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Technical Efficiency of Olive Growing Farms in Tunisia and Potential Demand for Olive Oil in Japan

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Abstract: In the face of growing international competitiveness, one of the main challenges for olive seeds and olive oil sector in Tunisia is the enhancement of productivity and the level of technology as well as open up non-traditional, emerging markets such as Japan. This study investigates firm level technical efficiency of production and its determinants in a sample of olive growing farms in Tunisia. It also explores the Japanese consumer behavior on olive oil and their potential demand in Japan. Results suggest olive growing farms in Tunisia can increase their production on an average by 29.8% through more efficient use of technology and production inputs. The irrigated olive farms are efficient, and introduction of the irrigation technique and the selection of variety such as Chétoui and Chemlali significantly contribute to upgrade the technical efficiency. Japanese consumers prefer on extra-virgin and virgin to olive oil, sweet taste and green color products with the price between 800 to 1000 Yen per 500 ml, and showed higher preference on olive oil that contains high concentration of polyphenol.

Key Words: Consumer behavior, Japan, Olive growing farms, Technical efficiency, Tunisia

1. Introduction

The olive oil constitutes an important part of the Tunisian export, accounting for 120,000 tons per year and representing 70% of total production. Tunisia occupies the fourth position as olive oil exporter preceded by Spain, Italy and Greece; however most of the olive oil is exported by bulk (99%). While Tunisian government sought to increase bottled olive oil exports up to 10% of total exports, this goal has not been achieved.

On the other hand, olive oil consumption in Japan showed an increasing trend during the last two decades due to dietary and health concerns. According to the official statistics, the volume of import of olive oil in Japan skyrocketed after the mid-90s. The origin of import was diversified during the 90s including Greece, France, Portugal, US, Turkey and Tunisia, however almost 99% of the import was from Spain and Italy (Japan Tariff Association, 2007).

In the face of growing international competitiveness, traditional olive oil producing countries such as Italy, Spain and Tunisia may have interest to strengthen their penetration in the Japanese market. For Tunisia as one of the main exporters of olive oil, the main challenge for the olive oil sector is to enhance the level of productivity and efficiency as well as to expand export destination to non-traditional emerging markets such as Japan. Investigation on the technical efficiency of olive oil production as well as its marketing for designing preferable product may provide valuable insights into potential improvement of productivity and export capacity.

A few studies are found in the literature of productivity analysis on production of olive seeds and olive oil. In Tunisia, Lachaal *et al.* (2005) analysed productivity and technical efficiency of the olive growing farms. Although the majority investigated the level of technical efficiency itself, few studies has focused on the effect of non-conventional inputs such as irrigation and varieties as factors to improve technical efficiency. Regarding the consumption analysis on olive oil, few studies, except Mtimet *et al.* (2009), focus on Japanese olive oil market. While Mtimet *et al.* (2009) investigated the olive oil consumer behaviour; healthy attribute of olive oil was not explicitly examined. Abaza *et al.* (2005) and Yamada *et al.* (2008) detected biological functions for cosmetic, medical and medicinal use in the extract of Tunisian olive oil in particular by applying the bioassay technique.

This study investigates firm level technical efficiency of production and its determinants in a sample of olive growing farms in Tunisia. Effects of the introduction of irrigation and difference in varieties on technical efficiency are explicitly examined. Also, this study examines Japanese olive oil consumer behaviour by using the conjoint analysis technique. Healthy attribute of olive oil indicated by the components of polyphenol was introduced in the product design. The objective is to identify the sources of technical efficiency of olive growing farmers in the first. Second, the factors determined the variations of technical efficiency among the olive growing farmers are identified. Third, consumer behavior on olive oil with different attributes is analyzed in Japan.

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2. Models

2.1. Technical efficiency

In this paper, the Battese and Coelli (1995) model of stochastic frontier production function is applied in the context of cross-sectional data. Assuming a Cobb-Douglas form, a standard production function is written as follows:

$$Y_i = \alpha K_i^{\beta_k} L_i^{\beta_l} M_i^{\beta_m} O_i^{\beta_o} e^{v_i - u_i}, \tag{1}$$

where α = exp(β_0); Y_i denotes olive production expressed in ton; K_i is the number of agricultural machinery (tractors, cultivators, sprayer) utilized in the production; L_i denotes the number of days of family and hired labour used; M_i is the volume of intermediate inputs (costs of fertilizer, pesticides, ploughing, water and other expenses measured by Tunisan Dinar) devoted to olive production; O_i denotes the number of olive trees; β_I (i = 0, k, l, m, o) is an unknown parameter to be estimated; v_i refers to statistical random disturbance terms, assumed to be an independently and identically distributed N (0, σ_v^2). u_i represents non-negative random variables, assumed to be iid as N (0, σ_u^2) with truncations at zero.

This model is specified in logarithmic form, as in (2).

$$\ln Y_i = \beta_0 + \beta_k \ln K_i + \beta_l \ln L_i + \beta_m \ln M_i + \beta_o \ln O_i + v_i - u_i, \tag{2}$$

In this specification, exp ($-u_i$), varies between 0 and 1, is a measure of technical efficiency of the ith farm. Following Battese and Coelli (1995), the technical efficiency of production of the ith farm is defined by the ratio of the observed output to the corresponding frontier output:

$$TE_i = \exp(-u_i), \quad 0 \le TE_i \le 1. \tag{3}$$

To investigate the relationship between technical efficiency and nonconventional inputs, the technical efficiency of ith farm can be endogenised as follows:

$$\begin{aligned} TE_i &= \delta_0 + \delta_1 IRR_i + \delta_2 EDU_i + \delta_3 TEC_i + \delta_4 LND_i \\ &\quad + \delta_5 D_{CT\,i} + \delta_6 D_{CMi} + \delta_7 D_{OFi} + w_i, \end{aligned} \tag{4}$$

where δ_i $(i = 0 \ldots 7)$ is an unknown parameter to be estimated; IRR is the share of irrigated olive trees to total; EDU is the discrete variable that represents the level of education of employee on a scale of 1 to 5 (1: illiterate, 2: quranic education, 3: primary, 4: secondary, 5: university); TEC is the discrete variable that represents the level of technology on a scale of 1 to 3 (1: traditional, 2: modern, 3: advanced); LND denotes total area of land devoted to olive cultivation; D_{CT} is the dummy variable of Chétoui variety that equals 1 if the farm cultivates this variety and zero if otherwise; D_{CM} is the dummy variable of Chemlali variety that equals 1 if the farm cultivates this variety and zero if otherwise; D_{OF} is the dummy of off-farm that equals 1 if the farm engages in off-farm activities and zero if otherwise; w_i represents the error term.

2.2. Conjoint analysis

The conceptual foundation of conjoint analysis arises from Lancaster (1966). Krystallis and Ness (2003), empirically applied this framework to the analysis on olive oil consumption. Following Mtimet *et al.* (2009), an ordered probit model has been selected for estimation. The model is built around a latent regression as follows:

$$y_i^* = \lambda x_i + \varepsilon_i, \tag{5}$$

where y^*_i denotes unobserved dependent variable; λ is a vector of unknown parameters to be estimated; x_i is the vector of independent variables, which corresponds in this study to the olive oil attributes; ε_i is the error terms vector assumed to be a normal distribution. As y^*_i is unobserved, what we do observe is the ranking variable y_i:

$$y_i = 1 \quad \text{if} \quad -\infty \le y^* \le \mu_1, y_i = 2 \quad \text{if} \quad \mu_1 \le y^* \le \mu_2,$$
$$y_i = 3 \quad \text{if} \quad \mu_2 \le y^* \le \mu_3, \ldots.. y_i = 8 \quad \text{if} \quad \mu_7 \le y^*, \tag{6}$$

where μ_j ($0 \le \mu_1 < \mu_2 < \ldots < \mu_{j-1}$) are unknown parameters (thresholds) to be estimated with λ.

3. Data

3.1. Technical efficiency of olive growing farms in Tunisia

The data used in this study were drawn from a survey conducted in Tunisia in February and Mach 2011. The olive growing farms surveyed were located in the northern governorate (Beja) of the country. The olive growing farms were randomly selected and the questionnaires were directed to the owner of olive growing farms. In total, 40 questionnaires were completed.

3.2. Olive oil consumer behavior in Japan

The survey was conducted by the NTT Resonant Inc. which provides internet research services in Japan. Randomly selected 3127 monitors were questioned through the web-questionnaire during the last week of March 2011. A total sample of 532 persons responded to the questionnaire.

The conjoint cards were described by six attributes: country of origin, price, olive oil type, taste, colour and component (**Table 1**). The choice of these attributes was based on the analysis on Tunisian olive oil by Abaza *et al.* (2005) and Yamada *et al.* (2008). The combination of the six attributes corresponding to a total number of 384 hypothetical products. To reduce the number of cards, an orthogonal design procedure (SPSS. 13) is used to lead a final design with 16 products. To avoid respondents' fatigue, we blocked the 16 cards into two groups with 8 cards each.

Table 1. Selected olive oil attributes and their corresponding levels.

Attributes	Levels
Region of origin	Italy
	Spain
	Tunisia
	Mediterranean
Price (500 ml bottle)	600 Yen
	800 Yen
	1000 Yen
	1200 Yen
Olive oil type	Extra virgin
	Virgin
	Olive oil(refined)
Taste	Bitter
	Sweet
Colour	Green
	Yellow
Component	High polyphenol
	Low polyphenol

Table 2. Parameter estimates and *t*-values of the stochastic frontier production function of a sample of olive growing farms in Tunisia. *, **, *** indicate significant at the 10% level, 5% level, 1% level, respectively.

Independent variables	Estimates	*t*-values
Constant	−6.130***	−22.272
ln *K*	0.070*	1.703
ln *L*	−0.107	−0.882
ln *M*	0.207***	3.211
ln *O*	1.021***	8.949
Variance parameters		
σ^2	0.273***	3.423
γ	0.940***	16.632
Log-likelihood	−10.002	

4. Results and Discussion

4.1. Technical efficiency of olive growing farms in Tunisia

Maximum likelihood estimates of the parameters of the stochastic frontier production are obtained using the computer program FRONTIER 4.1. In **Table 2**, estimated coefficients of number of agricultural machinery, intermediate inputs and the number of olive trees are positive and statistically significant. The negative coefficient of the labour input is insignificant. The estimate of variance parameter, γ, is positive and statistically significant at 1% level. Thus, the stochastic frontier function is empirically justified.

In **Table 3**, the average level of technical efficiency is 70.2%, ranging from a minimum of 31.6% to a maximum of 93.9%. Twenty three farms represented 57.5% in the sample are more efficient than the average; however 7.5% of the sample shows relatively inefficient with the scores showed less than 40%. These results suggest the possibility of enhancing efficiency for upgrading the productivity and competitiveness.

The OLS estimation results to investigate the relationship between technical efficiency and nonconventional inputs are presented in **Table 4**. The estimated coefficient of the rate of irrigated olive trees is positive and statistically significant. This result clearly indicates that the irrigation of olive trees contributes to increases in technical efficiency. The positive sign of the dummy variable of Chétoui (D_{CT}) and Chemlali

Table 3. Frequency distribution of technical efficiency for a sample of olive growing farms in Tunisia.

Technical efficiency (%)	Number of Farms	Percentage
0 < TE ≤ 40	3	7.50
40 < TE ≤ 70	14	35.00
70 < TE ≤ 100	23	57.50
Mean efficiency	70.2	
Min. efficiency	31.6	
Max. efficiency	93.9	

Table 4. Parameter estimates and *t*-values of sources of variation in technical efficiency of a sample of olive growing farms in Tunisia. *, **, *** indicate significant at the 10% level, 5% level, 1% level, respectively.

Independent variables	Estimates	*t*-values
Constant	0.460***	2.973
IRR	0.476***	3.510
EDU	−0.085***	−2.311
TEC	0.071	1.345
LND	−0.001*	−1.716
D_{CT}	0.286***	2.385
D_{CM}	0.357***	2.250
D_{OF}	0.167***	2.523
Adjusted R^2	0.359	
F-statistics	4.13***	
Observations	40	

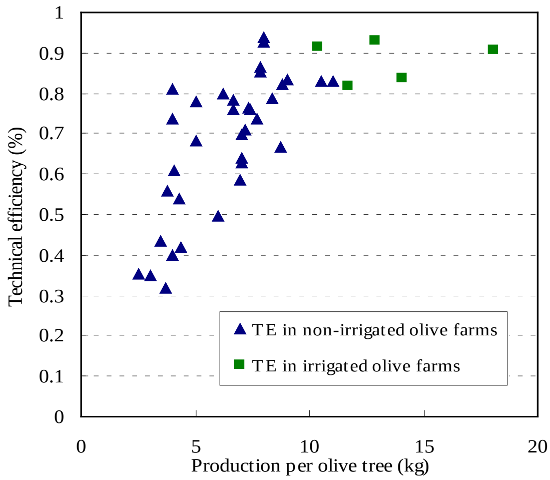

Fig. 1. The relation between productivity and technical efficiency of a sample of olive growing farms in Tunisia.

(D_{CM}) confirm the positive effect of cultivation of these varieties on the technical efficiency. The positive sign of the estimated coefficient of the off-farm dummy (D_{OF}) indicates the involvement with non-agricultural activities has positive effect on technical efficiency. The negative sign of area of olive cultivation (*LND*) indicates the efficiency tends to decline as the area become large.

Figure 1 shows the relation between the level of technical efficiency and productivity. While the level of technical efficiency and productivity vary across farms, it is clear that the irrigated olive farms are efficient. Comparing the most efficient group between the irrigated and the non-irrigated, the production per olive tree of the irrigated is higher than non-irrigated. This result implies that the irrigation contributes to further enhance the productivity.

Table 5. **Parameter estimates and standard errors of the ordered probit model of a sample Japanese consumers.** *, **, *** indicate significant at the 10% level, 5% level, 1% level, respectively.

Independent variables	Model 1 Estimates		Model 1 Standard error	Model 2 Estimates		Model 2 Standard error
Constant	-0.941	***	0.067	-0.674	*	0.344
Type						
Virgin	0.484	***	0.043	0.480	***	0.043
Extra virgin	1.104	***	0.056	1.088	*	0.554
Origin						
Italy	0.027		0.049	0.029		0.049
Spain	0.001		0.050	0.002		0.049
Tunisia	-0.093	*	0.051	-0.095	*	0.051
Taste: bitter	-0.283	***	0.036	-0.285	***	0.036
Colour: green	0.192	***	0.036	0.188	***	0.036
Component: high polyphenol	0.465	***	0.036	0.463	***	0.036
Price				1.048		0.802
$Price^2$				-0.001	**	0.000
800 JPY	0.046		0.049			
1000 JPY	-0.223	***	0.050			
1200 JPY	-0.318	***	0.051			
μ_2	-0.404	***	0.065	-0.139		0.344
μ_3	0.005		0.065	0.269		0.344
μ_4	0.372	***	0.065	0.636	*	0.344
μ_5	0.740	***	0.066	1.003	***	0.344
μ_6	1.149	***	0.067	1.412	***	0.344
μ_7	1.692	***	0.069	1.954	***	0.344
Observations	3504			3504		
LR1 $\chi^2_{(11)}$	873.2	***				
LR2 $\chi^2_{(10)}$				863.5	***	

4.2. Olive oil consumer behavior in Japan

Parameter estimates and standard errors of the ordered probit model are given in **Table 5**. The estimated coefficients of the both models showed clear results. First, the respondents prefer virgin and extra virgin olive oil to olive oil (refined). Second, respondents prefer a sweet taste olive oil rather than a bitter one. Third, respondents show also a higher preference for a green coloured olive oil compared with a yellow one. It is noteworthy that the positive and statistically significant estimation of the coefficient of the high polyphenol indicates respondents prefer olive oil that contains higher concentration of polyphenol. The coefficients correspond to the Italy and Spain origins are insignificant while that of Tunisia presents the negative sign. Finally, respondents' preference tends to increase when price increases from 600 and 800 Yen, but it decreases when price increases at the level more than 1000 Yen.

5. Conclusion

Results of the estimation of stochastic frontier production suggest that olive growing farms in Tunisia can increase their production on an average by 29.8% through more efficient use of technology and production inputs. The irrigated olive farms are most efficient than non-irrigated farms. It is also implied that the introduction of the irrigation technique and the selection of variety such as Chétoui and Chemlali significantly contribute to upgrade technical efficiency. Regarding the results of conjoint analysis, Japanese consumers prefer on extra-virgin and virgin to olive oil, sweet taste and green color products with the price between 800 to 1000 Yen per 500 ml. While the preference for the country of origin indicated at Tunisia is less compare with the label of Mediterranean, the consumers showed higher preference on olive oil that contains high concentration of polyphenol. The olive oil made of the variety of Chétoui that contains plenty of polyphenol would have a potential to be exported to this emerging market.

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