

Stochastic Frontier Analysis for Potatoes in Egypt and Spain

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ABSTRACT

The study has focused on estimate the technical efficiency of potatoes production in Egypt and compares it with Spain during the time period 1995-2013. The study applies the stochastic frontier approach for efficiency measurement and the specification of Battese and Coelli (1992) is employed. The results indicate that the technical efficiency in Egypt and Spain makes clear improving during 1995-2013.

INTRODUCTION

Potatoes are a major crop in Egypt and contribute immensely to human nutrition and food security (Karim, *et al.*, 2010). The weather conditions during growing seasons and farm management are considered one of the most important constrains on the ability to increase production (Amadi, *et al.*, 2009). There are three major cultivation seasons for potato in Egypt; Summer season cultivated during December and January, Nili season cultivated during late September and early October and winter season cultivated during late October and early November. Early potatoes from the EU's and non EU's Mediterranean area (Spain, Italy, Cyprus, Greece, Malta, Portugal, Morocco, Israel and Egypt) are harvested and then commercialized in the first semester of the calendar year while the season of earlier obtained in the Continental and Northern part of Europe starts in late May-June and has its pick in July-August (EC, 2007).

Problem and Objective of the Study

The production of potatoes in Egypt during the time period 1995-2013 shows decreasing in some years. The study aims to estimate the Maximum Likelihood (ML) and the technical efficiency (TE) of potatoes production in Egypt and compare it with Spain during the time period 1995-2013.

Methodology

For the panel data, a stochastic frontier production function can be expressed as follows:

$$Q_{it} = f(A_{it}, t; \alpha) e^{v_{it} - u_{it}}, \quad (1)$$

Where Q_{it} is the production of the i -th country in the t -th time period; A_{it} is a vector of input quantities of the i -th country in the t -th time period; t is the time trend index; α is a vector of unknown parameters to be estimated; v_{it} is a vector of random variables which are assumed to be iid. $N(0, \sigma_v^2)$ and independent of u_{it} ; and u_{it} is a vector of non-negative random variables which are assumed to account for technical inefficiency in production and are often assumed to be iid. $|N(0, \sigma_u^2)|$. Specifically, u_{it} is a vector of random disturbances. We can express technical efficiency (TE) as:

$$TE_{it} = \frac{Q_{it}}{f(X_{it}, t, \alpha) e^{v_{it}}} = e^{-u_{it}} \quad (2)$$

From an empirical perspective, according to Coelli *et al.* (2003) and Lambarraa *et al.* (2007), the production frontier function (1) can be specified as a translog function. But the estimation of production frontier function depends

on the distributional assumptions of u_{it} . The proposed stochastic frontier production function of Battese and Coelli (1992) is:

$$u_{it} = u_i \exp(-\eta[t - T]), \quad (3)$$

Where u_{it} are non-negative random variables which are assumed to account for technical inefficiency in production and are assumed to be iid. as truncations at zero of the $N(u, \sigma_u^2)$ distribution; and η is a parameter to be estimated. The production inputs comprise area of potatoes, while the output is production of potatoes. Potatoes production is expressed in thousand ton and potatoes area in thousand hectare.

RESULTS AND DISCUSSION

Table (1) and figure (1) show the potatoes production in Egypt and Spain during the time period 1995-2013. The minimum value of potatoes production in Egypt is 1769.91 thousand ton in 2000 and in Spain it is 2145.17 thousand ton in 2008, while the maximum value of potatoes production in Egypt is 4758.04 thousand ton in 2012 and in Spain it is 3913.80 thousand ton in 1995. The mean of potatoes production for the time period 1995-2013 in Egypt is 2817.74 thousand ton and in Spain it is 2825.24 thousand ton. The annual average percentage growth rate at the time period 1995-2014 for Egypt is 2.79% and for Spain is declining -3.15%.

Table 1. Potatoes Production in Egypt and Spain (1995-2013).

Year	Potatoes Production in Egypt (Thousand Ton)	Potatoes Production in Spain (Thousand Ton)
1995	2599.10	3913.80
1996	2626.02	3855.80
1997	1802.76	3253.94
1998	1984.01	3128.80
1999	1808.89	3367.40
2000	1769.91	3078.06
2001	1903.13	2992.42
2002	1985.32	3078.14
2003	2039.35	2664.96
2004	2546.61	2773.57
2005	3167.43	2563.46
2006	2312.79	2515.00
2007	2760.46	2479.58
2008	3567.05	2145.17
2009	3659.28	2719.29
2010	3643.22	2326.65
2011	4338.43	2455.10
2012	4758.04	2168.80
2013	4265.18	2199.60
Mean	2817.74	2825.24
Rate ^a	2.79	-3.15

Sources: FAOSTAT and own elaboration

(a) Annual average percentage growth rate (1995-2013)

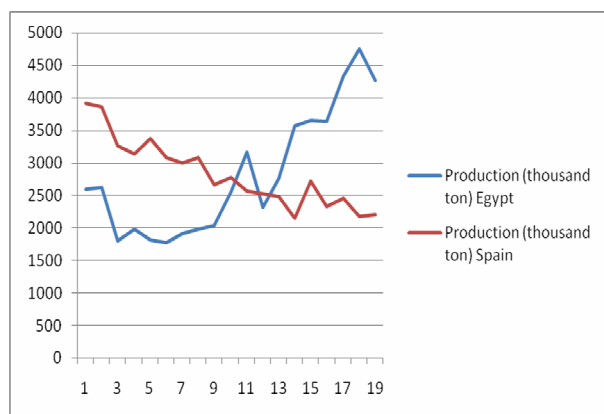


Figure 1. Potatoes Production in Egypt and Spain (1995-2013).

Source: own elaboration

Table (2) and figure (2) show the potatoes area in Egypt and Spain during the time period 1995-2013. The minimum value of potatoes area in Egypt is 75.02 thousand hectare in 2000 and in Spain it is 71.10 thousand hectare in 2013. The maximum value of potatoes area in Egypt is 177.19 thousand hectare in 2012 and in Spain it is 206 thousand hectare in 1995. The mean of potatoes area for the time period 1995-2013 in Egypt is 114.27 thousand hectare and in Spain it is 110.21 thousand hectare. The annual average percentage growth rate at the time period 1995-2014 for Egypt is 1.48% and for Spain is declining -5.74%.

Table 2. Potatoes Area in Egypt and Spain (1995-2013).

Year	Potatoes Area in Egypt (Thousand Hectare)	Potatoes Area in Spain (Thousand Hectare)
1995	123.04	206.00
1996	129.97	181.95
1997	82.56	150.08
1998	88.85	133.49
1999	77.66	136.10
2000	75.02	118.75
2001	79.72	115.13
2002	82.59	110.15
2003	82.85	101.10
2004	104.18	102.12
2005	126.28	95.00
2006	92.48	87.20
2007	107.95	85.73
2008	137.52	81.83
2009	138.48	85.37
2010	140.55	79.16
2011	164.14	79.87
2012	177.19	73.90
2013	160.18	71.10
Mean	114.27	110.21
Rate ^a	1.48	-5.74

Sources: FAOSTAT and own elaboration

(a) Annual average percentage growth rate (1995-2013)

Table (3) shows the potatoes seeds in Egypt and Spain during the time period 1995-2013. The minimum value of potatoes seeds in Egypt is 200 thousand ton in 2006, 2007 and in Spain it is 99 thousand ton in 2012, while the maximum value of potatoes seeds in Egypt is 516 thousand ton in 2012, 2013, and in Spain it is

273.70 thousand ton in 1995. The mean of potatoes seeds for the time period 1995-2013 in Egypt is 312.98 thousand ton and in Spain it is 152.92 thousand ton. The annual average percentage growth rate at the time period 1995-2014 for Egypt is 3.88% and for Spain is declining -5.44%.

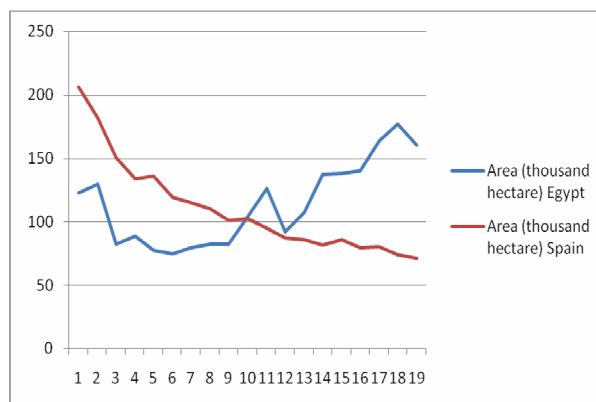


Figure 2. Potatoes Area in Egypt and Spain (1995-2013).

Source: own elaboration

Table (4) and figure (4) show the potatoes yield in Egypt and Spain during the time period 1995-2013. The minimum value of potatoes yield in Egypt is 20.20 ton/hectare in 1996 and in Spain it is 19 ton/hectare in 1995. The maximum value of potatoes yield in Egypt is 26.85 ton/hectare in 2012 and in Spain it is 31.85 ton/hectare in 2009. The mean of potatoes yield for the time period 1995-2013 in Egypt is 24.38 ton/hectare and in Spain it is 26.67 ton/hectare. The annual average percentage growth rate at the time period 1995-2013 for Egypt is 1.29% and for Spain it is 2.75%.

Table 3. Potatoes Seeds in Egypt and Spain (1995-2013).

Year	Potatoes Seeds in Egypt (Thousand Ton)	Potatoes Seeds in Spain (Thousand Ton)
1995	260.00	273.70
1996	263.00	261.51
1997	260.38	197.70
1998	290.38	193.07
1999	213.00	183.10
2000	215.84	183.10
2001	232.09	162.40
2002	235.00	157.30
2003	250.00	145.93
2004	240.00	136.30
2005	250.00	125.00
2006	200.00	123.00
2007	200.00	117.40
2008	407.00	121.40
2009	408.00	110.30
2010	476.00	111.70
2011	514.00	103.50
2012	516.00	99.00
2013	516.00	100.00
Mean	312.98	152.92
Rate ^a	3.88	-5.44

Sources: FAOSTAT and own elaboration

(a) Annual average percentage growth rate (1995-2013)

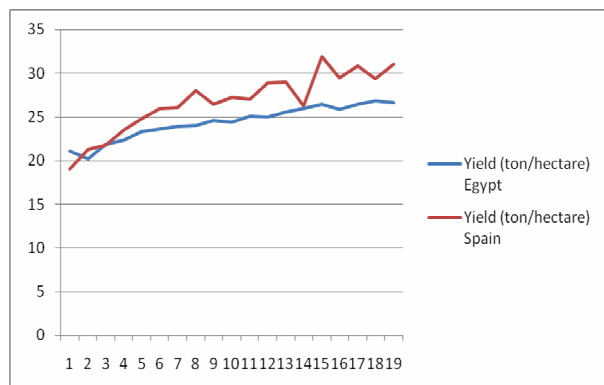


Figure 4. Potatoes Yield in Egypt and Spain (1995-2013). Source: own elaboration

Table 4. Potatoes Yield in Egypt and Spain (1995-2013).

Year	Potatoes Yield in Egypt (Ton/Hectare)	Potatoes Yield in Spain (Ton/Hectare)
1995	21.12	19.00
1996	20.20	21.19
1997	21.84	21.68
1998	22.33	23.44
1999	23.29	24.74
2000	23.59	25.92
2001	23.87	25.99
2002	24.04	27.95
2003	24.61	26.36
2004	24.44	27.16
2005	25.08	26.98
2006	25.01	28.84
2007	25.57	28.92
2008	25.94	26.22
2009	26.42	31.85
2010	25.92	29.39
2011	26.43	30.74
2012	26.85	29.35
2013	26.63	30.94
Mean	24.38	26.67
Rate ^a	1.29	2.75

Sources: FAOSTAT and own elaboration

(a) Annual average percentage growth rate (1995-2013)

Table (5) shows the ML estimates of Battese and Coelli (1992) specification for the potatoes production in Egypt and Spain during the time period 1995-2013. The coefficient of area (A_{it}) is positive and significant. The technical change (t) coefficient is positive and significant. As eta (η) value is statistically different from zero (it takes a positive value), this implies that technical inefficiency is not time-invariant; the level of technical efficiency improves in the analyzed period (as seen in table 6). The variance parameter, gamma (γ) has a positive value, which suggests the relevance of technical inefficiency in explaining output variability.

Table 5. ML of the Cobb-Douglas function (1995-2013).

Variables	Coefficients	Standard error	t-ratio
Constant	4.8	0.3526	13.612
$\ln A_{it}$	0.8692	0.0303	28.667
t_{-2}	0.0146	0.0027	5.4163
σ^2	0.0035	0.0027	1.3234
γ	0.5262	0.3577	1.4712
μ	0		
η	0.0414	0.0415	0.9983
Log likelihood function	64.9286		
LR test	19.2217		

Source: Own elaboration

Table (6) and figure (6) show the TE estimates for potatoes production in Egypt and Spain during the time period 1995-2013. In Egypt TE of the time period 1995-2013 vary from 0.8822 in 1995 to 0.9422 in 2013 and the mean of the period is 0.9154. The annual average percentage growth rate is 0.3662%. In Spain TE of the time period 1995-2013 vary from 0.9802 in 1995 to 0.9905 in 2013 and the mean of the period is 0.9860. The annual average percentage growth rate is 0.0581%. TE in Egypt and Spain makes clear improving during 1995-2013.

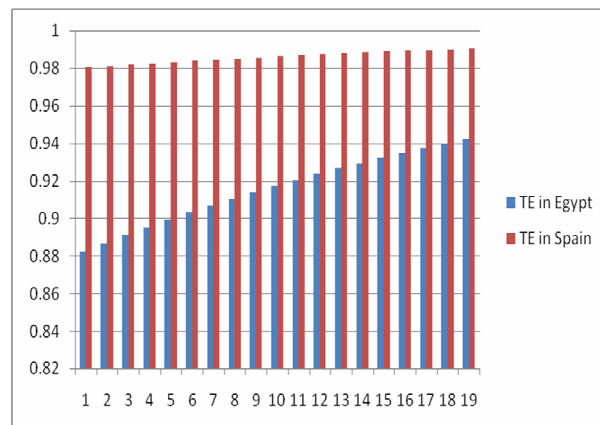


Figure 6. TE for Potatoes Production in Egypt and Spain (1995-2013). Source: own elaboration

Table 6. TE for Potatoes Production in Egypt and Spain (1995-2013).

Year	TE in Egypt	TE in Spain
1995	0.8822	0.9802
1996	0.8867	0.9810
1997	0.8910	0.9817
1998	0.8952	0.9825
1999	0.8992	0.9832
2000	0.9031	0.9839
2001	0.9069	0.9845
2002	0.9105	0.9851
2003	0.9139	0.9857
2004	0.9173	0.9863
2005	0.9205	0.9869
2006	0.9236	0.9874
2007	0.9266	0.9879
2008	0.9294	0.9884
2009	0.9322	0.9888
2010	0.9349	0.9893
2011	0.9374	0.9897
2012	0.9399	0.9901
2013	0.9422	0.9905
Mean	0.9154	0.9860
Rate ^a	0.3662	0.0581

Source: Own elaboration

(a) Annual average percentage growth rate (1995-2013)

CONCLUSION

There are three major cultivation seasons for potato in Egypt; Summer season cultivated during December and January, Nili season cultivated during late September and early October and winter season

cultivated during late October and early November. The study aims to estimate the Maximum Likelihood and the technical efficiency of potatoes production in Egypt and compare it with the technical efficiency of potatoes production in Spain during the time period 1995-2013. For the time period 1995-2013; the mean of potatoes production in Egypt is 2817.74 thousand ton and the annual average percentage growth rate is 2.79%. The mean of potatoes area in Egypt is 114.27 thousand hectare and the annual average percentage growth rate is 1.48%. The results indicate that ML estimates of Battese and Coelli (1992) specification for potatoes production in Egypt and Spain shows that the coefficient of area is positive and significant. The technical change coefficient is positive and significant. In Egypt, TE for 1995-2013 vary from 0.8822 in 1995 to 0.9422 in 2013, and the mean of the period is 0.9154. The annual average percentage growth rate is 0.3662%. The study recommends the increase the area of potatoes production; reclaim new agricultural areas; implement the land consolidation system to increase efficiency; improve the technology of potatoes production; and increase the research to get new potatoes varieties with higher productivity.

REFERENCES

Abou Hadid, A.F. (2015). Water requirements for potato production under climate change. *Global Journal of Advanced Research* 2(9): 1357-1375, ISSN: 2394-5788.

Amadi, C.O.E., Okonkwo, E.E.J.C., and Okocha, P.I. (2009). Inter-relationships between yield and yield attributes of potato grown under supra-optimal ambient temperatures. *Global Journal of Pure and Applied Sciences* 15: 5-14.

Battese, G.E., and Coelli, T.J. (1992). Frontier production function, technical efficiency and panel data: With application to paddy farmers in India. *Journal of Productivity Analysis* 3: 153-169.

Coelli T., Rahman S., and Thirtle, C. (2003). A stochastic frontier approach to total factor productivity measurement in Bangladesh crop agriculture, 1961-92. *Journal of International Development* 15: 321-333.

Coelli, T.J. (1996). A Guide to Frontier Version 4.1: A Computer Program for Stochastic

EC (2007). The Potato Sector in the European Union. Commission Staff Working Document. Commission of the European Communities, Brussels, SEC 533.

FAOSTAT (1995-2013). Statistics Division, Food and Agriculture Organization of the United Nations, Rome, Italy.

Farag, A.A., Abdrabbo, M. A., Gad El-Moula, M.M.H., McCarl, B.A., and

Frontier Production and Cost Function Estimation. CEPA Working Paper, No. 7/96, Centre for Efficiency and Productivity Analysis, University of New England, Armidale, Australia.

Karim, M.R., Hanif, M.M., Shahidullah, S.M., Rahman, A.H.M.A., Akanda, A.M., and Khair, A. (2010). Virus free seed potato production through sprout cutting technique under net-house. *African J. Biotech.* 9: 5852-5858.

Lambarraa, F., Serra, T., and Gil, J.M. (2007). Technical efficiency analysis and decomposition of productivity growth of Spanish olive farms. *Spanish Journal of Agricultural Research* 5 (3): 259-270.

تحليل استوكاستك للبطاطس في مصر وإسبانيا
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البطاطس محصول رئيسي في مصر وتسهم بشكل كبير في التغذية البشرية والأمن الغذائي. من اهداف هذه الدراسة تقدير الكفاءة الفنية لإنتاج البطاطس في مصر ومقارنتها بالكفاءة الفنية لإنتاج البطاطس في إسبانيا خلال الفترة الزمنية 1995-2013. في الفترة الزمنية 1995-2013؛ بلغ متوسط إنتاج البطاطس في مصر 2817.74 ألف طن ومعدل النمو السنوي 2.79%. بلغ متوسط مساحة البطاطس في مصر 114.27 ألف هكتار ومعدل النمو السنوي 1.48%. تشير النتائج إلى أن معامل الارض (المنطقة) إيجابي و معنوي وفقا للتوقعات السابقة، معامل التغير التقني إيجابي و معنوي. في مصر، تتفاوت الكفاءة الفنية للفترة 1995-2013 من مستوى أدنى يبلغ 0.8822 في عام 1995 إلى حد أقصى قدره 0.9422 في عام 2013 ومتوسط الفترة 0.9154، ومتوسط معدل النمو السنوي 0.3662%. توصي الدراسة بزيادة مساحة إنتاج البطاطس؛ استصلاح مناطق زراعية جديدة؛ تنفيذ نظام التجميع الحيازي لزيادة الكفاءة؛ تحسين تكنولوجيا إنتاج البطاطس؛ وزيادة البحوث للحصول على أصناف بطاطس جديدة ذات إنتاجية أعلى.