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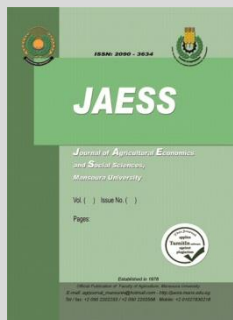
Maximum Likelihood Estimation for Oranges and Mandarins Production in Egypt

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ABSTRACT

Oranges and mandarins are classified as important citrus in Egypt. The study uses a stochastic frontier production function to measure the efficiency of production for oranges and mandarins in Egypt during 1997-2019. During the time period 1997-2019, the mean of oranges production is 2317.69 thousand ton, while the mean of mandarins production is 753.53 thousand ton. The minimum value of oranges production is 1441.652 thousand ton and for mandarins production is 421.811 thousand ton (1998), while the maximum value of oranges production is 3351.307 thousand ton and for mandarins production is 985.439 thousand ton (2015). In 2019, Noubaria governorate has the highest production of oranges and Mandarins, while Fayoum governorate has the lowest production of oranges, and Dakahlia governorate has the lowest production of Mandarins. The results of the study indicate that the efficiency for oranges and mandarins production make clear improving over time. The study recommends that the government should encourage and motivate farmers in different governorates to produce the most efficient crops in their governorates.

Keywords: Oranges, mandarins, efficiency

INTRODUCTION

Orange cultivation accounts for 65 percent of Egypt's total citrus production (Hamza and Beillard, 2012). Navel oranges are the primary variety grown in Egypt, accounting for 60 percent of total production. Along with navel oranges, the other five main varieties grown in Egypt include *Baladi* (local), Valencia, blood, *Khalily* (local), and the *Sukkari* (sweet orange (local)). Navel and Valencia are the main varieties grown for export. Egyptians tend to favor oranges over other fruits during the winter. Strong consumer demand for oranges during the winter is attributable to their affordable price compared to other winter fruits. Prices are a key determinant of consumption in Egypt. Orange production alone accounts for 30-35 percent of Egypt's total fruit production. Egyptian orange production is dependent on irrigation. The Nile River, along with fertile soil conditions and year round sunshine permit high yields and good quality fruit. The economic viability of Egypt's orange production is facilitated by low labor costs and proximity to major import markets. Although some Egyptian groves maintain orange trees for up to 25 years, trees in this climate are however most productive between years 4 and 15. Oranges are cultivated in almost all of Egypt's governorates (Hamza and Beillard, 2012). Mandarins rank second among the cultivated varieties of citrus, accounting for 26.1%. *Balady* (local) is the most widely planted variety (Salem and Sheta, 2002).

Problem and Objective of the Study

Egypt's population increases annually, which create a gap between the production of oranges and mandarins and its consumption. The study aims to measure the efficiency of production for oranges and mandarins in Egypt during 1997-2019.

Methodology

In this study, the maximum likelihood estimates are used for the estimation of the model. The study employed the stochastic frontier production function for oranges and mandarins production in Egypt:

$$Y_{it} = f(X_{it}, t; \beta) e^{v_{it} - u_{it}}$$

Where

Y_{it} is the oranges or mandarins production at t -th time period;

X_{it} is the area at t -th time period; t is the time variable; α is a vector of unknown parameters to be estimated; v_{it} is the error component, and u_{it} is the inefficiency error.

The Cobb-Douglas production function is an adequate representation of the data. The Cobb-Douglas production function can be defined as:

$$\ln Y_{it} = \beta_0 + \sum_{j=1} \beta_j \ln x_{jit} + \beta_t t + v_{it} - u_{it}$$

The study used the specification of Battese and Coelli (1992), the statistical error v is assumed to be independently and identically distributed as $N(0, \sigma_v^2)$.

The efficiency error u is assumed to be independent of v with the following definition:

$$u_{it} = u_i \exp(-\eta[t - T])$$

Where

the distribution of u_i is taken to be the non-negative truncation of the normal distribution $N(u, \sigma_u^2)$ and η is a parameter that represents the rate of change in technical inefficiency.

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The positive or negative value is associated with improvement or deterioration in the technical efficiency for oranges and mandarins production over time. The study used Frontier program (version 4.1), in which the variance parameters are expressed in terms of (Coelli, 1996):

$$\sigma_s^2 = \sigma_u^2 + \sigma_v^2; \gamma = \frac{\sigma_u^2}{\sigma_s^2} \text{ and } 0 \leq \gamma \leq 1.$$

The technical efficiency level for oranges or mandarins production at *t*-th time period (TE_{it}) is defined as the ratio of the actual output to the maximum potential output (Lambarraa et al., 2007) as follows:

$$TE_{it} = \frac{Y_i}{\exp(x_i\beta + v_i)} = \frac{\exp(x_i\beta + v_i - u_i)}{\exp(x_i\beta + v_i)} = \exp(-u_i)$$

Data

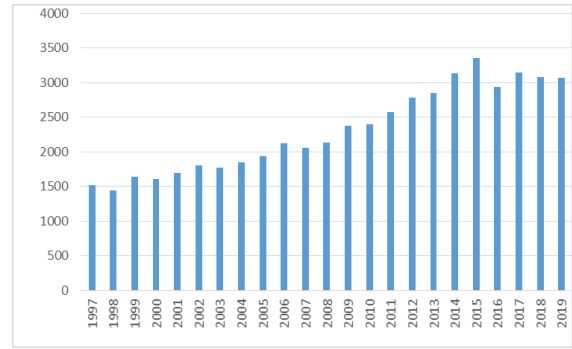
The data in this study represents the production and area of oranges and mandarins in Egypt from 1997 to 2019. The data obtained from FAOSTAT and the Ministry of Agriculture and Land Reclamation (MALR), Egypt. Table (1) shows the production, area, and yield of oranges in Egypt, while figure (1) shows the production of oranges in Egypt (1997-2019). The mean of production, area, and yield is 2317.69 thousand ton, 101.92 thousand hectare, and 22.45 ton/hectare, respectively.

Table 1. Production, Area, and Yield of Oranges in Egypt (1997-2019).

Years	Production (Thousand Ton)	Area (Thousand Hectare)	Yield (Ton/Hectare)
1997	1522.10	85.74	17.75
1998	1441.65	84.03	17.16
1999	1636.60	93.35	17.53
2000	1610.52	87.70	18.36
2001	1696.29	83.61	20.29
2002	1808.58	83.58	21.64
2003	1767.71	83.05	21.28
2004	1850.03	83.21	22.23
2005	1940.42	84.52	22.96
2006	2120.05	87.83	24.14
2007	2054.63	89.34	22.10
2008	2138.43	93.34	22.91
2009	2372.26	98.52	24.08
2010	2401.02	101.26	23.71
2011	2577.72	110.42	23.34
2012	2786.40	118.73	23.47
2013	2855.02	125.60	22.73
2014	3135.93	126.40	24.81
2015	3351.31	131.34	25.52
2016	2939.08	116.39	25.25
2017	3147.55	128.93	24.41
2018	3085.99	124.58	24.77
2019	3067.63	122.71	25.00
Mean	2317.69	101.92	22.45

Sources: FAOSTAT and own elaboration

Table (2) shows the production, area, and yield of mandarins in Egypt, while figure (2) shows the production of mandarins in Egypt (1997-2019). The mean of production, area, and yield is 753.53 thousand ton, 39.71 thousand hectare, and 18.69 ton/hectare, respectively.



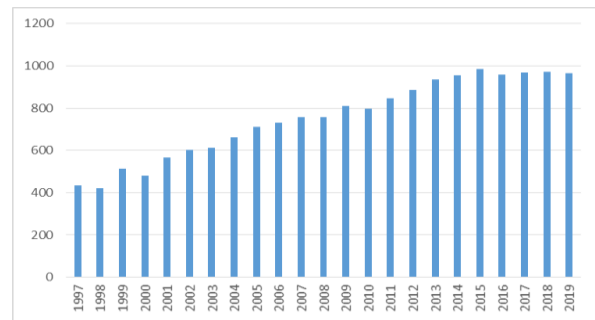
Source: Own elaboration

Figure 1. Production of Oranges in Egypt (Thousand Ton).

Table 2. Production, Area, and Yield of Mandarins in Egypt (1997-2019).

Years	Production (Thousand Ton)	Area (Thousand Hectare)	Yield (Ton/Hectare)
1997	434.55	30.05	14.46
1998	421.81	32.87	12.83
1999	511.76	34.00	15.05
2000	481.18	35.00	13.75
2001	564.85	35.84	15.76
2002	601.70	36.36	16.55
2003	612.56	37.48	16.34
2004	661.27	37.90	17.45
2005	711.46	38.32	18.57
2006	730.90	37.75	19.36
2007	758.11	38.27	19.81
2008	758.11	39.72	19.08
2009	809.80	40.24	20.13
2010	796.87	39.83	20.01
2011	848.07	41.26	20.55
2012	885.37	42.06	21.05
2013	936.76	44.55	21.03
2014	956.91	44.47	21.52
2015	985.44	44.94	21.93
2016	959.70	45.31	21.18
2017	967.35	46.05	21.01
2018	970.83	45.43	21.37
2019	965.96	45.60	21.19
Mean	753.53	39.71	18.69

Sources: FAOSTAT and own elaboration



Source: Own elaboration

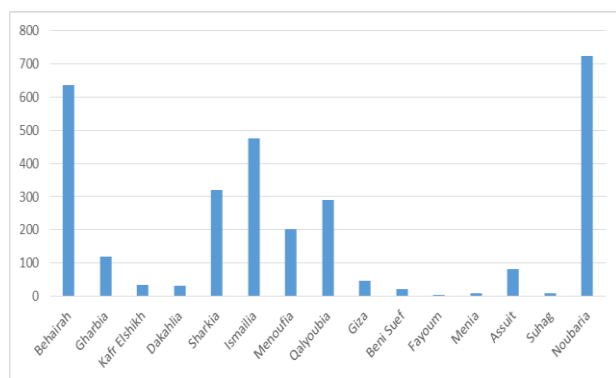
Figure 2. Production of Mandarins in Egypt (Thousand Ton).

Table (3) shows the production, area, and yield of oranges in the main governorates in Egypt (1997-2019). In 2019, Noubaria governorate (figure 3) has the highest production (724.91 thousand ton), while Fayoum governorate has the lowest production (3.62 thousand ton).

Table 3. Production, Area, and Yield of Oranges in the Main Governorates in Egypt (1997-2019).

Governorate	Production (Thousand Ton)	Production (Thousand Ton)	Area (Thousand Feddan)	Area (Thousand Feddan)	Yield (Ton/ Feddan)	Yield (Ton/ Feddan)
	1997	2019	1997	2019	1997	2019
Behairah	290.86	636.04	38.37	66.56	7.58	9.56
Gharbia	85.21	117.87	9.42	10.95	9.05	10.76
Kafr Elshikh	33.50	33.48	3.00	3.37	11.16	9.93
Dakahlia	36.11	32.33	4.21	3.50	8.58	9.23
Sharkia	208.50	320.43	31.47	40.90	6.63	7.83
Ismailia	73.34	475.15	8.93	45.89	8.21	10.35
Menoufia	194.02	202.46	20.84	20.32	9.31	9.96
Qalyoubia	302.99	289.04	28.73	26.79	10.55	10.79
Giza	28.21	46.13	4.32	5.93	6.53	7.78
Beni Suef	26.71	21.80	3.44	2.20	7.77	9.90
Fayoum	4.67	3.62	0.93	0.37	5.00	9.84
Menia	6.23	7.37	1.18	1.10	5.28	6.73
Assuit	63.50	82.49	7.87	10.23	8.07	8.06
Suhag	13.30	8.23	1.85	1.08	7.17	7.64
Noubaria	129.51	724.91	35.72	65.88	3.63	11.00
Mean	99.78	200.09	13.35	20.34	7.63	9.29

Sources: MALR in Egypt and own elaboration

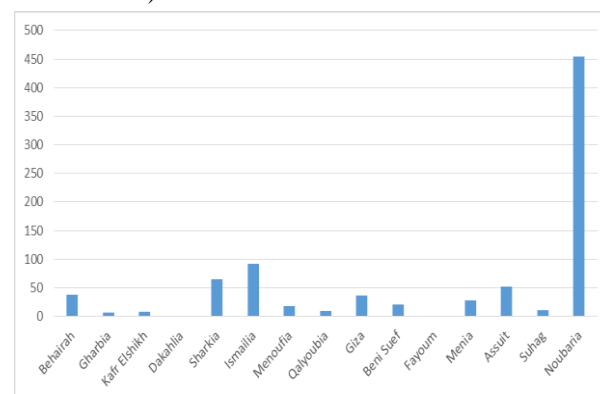


Source: Own elaboration

Figure 3. Production of Oranges in the Main Governorates in Egypt (2019).

Table (4) shows the production, area, and yield of mandarins in the main governorates in Egypt (1997-2019). In 2019, Noubaria governorate (figure 4) has the highest production (455.05 thousand ton), while

Dakahlia governorate has the lowest production (0.93 thousand ton).



Source: Own elaboration

Figure 4. Production of Mandarins in the Main Governorates in Egypt (2019).

Table 4. Production, Area, and Yield of Mandarins in the Main Governorates in Egypt (1997-2019).

Governorate	Production (Thousand Ton)	Production (Thousand Ton)	Area (Thousand Feddan)	Area (Thousand Feddan)	Yield (Ton/ Feddan)	Yield (Ton/ Feddan)
	1997	2019	1997	2019	1997	2019
Behairah	15.77	37.64	2.35	3.82	6.70	9.85
Gharbia	5.87	7.22	1.17	0.69	5.00	10.47
Kafr Elshikh	1.45	7.70	0.16	0.72	9.02	10.69
Dakahlia	1.34	0.93	0.17	0.17	7.78	5.57
Sharkia	64.18	65.54	14.33	11.46	4.48	5.72
Ismailia	9.76	92.14	1.65	12.75	5.91	7.23
Menoufia	19.87	17.88	2.58	2.06	7.70	8.69
Qalyoubia	29.07	8.73	3.11	0.83	9.34	10.53
Giza	59.17	35.85	7.33	5.36	8.07	6.69
Beni Suef	8.20	20.75	1.49	2.04	5.50	10.16
Fayoum	1.14	1.57	0.31	0.15	3.71	10.34
Menia	11.99	27.49	1.99	3.31	6.03	8.30
Assuit	18.60	52.68	2.78	4.83	6.68	10.90
Suhag	6.07	10.46	0.89	1.32	6.82	7.90
Noubaria	178.09	455.05	30.49	44.18	5.84	10.30
Mean	28.70	56.11	4.72	6.25	6.57	8.89

Sources: MALR in Egypt and own elaboration

RESULTS AND DISCUSSIONS

Results

Table (5) shows the results of technical efficiency for oranges and mandarins production in Egypt during 1997-2019. The technical efficiency for oranges and mandarins production make clear improving over time. The mean of technical efficiency for oranges is 94.61%, while for mandarins is 93.26% in the studied period.

Table 5. Results of Technical Efficiency for Oranges and Mandarins Production in Egypt (1997-2019).

Year	Orange	Mandarin
1997	0.7181	0.6541
1998	0.7783	0.7253
1999	0.8273	0.7842
2000	0.8663	0.832
2001	0.8971	0.8701
2002	0.9211	0.9001
2003	0.9397	0.9234
2004	0.9541	0.9415
2005	0.9651	0.9554
2006	0.9734	0.9661
2007	0.9798	0.9742
2008	0.9847	0.9805
2009	0.9884	0.9852
2010	0.9912	0.9888
2011	0.9934	0.9915
2012	0.9950	0.9936
2013	0.9962	0.9951
2014	0.9971	0.9963
2015	0.9978	0.9972
2016	0.9983	0.9979
2017	0.9988	0.9984
2018	0.9991	0.9988
2019	0.9993	0.9991
Mean	0.9461	0.9326

Source: Own elaboration

CONCLUSION AND RECOMMENDATION

Oranges and mandarins are classified as important citrus in Egypt. This study used a stochastic frontier production function to measure the efficiency of production for oranges and mandarins in Egypt during 1997-2019. During the time period 1997-2019, the

mean of oranges production is 2317.69 thousand ton, while the mean of mandarins production is 753.53 thousand ton. The results show that the mean of technical efficiency for oranges and mandarins production more than 90% in the studied period. The study recommends increasing the area and improving the technology to produce oranges and mandarins in Egypt; the government should encourage and motivate farmers in different governorates to produce the most efficient crops in their governorates.

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تقدير الإمكانية القصوي لإنتاج البرتقال واليوسفي في مصر

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الملخص

يصنف البرتقال و اليوسفي على أنهما من الحمضيات الهامة في مصر. تهدف الدراسة إلى قياس الكفاءة الفنية لإنتاج البرتقال واليوسفي في مصر أثناء 1997-2019. في الفترة الزمنية 1997-2019، بلغ متوسط إنتاج البرتقال 2317.69 ألف طن، و متوسط إنتاج اليوسفي 753.53 ألف طن. تشير النتائج إلى أن متوسط الكفاءة الفنية لإنتاج البرتقال و اليوسفي أكثر من 90 % خلال الفترة المدروسة. توصي الدراسة بزيادة المساحات المزروعة و تحسين التكنولوجيا لإنتاج البرتقال واليوسفي في مصر؛ أن تشجع الحكومة المزارعين في مختلف المحافظات على إنتاج المحاصيل الأكثر كفاءة في محافظاتهم.

الكلمات الدالة: البرتقال، اليوسفي، الكفاءة