Minia J. of Agric. Res. & Develop.
Vol. (37), No. 1, pp. 13-23, 2017

FACULTY OF AGRICULTURE

A COMPARATIVE STUDY BETWEEN CONVENTIONAL AND ORGANIC HERBS AND SPICES FARMING IN EGYPT

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Received: 10 Jan. (2017) Accepted: 19 Feb. (2017)

ABSTRACT

The main purpose of this study is to compare the efficiency ratings of organic and conventional herbs and spices farms in the Egyptian delta. To do so, we use Stochastic Production Frontier (SPF) analysis with a Cobb-Douglas stochastic frontier model as a functional form specification for our data. Additionally, we study the factors affecting technical efficiency scores reflecting farmer and farm characteristics (i.e. farmer experience, type of soil and irrigation, location in different governorates as indicator of being located in a less favored area). Productivity differences between both agricultural practices are assessed by computing output elasticity of different inputs.

Our analysis adopts cross sectional, farm-level data collected from a random sample of 235 (135 organic and 100 conventional) farms that specialize in herbs and spices. Output elasticities of different inputs show that organic farms exhibit higher output elasticities than conventional farms. Labour and area are found to be the most productive factors in organic farming. Organic farmers, on average, are more technically efficient than their conventional counterparts (efficiency ratings are approximately 0.66 and 0.56, respectively). Hence, our results suggest that, by using available resources more efficiently and without changing current technology, organic (conventional) farms can increase their output by about 37% (46%). Concerning the factors influencing the technical efficiency, they are found to be relevant.

Keywords: technical efficiency, stochastic frontier analysis, Egypt, organic farms

INTRODUCTION

Herbs and spices (H&S) are commonly used as flavor for food and medicinal purposes as well. There are many similarities between H&S. The main difference between an herb and a spice is from where it is obtained on a plant. Herbs usually come from the leafy part of a plant; spices can be obtained from seeds, roots, or some other vegetative substance. Herbs have more uses than spices. For instance, herbs are used more frequently than spices for medicinal use, fragrance, cosmetics and flavoring. There are many H&S produced for many different growing markets. H&S are a minor but important constituent, increasing a little the cost of the food in which they are used. Demand is relatively inelastic to price changes (CBI, 2015; Sallam and Shelaby, 2011).

In 2014, the EU imports of H&S reached 533 thousand tons with a value of € 1.9 billion. The volume of imports increased on average by 3.8% per year between 2010 and 2014, and the imports value has increased by 10% per year. Western Europe is considered the largest consumer of H&S followed by Eastern Europe; UK, Germany, Romania and Hungary, are the largest consumers of H&S for the period 2010 to 2013, respectively. Imports from developing countries[1] reached 302 thousand tons, which represents 57% of total EU with the largest importers Netherlands, Germany, UK and Spain, respectively (CBI, 2015). Developing countries are the source of almost all spices traded in the EU, and after importing there is a substantial intra-EU trade for these products. The main products imported from developing countries were capsicums (25% of imported volume), ginger 23% and pepper 21%. Spices prices imported from developing countries increased on average by 6.8% per year for the period 2010 and 2014. The prices for different products increased by vanilla (24% per year), pepper 20%, cloves 20% and cinnamon 10%. The overall upward price trend is due to the growing global demand (CBI, 2015).

The objective of this paper is to compare the technical efficiency (TE) between organic and conventional herbs and spices farms in Egypt using the Stochastic Production Frontier (SPF) methodology. The contribution of this work is twofold: first, it focuses on the Egyptian agricultural farming, in contrast to the predominant literature; developing countries have not received much attention. Second, despite the current relevant increase of organic farming in Egypt, the literature on the TE of organic farming is scarce. This paper contributes to the scarce literature on organic farming in Egypt by carrying out a comparative study of TE scores for organic and conventional herbs and spices farms. Assessing technical efficiency scores helps in identifying whether economic

[1] For a list of developing countries, see the OECD DAC list

agents use their resources optimally to achieve the production objectives.

INDUSTRY ANALYSIS

The production of H&S in Egypt is concentrated in middle Egypt. As for cultivated areas, it ranges from 5 to 200 feddans (1 feddan = 4200m^2) depending on the type of farm whether it is family farming or private sector agribusiness. This has forced exporters and processors not to deal directly with farmers for the small areas of cultivation, but rather deal with local traders who collect the produce from many farmers. Taking into consideration marketing channels are characterized by transport without refrigeration; hence, products have short shelf lives. These local traders have requested quality standards from farmers for exporters the Global GAP and EC834/2007. The most important products produced in Egypt are fennel, marjoram, basil, mint, and chamomile. H&S cultivation in Egypt is for exportation in the first place, since 80% go to exporting purposes and only 20% of the production is marketed in the Egyptian market. Almost 80% of H&S produced in Egypt from conventional practices and only 20% is from organic practices. This is because of the high cost of organic certification, in addition to that, organic farms yield less produce and require more elaborate skills not available in most parts of Egypt (Sallam and Shelaby, 2011).

Organic agriculture in Egypt is growing rapidly due to the increased public awareness of the benefits associated to this production system, in addition to, the growing demand for organic food and fibres in both the domestic and export markets. Consequently, organic farming cultivate area in Egypt has increased from 15 thousand hectares operated by 460 organic farms in 2006 to 85.8 thousand hectares operated by 790 producers in 2012 (FiBL and IFOAM, 2016). About half of the organic farms in Egypt are located in the middle Egypt, especially in Fayoum governorate. Egyptian Organic farms are generally smallholdings, on average, ranges from 4.5 to 20 hectares. A few Agribusinesses are larger than 1000 Feddan, but they account for 20% of all organic farmland and are located in the Nile delta and in Upper Egypt (Kledal et al., 2008; Guesmi *et al.*, 2014).

METHODOLOGY

The assessment of farm Technical Efficiency (TE) and the factors that illustrates TE provides valuable information to enhance farm management and economic performance. Avoiding sources of inefficiency and waste of resources is necessary for economic sustainability. Generally, a farmer who operates with a high TE level obtains economic results better than a farmer who does not. In this regard, productive efficiency studies have important effects on economic performance, technological innovation and the overall input use in the agricultural sector.

There are two leading approaches extensively used to estimate TE: parametric Stochastic Frontier Analysis (SFA) or deterministic frontier analyses and non-parametric approaches like Data Envelopment Analysis (DEA). Non-parametric techniques are more flexible than parametric approaches because they can be applied without knowing the proper specification of the functional form describing the production function. However, they do not allow to distinct inefficiency effects from random noise. SFA was first introduced simultaneously by Aigner *et al.*, (1977) and Meeusen and Van den Broeck (1997); in their model, they differentiated between exogenous shocks outside the firm's control and inefficiency. In contrast to DEA and Deterministic Frontier Analyses, SFA accounts for random noise and can be used to conduct conventional tests of hypotheses. The general model is specified as:

$$y_i = f(X_i;\beta)\ exp(e_i);\ e_i = v_i - u_i, i = 1,2,\dots,N \quad (1)$$

where, y_i represents the level of output and *i*-th observation (farm); X is the vector of input quantities used by the i-th farm in the production process; β is the vector of parameters to be estimated; and f (X_i; β) is a suitable functional form for the frontier, we adopt the cobb-Douglas functional form in our analysis. From a statistical point of view, the error term e_i in model (1) can be decomposed into two components, u_i and v_i; it is assumed that u_i and v_i are independently distributed from each other.

The first part, v_i is a standard random variable capturing the random noise that arises from (a) the unintended omission of relevant variables from vector X_i (Oude Lansink *et al.*, 2002); (b) from measurement errors and approximation errors associated with the choice of the functional form; (c) unexpected changes in production (weather influences, for example); and (d) other factors that are not under the control of the farm. The first part v_i is usually assumed to be symmetric, independent and identically distributed as N (0, σ^2). The random error v_i can be positive or negative and so the stochastic output can vary about the deterministic part of the model (1). The second part, u_i, is a one-sided, non-negative random variable representing the stochastic shortfall of the i-th farm output from its production frontier, because of the existence of technical inefficiency. The definition of TE is based upon the distance of the firm from the production frontier. Depending on the selection of the reference to measure efficiency, two different efficiency measures can be distinguished (Kumbhakar and Lovell, 2000). First, the input-oriented approach, referred to as Shephard-type measure, is defined as the ratio of the minimum feasible to observed input use, given the production technology and the level of output. Second, the output-oriented measure, referred to as a Debreu-type of measure, is defined as the relation of the observed to maximum feasible output, given the inputs use and production technology.

Both measures are identical under constant returns to scale (Färe and Lovell, 1978). In contrast to vi, several specifications of density distribution have been proposed for ui. The most common specifications are the half-normal, gamma, exponential, and truncated normal distributions. The truncated normal and gamma models allow for a wider range of distributional shapes. Battese and Coelli (1995) suggested that the use of a single-stage approach yields more consistent and robust results than using the two-stage estimation procedure, which is inconsistent in its assumption regarding independence of the inefficiency effects. These authors proposed the following TE effects model:

$$u_i = \delta_o + \sum_{m=1}^{M} \delta_m Z_{mi} + \varepsilon_i \qquad (2)$$

where (Z_{mi}) are farm-specific variables associated with technical inefficiencies; δ_0 and δ_m are parameters to be estimated; and ε_i is a random variable with zero mean and finite variance ($\boldsymbol{\sigma}_\varepsilon^2$) defined by the truncation of the normal distribution such that:

$$\varepsilon_i \geq -[\delta_o + \sum_{m=1}^{M} \delta_m Z_{mi}] \qquad (3)$$

The mean of (u_i), is farm-specific while the variance components are assumed to be equal ($\sigma_u^2 = \sigma_\varepsilon^2$). The model formulation (2) recognises and explains sources of inefficiency that change among farmers. The output oriented measure of TE can be stated as the ratio of observed output to the corresponding stochastic frontier output, the measure takes a value between 0 and 1:

$$\mathrm{TE_i} = \frac{y_i}{f\left(\mathbf{X}_i;\boldsymbol{\beta}\right)\exp\left(v_i\right)} = \frac{f\left(\mathbf{X}_i;\boldsymbol{\beta}\right)\exp\left(v_i\right)\exp\left(-u_i\right)}{f\left(\mathbf{X}_i;\boldsymbol{\beta}\right)\exp\left(v_i\right)} = \exp\left(-u_i\right) \qquad (4)$$

Different procedures have been used in the literature to estimate the model presented above, the widely used procedures are Maximum Likelihood (ML) and Corrected Ordinary Least Squares (COLS) techniques. Battese and Coelli (1995) suggested the use of ML, showing that this estimator outperforms the COLS estimator in the case when the influence of the inefficiency error to the total error term is large. We estimate the parameters of the model defined by (1) and (2) by ML. The log likelihood function to be maximized for a sample of *i* producers is specified as:

$$\ln \mathrm{L} = \mathrm{constant} - \frac{1}{2}\ln(\sigma_u^2 + \sigma_v^2) - \sum_i \ln \Phi\left(\frac{u_i}{\sigma_u}\right) + \sum_i \ln \Phi\left(\frac{u_i^*}{\sigma^*}\right) - \frac{1}{2}\sum_i \ln \frac{(\varepsilon_i + u_i)^2}{\sigma_u^2 + \sigma_v^2} \qquad (5)$$

As is usual, the variance parameters of the likelihood function are estimated in terms of $\sigma^2 = \sigma_u^2 + \sigma_v^2$ and $\gamma = \sigma_u^2/\sigma^2$ following (Battese and Corra, 1977); when γ is closer to one, deviations from the frontier are mainly due to the technical inefficiency effects. Conversely, when γ is close to zero, the deviations are mainly due to noise and the average response production function is an adequate representation of the data. On the other hand, one should note that γ cannot be interpreted as the ratio of the variance of the technical inefficiency term to the total residual variance. The variance of u_i is equal to $\gamma[(\pi-2)/\pi]\sigma^2$ not σ_u^2. As a result, the relative contribution of inefficiency effects to the total variance γ^* is equal to $\gamma^* = \gamma/\left[\gamma + \frac{1-\gamma}{\pi/(\pi-2)}\right]$ following (Coelli et al., 1998).

RESULTS

Cross sectional data is used in the analysis, data are collected from a sample via a face-to-face interviews with farmers located in Fayoum, Sharkia, Behera and Kafr ElShiekh governorates for winter 2015, specialized in organic and conventional production of herbs and spices. The data collected represent farm and farmer's characteristics to be used in the assessment of technical efficiency for the conventional and organic farms. A sample of 235 farms were collected which consists of 135 organic farms and 100 conventional farms. The identification of the organic farms was based on a list of certified organic farmers obtained from ECOA[2]. Analysis was carried out using STATA 11 software. The Cobb-Douglas production function and the inefficiency models were estimated in one-step.

The variables included in the production function, the dependent variable (Yi) representing total production of herbs measured in tons, and the factors of production are cultivated area (X1) measured in feddan, labour (X2) measured in the number of hours per year, the expenditure on fertilizers and pesticides (X3) measured in Egyptian pounds. Livestock (X4) measured as the number of animal heads used in the farm. While the variables of the inefficiency equation are farmers' experience (Z1) measured as the number of years dedicated to agriculture, (Z2) a dummy reflect the Clay soil and (Z3) a dummy that reflect the loamy soil, the base is the sandy soil. (Z4) a dummy that reflect the drip irrigation system, (Z5) a dummy that reflect the Sprinkler irrigation system, the base is surface irrigation. (Z6) a dummy that reflect Behera governorate, (Z7) a dummy that reflect Fayoum governorate, (Z8) a dummy reflect Ismaillia governorate, the base is Beni Suif governorate.

Descriptive statistics for the production structure of conventional and organic farms are presented in table (1). The average yield for conventional farms is 1.5 tons compared with 1.7 tons per feddan in organic farms. The average cultivated area in organic farms is 50 feddans while 20 feddan in conventional farms. According to the results in table (2), the Cobb-Douglas production function estimates indicate that increasing the cultivated area, labour and livestock in both organic and conventional farms will lead to the increase in herbs output with cultivated area being the

[2] The Egyptian Center of Organic Agriculture (ECOA) is a domestic certification body for different types organic farming certifications.

largest contributor. While fertilizer and crop protection inputs and livestock are found to be relevant in conventional farms only, this is expected since organic farms have increased their consumption bio fertilizers.

According to table (3), farmers with more experience will be more technically efficient, that is TE increases with skills and practice of farmer with experience has more effect in organic farms than conventional farms. The results also show that TE can be affected by soil type, irrigation system and location in different governorates. In organic farms, loamy and clay soil improve the technically efficient compared with the base category which is the sandy soils. The dummy variable that reflects the irrigation system shows that drip and sprinkler systems are more technically efficient than the base category that is the surface irrigation. Regarding the location of farms, results show that organic farms located in lower Egypt are more technically efficient than upper Egypt.

According to table (4), TE scores for conventional and organic farms are calculated as an output-oriented measure following Battese and Coelli (1995). The average technical efficiency score is 54% for conventional farms and 63% for organic farms. Moreover, these technical efficiencies range from a minimum of 20% for conventional farmers to and 41% for organic to a maximum of 93% for conventional and 98% for organic farms. The results indicate that if organic farms will effectively use available resources and at the current technology it will be able to increase the output by 37% on average. Improving TE levels can reduce production costs and improve the economic viability of farms.

Improving efficiency may encompasses upgrading farm operational activities, developing policies from the government and scientific research. At the research level, further analysis will help to identify other inefficiency causes, as well as their effect on efficiency with attention on those reasons that cause higher impacts on efficiency and they should be the ones receiving further focus by farm managers and policy makers. Refined methods including risk attitudes may allow more accurate efficiency estimates.

CONCLUSIONS

The objective of this study is to compare the efficiency scores of organic and conventional herbs and spices farms in Egypt and to attempt to identify the factors that affect technical efficiency levels. Productivity differences between the two agricultural practices are also measured by means of calculating the output elasticity of different inputs. To do so, we use the Stochastic Production Frontier (SPF) methodology. Results derived from the SFA permit comparing output elasticity for different inputs between the two groups. The study shows that organic farms, exhibit higher partial output elasticities for cultivated area, labour and livestock except fertilizer and pesticides compared to conventional farms.

The results derive some interesting policy implications. Organic farms are more technically efficient than conventional farms, since high technical efficiency is a prerequisite for economic efficiency (Tzouvelekas et al., 2001), this will provide incentives for more farms to adopt organic practices, which will lead to more production and access to export market with price premiums. Additionally, to promote organic production practices, strategies intended for information provision, extension services, education and training activities and providing financial assistance for farmers to adopt organic production.

Table 1: Descriptive stats of farms' production and inputs

Variable	Unit	Conventional farms average	Organic farms Average
Yield	Ton/fed.	1.5	1.7
Area	Fed.	20	50
Labour	Hours/fed	1210	1350
livestock	No. of heads	15	43
Fertilizers and pesticides	L.E/fed	1715	1197

Table 2: ML estimates for SPF parameters for conventional and organic data

Variables	Conventional Farms Estimate	Organic Farms Estimate
Cultivated area (X1)	0.616***(0.104)	0.881*** (0.033)
Labour (X2)	0.008(0.048)	0.055***(0.009)
fertilizer and pesticides (X3)	0.110***(0.067)	0.009 (0.005)
Livestock (X4)	0.087***(0.021)	0.045***(0.003)

*** indicate statistical significance at the 1%.
Standard errors in parenthesis

Table 3: ML estimates of the inefficiency effects model for both farms data

Variable	Conventional Farms Estimate	Organic Farms Estimate
Experience (Z1)	-0.073*(0.040)	-0.114***(0.053)
Soil1 (Clay soil) (Z2)	-0.109(0.229)	-0.505*(0.278)
Soil2 (Loamy) (Z3)	-0.150(0.190)	-0.499***(0.207)
Irrigation2 (Drip irrigation) (Z4)	-0.270(0.293)	-0.101***(0.020)
Irrigation3 (Sprinkler irrigation) (Z5)	-0.067(0.273)	-0.399(0.362)
Governorate1 (Behera gov.) (Z6)	-0.044*(0.026)	-0.553***(0.263)
Governorate2 (Fayoum gov.) (Z7)	-0.219**(0.110)	-0.182***(0.082)
Governorate3 (Ismaillia gov.) (Z8)	-0.171(0.274)	-0.842***(0.397)
$\sigma^2 = \sigma_u^2 + \sigma_v^2$	0.254	0.214
$\gamma = \sigma_u^2/\sigma^2$	0.780	0.481
Log likelihood function	-46.067	-48.216

***, (**), [*] indicate statistical significance at the 1%,(5%),[10%].
Standard error in parenthesis

Table 4. Frequency distribution of technical efficiency for farms

TE-Range (%)	Conventional	(%)	Organic	(%)
0-20	0	0	0	0
20-40	10	10	0	0
40-60	27	27	64	48.5
60-80	37	37	27	20.5
80-100	26	26	41	31
Total of sample	100	100	132	100
Mean efficiency	0.54	----	0.63	----
Minimum	0.20	----	0.413	----
Maximum	0.930	----	0.985	----

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دراسة مقارنة بين الزراعة التقليدية والعضوية للاعشاب والتوابل في مصر

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تهدف هذه الدراسة الى مقارنة الكفاءة الفنية للمزارع العضوية والتقليدية المنتجة للأعشاب والتوابل في الدلتا المصرية. ولتحقيق ذلك، أستخدم تحليل Stochastic Production Frontier مع استخدام شكل الدالة كوب دوغلاس لبياناتنا. بالإضافة إلى ذلك، دراست العوامل التي تؤثر على درجات الكفاءة التقنية مثل خصائص المزارعين والمزارع (مثل خبرة المزارعين ونوع التربة والري والموقع في مختلف المحافظات كمؤشر على وجودها في منطقة أقل خدمية). حيث تم تقييم الفروق الإنتاجية بين كل من الممارسات الزراعية من خلال حساب مرونة الانتاج من المدخلات المختلفة.

أعتمد التحليل على البيانات االأولية على مستوى المزرعة التي تم جمعها من عينة عشوائية حجمها 235 مزرعة (135 مزرعة عضوية و 100 مزرعة تقليدية) متخصصة في انتاج الأعشاب والتوابل. وأظهرت مرونة الإنتاج من المدخلات المختلفة أن المزارع العضوية ذات مرونة إنتاجية أعلى مقارنة بالمزارع التقليدية. يعتبر العمل والمنطقة أكثر العوامل إنتاجية في الزراعة العضوية. والمزارعون بالاسلوب الإنتاج العضوي، في المتوسط، أكثر كفاءة من الناحية التقنية من نظرائهم التقليديين (تبلغ تقديرات الكفاءة حوالي 0.66 و 0.56 على التوالي). ومن ثم، تشير نتائج البحث إلى أن المزارع العضوية (التقليدية) يمكن أن تزيد من إنتاجها بنحو 37٪ (46٪)، وذلك باستخدام الموارد المتاحة بكفاءة أكبر ودون تغيير التكنولوجيا الحالية. وفيما يتعلق بالعوامل المؤثرة على الكفاءة التقنية، وجد أن لها تاثير معنوي احصائيا .