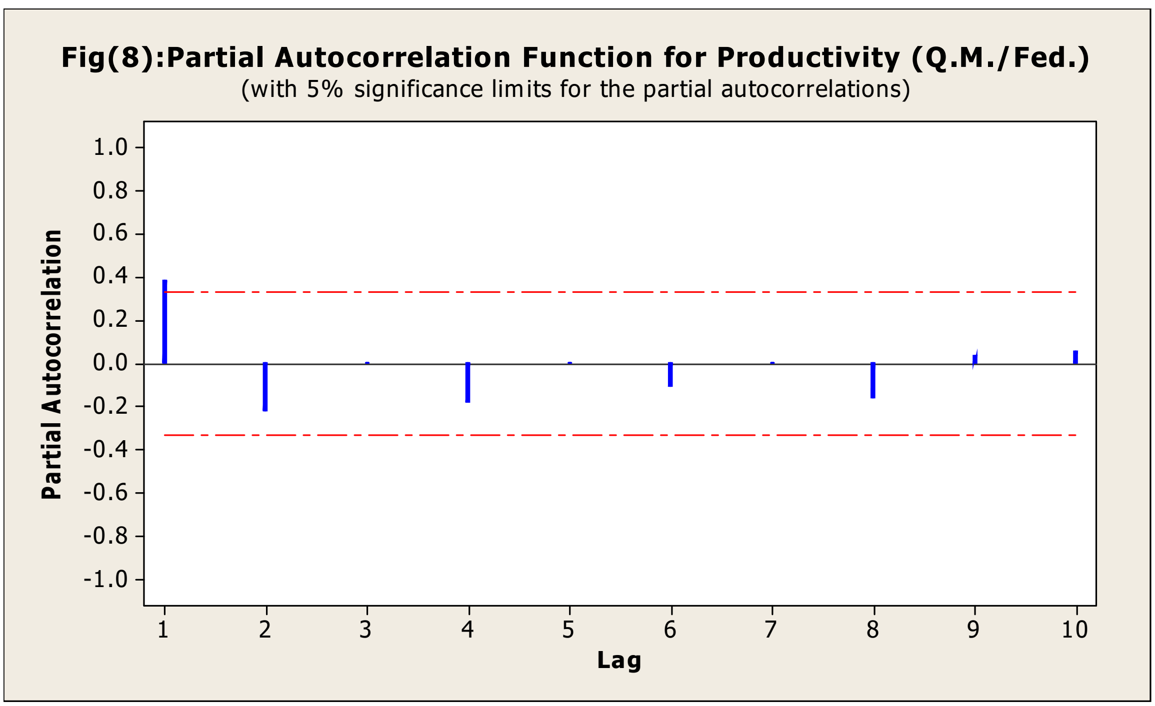
Estimation: By examining the Partial Auto-correlation function with the original series as in Figure (8), we find that this parameter falls outside the boundaries of the confidence interval at one gap. Therefore, the Auto-regression model (AR) and Moving Average model (MA) must be applied. Finally, the best model is shown in Table (5).

Diagnostic checking: By estimating Auto-correlation function (ACF) and Partial Auto-correlation Function (PACF) of Residuals estimated models (ei), it was found that they are within confidence limits, where it is clear from the two Figures (9) and (10), that there is no specific behavioral pattern for the Auto-correlation function and Partial Auto-correlation function of the Residuals and this indicates the quality of the model *(Ibrahim 2015).*



Fig(7):Autocorrelation Function for Productivity (Q.M./Fed.)
(with 5% significance limits for the autocorrelations)

Source: calculated from Table (1) in the Annex



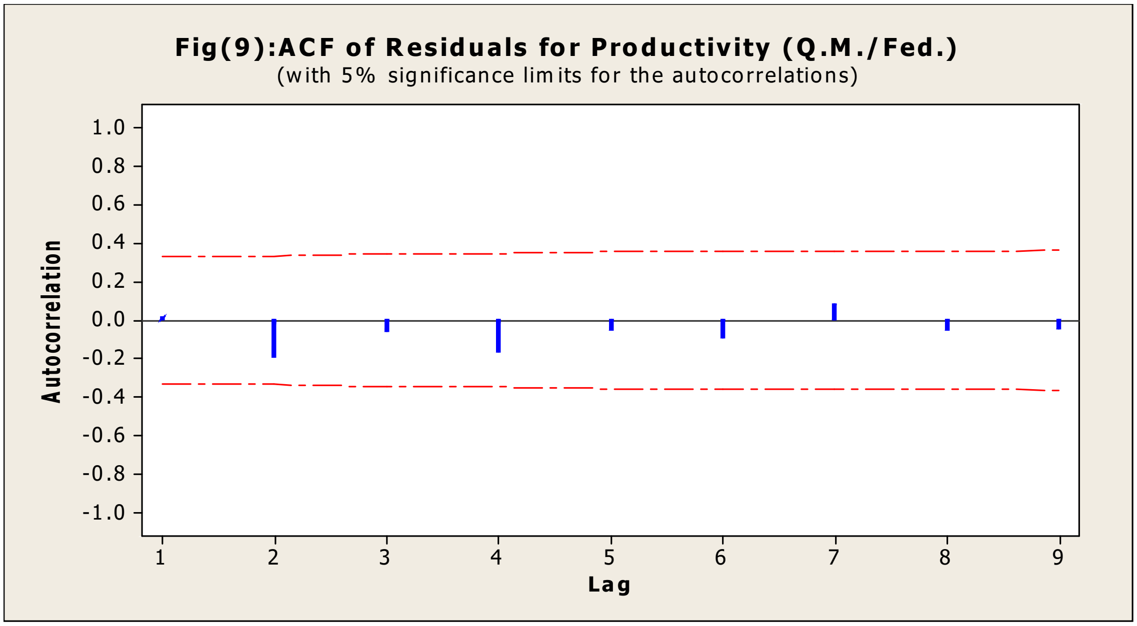
Fig(8):Partial Autocorrelation Function for Productivity (Q.M./Fed.)
(with 5% significance limits for the partial autocorrelations)

Source: calculated from Table (1) in the Annex

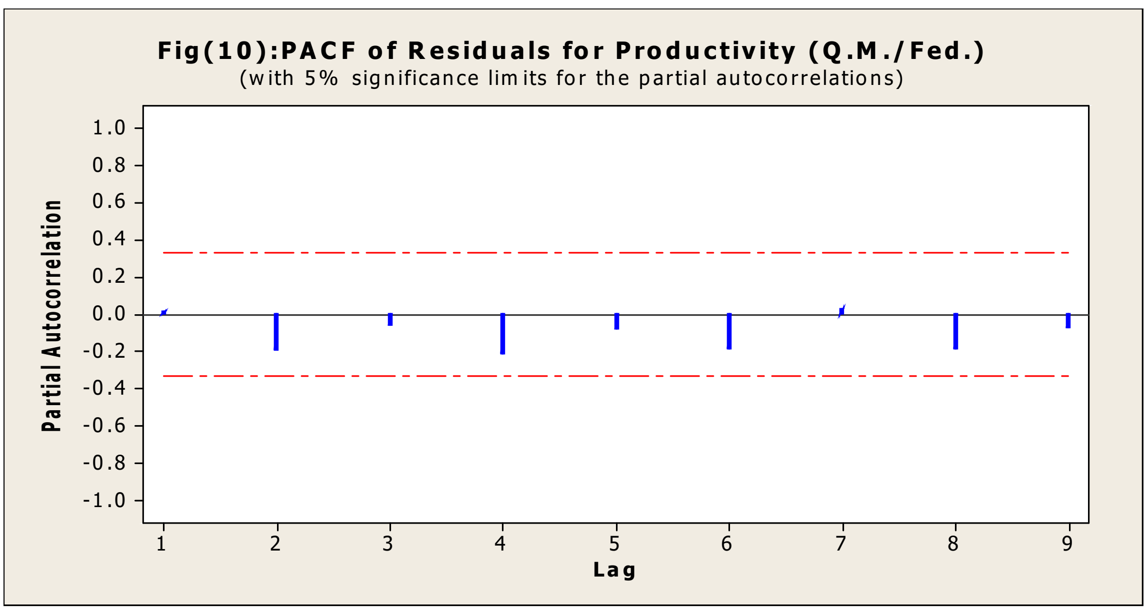
Table 5. Final Estimates of Parameters for Productivity of the Cotton crop (1-1-1)

Type	Coef	SE Coef	T-value	P-value
AR 1	0.4901	0.1609	3.05	0.004
MA 1	1.0419	0.0793	13.14	0.000
Constant	0.002471	0.008973	0.28	0.785

Source: calculated from Table (1) in the Annex.



Source: calculated from Table (1) in the Annex.



Source: calculated from Table (1) in the Annex

Forecasting: Table (6) shows the results of productivity forecast were 7.06 quintals in 2018 then dropped to 6.61 quintals in 2025.

Table 6. Results of the forecasting for the best dynamic models using Box-Jenkins Models.

Year	2018	2019	2020	2021	2022	2023	2024	2025
Forecast (Q.M)	7.0569	6.8128	6.6957	6.6407	6.6163	6.6067	6.6045	6.6059

Source: calculated from Table (1) in the Annex.

The Production

Identification: The Production for the cotton crop, deduced from the original data, is shown in Figure (11). It is evident that the data series is not static, due to a decreasing of a general trend, which means that the instability of the average by using Auto-correlation function (ACF) and Partial Correlation function (PCF), to detect the stability of the time series. The results indicate in Table (7) the significance of Autocorrelation and partial correlation coefficient values, which indicates that the time series is not static *(Ahmed 2015)*.

Table 7. Autocorrelation and Partial Correlation of Production of the Cotton crop

<table>
<tr><th>Autocorrelation</th><th>Partial Correlation</th><th></th><th>AC</th><th>P.A.C.</th><th>Q-Stat</th><th>Prob</th></tr>
<tr><td>. |******|</td><td>. |******|</td><td>1</td><td>0.791</td><td>0.791</td><td>25.720</td><td>0.000</td></tr>
<tr><td>. |**** |</td><td>. | . |</td><td>2</td><td>0.617</td><td>-0.025</td><td>41.773</td><td>0.000</td></tr>
<tr><td>. |**** |</td><td>. |*. |</td><td>3</td><td>0.558</td><td>0.209</td><td>55.310</td><td>0.000</td></tr>
<tr><td>. |**** |</td><td>. | . |</td><td>4</td><td>0.521</td><td>0.057</td><td>67.462</td><td>0.000</td></tr>
<tr><td>. |*** |</td><td>. | . |</td><td>5</td><td>0.460</td><td>-0.006</td><td>77.203</td><td>0.000</td></tr>
<tr><td>. |** |</td><td>.*| . |</td><td>6</td><td>0.349</td><td>-0.138</td><td>82.995</td><td>0.000</td></tr>
<tr><td>. |** |</td><td>. | . |</td><td>7</td><td>0.294</td><td>0.062</td><td>87.238</td><td>0.000</td></tr>
<tr><td>. |** |</td><td>.*| . |</td><td>8</td><td>0.244</td><td>-0.077</td><td>90.245</td><td>0.000</td></tr>
<tr><td>. |*. |</td><td>. | . |</td><td>9</td><td>0.203</td><td>0.032</td><td>92.399</td><td>0.000</td></tr>
<tr><td>. |*. |</td><td>.*| . |</td><td>10</td><td>0.146</td><td>-0.068</td><td>93.551</td><td>0.000</td></tr>
<tr><td>. |*. |</td><td>. | . |</td><td>11</td><td>0.110</td><td>0.047</td><td>94.236</td><td>0.000</td></tr>
<tr><td>. |*. |</td><td>. | . |</td><td>12</td><td>0.077</td><td>-0.064</td><td>94.580</td><td>0.000</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>13</td><td>0.020</td><td>-0.053</td><td>94.606</td><td>0.000</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>14</td><td>-0.011</td><td>-0.005</td><td>94.614</td><td>0.000</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>15</td><td>-0.029</td><td>0.005</td><td>94.670</td><td>0.000</td></tr>
<tr><td>. | . |</td><td>. | . |</td><td>16</td><td>-0.022</td><td>0.044</td><td>94.703</td><td>0.000</td></tr>
</table>

Source: calculated from Table (1) in the Annex

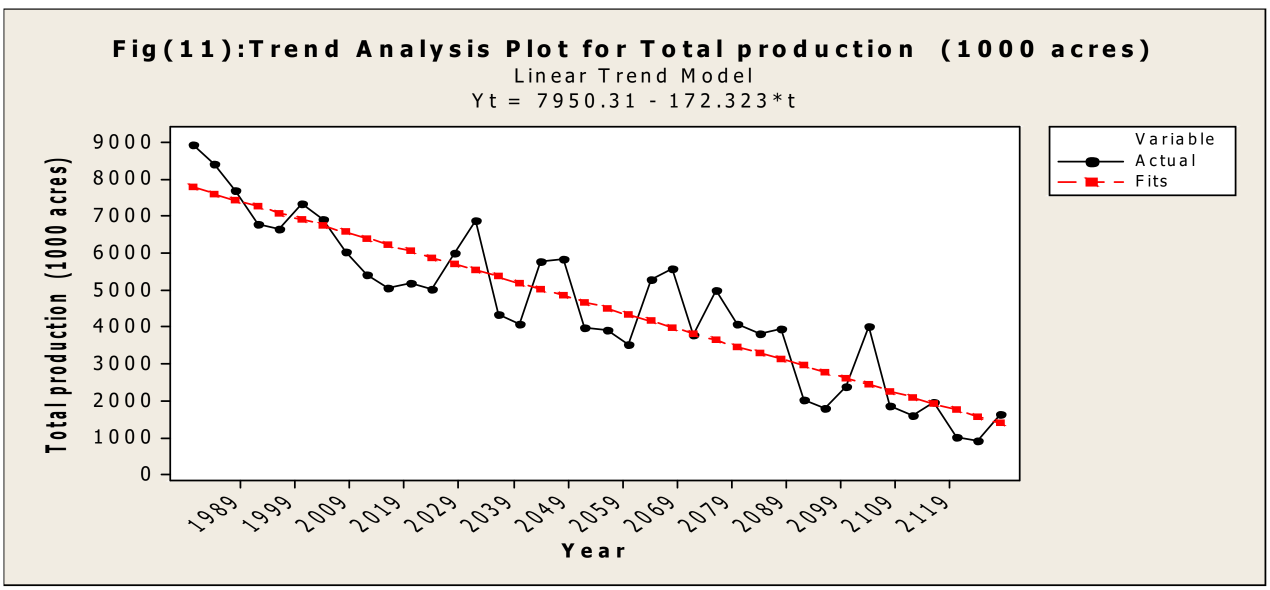
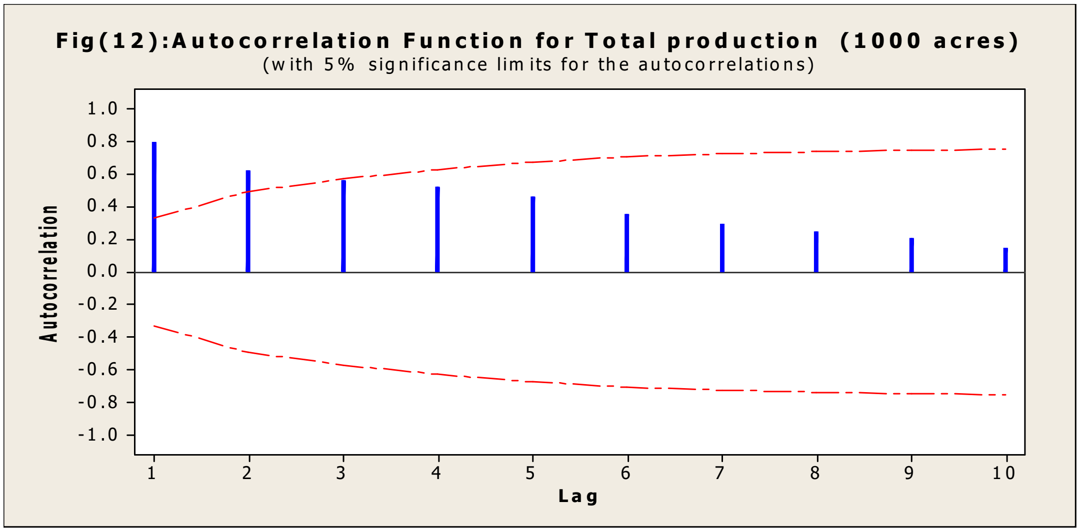


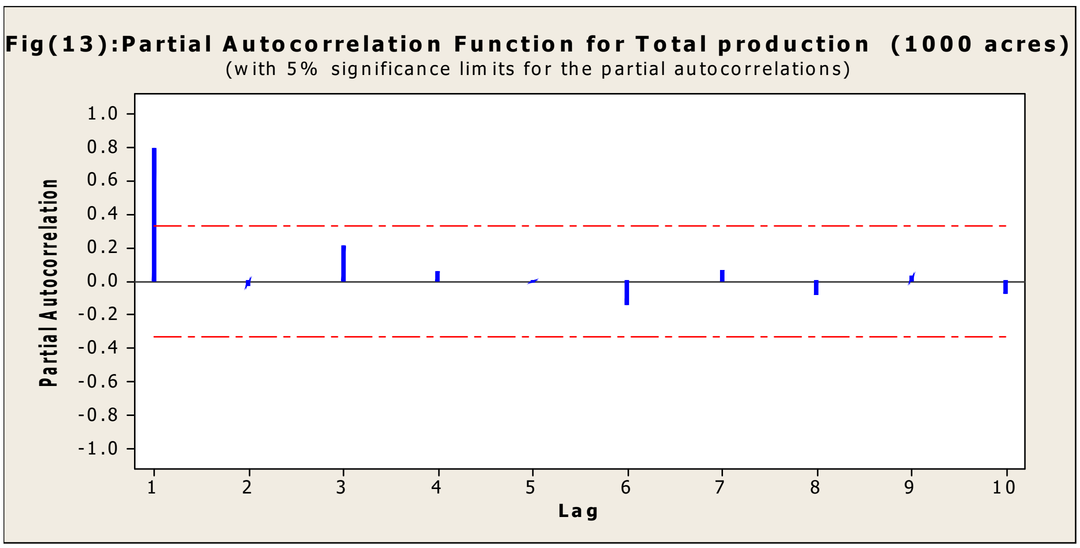
Fig. 11. Time Series Plot of Production of the cotton crop

Source: calculated from Table (1) in the Annex

Also, by the drawing of the original data of the Auto-correlation function (ACF), we get figure (12). Making the drawing of the original data of the Partial Auto-correlation Function (PACF) for Production of the cotton crop we get figure (13), The results showed the significance of the Partial Auto-correlation Coefficient, Function., which means rejecting the basic assumption that "the sum of the squares of single correlation coefficients are significant", it means there are correlations known as full test.



Source: calculated from Table (1) in the Annex



Source: calculated from Table (1) in the Annex

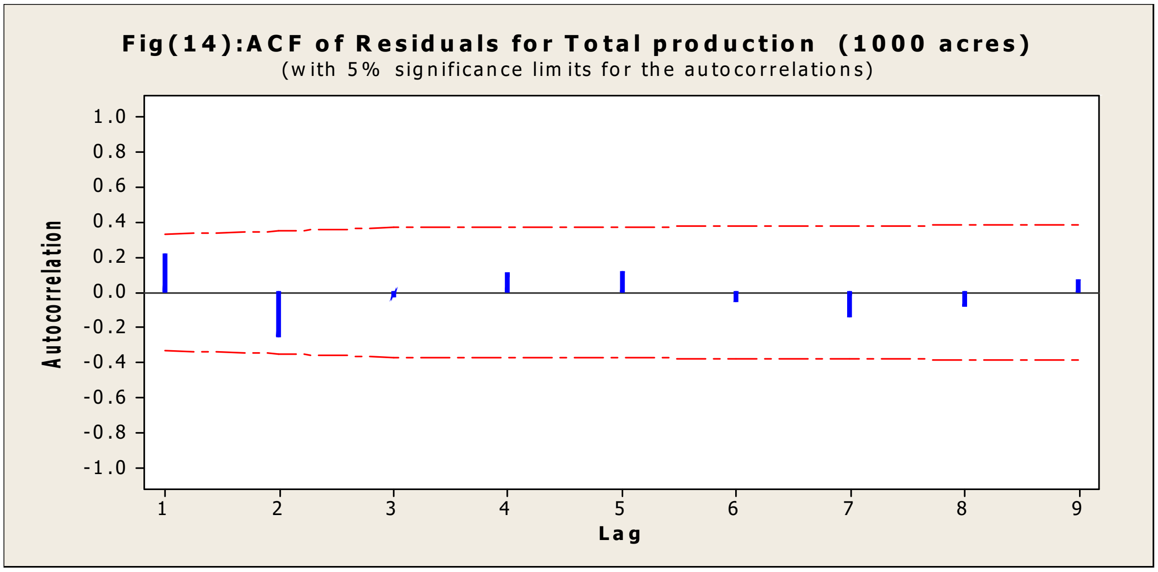
Estimation: By examining the Partial Auto-correlation function with the original series as in Figure (13), we find that this parameter falls outside the boundaries of the confidence interval at one gap. Therefore, the Auto-regression model (AR) and Moving Average model (MA) must be applied. Finally, the best model is shown in Table (8) *(Eliw et al. 2019).*

Table 8. Final Estimates of Parameters for Production of the Cotton crop (0-1-1).

Type	Coef	SE Coef	T-value	P-value
MA 1	0.9562	0.0854	11.19	0.000
Constant	-174.21	12.95	-13.45	0.000

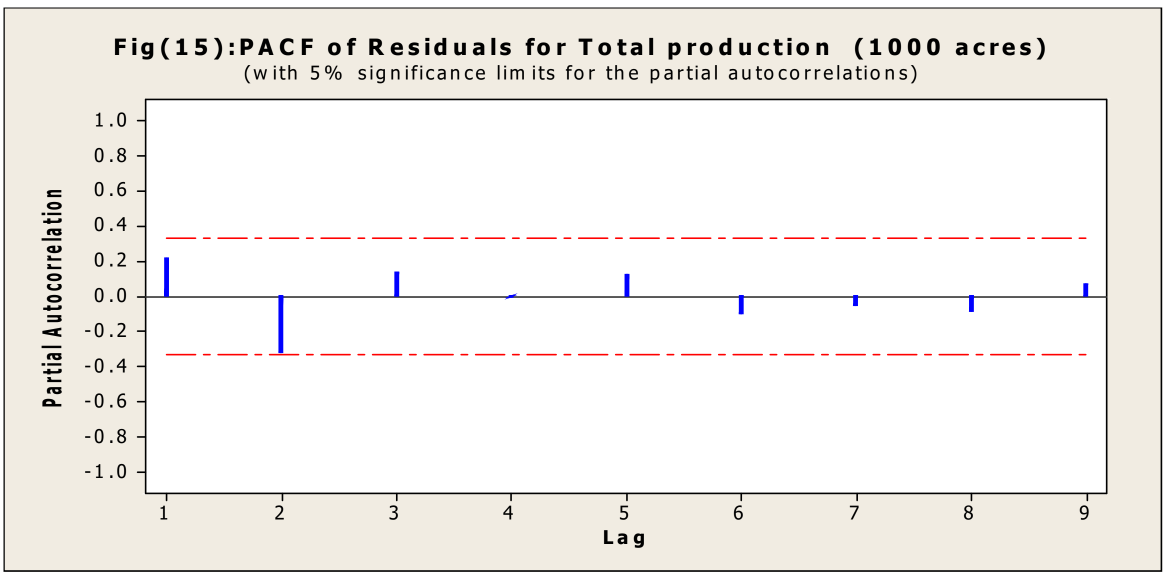
Source: calculated from Table (1) in the Annex.

Diagnostic Checking: By estimating Auto-correlation function (ACF) and Partial Auto-correlation Function (PACF) of Residuals estimated models (ei), it was found that they are within confidence limits, where it is clear from the two Figures (14) and (15) that there is no specific behavioral pattern for the Auto-correlation function and Partial Auto-correlation function of the Residuals and this indicates the quality of the model *(El Sayed 2016).*



Fig(14):ACF of Residuals for Total production (1000 acres)
(with 5% significance limits for the autocorrelations)

Source: calculated from Table (1) in the Annex.



Fig(15):PACF of Residuals for Total production (1000 acres)
(with 5% significance limits for the partial autocorrelations)

Source: calculated from Table (1) in the Annex.

Forecasting: Table (9) shows the results of the forecast of Production of the cotton crop which reached 1173.61 thousand quintals in 2018, then reduced to 128.33 thousand quintals in 2024. Then after 2024, the Production of the cotton crop of Egypt ceased permanently *(Nassar 2015).*

Table 9. Results of the forecasting for the best dynamic models using Box-Jenkins Models.

Year	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
Forecast (1000 Q.M)	1173.61	999.39	825.18	650.97	476.76	302.55	128.33	-45.88

Source: calculated from Table (1) in the Annex.

Conclusion and Recommendations: The Egyptian cotton crop is considered one of the important strategic crops, as it is one of the main pillars of the Egyptian national economic structure, Also, the cultivation of this crop employs more than one million workers, To achieve the Aims of this study, we used ARIMA models because these models combine the method of Autoregression, the moving average of the time series to the forecasting of the cultivated area, productivity, and production of the cotton crop where these models are characterized by high accuracy in the analysis of Time series, We found from the results the cultivated area of that crop reached 230.30 thousand acres in 2018, then decreased to 27.85 thousand acres in 2024. After that, the production of the cotton crop in Egypt will cease because there will be no area planted of cotton crop in Egypt after the year 2024. Also, the results of the productivity forecast were 7.06 quintals in 2018, and then dropped to 6.61 quintals in 2025. Also, the results of the forecast of production of the cotton crop the production reached 1173.61 thousand quintals in 2018, then reduced to 128.33 thousand quintals in 2024. Then after 2024, the production of Egyptian cotton crop will cease permanently *(Al-Gendi et al. 2016).*

Based on the research results, we recommend the following:

i. Reducing production costs by assessing the real costs of production inputs, eliminating or rationalizing administrative costs.
ii. Study support methods in cotton crop-producing countries, such as India, Pakistan, the United States, and Brazil, and their application in Egypt.
iii. Improving productivity through many factors, such as the production of new varieties that promote acres productivity.
iv. Importing new genetic assets to hybridize with Egyptian Cotton.
v. The government sets a forced price for the cotton crop.
vi. Providing the cotton crop production requirements, such as fertilizers and pesticides at affordable prices.
vii. Activating the role of agricultural guides in educating producers about harvesting and packing, and not using sisal filaments in sewing cotton bags.
viii. Identify a tripartite agricultural cycle to eliminate randomness in agriculture.
ix. Encourage the use of agricultural mechanization in cotton crop cultivation, from agriculture to harvesting.

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ANNEX

Table 1. Economic variables of the Egyptian cotton crop over the period 1980-2017.

Years	Area (1000 acres)	Productivity (Q.M)	Production (1000 Q.M)
1980	1244.53	7.18	8941.38
1981	1178.42	7.14	8413.92
1982	1065.84	7.21	7684.71
1983	998.28	6.80	6788.30
1984	983.56	6.77	6658.70
1985	1081.01	6.79	7340.06
1986	1054.86	6.54	6898.78
1987	979.79	6.15	6025.71
1988	1013.96	5.35	5424.69
1989	1005.53	5.03	5057.82
1990	993.05	5.21	5173.79
1991	851.28	5.90	5022.55
1992	840.29	7.15	6008.07
1993	884.31	7.78	6879.93
1994	721.44	6.00	4328.64
1995	710.21	5.72	4062.40
1996	920.91	6.26	5764.90
1997	859.26	6.80	5842.97
1998	788.88	5.05	3983.84
1999	645.42	6.07	3917.70
2000	518.32	6.78	3514.10
2001	731.11	7.23	5285.90
2002	706.41	6.88	5565.90
2003	535.09	7.07	3783.10
2004	714.73	6.97	4981.70
2005	656.59	6.22	4084.00
2006	536.40	7.10	3808.40
2007	574.57	6.86	3941.60
2008	312.71	6.46	2020.10
2009	284.43	6.30	1791.90
2010	369.14	6.49	2395.70
2011	520.12	7.74	4025.70
2012	333.36	5.59	1863.50
2013	286.72	5.61	1608.50
2014	369.18	5.30	1956.70
2015	240.87	4.22	1016.50
2016	131.75	6.97	918.30
2017	216.95	7.56	1640.10

Source: *Calculated using on data collected from the Ministry of Agriculture and Land Reclamation, Economic Affairs Sector, Central Administration for Agricultural Economics, Bulletin of Agricultural Economics; Different Issues.*

Table 2. The average and standard deviation of cultivated area, Productivity, and Production of the Egyptian cotton crop.

Variables		N	Minimum	Maximum	Mean	Std. Deviation	CV
Area	(1000 acres)	38	131.75	1244.53	706.82	301.72	42.69
Productivity	(Q.M)	38	4.22	7.78	6.43	0.83	12.91
production	(1000 Q.M)	38	918.30	8941.38	4590.01	2095.55	45.65

Source: calculated from Table (1) in the Annex.