International Journal of Agricultural Economics
2017; 2(4): 96-109
http://www.sciencepublishinggroup.com/j/ijae
doi: 10.11648/j.ijae.20170204.12

SciencePG
Science Publishing Group

Report

Economic Modelling and Forecasting of Sugar Production and Consumption in Egypt

Bader Esam A.

Department of Agricultural Economics, Faculty of Agriculture, Damietta University, Damietta, Egypt

Email address:
esbadr@du.edu.eg

To cite this article:
Bader Esam A. Economic Modelling and Forecasting of Sugar Production and Consumption in Egypt. *International Journal of Agricultural Economics*. Vol. 2, No. 4, 2017, pp. 96-109. doi: 10.11648/j.ijae.20170204.12

Received: April 12, 2017; **Accepted**: April 27, 2017; **Published**: June 19, 2017

Abstract: Sugar is considered one of the strategic commodities in Egypt. The domestic production of sugar is still insufficient to meet the consumption needs, which increases the food gap of sugar. This paper analyses the main features of the production and consumption of sugar in Egypt. Descriptive and quantitative analysis are used relying on data obtained from the Ministry of Agriculture and Land Reclamation for the period (2000-2015). Results indicate that the total sugar production and consumption in Egypt are increased with an annual significant growth rate of 4.08% and 3.26%, respectively. Water productivity for sugar beet is more than sugar cane, with a net return per unit of water of 684.40 and 474.19 LE/1000M3, respectively. The average monthly profitability for sugar beet is about 0.16 which is higher than sugar cane (0.11). Nerlove's model shows that producers responsive to net return in cane production, with elasticity of response about 0.02 and to prices and one year lag of area in sugar beet production, with elasticities of response about 0.57 and 0.40, respectively. The most important factors that influence the food gap of sugar are the domestic production, per capita consumption, and population. Finally, the forecast figures base on ARIMA models show that sugar production and consumption are predicted to increase over the forthcoming decades, and in spite of these, the food gap of sugar would be about 735.43 thousand tons with self-sufficiency rate of 76.26% for the year 2025. For this reason, Egypt should exert more efforts to increase sugar production by increasing beet area, raising the delivery prices, adopting high yielding varieties of sugar crops and rationalizing per capita sugar consumption to reduce the size of sugar gap.

Keywords: Egypt, Food Gap of Sugar, Sugar Crops, Supply Response, ARIMA

1. Introduction

In Egypt, sugar is an important food commodities because of its strategic position in consumption as well as for industrial use. Sugar consumption has been driven by population growth associated with changes in food consumption patterns. Per capita consumption of sugar has been growing fast since 2000 in Egypt and was recorded at 27 kg/capita and 34 kg/capita in 2015, due to population growth and income level increase. Sugar production depends on two main crops, sugar cane and sugar beet. Sugar cane was the only source to produce sugar until the sugar beet was adopted by the Government of Egypt by 1982. Cane and beet represent the main sources of sugar that contributed to about 61.28% and 38.72%, respectively, of the total sugar production during the period (2000-2015) [8].

Due to land and water scarcity in Egypt at the increase of sugar demand, some efforts were made by the state to increase the cultivated area and productivity of sugar beet source during the last years. Whereas, cane crop needs more water resources per Feddan, reached about 11032M3 of irrigation water in 2014 [3].The average amount of sugar production in Egypt is about 2.15 million tons during the last five years (2011-2015). While the total consumption of sugar was about 2.93 million tons, and the food gap of sugar is about 799.4 thousand tons. The self-sufficiency rate was about 72.8% during the same years, indicating that the 27.2% of local sugar consumption was covered by imports [9].

Despite the observed increase in sugar production in Egypt, there is a wide gap between the domestic production and consumption of sugar, where the average gap accounted for about 799.4 thousand tons with self-sufficiency ratio was about 72.8% during the period (2011-2015). This gap is covered through sugar imports, which negatively affect Egypt's agricultural trade balance. The analysis of variables associated with production and consumption of over time reveals a clear picture of expected food gap of sugar.

Therefore, this paper aims to analyze econometrically sugar production and consumption in Egypt. Specifically, there are four aims for this study: First, studying the performance of production and estimating the supply response function for sugar crops. Second, assessing the operational efficiency of sugar processing. Third, analyzing sugar consumption and gap during the period (2000-2015), to determine the most important factors influencing the gap of sugar. Finally, forecasting to future production, consumption and food gap of sugar to give food policy recommendations eliminate sugar gap in Egypt. The paper is organized as follows: Section (2) describes methodology and data, section (3) discusses results and discussions, and section (4) presents conclusion and recommendations.

2. Methodology and Data

The study applies descriptive and statistical methods to analyse the data in order to achieve the aims of the study. Simple regression is used to estimate growth rates for cultivated area, yield, production, and consumption of sugar crops. Decomposition analysis is used to estimate the components of production changes. A multiple regression analysis and the stepwise method with double logarithmic form are used to determine the most important factors influencing the food gap of sugar, in addition to, some statistical methods such as Marc Nerlove's1958 partial adjustment lagged model which is used to estimate area response to some economic variables. At last the Auto Regressive Integrated Moving Average (ARIMA) model is used to forecast the production, consumption, and sugar gap in Egypt.

(1) Nerlove Supply Response Model

Farmers allocate their land resource, depending on their expected net return. They can seldom make hundred per cent adjustment while responding to economic variables. Lagged prices of crops and the competing variable are available to farmers. Also, the agricultural production is determined by natural conditions, where the agricultural products generally take time to adjust to the changes in economic variables. For these reason, the partial adjustment lagged model is widely used by researchers [1], [7], [12], and [10], to measure the farmers' behaviour.

A typical specification can be written as follows:

$$X_t^* = a + bP_{t-1} + E \quad (1)$$

Where X_t^* is the desired cultivated area of crop at time t. P_{t-1} is the lagged crop price, E_t error term. Since the desired cultivated area of crop is an unobservable variable, the Nerlove formulation can be specified as follows:

$$X_t - X_{t-1} = \beta(X_t^* - X_{t-1}) \quad 0 \prec \beta \prec 1 \quad (2)$$

The current supply is:

$$\begin{aligned} X_t &= X_{t-1} + \beta(X_t^* - X_{t-1}) \\ X_t &= \beta X_t^* + (1-\beta)X_{t-1} \end{aligned} \quad (3)$$

By substituting equation 3 in equation 1, the response supply model can written as follows:

$$X_t^* = a + bP_{t-1} + (1-\beta)X_{t-1} + E \quad (4)$$

β is the coefficient of adjustment, represents the cause of difference between the short-run and long-run supply elasticities. $X_t - X_{t-1}$ is the actual change, and $X_t^* - X_{t-1}$ is the desired change. The first equation is a behavioural relationship, stating that the desired cropped area depends on the crop price in the previous year. The second equation states that the actual area of crop plus a proportion of the difference between the desired area in period t and area in period t-1.

Due to natural condition of the crop production, producers cannot fully adjust their current area to the desired area in response to changes in economic variables. The β parameter determines how the farmers are adjusting to their expectations. The value of β ranges between 0 and 1. When the value is close to one, that means the farmers are quickly adjusting to the changing of economic variables. Relations with equation 1 and 2 give the reduced form which eliminates the unobserved variable by an observed variable.

$$X_t = a + b\,X_{t-1} + bP_{t-1} + E_t \quad (5)$$

Equation 5 provides a simple version of the partial adjustment model and the parameters of this model can be estimated using OLS [5]. To test the response of producers to economic variables, the partial adjustment model will be estimated in the double logarithmic functional form. The estimated parameter b can be readily interpreted as supply elasticities. The model was estimated as presented below:

$$\ln X_{jt} = a + b_1 \ln X_{jt-1} + b_2 \ln p_{jt-1} + b_3 \ln N_{jt-1} + b_4 \ln N^*_{it-1} + E_t \quad (6)$$

Where:

$\ln X_{jt}$: Natural log of area under crop j in period t,

$\ln X_{jt-1}$: Natural log of area under crop j lagged by one year (x_{jt-1}),

$\ln p_{jt-1}$: Natural log of crop price in period (t-1),

$\ln N_{jt-1}$: Natural log of net return of crop j in period (t-1),

$\ln N^*_{it-1}$: Natural log of net return of competitive crops in period (t-1),

E_t : Error term,

b_1, b_2, b_3, b_4 The coefficients to be estimated.

(2) ARIMA Forecasting Model

Auto Regressive Integrated Moving Average (ARIMA) is the method first introduced by Box-Jenkins (1976). This model has been commonly used in practice for forecasting time series data [11]. The model has been chosen as the basic model in this study for the forecasting because the model assumes and considers the none zero autocorrelation between the successive values of the series data. The model consists of two parts [6], [11]:

First, the notation (AR) of Autoregressive model of order p can be written as follows:

$$Y_t = \theta + \delta_1 Y_{t-1} + \delta_2 Y_{t-2} + \delta_p Y_{t-p} + E_t$$

Where Y_t is the independent variable at time t, θ is the constant, $\delta_1, \delta_2, \delta_p$ are the parameters of the model and E_t is the terms of error at time t, $Y_{t-1}, \ldots, Y_{t-P}$ are explanatory variables at time lag $t-1$, p is the number of values. In AR process, the value of time series variable depends on its previous values.

Second, the notation MA (q) refers to the Moving Average model of order q, which can be written as follows:

$$Y_t = \theta + E_t + \gamma_1 E_{t-1} + \gamma_2 E_{t-2} \ldots\ldots - \gamma_q E_{t-q}$$

Where E_{t-1} , ….. E_{t-q} are the forecast errors at time $t-1, \ldots t-q$ respectively, $\gamma_1 \ldots \gamma_q$ are the coefficients to be estimated. The forecast errors represent the effect of variable which not explained by the model.

The simple form of ARMA (p, q)

$$Y_t = \theta + \underbrace{\delta_1 Y_{t-1} + \ldots\ldots + \delta_p Y_{t-p}}_{Autoregressive} + \underbrace{\gamma_1 E_{t-1} + \ldots\ldots + \gamma_q E_{t-q}}_{Moving\ Average} + E_t$$

In case of none stationary series with unit root, stationary can sometimes be achieved by taking first, second or higher difference of the original series. The number of differences required to make the series stationary is known as the order of integration and denoted by d.

The simple ARIMA (p, d, q) model can be written as follows:

$$\Delta_d Y_t = \theta + \delta_1 \Delta_d Y_{t-1} + \ldots\ldots + \delta_p \Delta_d Y_{t-p} + \gamma_1 E_{t-1} + \ldots\ldots + \gamma_q E_{t-q} + E_t$$

The Box- Jenkins producer of ARIMA modelling consists of the following four steps namely Identification of the model (based on Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF), estimation of model parameter, diagnostic checking, and forecasting time series data. In this study, with the help of SPSS 17 computer package, ARIMA models are applied for the sugar production, consumption, and gap.

Data Sources

The study is based on secondary data covering the time period starting from 2000 to 2015 which was published by the Government of Egypt: the Ministry of Agriculture and Land Reclamation (MALR), Sugar Crops Council, the annual report of sugar crops, and, the General Department of Agricultural Statistics. Also, data was obtained from the Central Agency for Public Mobilization and Statistics of Egypt (CAPMAS): Annual bulletin for consumption of food commodities and Statistical Year Book. In addition data is related to research and references associated with the subject of the study.

3. Results and Discussion

3.1. Economic Analysis of Sugar Crop Production

In Egypt, sugar production depends on both sugar cane and sugar beet crops, in addition sugar processing of sugar factories, which affects the produced sugar. Sugar production fluctuated from a minimum of 976.50 thousand tons in 2002 and a maximum of 1024.40 thousand tons in 2014. Sugar cane is the major industrial crop in Egypt. It is a source of raw material to sugar industry and various related industries as well as it provides employment for many people. Sugar cane is grown on 329 thousand *Feddan*, with total annual production of 1024 thousand tons [8]. Sugar cane cultivation in Egypt is concentrated in EL-Minia, Sohag, Qena, and Aswan governorates which represent about 98% of the total area of sugar cane, with a productivity of about 50 ton/*Feddan*. Sugar factories are constructed in these governorates with actual operational efficiency.

3.1.1. Growth Performance of Area, Yield, and Production for Sugar Crops

Table 1 in the Appendix shows the cultivated area, yield, and production for sugar crops during the period (2000-2015). The estimated growth rates for cultivated area, yield, and production for sugar crops during the study period are presented in Table 1.

Sugar Cane Crop

Sugar cane crop has played an important role in improving the supplies of sugar. Cultivated area of sugar cane crop ranged between a minimum of 307.2 thousand *Feddan* in 2000 and a maximum of around 332.02 thousand *Feddan* in 2015. A simple linear trend shows that cultivated area under sugar cane increased by an annual growth rate of 0.32%. However, the yield under sugar cane decreased from 50.96 ton/*Feddan* in 2006 to 48.29 ton/*Feddan* in 2014, with an annual growth rate of 0.62 during the study period. Despite the growth rate in cultivated area of sugar cane, it could not offset the declining trend of yield, which resulted in decrease of production. The production of sugar cane crop increased from a minimum of 15129.6 thousand tons in 2000 to a maximum of around 17056.59 thousand tons in 2008 and then declined to 16053.65 thousand tons in 2015, with an annual average rate of 0.64%.

Table 1. *Time Trend Estimates of Cultivated Area, Yield, and Production for Sugar Crops in Egypt during (2000-2015).*

Crop	Equation	Intercept	Regression coefficients			R^2	F-ratio	Annual Average	Growth Rate %
			b_1	b_2	b_3				
Sugar Cane									
Cultivated Area	Linear	315.01	1.05	-	-	0.42	10.09**	323.27	0.32
Yield	Cubic	47.90	1.16	-0.15	0.005	0.75	12.11**	49.53	-0.62
Production	Cubic	14369.80	770.80	-88.01	2.87	0.57	5.32**	16013.48	-0.64
Sugar Beet									
Cultivated Area	Linear	35.90	29.23	-	-	0.92	157.37**	284.35	11.28
Yield	Cubic	22.04	-1.01	0.18	0.01	0.51	4.08*	20.45	-0.58
Production	Linear	962.37	559.02	-	-	0.91	135.90**	5714.11	9.78

Source: Calculated Based on Data from MALR, Various Issues.
** Indicates significant at one percent level of significance,* Indicates significant at five percent level of significance.

Sugar Beet Crop

Cultivated area of sugar beet crop increased from a minimum of 135.62 thousand *Feddan* in 2000 to a maximum of 545.2 thousand *Feddan* in 2015, with a highly significant growth rate of 11.28%. The time trend explains 93% of the variation in cultivated area of sugar beet. However, its yield decreased from a maximum of 21.98 ton/*Feddan* in 2007 to a minimum of around 17.51 ton/*Feddan* in 2015, with an annual average rate of about 0.58% during the study period. The time series trend is statistically significant at the 0.05 probability level and it explains 51% of the variation in the yield of sugar beet.

Under the combined effect of cultivated area and yield, the growth rate of production showed a significant increase by 9.78% in the same period, where the highly growth rate in the cultivated area could offset the declining trend of yield which resulted in increase of production. The production of sugar beet crop ranged from a minimum of 2857.73 thousand tons in 2001 to a maximum of 10044.65 thousand tons in 2013. The time series trend is statistically significant at the 0.01 probability level and it explains 91% of the variation in production of sugar beet crop.

3.1.2. Decomposition of Changes in Sugar Crop Production

Decomposition analysis is used to estimate the contribution of different components in the change of production for sugar crops. The analysis uses averages of production and cultivated area to decompose the difference in the changes in mean production between the two periods, namely period I (2006-2010) and period II (2011-2015). Table 2 presents the change in average production and the contribution of different factors to this change. Average production of sugar cane decreased by 2.53% between the two periods. Mean yield was the main component to the change in average cane production in Egypt, which contributed 133.65% to the change, while, change in the mean area was a negative effect. Contribution of interaction between changes in mean area and mean yield are accounted for 1.18%.

Regarding to sugar beet, average production of this crop increased from 5533.85 thousand tons in period I to 9171.60 thousand tons in period II, with a percentage increase of 165.74%. The main contributor to this increase in beet production was cultivated area, its share was 111.67%, while yield contribution was negative to the increase in production and the effect of interaction term between changes in mean yield and area was also negative to the change in production.

Table 2. *Components of Change in Production in Egypt in Period I (2006-2010) and Period II (2011-2015).*

Crop	Average Production (Thousand tons)		Component of Change (in Percent)			
	Period I	Period II	Mean area	Mean yield	Interaction Effect	Total
Sugar Cane	16288.76	15876.05	-34.83	133.65	1.18	100.00
Sugar Beet	5533.85	9171.60	111.67	-6.73	-4.94	100.00

Source: Calculated Based on Data from MALR, Various Issues.

3.1.3. Development Trend of Economic Indicators for Sugar Crops

The factors affecting the producers decision to cultivate sugar crops include the price, production costs, and the net return. The growth rate of the most important economic indicators are shown in Table 3. It indicates that the prices and the production costs of sugar cane increased by growth rate of 10.93% and 11.29%, respectively. This refers to the increasing rate in production costs which was more than the price affecting the net return for the farmers. Therefore, a simple linear trend shows that the net return of this crop grew at a significant annual rate of 9.43%. Its return/cost ratio also increased recording a significant annual growth rate of 1.26%.

Table 3. *Time Trend Estimates of Economic Indicators for Sugar Crops in Egypt during (2000-2014).*

Crop	Equation	Intercept	Regression Coeff.		R^2	F-ratio	Annual Average	Growth Rate %
			b_1	b_2				
Sugar Cane								
Price	Linear	24.99	2.74	-	0.94	197.37**	198.93	10.93
Total Cost	Linear	604.91	703.26	-	0.79	48.39**	6231.00	11.29
Net Return	Linear	831.59	319.99	-	0.86	81.32**	3391.58	9.43
Return/Cost	Cubic	1.04	0.18	-0.01	0.63	10.09**	1.59	1.26
Sugar Beet								
Price	Linear	32.15	23.70	-	0.95	238.01**	221.67	10.69
Total Cost	Linear	539.62	245.83	-	0.78	46.33**	2506.23	9.81
Net Return	Cubic	43.199	275.35	3.72	0.92	71.04**	2552.41	8.46
Return/Cost	Cubic	0.94	0.28	-0.01	0.55	7.44**	2.01	2.14

Source: Calculated Based on Data from MALR, Various Issues.

** Indicates significant at one percent level of significance.

The prices and production costs of sugar beet increased by growth rate of 10.69% and 9.81%, respectively. This refers to the increasing rate in output price which was more than the production cost contributing to increasing the net return for the producers by a significant growth rate of 8.46% during period (2000-2014). Under the price effect, the growth rate of return/cost ratio showed a significant increase in the same period, where it grew by 2.14%.

3.1.4. Productivity and Profitability of Sugar Crops

The technical and economic indicators of sugar crops per *Feddan* in Egypt are summarized in Table 4. While the cultivated area was 325.11 and 433.75 thousand *Feddan* for cane and beet, respectively, the supplied area to sugar factories was to come from only about 242.4 and 423.49 thousand *Feddan* as average period (2010-2014). The supplied production quantity was 9136.20 and 7776.92 thousand tons representing 57.88% and 95.99% of total production, for cane and beet, respectively. The difference between total and supplied production for sugar cane about 42.12% represents non-official deliveries used in cane syrup processing or other related sugar industries. Therefore, sugar cane factories has limited crushing capacity and can process no more than 58% of the total available sugar cane crop. This shows an existence of leaking or losses in production and the designed capacity of sugar cane factories was not fully used efficiently.

With respect to estimating productivity, the average produced sugar was about 4.25 and 2.60 ton/*Feddan* for cane and beet crops, respectively. The amount of sugar produced from one *Feddan* for beet is approximately 61% of sugar produced from one *Feddan* devoted to cane production. The sugar produced from one cubic meter of water for cane is about 53% of the sugar produced from one cubic meter of water for beet. The net return per unit of land for sugar cane was more profitable with a net return of 4828.64 LE/*Feddan*, more than sugar beet with net return of 2225.71 LE/*Feddan.* While water productivity for sugar beet was more than sugar cane, with a net return per unit of water of 684.40 and 474.19 LE/1000M3, respectively. The average quantities of water applied for sugar cane and beet were 10183 and 3252 M3/*Fedddan*, respectively. According to the above economic indicators the beet is more efficient of water resources in producing sugar than cane.

Regarding profitability, the return on investment was used as a measure of profitability for the production of sugar crops. The results showed that the average profitability per season was about 1.35 and 1.09 for sugar cane and beet, respectively. This implies that the production of sugar crops is profitable during the period. While the average monthly profitability for sugar beet was about 0.16, which is higher than the profitability for sugar cane (0.11). This means an increase of the profitability in the cultivation of sugar beet by about 45.45% higher than sugar cane. Sugar beet gives more net return than sugar cane due to the short period of time of 7 months for beet as compared to cane which takes 12 months.

Table 4. *Technical and Economic Indicators for Sugar Crops in Egypt, As Average Period (2010-2014).*

N	Indicator	Sugar Cane	Sugar Beet
1	Cultivated Area (1000 *Fed.*)	325.11	433.75
2	Partial Productivity (ton/*Fed.*)	48.64	20.69
3	Total Production Quantity (1000 ton)	15783.55	8101.26
4	Supplied Area (1000 *Fed.*)	242.40	413.49
5	Supplied Production Quantity (1000 ton)	9136.20	7776.92
6	%Supplied Production of Total Production	57.88%	95.99%
7	Sugar Produced (ton/*Fed.*)	4.25	2.60
8	Water Applied (m^3/*Fed.*)	10183	3252
9	Sugar Produced from Water Unit (ton/1000 m^3)	0.42	0.80
10	Production Costs	3589.42	2041.79
11	Total Return (L.E./*Fed.*)	8418.06	4267.49

N	Indicator	Sugar Cane	Sugar Beet
12	Net Return per Land Unit (L.E./*Fed.*)	4828.64	2225.70
13	Net Return per Water Unit (L.E./1000 M^3)	474.19	684.41
14	Profitability* per Season	1.35	1.09
15	Profitability per Month	0.11	0.16

*Profitability = Net Return/ Total Cost
Source: Calculated Based on Data from MALR: Economic Affaire Sector, Central Administration Agricultural Economy, Various Issues, and Council of Sugary Crops- Sugar Production.

3.1.5. Area Supply Response of Sugar Crops in Egypt

This section deals with the estimation of supply response for sugar crops using a Nerlove area model. The statistical analysis was based on secondary data covers a period of 2000-2015. The model states that the current area of sugar crops depends on many factors such as (X1) area under the crop lagged by one year, (X2) crop price, (X3) net return of the crop, and (X4) net return of the competitive crops in the same season. The competitive season for cane was long clover and maize as growing rotation, in the case of sugar beet the competitive crops were long clover and wheat. The estimated regression equations for sugar crops area response are presented in Table 5. The variables that appear statistically significant are shown in the Table. As expected, the estimated coefficients of lagged area, crop price, and net return of the crop have positive values.

The sugar cane area responses to change in the crop net return, with elasticity of response about 0.02. This means that as net return per *Feddan* rises by 1%, the cultivated area under cane would tend to rise by only 0.02%. The cultivated area of sugar beet responses to change in both area under the crop lagged by one year and crop price, with partial elasticity of response about 0.40 and 0.57, respectively. The model elasticity was 0.97 indicating an increase in both areas under the crop lagged by one year and crop price by 1% leads to an increase in cultivated area under sugar beet by 0.97%. This means that farmers can make adjustment on area allocation under sugar beet through the manipulation of the price of beet.

Table 5. *Estimated Coefficients and Related Statistics for Area Supply Response for Sugar Crops in Egypt.*

Dependent Variable (Cultivated Area)	Equation	Intercept	Regression coefficients			R^2	F-ratio
			b_1 Lagged Area	b_2 Crop Price	b_3 Crop Net Return		
Sugar Cane	Double Log	5.56	-	-	0.02	0.48	8.89**
		8.48			2.98**		
Sugar Beet	Double Log	0.29	0.40	0.57	-	0.96	133.93**
		0.85	2.70*	4.06**			

Where: b_1 is the parameter of (X_1) area under the crop lagged by one year, b_2 is the parameter of (X_2) crop price, and b_3 is the parameter of (X_3) the crop net return.
Source: Computed Based on Data from MALR
**significant at one percent level, *significant at five percent level of significance.

3.2. Performance of Sugar Industry in Egypt

There are some features of technical performance such as crushing capacity and its utilization, the availability of sugar cane for crushing, extraction ratio, and operational efficiency. Table 6. shows sugar factories and their design capacity as well as utilization percentage. Due to the fact that sugar industry depends on the availability of the sugar cane, factories are located within the cane growing area in Egypt. Most of these factories are located in upper Egypt specifically in Menia, Sohag, Qena, Luxor, and Aswan. There are eight cane factories which are managed by the Egyptian sugar company integrated industries. The capacity utilization varies from among factories based on the cultivated area under sugar crops close to factory zone, supplied production of sugar crops for processing, and delivery prices. Despite constructing sugar cane factories designed with a capacity reached about 10.20 million tons of sugar cane, their capacity utilization percentage was 83.23% as average of the period (2010-2014). The maximum capacity utilization was 115.44% for Edfou factory, while the minimum capacity rate was about 50.21% of their full capacity for Abou Korkas factory. The low capacity utilization percentage is attributed to lack of cane for grinding, while the capacity utilization percentage of all beet factories was about 96.95% of the installed capacity during the same period. With respect to estimating capacity utilization of beet the rate reached its maximum with a bout of 117.12% at Kafr El Sheikh factory and its minimum was about 55.16% at Alexandria factory. The high utilization capacity was due to an increase in quantities of supplied sugar beet.

Table 6. *Technical Performance of Sugar Factories in Egypt, (2010-2014).*

Sugar Cane			**Sugar Beet**		
Factory	**Installed Capacity (thousand tons)**	**Capacity Utilization (%)**	**Factory**	**Installed Capacity (thousand tons)**	**Capacity Utilization (%)**
Abou Korkas	700	50.21	Kafr El Sheikh	1750	117.21
Gerga	1000	55.89	Dakahlia	1750	111.93
Nagy Hamady	1700	86.02	Fayoum	1250	99.70
Deshna	1000	76.91	Nobaria	1000	84.28
Quos	1600	93.78	EL-Nil	1000	78.41
Armant	1300	98.62	Abou korkas	550	111.33
Edfou	1100	115.44	Alexandria	1000	55.16
Kom-embou	1800	104.57	Average	8300	96.95
Average	10200	88.23			

Source: Calculated Based on Data from MALR, Council of sugary crops, Annual Report, Various Issues.

Table 7 shows the trends of produced sugar and its percentage of total supplied production, extraction ratio, and operation efficiency during the period (2000-2014). The average extraction rate was about 11.39% and 13.57% for sugar cane and beet, respectively. This rate was lower than theoretical ratio, indicating an existence of unused capacity of sugar factories. Also, the extraction rate is influenced by the quality of sugar cane delivered by the farmers and weather conditions.

The average of operation efficiency was about 85.29% and 90.97% for sugar cane and sugar beet, respectively. This indicates that the resources used in sugar cane processing were inefficient. There were lower capacity utilization of factories problems because the availability of cane which is supplied to factories by farmers and low delivery prices. The supplied production of cane declined by an annual rate of 0.48% during the same period. Sugar processed grew at a significant annual rate of 1.10% resulting from the increase of extraction rate. The operation efficiency recorded a significant annual growth rate of 1.60%. The time trend variable explains 49% of the variation in operation efficiency of cane factories.

Table 7. *Time Trend Estimates of Technical Performance Indicators for Sugar Processing in Egypt During (2000-2014).*

Crop	**Equation**	**Intercept**	**Regression coefficients**			R^2	**F-ratio**	**Annual Average**	**Growth Rate %**
			b_1	b_2	b_3				
Sugar Cane									
Supplied Production	Linear	9794.27	- 45.71	-	-	0.30	5.53*	9428.57	- 0.48
Sugar Processed	Linear	979.84	0.011	-	-	0.39	8.27**	1074.70	1.10
Extraction Rate	Exponential	10.01	0.016	-	-	0.49	12.33**	11.39	1.60
Operation Efficiency*	Exponential	74.67	0.016	-	-	0.49	12.33**	85.29	1.60
Sugar Beet									
Supplied Production	Linear	2069.17	0.096	-	-	0.86	82.82**	2279.09	9.60
Sugar Processed	Linear	278.11	0.097	-	-	0.91	138.34**	664.76	9.70
Extraction Rate	Cubic	12.28	0.84	-0.12	0.01	0.34	1.88	13.57	N.s.
Operation Efficiency	Cubic	81.91	5.62	-.81	0.03	0.34	1.88	90.97	N.s.

*Operation Efficiency = Extraction ratio/Theoretical Extraction ratio
Extraction ratio = Sugar processed /supplied quantity of cane or beet
N.s. = not significant
Source: Calculated Based on Data from MALR, Council of sugary crops, Annual Report, Various Issues.
** Indicates significant at one percent level * Indicates significant at five percent level.

During the period (2000-2014), the supplied production to the beet factories was highly significant, with an annual growth rate of 9.60%. The quantity of sugar processed also grew at a significant annual rate of 9.70%. and 91% of the variation in sugar production is explained by the time factor. Although supplied production contributed significantly to an increase in sugar processed levels, extraction rate for beet processing showed a stagnant position. Where the derived growth rate of these variables was considered zero, as the time response coefficient was statistically insignificant.

3.3. Economic Analysis of Sugar Consumption

3.3.1. Development of The Sugar Production, Consumption, and Gap in Egypt

According to Table 2 in the Appendix, the production of sugar in Egypt is about 1.73 million tons as average of the period (2000-2015). Sugar cane contributed to about 1057.31 thousand tons representing 61.28% of the total sugar production, while sugar beet accounted only for 668.01 thousand tons with a percentage 38.72% of the production in the same study period. It is observed that the share of sugar cane decreased from a maximum of 74.47% in 2000 to a minimum of 43.52% in 2015. While the share of sugar beet increased from a minimum of 25.53% in 2000 to a maximum of 56.75% in 2015, resulting from some efforts made by the state to increase its cultivated area and productivity during the last years. The sugar beet production increases with a significant annual rate of 9.68% of the average production during the period of study (699.17 thousand tons). But, for sugar cane, the time trend variable is insignificant. The trend of total sugar production increases with an annual significant rate of 70.46 thousand tons representing about 4.08% of the total production during the same period.

The consumption of sugar increased from a minimum of 1800 thousand tons in 2000 to a maximum of 3100 thousand tons in 2015, with an annual significant rate of 82.23 thousand ton representing about 3.26% of the average total consumption (2520.63 thousand tons) during the period of (2000-2015). Per capita sugar consumption has increased by 0.45 kg/year, with an annual growth rate of 1.34%. The lack of local production to satisfy the consumption of sugar led to a gap in sugar reached about 406.60 thousand ton in 2000 and increased to a maximum of around 1109.30 thousand tons in 2009, with an annual growth rate of 1.97%.The rate of self-sufficiency of sugar decreased from 77.41% in 2000 to 59.22% in 2009 then increased to 76.53% in 2015, with an annual growth rate of 0.48% during the period of study. Therefore, the imported quantity of total sugar has changed from the minimum reached about 407 thousand tons in 2000 to the maximum of 1110 thousand tons in 2009, then decreased to 728 thousand tons in 2015. The decrease in sugar import in the year 2009 as a result of increased imports in the year 2008 due to defaults, many transactions resulted from the global financial crises. The trend of sugar imported increased with a statistically significant rate of 2.35%, as shown in Table 8.

Table 8. *Time Trend Estimates of The Production, Consumption, Per Capita Consumption, Self-sufficiency, Gap, and The Import for Sugar in Egypt during (2000-2015).*

Crop	Equation	Intercept	Regression coeff.		R^2	F	Annual Average	Growth rate
			b_1	b_2				
Production	Quadratic	1359.40	-7.06	4.56	0.94	109.33^{**}	1725.32	4.08
Cane Source	Quadratic	989.95	9.13	-0.57	0.07	0.51	61.28	N.S.
Beet Source	Quadratic	367.39	-13.58	4.78	0.95	119.83^{**}	38.71	9.68
Consumption	Linear	1799.00	91.63	-	0.94	214.59^{**}	2520.63	3.64
Per Capita Consumption	Linear	29.63	0.45	-	0.67	28.70^{**}	33.46	1.34
Sugar Food Gap	Quadratic	260.56	151.47	-7.98	0.82	29.01^{**}	801.55	1.97
Self-sufficiency	Quadratic	79.76	-4.43	0.28	0.73	17.21^{**}	68.20	0.48
Import Quantity	Quadratic	241.62	152.93	-7.80	0.78	23.34^{**}	812.37	2.35

Source: Calculated Based on Data from MALR, Council of sugary crops, Annual Report, Various Issues.
**Indicates significant at one percent level of significance.

3.3.2. Factors Influencing the Sugar Gap

Multiple regression analysis analysis was used to determine the most important factors that influence the sugar gap. The double log model was chosen. It is assumed that the factors influence the sugar gap are (X1) domestic production (thousand tons), (X2) average annual per capita consumption of sugar (kg), (X3) the number of population(million inhabitants), (X4) the import price($/ton), and (X5) the average of per capita income during the period (2010-2014). The results of the model estimation as in the Table 9.

Table 9. *Estimates of the Determinants of the Food Gap of Sugar in Egypt.*

Dependent Variable	Estimated Model	Intercept	Regression Coefficients			R^2	F
			b_1 Production	b_2 Per capita	b_3 Population		
Sugar gap amount	Double Logarithmic	-1.98 -3.53^{**}	-1.66 -8.03^{**}	3.33 11.60^{**}	2.35 4.29^{**}	0.97	174.24^{**}

Where: b_1 is the parameter of (X_1) domestic production (thousand tons), b_2 is the parameter of (X_2) average annual per capita consumption of sugar (kg), and b_3 is the parameter of (X_3) the number of population (million inhabitants).
Source: Calculated Based on Data from MALR, CAPMAS and FAO, Various Issues.
** Indicates significant at one per cent level of significance.

From the analysis in Table 9, the influence of per capita and number of population are positive and domestic production is negative. An increase in the per capita consumption of sugar and population by 1% leads to an increase in the gap of sugar by 3.33% and 2.35%, respectively, while an increase in the quantity of sugar production results in a decrease in sugar gap by about 1.76%. The local production of sugar is the most important factor influencing the amount of sugar gap, where local production is unable to meet the growing demand of the population.

3.4. Forecasting Sugar Production and Consumption in Egypt

The projection provides a policy-neutral starting point that can be used to analyze national sugar needs. The projections are made for the years 2016 to 2025. The analysis is to estimate future production, consumption and gap of sugar in Egypt using the Auto-Regressive Integrated Moving Average (ARIMA). Diagnostic checking on residual terms was made applying the ACF and PACF functions of the time series data. By using best fitted model, the forecast value and 95% confidence level for ten years are shown in the Table 10.

The model predicted overall an increase in sugar production. The prediction for 2025 is resulted approximately 3025 thousand tons at confidence interval 95%, representing about 27.51% over the production value in 2015. The minimum and maximum projections showed an increase in production levels which may reach up to 2102.78 and 3947.35 thousand tons as a lower and upper values, respectively, by the year 2025.

The best fitted ARIMA model applied for sugar consumption was (0,1,0). ARIMA model projected that consumption will increase from 3100 in 2015 to 3966.67 thousand tons in 2025, with an increase ratio of about 28% more than its value in 2015 (Table 10). With 95% confidence interval, the maximum consumption would increase from 3297.90 thousand tons in 2016 to 4318.43 thousand tons in 2025. This increase may be due to an increase in population of Egypt and per capita consumption.

Table 10. *Forecasted Values for Sugar Production, Consumption and Gap in Egypt, with 95% Confidence Interval.*

Year	Sugar Production, ARIMA (0,1,0)			Sugar Consumption, ARIMA (0,1,0)			Sugar Gap ARIMA (1,0,0)		
	Forecast	95% Limit		Forecast	95% Limit		Forecast	95% Limit	
		Lower	Upper		Lower	Upper		Lower	Upper
2016	2437.67	2146.01	2729.32	3186.67	3075.43	3297.90	729.62	427.29	1031.96
2017	2502.93	2090.47	2915.39	3273.33	3116.02	3430.64	731.16	351.86	1110.45
2018	2568.20	2063.04	3073.36	3360.00	3167.33	3552.67	732.32	315.22	1149.41
2019	2633.47	2050.16	3216.77	3446.67	3224.19	3669.14	733.20	295.88	1170.51
2020	2698.73	2046.58	3350.89	3533.33	3284.60	3782.06	733.86	285.36	1182.37
2021	2764.00	2049.60	3478.40	3620.00	3347.53	3892.47	734.37	279.56	1189.18
2022	2829.27	2057.63	3600.91	3706.67	3412.36	4000.97	734.75	276.37	1193.14
2023	2894.53	2069.61	3719.45	3793.33	3478.71	4107.96	735.04	274.62	1195.47
2024	2959.80	2084.84	3834.76	3880.00	3546.29	4213.71	735.26	273.67	1196.85
2025	3025.07	2102.78	3947.35	3966.67	3614.91	4318.43	735.43	273.17	1197.69

LCL=Lower Confidence Limit and UCL=Upper Confidence Limit
Source: Calculated Based on Data from MALR.

The best fitted ARIMA model applied for sugar gap was (1,0,0) for sugar gap. Forecasting results implies that the forecast values of sugar gap is tend to stability over the next years. The maximum values would increase from 801.55 thousand tons to 1197.69 thousand tons in 2025, for the 95% confidence interval. This can be resulted from the overpopulation and/or change in the consumption patterns of Egyptian people. This forecast would be helpful for decision makers to foresee the future situation of sugar production, import, consumption and select appropriate policy. Egypt will import 735 thousand tons of sugar over the coming year to fill the gap between consumption and production.

4. Conclusions and Recommendations

From the findings above, the production of sugar beet crop increased and sugar cane declined during the period (2000-2015). This increasing in sugar beet production was due to increase in the area of this crop. Sugar beet is more efficient in using water resources. It recorded the highest value of net return per unit of water, while sugar cane has lowest value. The area supply response of sugar crops investigated using Nerlove's model. Farmers responsive to the net return per area unit in cane production and to prices and one year lag of area in beet production. The farmers can make adjustment on area allocation under beet through raising the price of beet crop.

Cane factories operate at low capacity utilization due to lack of cane for grinding, while beet factories work at full capacity. The operation efficiency for sugar beet was higher than sugar cane. The sugar industry is making losses and the problem of the availability of cane. Although sugar production increased, it could not satisfy the sugar consumption which resulted in food gap of sugar and increased imported quantity of sugar. The selected ARIMA models provide an adequate predictive model for sugar situation. The models have been followed to forecast the production, consumption and gap of sugar from 2015 to 2025. These forecast values could be used for formulating food policies especially for sugar.

Based on the findings several recommendations would be made for the future policy with respect to food gap of sugar in Egypt, as follows:

(1) Cultivated area under sugar cane must be maintained based on capacity utilization of sugar cane factories,
(2) Adopting an integrated strategy to expand the production of sugar through increasing area under sugar beet in new lands,
(3) There is a great need for developing high yielding varieties of sugar crops,
(4) Encourage the producers to increase sugar crop productivity through modern technology,
(5) Raising the delivery prices of sugar crops based on production costs considering a suitable profit margin for farmers to encourage them to continue cultivating of sugar cane or expand cultivation of beet crops,
(6) Improve manufacturing efficiency, raising the utilization efficiency of the sugar factories.
(7) The necessity of rationalizing per capita sugar consumption to reach world per capita level at 24 Kg/year and to develop awareness program for the healthy consumption of sugar.

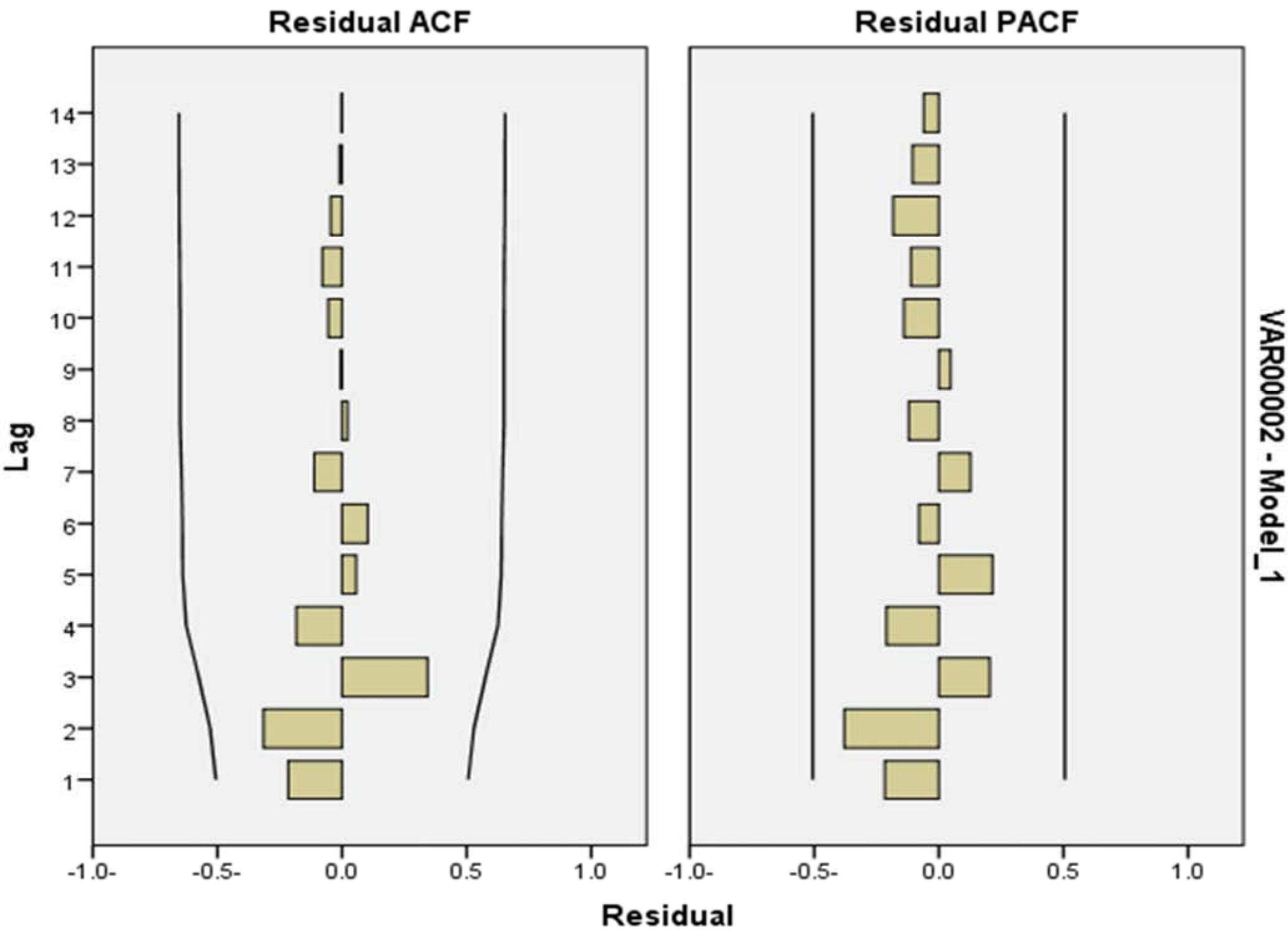

Figure 1. *Residuals Autocorrelation Plot for Sugar Production of ARIMA (0,1,0).*

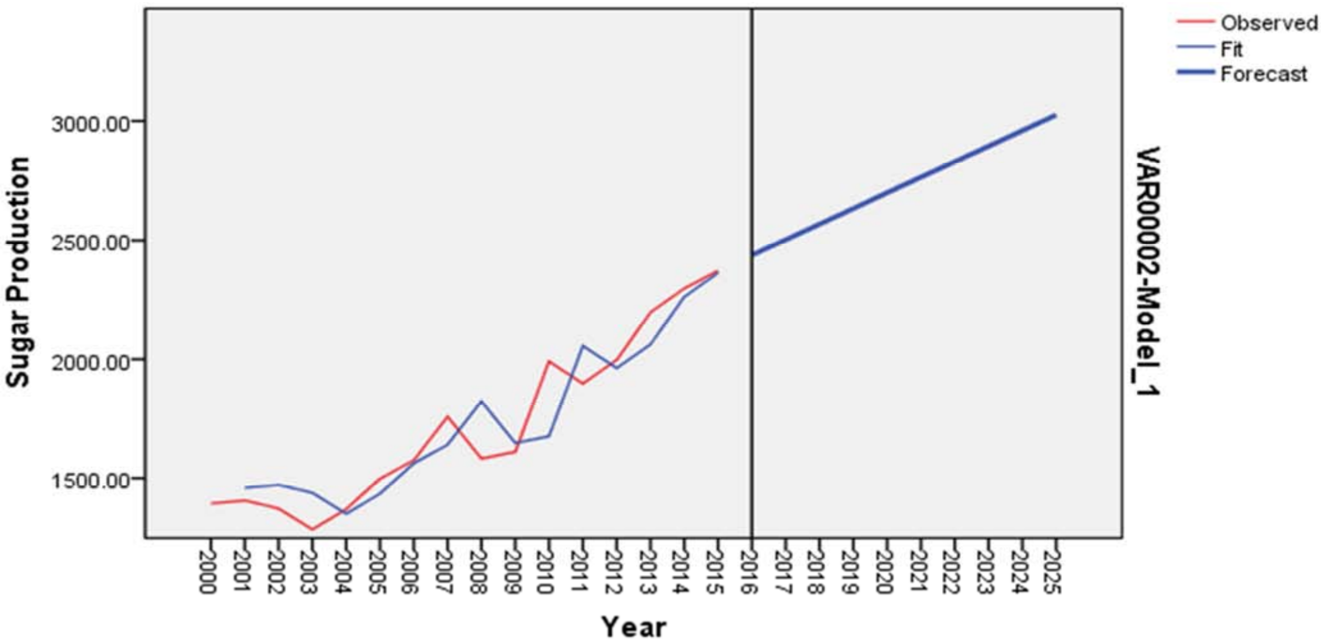

Figure 2. *Forecasted Values for Sugar Production in Egypt, with 95% Confidence Interval.*

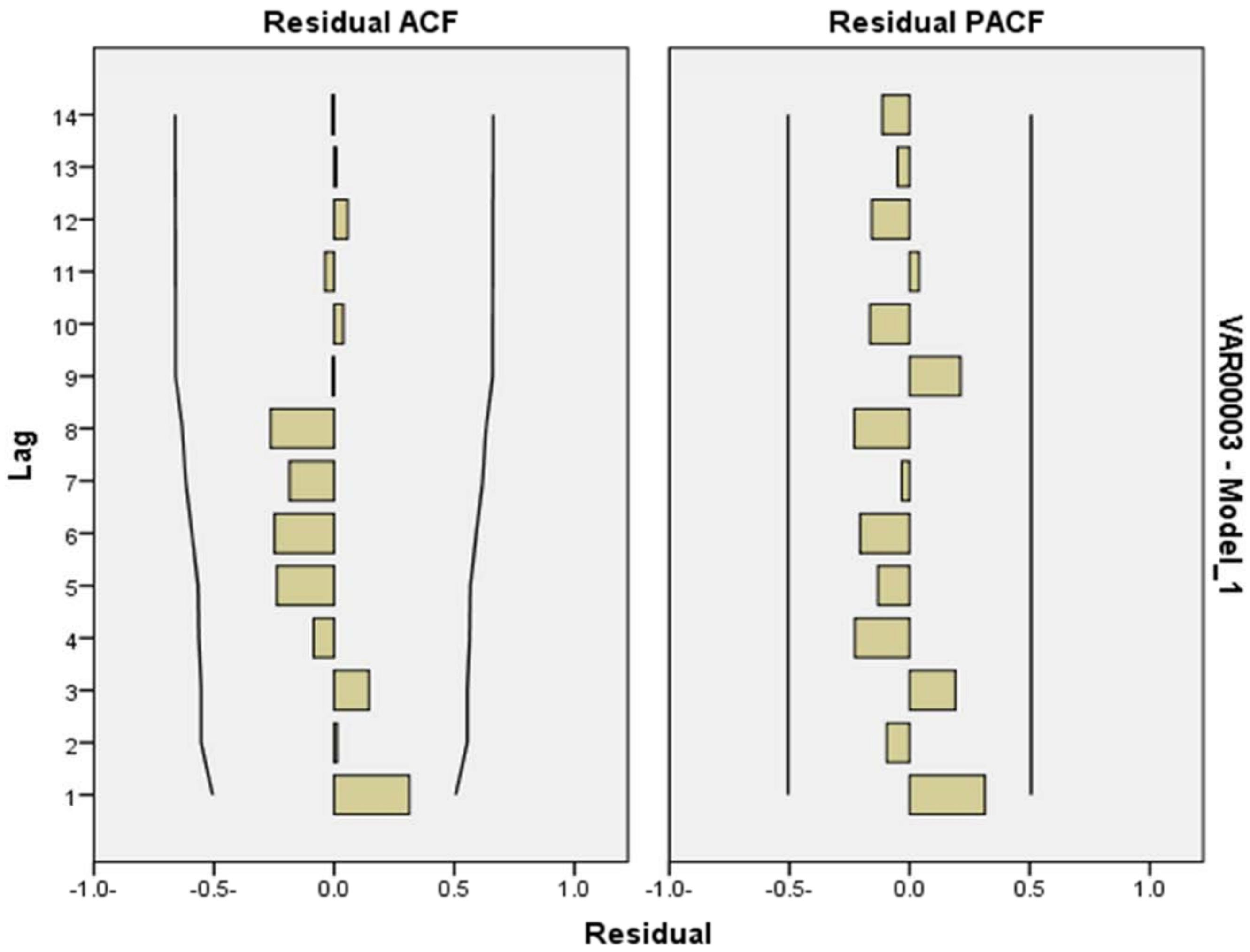

Figure 3. *Residuals Autocorrelation Plot for Sugar Consumption of ARIMA (0,1,0).*

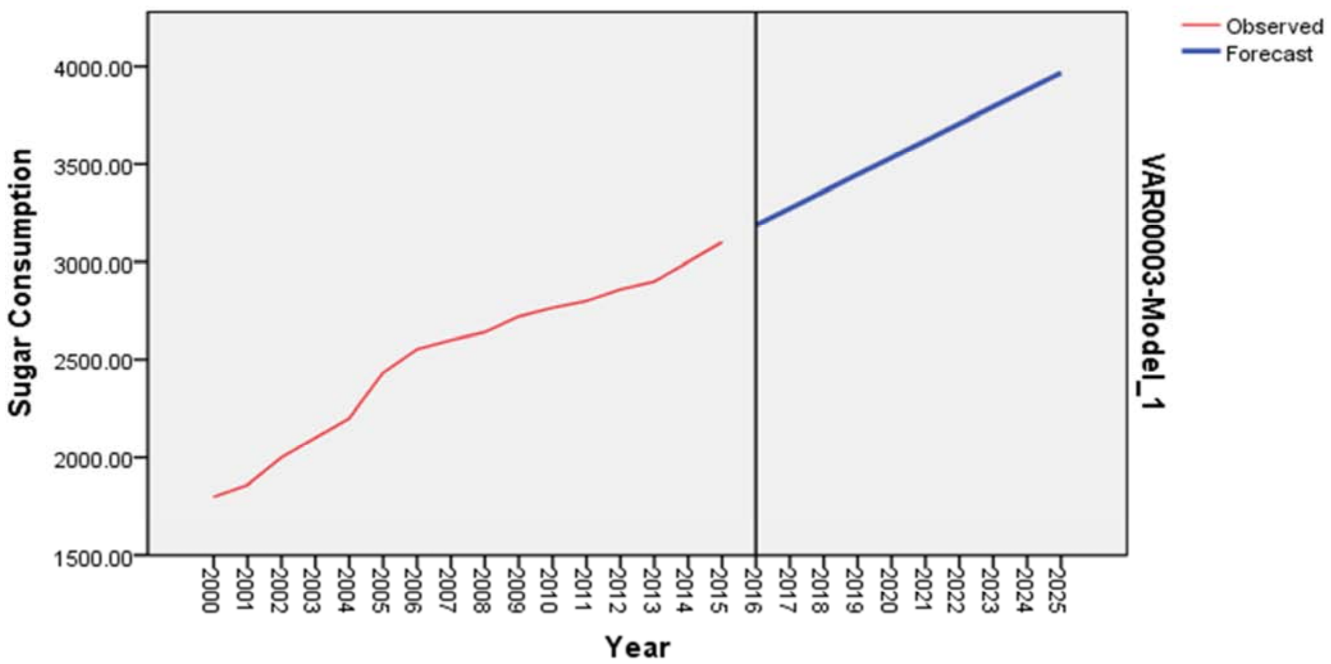

Figure 4. *Forecasted Values for Sugar Consumption in Egypt, with 95% Confidence Interval.*

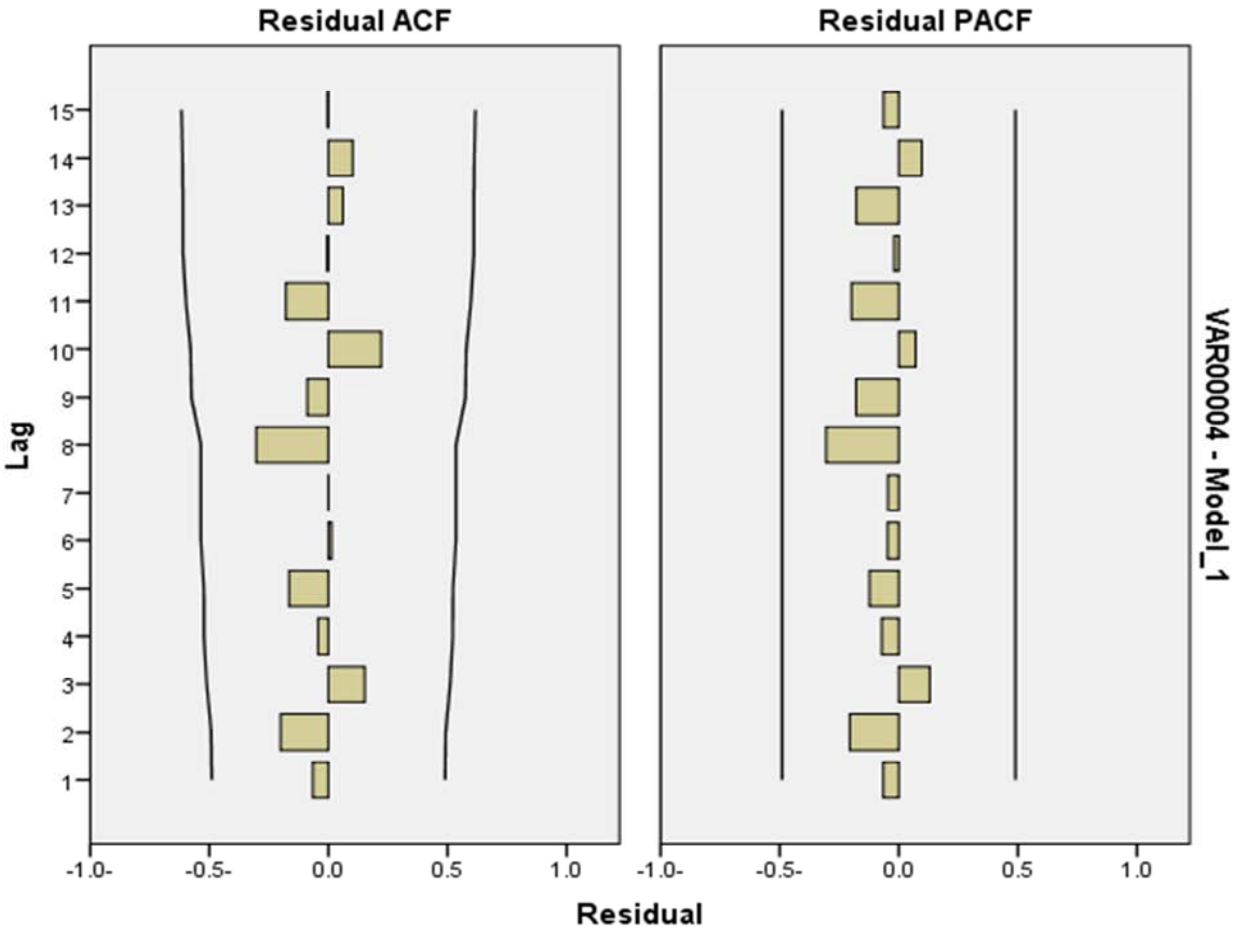

Figure 5. *Residuals Autocorrelation Plot for Sugar gap of ARIMA (1,0,0).*

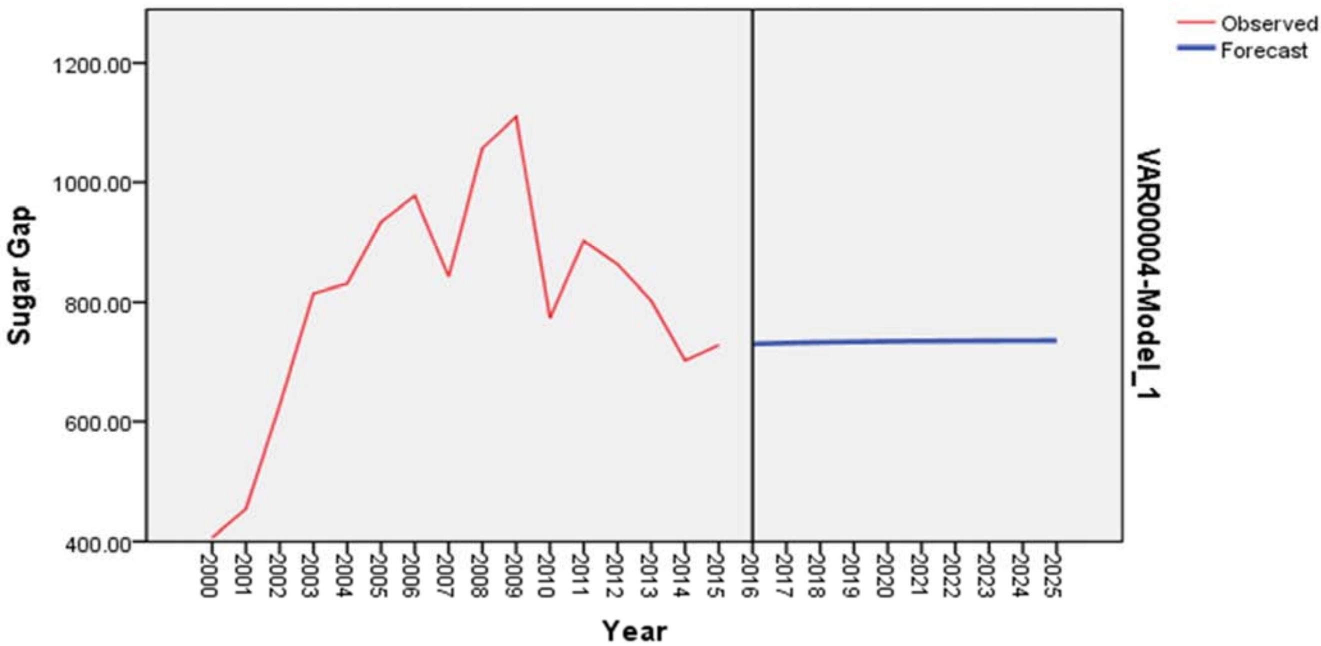

Figure 6. *Forecasted Values for Sugar Gap in Egypt, with 95% Confidence Interval.*

Appendix

Table A1. *Development of Production Indicator's for Sugar Crops in Egypt.*

Year	Sugar Cane			Sugar Beet		
	Area (000Feddan)	Yield (ton/Feddan)	Production (000tons)	Area (000Feddan)	Yield (ton/Feddan)	Production (000tons)
2000	307.20	49.25	15129.60	135.62	21.31	2890.36
2001	318.90	49.90	15913.11	149.10	20.04	2857.73
2002	312.00	49.53	15453.36	153.80	20.60	3168.28
2003	323.40	49.65	16056.81	131.32	20.50	2692.06
2004	327.20	50.40	16490.88	140.98	20.29	2860.55
2005	322.00	50.77	16347.94	167.84	20.50	3429.54
2006	321.40	50.96	16378.54	186.40	20.95	3904.97
2007	326.90	50.78	16599.98	248.31	21.98	5458.21
2008	335.10	50.90	17056.59	257.67	19.92	5132.59
2009	323.60	48.88	15817.57	264.60	20.16	5333.51
2010	316.70	49.23	15591.14	385.68	20.30	7840.00
2011	325.10	49.50	16092.45	394.30	20.70	7486.00
2012	326.00	48.43	15788.18	424.00	21.50	9126.00
2013	325.75	47.74	15551.31	460.48	21.80	10044.00
2014	329.15	48.29	15894.65	504.30	19.15	9657.00
2015	332.03	48.35	16053.65	545.20	17.51	9545.00
Average	323.27	49.53	16013.48	284.35	20.45	5714.11

Source: Ministry of Agriculture and Land Reclamation (MALR): Economic Affaire Sector, Central Administration Agricultural Economy, Various Issues.

Table A2. *Development of Economic Indicators for Sugar Production and Consumption in Egypt During (2000-2014).*

Year	Production (000tons)	% of Sugar Cane Source	% of Sugar Beet Source	Imports (000tons)	Consumption (000tons)	Per Capita Consumption (Kg)	Sugar Gape	Self-sufficiency (%)
2000	1393.40	74.47	25.53	407.00	1800.00	28.19	406.60	77.41
2001	1406.00	71.77	28.23	401.00	1860.00	28.54	454.00	75.59
2002	1372.60	71.14	28.86	628.00	2000.00	30.02	627.40	68.63
2003	1285.30	73.01	26.99	815.00	2100.00	31.02	814.70	61.20
2004	1369.50	73.16	26.84	831.00	2200.00	31.74	830.50	62.25
2005	1497.70	69.99	30.01	935.00	2432.00	34.42	934.30	61.58
2006	1575.40	68.05	31.95	978.00	2553.00	35.45	977.60	61.71
2007	1757.90	61.17	38.83	843.00	2600.00	35.30	842.10	67.61
2008	1582.30	67.95	32.05	1058.00	2640.00	35.11	1057.70	59.94
2009	1610.70	62.92	37.08	1110.00	2720.00	35.36	1109.30	59.22
2010	1991.30	50.29	49.71	774.00	2765.00	35.14	773.70	72.02
2011	1897.70	51.91	48.09	903.00	2800.00	34.77	902.30	67.78
2012	1997.00	49.93	50.07	863.00	2860.00	34.65	863.00	69.83
2013	2197.70	46.93	53.07	1003.00	2900.00	35.45	802.30	73.26
2014	2298.25	44.57	55.43	721.00	3000.00	34.97	701.75	76.61
2015	2372.40	43.25	56.75	728.00	3100.00	35.27	727.60	76.53
Average	1725.32	61.28	38.72	812.38	2520.63	33.46	801.55	68.45

Source: Calculated Based on Data from Ministry of Agriculture and Land Reclamation (MALR), Council of Sugary Crops- Annual Report, Various Issues.

References

[1] Belete, A. (1995) Econometric Analysis of Supply Response among Summer Wheat Growers in Lesotho. UNISWA Journal of Agriculture Vol.4, 73-80.

[2] CAPMAS. Central Agency for Public Mobilization and Statistics, Annual Bulletin for Consumption of Food Commodities, Various Issues, Cairo, Egypt.

[3] CAPMAS: Statistical Year Book, Various Issues, Cairo, Egypt.

[4] FAO. www.faostst.org. FAOSTAT Database, Different Years.

[5] Gujarti, N. D. (1995) Basic Econometrics, McGraw-Hill Book Company, 2nd Edition, Singapore.

[6] Hossain, Kazi Abrar (2015) Impact of Ramadan on Global Raw Sugar Prices, East West University, MSC thesis.

[7] Leaver, R. (2003) Measuring the Supply Response Function of Tobacco in Zimbabwe Aggreko, Vol 43,113-129.

[8] MALR, Ministry of Agriculture and Land Reclamation, Council of Sugary Crops Annual Report, Egypt, Various Issues.

[9] MALR: Ministry of Agriculture and Land Reclamation, Economic Affairs Sector, General Administration for Statistics, Agricultural Economic Bulletin, Egypt, Various Issues.

[10] Mythili G. (2008) Acreage and Yield Response for Major Crops in the Pre-and Post-Reform Periods in india: A Dynamic Panal Data Approach, Report prepared for IGIDR-ERS/USDA Project: Agricultural Markets and Policy. Mumbai, India.

[11] Suresh, K. K., and Priya, S. R. K. (2011) Forecasting Sugarcane Yield of Tamil Nadu Using ARIMA Models. Sugar Technology, 13 (1), 23-26.

[12] Wasim P. M. (2005) Milk Production Response in Pakistan. The Lahore Journal of Economics Vol.10 (1), 105-121.