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ECONOMETRIC STUDY OF SUGAR BEET CROP IN EGYPTIAN NEW LANDS

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Abstract

Sugar beet is a strategic crop and appropriate for cultivation in new lands because it consumes little quantities of water for irrigation. Recently, the sugar gap increases by about 0.74 million tons in 2018, that led to Egypt became a sugar importer. So, this research aims to identify the most important variables that affect cultivated areas of sugar beet crop in new lands in long-run during (2004/2005-2018/2019) using Autoregressive Distributed Lag model.

Results found that cultivated areas and production of sugar beet crop increased in new lands by about 25.3% and 27%, respectively during the study period. So, new lands are suitable for sugar beet crop cultivation in new lands under limited resources. However, the yield was unstable during the study period.

By using Autoregressive Distributed Lag, there will be a relationship between cultivated areas of sugar beet crop and production, previous farm price and cost in long-run. Hence, productive decision makers should focus on these variables to contribute in increasing cultivated areas to achieve food security of sugar in Egypt.

Keywords: Sugar Beet, Cointegration, ARDL, Long-run, New Lands.

Introduction

Horizontal expansion through reclamation in new lands is the main objective of agricultural development (Adriansen, 2009) which is an attempt to realize food security by increasing cultivated area from food crops (MALR, 2018). However, these lands suffer from restricted water resources, low productivity and raising reclamation costs (El-khalifa and Zahran, 2020).

So, it is necessary to identify appropriate crops for these lands, that are compatible with limited resources and efficient use from them to achieve agricultural sustainable (FAO, 2018).

Sugar is a strategic commodity and its production in Egypt depends on both of sugar cane and sugar beet crops (MALR, 2018). Sugar beet became a strategic crop, particularly when decline of cultivated areas of sugar cane because it drains massive amounts of irrigation water by about 12.000- 13.000 m^3/ feddan[1] (CAPMAS, 2018).

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Therefore, Egypt has interested in increasing production of sugar beet and encouraging farmers to plant in the new lands northern Egypt. Sugar beet represents about 75% of total cultivated area of sugar beet (CAPMAS, 2018). The amount of sugar produced from sugar beet was about 56% of total sugar production in Egypt in 2018 (Sugar Crops Council, 2017/2018).

Sugar beet could be cultivated in new lands because it bears various climatic conditions and consumes a little irrigation water of about 3500 m^3/feddan (MALR, 2018).

Recently, it is begun to depend on sugar beet crop to increase sugar production to cover the gap and achieve self-sufficiency by increasing cultivated area from 4.2 thousand feddan[1] in 2004/2005 to 215 thousand feddan in 2018/2019 in new lands (Agricultural Statistics Bulletin, 2004/2005-2018/2019).

So, the research problem represented continuation increase of sugar gap by about 0.74 million tons in 2018 due to increase consumption rates as a result of population growth, where quantity consumed of sugar by about 4.2

million tons compared to quantity of sugar production by about 3.4 million tons (FAOSTAT, 2018). Then, Egypt became a sugar importer to cover the production deficit.

The research aims to identify the most important variables that affect cultivated areas of sugar beet crop in new lands in long- run during the period (2004/2005-2018/2019). Objectives of this research are:

Identifying some variables of sugar beet crop.

Estimating the relationship between these variables and cultivated areas of sugar beet crop in short and long-run.

Material and Method

Methodology and Data Resources

Methodology : This work is based on a method of descriptive and quantitative economic analysis using means, growth rates, unit root test and Autoregressive Distributed Lag (ARDL) to estimate relationship between cultivated area (Yt) of sugar beet crop and some variables (Xn) in short and long-run.

ARDL is one of the cointegration methods, which assumes a balanced relationship between variables in the long- run, that can be applied by Bound test which developed by (Pesaran *et al*., 2001) compared to other methods of cointegration (Engle and Granger, 1987; Johansen, 1995) within the framework Vector Autoregression (VAR) model to tackle the spurious regression problem (Granger and Newbold, 1974).

Advantages of ARDL model:

a) Applied when time series of variables are mixed integration I (1) and I (0).

b) Efficient results are obtained in the case of small sample size.

c) Helps in estimating the integrative relations between variables in short and long-run at the same formula (Nkoro and Uko, 2016).

Bound test is applied by comparing the calculated F-statistic with critical values at I (1) and I (0) (Pesaran *et al*., 2001; Narayan, 2005).

If calculated F-statistic exceeds critical values then the H_0 is rejected, it means that, there is cointegration, but if calculated F-statistic did not exceed critical values then the H_1 is rejected, it means that there is not cointegration.

When there is cointegration among variables, this could be applied within the framework of Error Correction model ECM (Granger, 1988). It measures speed of balance from short-run to long-run and it should be a negative value and statistically significant (Nkoro and Uko, 2016).

The ARDL model is formula ted as follows between the selected variables (Pesaran *et al*., 2001):

$$Y_t = f(x_1, x_2, x_3)$$

$$ln\hat{Y}_t = \alpha + \beta_1 ln\, x_1 + \beta_2 ln\, x_2 + \beta_3 ln\, x_3 + \varepsilon_t$$

$ln\hat{Y}_t$ = Cultivated area of sugar beet crop at time t.

$ln x_1$ = Amount of production of sugar beet.

$ln x_2$ = Pervious farm price of sugar beet (Real value using base year 2000/2001).

$ln x_3$ = Production costs of sugar beet (Real value using base year 2000/2001).

α = The intercept term.

$\beta_{1, 2, 3}$ = Parameters of independent variables

ε_t = Random error.

Diagnostic tests for ARDL model results quality and accuracy:

a) Breusch-Godfrey Serial Correlation (LM Test): to detect Autocorrelation (Godfrey, 1978).

b) Normality Test: using Jarque-Bera (Jarque and Bera, 1980).

c) Breusch-Pagan-Godfrey Test: to detect Heteroskedasticity (Engle, 1982).

After estimating Error Correction Model (ECM), Cumulative Sum of Squares of Residuals (CUSUMSQ) should be applied to ensure stability of estimated ARDL model. Stability is achieved for coefficients when CUSUMSQ statistically falls within critical limits at 5% significance and coefficients are unstable when CUSUMSQ statistically falls out of critical limits (Granger, 1988; Borensztein *et al*., 1998).

Data Resources

This research based on published and unpublished data of Egyptian Ministry of Agriculture and Lands Reclamation (Agricultural Statistics Bulletin, 2004/2005-2018/2019), National project for developing and serving the lands of young graduates in the new lands, Nubaria (2004/2005-2018/2019), Central Agency for Public Mobilization and Statistics (CAPMAS, 2004/2005-2018/2019), Food and Agriculture Organization of the United Nations (FAO, 2018), International Network and previous studies related to the subject of the study.

Results and Discussion

The variables of sugar beet crop

Cultivated areas : Cultivated areas of sugar beet crop in Egypt represented about 364 thousand feddans during the period (2004/2005-2018/2019), where cultivated area

Table 1: Economic variables of sugar beet crop in new lands during (2004/2005– 2018/2019)

Years	Cultivated area 1000 (Feddan)	Production (1000 ton)	Yield (ton/feddan)	*Farm price** (Pound/ton)	*Costs (Pound/feddan)
2004/2005	4.2	65	15.5	190	146
2005/2006	7.9	119	15.1	204	153
2006/2007	19.7	360	18.3	223	167
2007/2008	22.5	425	18.9	275	189
2008/2009	44.7	785	17.6	377	230
2009/2010	53.9	969	18	313	245
2010/2011	78.5	1381	17.6	423	277
2011/2012	71.4	1281	17.9	393	304
2012/2013	133	2546	19.2	417	325
2013/2014	146	2674	18.3	417	353
2014/2015	153	2902	19	440	372
2015/2016	160	3061	19.1	451	432
2016/2017	167	3592	21.5	460	461
2017/2018	177	3660	20.7	491	530
2018/2019	215	4086	19	567	640
Mean	**96.9**	**1860**	**18.4**	**376**	**322**
Minimum	**4.2**	**65**	**15.1**	**190**	**146**
Maximum	**215**	**4086**	**21.5**	**567**	**640**

* Real value using base year 2000/2001. ** Farm price of pervious year (2003/2004).
Source: Calculated from Ministry of Agriculture and Land Reclamation, Economic Affairs Sector, bulletin of the agricultural statistics, (2004/2005-2018/2019) and unpublished data from the national project for developing and serving the lands of young graduates in the new lands, Nubaria, (2004/2005-2018/2019).

in new lands represented about of 26.6% from total area at the same period (Agricultural Statistics Bulletin, 2004/2005-2018/2019).

Table 1 shows that cultivated areas of sugar beet crop in new lands during the study period (2004/2005-2018/2019) reached to about 96.9 thousand feddans. Maximum areas were in 2018/2019 reached to about 215 thousand feddans while the minimum areas were 4.2 thousand feddans in 2004/2005.

On the other hand, table 2 shows that cultivated areas of sugar beet crop increased with significant annual growth rate by about 25.3% during the study period.

This indicates that new lands contributed to increase cultivated areas of sugar beet crop during the study period. It means that sugar beet is suitable for planting in new areas under the limitation of resources in these lands, also all of Boutros *et al*., 2012; Elgendy *et al*., 2013; Attia and Khalifa, 2015 and El-khalifa and Zahran, 2020 proved that finding in different crops.

Production and yield : Table 1 shows the production amounts of sugar beet crop in new lands during the study period which reached to about 1.9 million tons. It increased from minimum production value of 0.065 million tons in 2004/2005 to maximum production value of 4.1 million tons in 2018/2019.

Table 2 shows that production amounts increased with significant annual growth rate of about 27% during the study period. It refers to increase in cultivated areas in new lands which led to an increase in the production of sugar beet crop during the study period as Boutros *et al*., 2012; Attia and Khalifa, 2015; El-Nakady and Abdel Shaheed, 2017 proved that in different crops.

Table 2: Growth functions of economic variables during (2004/2005 – 2018/2019).

Variables	Suggested Equation	R^{-2}	F	Mean	Growth Rate%	T
Cultivated area	$\hat{Y}_{t=} e^{2.1 + 0.253 Xt}$	0.86	86^{***}	96.9	25.3	9.3^{***}
Production	$\hat{Y}_{t=} e^{4.9 + 0.270 Xt}$	0.86	88.6^{***}	1860	27.0	9.4^{***}
Yield	$\hat{Y}_{t=} e^{2.8 + 0.016 Xt}$	0.59	21.2^{***}	18.4	1.6	4.6^{***}
Farm price	$\hat{Y}_{t=} e^{5.3 + 0.070 Xt}$	0.85	80.4^{***}	376	7.0	8.9^{***}
Costs	$\hat{Y}_{t=} e^{4.9 + 0.102 Xt}$	0.99	1410^{***}	322	10.2	37.6^{***}

Notes: $\hat{Y}$ dependent variable; X_t time by years. (***) statistically significant difference at the 0.001.
Source: Data analyses from table (1) using SPSS.25.

That led to an increase in yield of sugar beet crop by about 18.4 tons /feddan during the study period with significant annual growth rate of about 1.6%.

However, yield values fluctuate between low and high during the study period, that the minimum yield value was 15.1 tons /feddan in 2004/2005 and the maximum yield value was 21.5 tons /feddan in 2016/2017 (Agricultural Statistics Bulletin, 2004/2005-2018/2019). This may be due to the type of imported sugar beet seeds which may cause instability in yield values. So, best varieties due to yield and quality traits under the Egyptian conditions should be taken in consideration before selection as mentioned by Hanan and Yasin, 2013.

From last results, cultivation of sugar beet crop in new lands is suitable and this led to depend on its production to contribute in achieving food security of sugar (Hanan and Yasin, 2013; El-Nakady and Abdel Shaheed, 2017).

Farm price : Farm price is one of the most important variables that affect agricultural decision-maker (MALR, 2020).

Tables 1, 2 show that real value of farm price of pervious year in new lands during the study period reached to about L.E 367 pounds/ton with significant annual growth rate of about 7%. It increased from minimum price of L.E 190 pounds/ton in 2004/2005 to maximum price of L.E 567 pounds/ton in 2018/2019 (Agricultural Statistics Bulletin, 2004/2005-2018/2019).

Farm price of pervious year defines the cultivated areas in current year, especially in sugar beet crop (Boutros *et al*., 2012 and Attia and Khalifa, 2015).

Production cost : MALR, 2020 defines production cost as an important variable for the production process success. Tables 1, 2 show real value of cost in new lands during the study period which reached to about L.E 322 pounds/feddan with significant annual growth rate of about 10.2%. It increased from minimum cost of L.E 146 pounds/ feddan in 2004/2005 to maximum cost of L.E 640 pounds/ feddan in 2018/2019.

It was found that cost increased yearly in new lands, this could affect cultivated areas of sugar beet crop. Also, Zaki *et al*., 2018 and El-khalifa and Zahran, 2020 proved that results in other researches.

Table 3: Results of ADF test for variables.

Variables	Lag	At level	At first difference	I(d)
Y	2	-6.06^{***}	-	I(0)
X_1	2	-6.56^{***}	-	I(0)
X_2	5	-	-5.56^{***}	I(1)
X_3	1	-	-3.36^{**}	I(1)
Note: ***(1%) and **(5) levels of significance. Source: results of unit root test using Eviews.11				

Table 4: Bound Test in long -run coefficients.

ARDL(1, 0, 0, 0) model	Coefficients		Bound Test
Variables	Short-run	Long-run	F-statistic
X_1	0.854^{***}	0.879^{***}	147^{***}
X_2	0.274^{NS}	0.282^{NS}	
X_3	-0.048^{NS}	-0.050^{NS}	
CointEq (-1)	-0.972^{***}		
Note: ***(1%) levels of significance, (^{NS}) non-significant. Source: Analyses using Eviews.11.			

Estimating the relationship between these variables and cultivated areas of sugar beet crop in short and long-run.

Unit root test : This test is for examination of the variables stationarity before estimating ARDL Bound test using Augmented Dicky Fuller (ADF) test. Unit root test is clarified as a high power and properties (Dickey and Fuller, 1979). Unit root tests are executed to determine the integrating level of variables by using number of lag periods which were determining for each variable (Lee, 2012; Alimi, 2014; Greaves, 2018 and Garidzirai, 2020).

Results of table 3 showed that variables (cultivated areas and production) of sugar beet were stable at level I(0) but variables (cost and farm price) were non-stationary at level and they become stationary at first difference I(1) at 1% and 5% significance (Fatukasi *et al*., 2015 ; Monineath, 2018).

So, ARDL Bound test approach could be applied for using mixed integration I(1) and I(0) variables (Alimi, 2014; Nkoro and Uko, 2016 and Mahmood *et al*., 2017).

In case of different order I(1), I(0), ARDL is the most efficient in long-run.

Bound Test : Table 4 Shows that F-statistic value of Bound test was about 147 and it exceeds critical values at 1% significance (Narayan, 2005). It indicates that a long-run cointegration relation among production, farm price, cost and cultivated areas of model is existing.

Table 4 also, shows that bound test results in long-run relationship coefficients.

The coefficient of production X1 was positive and statistically significant at 1%. It means that increase by

Table 5: Diagnostic Tests of ARDL model.

Tests	F-statistic	Prob.
LM Test	1.55	0.277
Jarque-Bera	1.44	0.486
Breusch-Pagan-Godfrey	0.55	0.708
Source: calculation using Eviews.11.		

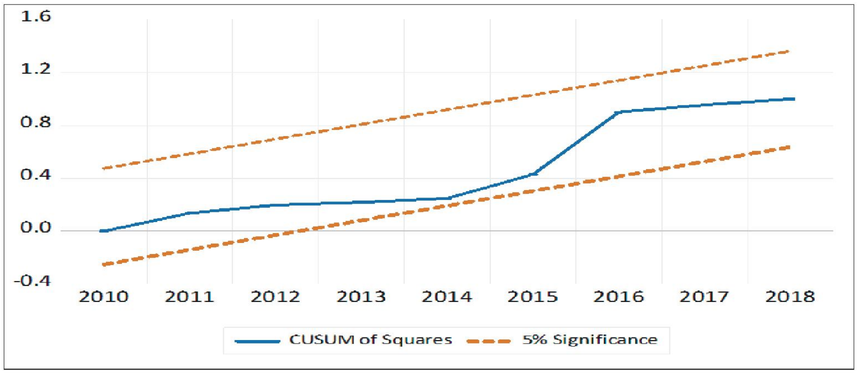

Fig. 1: Plot of CUSUMSQ Test. (Source: Output of results using Eviews.11)

1% in production led to increase by 0.879% of cultivated areas of sugar beet in long-run during the study period.

The coefficient of farm price X2 was positive but statistically insignificant. It means that increases by 1% in previous farm price led to increase by 0.282% of cultivated areas of sugar beet in long-run during the study period.

And the coefficient of cost X3 was negative and statistically insignificant. So, increase by 1% in cost led to decrease by 0.050% of cultivated areas of sugar beet in long-run during the study period.

In the short-run, table 4 indicates that the coefficient of production X1 was positive and statistically significant at 1%. It leads to increase by 0.854 % of cultivated areas of sugar beet. Therefore, the insignificant relationship between previous farm price, cost and cultivated areas of sugar beet might not be affected in the short run.

Previous findings are agreed with the economics logic, where the productive decisions of cultivated area of sugar beet crop may be affected by increasing in production and previous farm price. In addition, the most important factor affected on production efficiency of sugar beet was cost in long-run relationship in new lands (Lee, 2012; El-Gonimy, 2012; Hamude *et al*., 2013; Alimi, 2014; Fatukasi *et al*., 2015; Greaves, 2018 and Monineath, 2018).

Table 4 shows the coefficient of error correction model Coint Eq is negative and statistically significant at 1%. That indicates that the long-run relationship between the variables was exist. Its value was – 0.972.

It means that speed up of model to return equilibrium, that model is corrected from short-run toward long-run equilibrium at adjustment rate of 97.2%. That was referred to cultivated areas of sugar beet which could be adjusted back according to changes in production and price within the long-run equilibrium (Hamude *et al*., 2013; Amer, 2017 and Monineath, 2018).

Diagnostic and stability Tests: Table 5 shows some diagnostic tests to ensure quality of short run ARDL model. The results indicated that the model accepted null hypothesis, there is no Autocorrelation, no Heteroskedasticity and there is normal distribution of residuals.

Last finding made sure of non-existing of spurious regression in results (Hamude *et al*., 2013; Mahmood *et al*., 2017; Monineath, 2018; Akadiri *et al*., 2020).

Finally, Cumulative Sum of Squares of Residuals (CUSUMSQ) for short and long–run coefficients (Pesaran *et al*., 2001; Borensztein *et al*., 1998) proved stability of variables of ARDL model during the study period.

Fig. 1 shows that stability of the ARDL model, where CUSUMSQ statistically falls within critical limits. It means that there is a stability between variables in short and long-run relationships during the study period at 5% significance. Many other studies applied last test (Alimi, 2014; Mahmood *et al*., 2017; Monineath, 2018; Garidzirai. 2020; Akadiri *et al*., 2020) to check the stability parameters of variables in long-run.

Conclusion

It is concluded that, ARDL model helped in proving the long-run cointegration relation among production, farm price, cost and cultivated areas variables of sugar beet. Cultivation of sugar beet crop is suitable in new lands to depend on its production to contribute in achieving food security of sugar in long-run.

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