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The Farm Price and The Cultivation Area of Wheat in Egypt: Effectiveness and Supply Response Measurements

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Abstract.

This study empirically analyzes the supply response of farm prices on wheat areas cultivated in Egypt during (1990-2022), using the *Nerlove* model. The result is clear that the wheat area in Egypt rise from 1.9 million feddan in 1990 to 3.4 million feddan in 2022, representing an increase in area of about 80%. After estimating the model and chick for the diagnostic problems, the results show that the speed of adjustment is 0.335, meaning that every year only one-third of the gap between the actual and desired area cultivated in wheat. The short-run elasticity shows that with a 10% change in wheat farm price on average, the wheat area changes by 1.54% in the same direction. The long-run elasticity shows that with a 10% change in wheat farm price on average, the area cultivated changes by 4.59% in the same direction. So, the results of this study adapt economic relations, which can enhance the recent studies on wheat growing in Egypt. Also, policymakers and decision-makers can determine the plan for wheat production.

Keywords Wheat, Supply response, Nerlove model, Partial adjustment model (PAM), elasticity.

1 INTRODUCTION.

Wheat is one of the most strategic crops not only in Egypt, but also around the world, where it is consumed around the world (Igrejas, Ikeda, & Guzmán, 2020). The area cultivated of wheat reached 521.8 million feddan in 2022 all over the world, producing 808.44 million tons (FAO, 2023).

The importance of wheat comes from the contribution of wheat cereals of proteins, carbohydrates, vitamins, minerals, (notably B vitamins), and fibers (Shewry & Hey, 2015). Wheat straw is not less important than cereal wheat, which is used not only in livestock feeds that contain fibers, fats, proteins, and cellulose, but also as an organic environment to improve the production and chemical properties of mushrooms (Elattar, Hassan, & Awd-Allah, 2019). In addition, wheat straw is used to produce biofuel (Qureshi, Saha, Cotta, & Singh, 2013), and to produce biodegradable plastic (Kuddus & Ramteke, 2023).

For decades, Egypt has imported wheat to bridge the gap between production and consumption, because the production level does not match the consumption level (Abdelaal & El-Shafei, 2021), Egypt's import of wheat represents 5% of world imports, ranking in the world imports the second after Indonesia (ITC, 2023). In recent years wheat Egyptian imports sequentially rise, where the increasing population and high consumption makes pressure on demand for wheat in Egypt, where the rate of self-sufficiency in wheat reached about 48.2% in 2021, where it was 74.4% in 2009 (CAPMAS, Annual Bulletin of the Movement of Production, Foreign Trade & Available for Consumption of Agricultural Commodities, 2022), in spite Egypt produce by 32.75% of African wheat production in average of last five years (2018-2022) (FAO, 2023)

2 MATERIALS AND METHODS.

The main objective of this study is to investigate the effect of farm prices on the wheat area in Egypt. The study of wheat supply applied the *partial adjustment model* (PAM), based on secondary time series data from the Statistical Yearbook (CAPMAS, Statistical Yearbook), and the Bulletin of Agricultural Statistics (EAS), from 1990 to 2022, using the *Nerlovian model* to analyze the response of wheat supply in Egypt.

This study estimates the response of wheat supply to changes in price in the both of short-run and long-run during (1990-2022) in Egypt. The Nerlove model is a powerful tool used to analyze both the speed and level of adjustment of actual and desired areas (Yu, Liu, & You, 2010).

2.1 Empirical Nerlovian model.

Nerlovian models are dynamic models built to examine the farmer's production reaction based on price expectations and partial adjustment area (Yu, Liu, & You, 2010).

The main idea of this model is that the cultivated area is a function of the expected price P_t^*; however we cannot observe this price. We must represent the expected price in terms of the variable we observe, in particular last year expected price P_{t-1}^* can be represented by last year area cultivated A_{t-1} (NERLOVE, 1956). The model used area as a proxy variable for output because farmers control more of the crop area than output. (Kohli, 1996)

The original model has a partial adjustment mechanism; that makes the economic assumption that a change in P_t is fully reflected in A_t during the same period t. If the dependent variable A_t is not completely adjusted to a change in $P_t$in the same period t, then we specify A_t^* as the desired level of A_t after a change in P_t. (Vogelvang, 2005).

The Nerlovian model is an ad hoc specification of the supply response including partial adjustment and expectation formation. (Wickens, M. R., & Greenfield, J. N., 1973).

$$A_t^* = \beta_0 + \beta_1 P_{t-1} + \varepsilon_t \qquad \textbf{Eq. 1}$$

Where A_t^* is the planned or desired cultivated area of wheat in Egypt at time t, P_{t-1} is the farm gate price of wheat in past year $t-1$, and ε_t is the error term. This accounts for the random factors affecting the area cultivation.

$$A_t - A_{t-1} = \delta(A_t^* - A_{t-1}) \qquad \textbf{Eq. 2}$$

Where $A_t - A_{t-1}$ is the actual change in cultivated area, and $A_t^* - A_{t-1}$ is a desired change. (ASTERIOU & HALL, 2021).

Where A_t is the actual area that cultivated in time t, A_{t-1} is the area cultivated in time $t-1$, δ is the partial-adjustment coefficient, which lay between 0 and 1 $(0 < \delta \le 1)$, which 1 mean the area planned is equal to area cultivated $A_t = A_t^*$ (Maddala & Lahiri, 2009)

By substitution of Eq. 1 with Eq. 2, then:

$$\boldsymbol{A_t - A_{t-1} = \delta(\beta_0 + \beta_1 P_{t-1} + U_t - A_{t-1})} \qquad \textbf{Eq. 3}$$

Eq. 3 can be written as:

$$\boldsymbol{A_t = \delta(\beta_0 + \beta_1 P_{t-1} + U_t - A_{t-1}) + A_{t-1}} \qquad \textbf{Eq. 4}$$

We can express Eq. 4 as:

$$\boldsymbol{A_t = \delta\beta_0 + \delta\beta_1 P_{t-1} - \delta A_{t-1} + A_{t-1} + \delta U_t} \qquad \textbf{Eq. 5}$$

This equation is called the *partial-adjustment model* (PAM) (Gujarati, 2004) or the short-run supply model. And Eq. 5 can be written as:

$$\boldsymbol{A_t = \delta\beta_0 + \delta\beta_1 P_{t-1} + (1-\delta)A_{t-1} + \delta U_t} \quad \textbf{Eq. 6}$$

Where $1/\delta$ denotes the speed of adjustment. After estimating the coefficient in Eq. 6, we can estimate Eq. 1, as follows:

$$\hat{A}_t^* = \hat{\beta}_0 + \hat{\beta}_1 P_{t-1} + \varepsilon_t \quad \textbf{Eq. 7}$$

Where $\hat{A}_t^*$ is the desirable level of wheat area cultivation in Egypt, which depends on the level of price in the last year. $\hat{\beta}_1$ is the rate of change in area under cultivation per unit change in the lag year price of wheat, $\partial A_t/\partial P_{t-1} = \hat{\beta}_1$, and this model is the supply response function in the long run.

$$\hat{\beta}_0 = \frac{\delta\beta_0}{\delta} \quad \& \quad \hat{\beta}_1 = \frac{\delta\beta_1}{\delta} \quad \& \quad \hat{U} = \frac{\delta U_t}{\delta} \quad \textbf{Eq. 8}$$

From those models:

- The short-run reaction of area to a unit change in price is $\delta\beta_1$
- The long-run reaction given by $\hat{\beta}_1$

2.2 Elasticity of the supply model.

The responsiveness of the area under cultivation with respect to the changes in lag year prices is evaluated at the mean values $\bar{P}_{t-1}$ and $\bar{A}_t$ as follows:

$$\varepsilon_{SR} = \frac{\partial A_t/\partial P_{t-1}}{A_t/P_{t-1}} = \beta_1^* * \frac{\bar{P}_{t-1}}{\bar{A}_t} \quad \textbf{Eq. 9}$$

Where ε_{SR} is the short-run elasticity (Leaver, 2004).

$$\varepsilon_{LR} = \frac{\varepsilon_{SR}}{\delta} \quad \textbf{Eq. 10}$$

Where ε_{LR} is the long-run elasticity. Because the coefficient of partial adjustment is less than unity, so the long-run elasticity is relatively higher than the short-run elasticity.

To achieve this methodology, the Statistical Analysis System (Stata 18) software was used (StataCorp, 2023) to obtain this model and analyze the parameters, statistical hypotheses, and elasticities that achieved the research objectives.

3 RESULTS AND DISCUSSION

3.1 Descriptive analysis

Wheat area cultivated in Egypt rise from 1.9 million feddan in 1990 to 3.4 million feddan in 2022 as shown in **Figure 1**. Wheat price was less than 1 thousand Egyptian pound during (1990-2007), then the price rise gradually until 2021 which was 4.7 thousand Egyptian pound.as shown in **Figure 1**

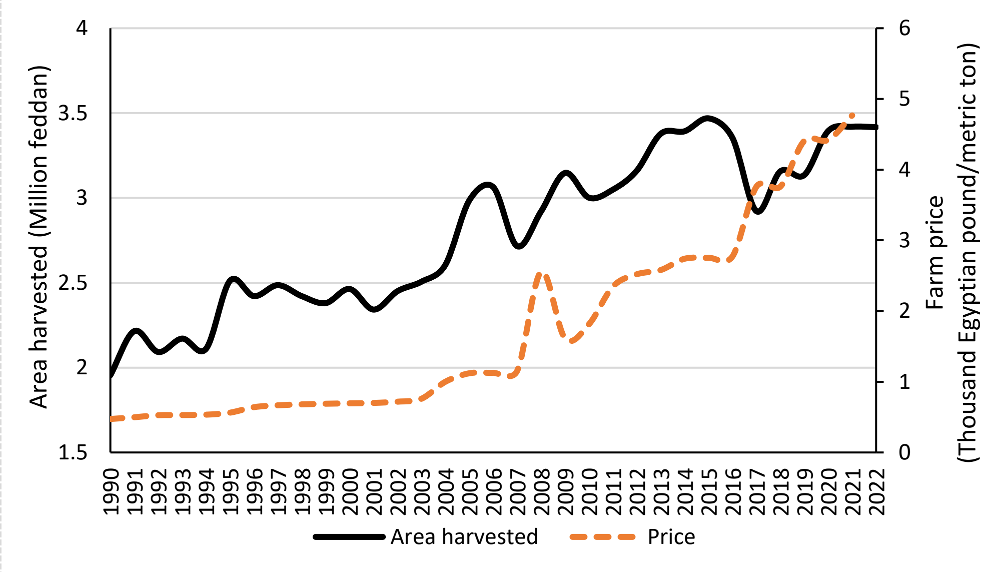

Figure 1: Area cultivated and price of wheat in Egypt during (1990-2022)

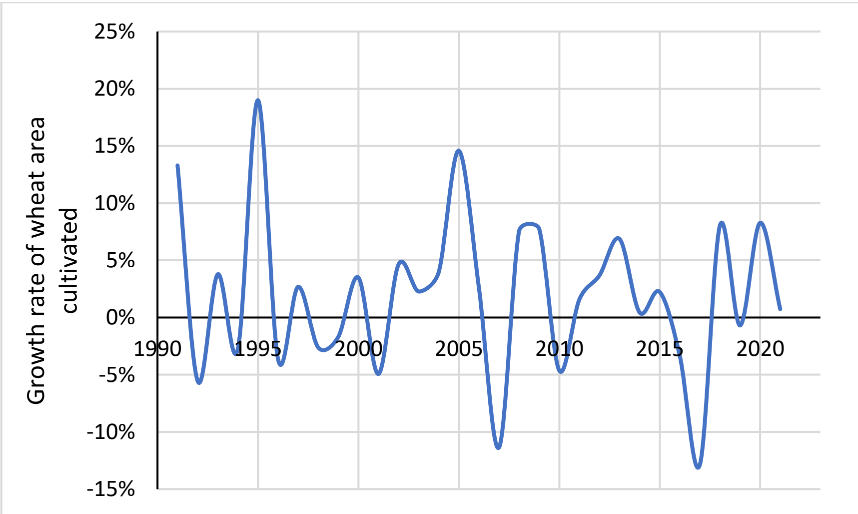

Figure 2: Area wheat cultivated growth rate during (1990-2022)

The growth rate in the area cultivated of wheat was approximately ±15%, except in 1995 when it was 19%, as shown in **Figure 2**.

The wheat price growth rate fluctuation was more intensive than area specially in the period (2007-2010) influenced by the world food price crisis, the world bank estimate in 2008 that wheat supply may have reduced by 4% (Mitchell, 2008) (Gilbert, 2010), this changes in wheat price growth rate can be shown in **Figure 3**

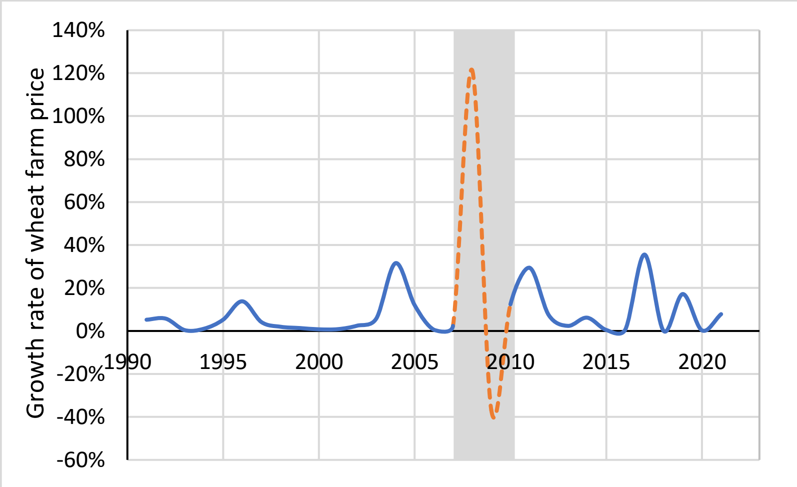

Figure 3: Wheat price growth rate during (1990-2022)

3.2 Estimating the supply response model

After estimating the *Nerlovian* model, the results show that the area cultivated of wheat in Egypt was positively affected by the area cultivated last year and the farm price last year. **Table 1** shows the short-run of wheat supply response.

Table 1: Regression results for the *Nerlovian* supply response model.

A	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Price (t-1)	0.096	0.038	2.51	0.018	0.018	0.174	**
Area (t-1)	0.665	0.113	5.90	0.000	0.435	0.895	***
Constant	807.808	262.102	3.08	0.004	271.75	1343.866	***

Mean dependent var	2820.498	SD dependent var	447.382
R-squared	0.873	Number of obs	32
F-test	99.687	Prob > F	0.000
Akaike crit. (AIC)	420.377	Bayesian crit. (BIC)	424.774

*** p<.01, ** p<.05

3.3 Goodness of fit:

The results show that all the coefficients are statistically significant at the 5% and 1% levels, and the F-test is highly significant, with a coefficient of determination of 0.873. This means that the model has a response of 87.3% to the changes in wheat area in Egypt.

3.4 Diagnostic check:

To ensure that our econometric approach was correct, the diagnostic check tests were run as follows:

3.4.1 Serial correlation:

Because the model is autoregressive model (the regressor includes the lagged value of regressand or dependent variable), the Breuschâ-Godfrey LM test is used, and the results are shown in **Table 2.**

Table 2: The Breuschâ-Godfrey LM test.

Breuschâ-Godfrey LM test for autocorrelation chi^2	df	Prob>Chi^2
0.001	1	0.974

The result proved that the model is free from serial correlation which the probability of chi^2 is 97% which is more than 5%.

3.4.2 Normality test.

Table 3 shows that the probability of chi^2 is 92%, which is more than 5%, indicating that the residuals are normally distributed.

Table 3: Skewness and kurtosis tests for normality of residuals.

Variable	Obs	Pr(skewness)	Pr(kurtosis)	Adj $chi^2(2)$	Prob>chi^2
Residuals	32	0.796	0.766	0.160	0.925

The same result can be observed in **Figure 4**.

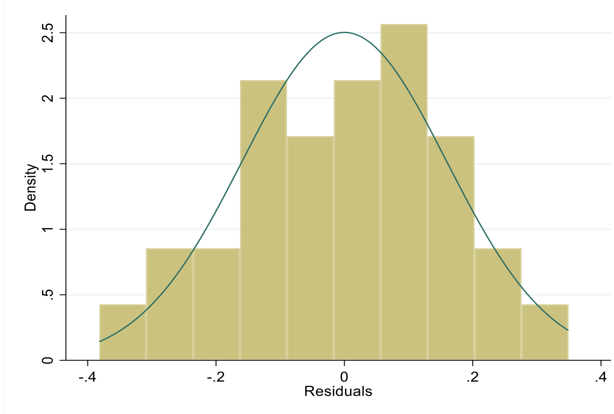

Figure 4: The residuals density and normal graph

3.4.3 Heteroskedasticity test.

By estimating White's test, the result shows that the model is homoscedastic, where the probability of chi[2] is 85% which is more than 5%, as shown in **Table 4**.

Table 4: The result of Heteroscedasticity White's test.

Source	chi^2	df	p
Heteroskedasticity	1.960	5	0.854
Skewness	3.090	2	0.213
Kurtosis	0.080	1	0.781
Total	5.130	8	0.744

3.5 Interpretation the model.

The relationship between the wheat farm price and cultivated area is shown in **Figure 5**, which represents the supply curve of wheat during the study period.

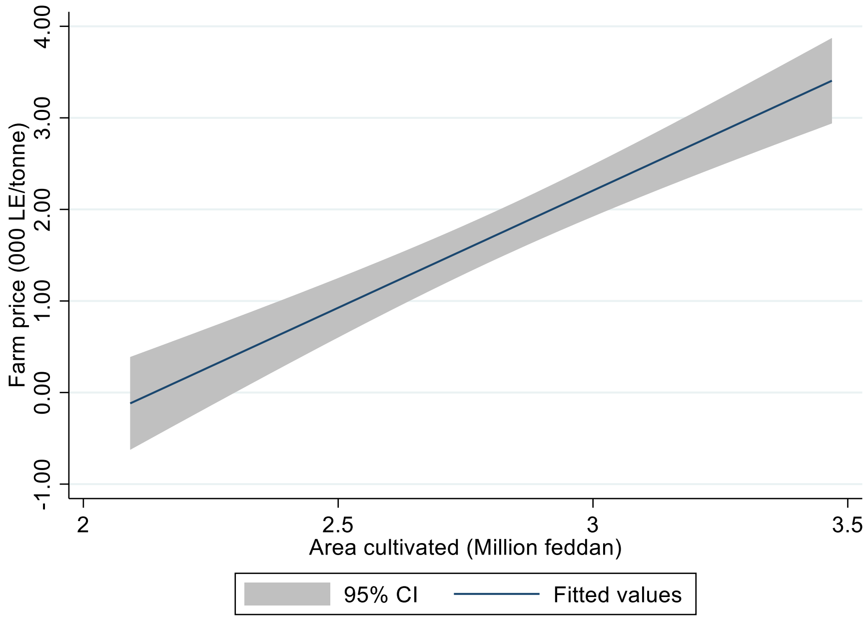

Figure 5: The Supply curve with a 5% confidence interval for wheat in Egypt.

$$A_t = 807.808 + 0.096P_{t-1} + 0.665A_{t-1} \quad \textbf{Eq. 11}$$

$$(2.51)^{**} \quad (5.90)^{***} \quad (3.08)^{***}$$

$$R^2 = 0.873 \qquad F = 99.69^{***}$$

The results in **Table 1** and **Equation 11** represent this function by estimating the *Nerlovian* supply response function in the short-run.

The speed of the adjusted coefficient is 0.335. This discrepancy between the actual change and desired change in cultivated area can be eliminated to the extent of 0.335 units every year.

The long-run supply function is represented by **Equation 12**.

$$A_t = 2410.782 + 0.287\, P_{t-1} \qquad \textbf{Eq. 12}$$

3.6 Price elasticity.

The short-run elasticity is 0.154, showing that a 10 % increase in the lagged price of wheat farm price induces wheat farmers to allocate the area cultivated by 1.54 % in the current year.

The long-run price elasticity is 0.459, explaining that the cumulative effect of price changes on the current year's change is such that. If the lagged price increases by 10 %, then the wheat area cultivated in the current year will increase by 4.59 % per year.

4 Conclusions

This study used annual data for the yearly area of wheat cultivation in Egypt and the farm price from (1990-2022), to analyze the supply response of wheat in Egypt in both short run and long run. The Nerlovian model estimates, and according to the result, the speed of adjustment in the cultivated area is 0.335, which indicates a slow speed of adjustment. In addition, the supply price elasticity of wheat in Egypt is inelastic in the short and long run, which means that the change in wheat area is less than the change in farm price. This means that to increase the cultivated area of wheat and thus increase local wheat production, more incentive procedures must be considered, represented by increasing the support provided to wheat farmers, as well as setting a guaranteed price for wheat, contracting with farmers, and obtaining agricultural insurance to ensure that the farmer avoids losses that may harm him in the future, and encourage an increase in cultivated area of wheat. So, the results of this research adapt the economic relations that can be applicable in this field, which can enhance the new studies for wheat growing in Egypt. Also, it can help policymakers and decision-makers determine the layout of the wheat production.

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السعر المزرعي والمساحة المزروعة للقمح في مصر: قياسات الفعالية واستجابة العرض

أحمد محمد عبد العزيز الشافعي

قسم الاقتصاد الزراعي – كلية الزراعة – جامعة المنيا

يعد القمح أحد المحاصيل الاستراتيجية الهامة في مصر والعالم، حيث يزرع منه على مستوى العالم حوالي 522 مليون فدان يغل إنتاج قدره حوالي 808 مليون طن قمح، وعانت مصر لعقود من فاتورة واردات القمح لسد الفجوة بين الإنتاج والاستهلاك حيث تمثل واردات مصر من القمح 5% من إجمالي واردات القمح العالمية وهي بذلك تحتل المركز الثاني كأكبر مستورد للقمح على مستوى العالم، وتهدف هذه الدراسة لتحليل استجابة العرض لمحصول القمح في مصر خلال الفترة (1990–2022)، باستخدام نموذج التعديل الجزئي لنيرلوف، وأوضحت النتائج أن مساحة القمح المزروعة في مصر ارتفعت من 1.9 مليون فدان في عام 1990 إلى 3.4 مليون فدان في عام 2022، مما يمثل زيادة في المساحة بنسبة حوالي 80%. وبعد تقدير النموذج والتحقق من خلو النموذج من مشكلات القياس، أظهرت النتائج أن سرعة التكيف هي 0.335، مما يعني أنه كل عام يتم تغطية فقط ثلث الفجوة بين المساحة الفعلية والمساحة المرغوب زراعتها بالقمح. كما تُظهر النتائج أن المرونة في المدى القصير تبين أن التغير في سعر القمح المزرعي بنسبة 10%، يؤدي إلى تغير المساحة المزروعة من القمح بحوالي 1.54% في نفس الاتجاه. وتُظهر المرونة في المدى الطويل أنه مع تغير السعر بنسبة 10%، تتغير المساحة المزروعة من القمح بنسبة 4.59% في نفس الاتجاه، وهذا يعني أنه لزيادة المساحة المزروعة من القمح ومن ثم زيادة الإنتاج المحلي يتوجب اتخاذ إجراءات تحفيزية أكثر تتمثل في زيادة الدعم المقدم لمزارعي القمح وكذلك وضع سعر ضمان للقمح والتعاقد مع المزارعين والتأمين الزراعي بما يضمن للمزارع تجنب حدوث خسائر قد تضر به في المستقبل مما يشجع على زيادة المساحة المزروعة من القمح، لذا فإن نتائج هذا البحث تتفق مع النظرية الاقتصادية كما انها تساعد صانع القرار في تحديد مخطط إنتاج القمح في مصر.

Table 5: The wheat area cultivated and farm price in Egypt during (1990-2022)

year	Area cultivated (000 feddan)	Farm price (LE/ton)	Area cultivated (000 feddan) (t-1)	Farm price (LE/ton) (t-1)	growth rate (%)	
					Area	Price
1990	1955	473	-	-	-	-
1991	2215	498	1955	473	13.30	5.24
1992	2092	527	2215	498	-5.55	5.75
1993	2171	529	2092	527	3.78	0.39
1994	2111	534	2171	529	-2.76	1.06
1995	2512	563	2111	534	19.00	5.28
1996	2421	640	2512	563	-3.62	13.82
1997	2486	667	2421	640	2.68	4.14
1998	2421	680	2486	667	-2.61	1.96
1999	2380	689	2421	680	-1.69	1.37
2000	2463	695	2380	689	3.50	0.77
2001	2342	701	2463	695	-4.93	0.86
2002	2450	718	2342	701	4.64	2.47
2003	2506	760	2450	718	2.28	5.85
2004	2605	1000	2506	760	3.96	31.58
2005	2985	1120	2605	1000	14.58	12.00
2006	3064	1127	2985	1120	2.63	0.60
2007	2716	1153	3064	1127	-11.36	2.37
2008	2920	2553	2716	1153	7.54	121.39
2009	3147	1613	2920	2553	7.76	-36.81
2010	3001	1813	3147	1613	-4.63	12.40
2011	3049	2347	3001	1813	1.57	29.41
2012	3161	2520	3049	2347	3.68	7.39
2013	3378	2580	3161	2520	6.87	2.38
2014	3393	2740	3378	2580	0.45	6.20
2015	3469	2753	3393	2740	2.24	0.49
2016	3353	2773	3469	2753	-3.34	0.73
2017	2922	3760	3353	2773	-12.87	35.58
2018	3157	3760	2922	3760	8.05	0.00
2019	3135	4407	3157	3760	-0.69	17.20
2020	3394	4420	3135	4407	8.28	0.30

2021	3419	4767	3394	4420	0.74	7.84
2022	3417	5400	3419	4767	-0.07	13.29

Source: 1- EAS, *Bulletin of the agricultural statistics*
2- CAPMAS, *Statistical Yearbook*

Table 6: Descriptive Statistics of the study variables

Variables	Obs	Mean	Std. Dev.	Min	Max	Skew.	Kurt.
Area	33	2794.271	465.399	1955	3468.86	-0.09	1.676
Area (t-1)	32	2774.81	459.001	1955	3468.86	-0.05	1.698
Price (t-1)	32	1746.279	1349.031	473.333	4766.667	0.87	2.473

Source: Calculated from data in **Table 5.**