Journal of Applied Sciences

ISSN 1812-5654

Journal of Applied Sciences 7 (4): 499-502, 2007
ISSN 1812-5654

Determinations of Total Factor Productivity with Cobb-Douglas Production Function in Agriculture: The Case of Aydin-Turkey

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Abstract: Measurement of productivity and the choice of criteria in the process of measurement is quite essential in productivity analysis. The purpose of this study is to determine the total factor productivity of crop producing farms in the province of Aydin comparatively, in terms of land size using Cobb-Douglas production function. In addition, the input efficiencies and return to scales were computed. The results show that as farm size increases the TFP increases as well. Also, gross production value increases by the increase in labor in small farms, land size in medium farms and variable inputs in large farms.

Key words: Cobb-douglas, total factor productivity, crop production, Aydin

INTRODUCTION

Economical problems underlie many events or problems that seem to be hard to explain and solve. The efforts for economical development have become important in terms of salvation from poverty in underdeveloped countries and securing future by maintaining power in developed countries.

Measurement of productivity and criteria to be used in such measurement seem to be a complicated task in the agricultural sector as in all other sectors of economy. Insufficient data that may be effective in determination of productivity and lack of techniques used in measurement are the significant problems in determination of productivity especially in developing countries. In this context, it is very difficult to find the criteria that are applicable to all countries and may be applied in agricultural sectors, while determining the criteria of productivity. This is because of the fact that labor, plot and capital capacities, which are taken as criteria in productivity, as well as the general agricultural policies are not institutionalized sufficiently as providing robust economical results in developing countries.

Transformations and technological developments occurred in the agricultural sector in time have absolutely affected productivity. However, it is a fact that the term productivity is not only restricted to yield productivity. Yield productivity increases gradually in especially farms, which are engaged in agricultural production. However, it is a fact that productivity will not increase continuously. The producers are unable to utilize the agricultural production factors at an optimum level due to insufficient capital and/or lack of technical knowledge and this influences the yield productivity and thus the income of the producers negatively. Therefore, we need studies that determine input usage levels of the producers for each product within the model and put forth the rate of utilization for each input. In this study, the input-output relations of the enterprises engaged in agricultural production in Aydin province are examined and it is endeavored to put forth the income usage levels of the enterprises in this context.

The basic purpose of this study is to reveal the Total Factor Productivity (TFP) of the enterprises engaged in production of agricultural products in Aydin province in a comparative manner considering the size of the enterprises. However, the efficiency and yields of the enterprises in input utilization based on their sizes as well as the changes that may occur in the gross production against the increase or decreases to be introduced in the input levels will be calculated.

There are many studies of productivity growth in agriculture, there are surprisingly few studies productivity using cross-section data in agriculture. Jorgenson *et al.* (1987) used a cost function approach for each major sector of the US economy to estimate rates of sectoral productivity growth and concluded that productivity growth had been more rapid in agriculture than in other sectors. Lewis *et al.* (1988) used a production function approach to calculate productivity growth rates for agriculture and for the remainder of the Australian economy (industry plus services) and concluded that the

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rate of productivity growth in agriculture had been higher than for the remainder of the economy. Martin and Warr (1993) found a bias toward agriculture consistent with higher TFP growth in their profit function study of Indonesia.

It was reported that the productivity rise in agricultural sector was fast during 1970-1980s and slow during 1990s in Indonesia in a study that calculated TFP in agriculture during 1961-2000 with Tornqvist index (Fuglie, 2004). In the productivity calculations conducted in Japan during 1981-2000 using Hicks-Moorsteen-Bjurek index, it was reported that the most important two components were technical change and efficiency change (Nemoto and Goto, 2005).

The annual productivity rise was found as 2.5% in Argentina, Brazil, Paraguay and Uruguay in a study, which calculated the agricultural productivity in these countries during 1972-2001 using translog frontier production function (Bharati and Fulguniti, 2006).

When production correlations in agriculture should be examined, it is required to determine the productivity of the factors used in production. Introduction of TFP value facilitates the comparing studies in spite of measuring the productivity of production factors separately. Although TVP value can be measured by examining the time series, it can be measured by estimation of Cobb-Douglas type production function as a logarithmic factor (McCloskey, 1972). Fleisher and Yunhua (1992), who determined the productivity level of Chinese agriculture employing Cobb-Douglass production function and cross section data, reported that TFP decreases significantly in multiple plots. In a study that compared TFP of cooperatives with that of the private sector dairy farms, it was reported that the productivity increase was faster in the private sector farms and also the technical efficiency was higher in such farms. However, it was concluded that this increase was caused by the fact that such farms were smaller and that the economies of scale was more important (Piesse *et al*., 1996).

In a study conducted in Turkey using translog production function with cross section data method, it was concluded that the agricultural income could be enhanced through effective utilization of the factors in the farms. It was determined that the quantity of fertilizers used and the number of animals raised in the farms were insufficient when the existing capacities were considered. In addition, manpower surplus was determined in the farms (Akcay and Esengun, 1999). In another study conducted in Turkey using input oriented data envelopment analysis with cross section data method, it was reported that the main factor determining the technical efficiency was the land fragmentation (Alemdar and Oren, 2006).

MATERIALS AND METHODS

The main materials of the study consist of the data obtained from the agricultural enterprises located in the borders of the central district of Aydin province. 5560 farms registered in the Direct Income Support records of Provincial Directorate of Agriculture in Aydin were taken as the main group. Since many farms in our country do not maintain bookkeeping records, data about the said farms could only be obtained through the use of questionnaires. Questionnaire Forms prepared for the study were completed with the producers in October and November 2004 by interviewing them face to face.

The farms were classified in three groups based on the size of their plots (smaller than 30 da, between 31 and 100 and 101 da of more). The number of farms to be sampled was found and collected for each farm size group separately based on the following formula using layered random sampling method (Yamane, 1967). The sample volumes were determined as 31, 13 and 40 for the Group I, II and III, respectively and data belonging to a total of 84 farms were analyzed.

$$n = \frac{N.S^2.t^2}{e^2(N-1)+S^2.t^2} \quad (1)$$

Here, n is the sample volume of the layer, N is the number of farms (5560), S^2 is the layer variance, t is the confidence limit (1.96 for 95%), e is the acceptable maximum margin of error (15%). The numbers of farms obtained as a result of running this formula are given in Table 1.

In the examination conducted in order to determine the productivity levels of the enterprises engaged in agricultural products, selections among the agricultural products were made in order to ensure that the data based on enterprises were in line with each other. During product selection, the criteria, such as the fact that the products are specific to the region and the quantities of production, were considered while conducting product due to their high production quantities and these five products are brought within the scope of the study.

Table 1: Distribution of enterprises according to the population

Variables	Group I	Group II	Group III
Land (da)	1-30	31-100	100 -+
Number of enterprises in Layer (unit)	3274	1970	316
Coefficient of variances in Layer (%)	42.28	25.02	51.23
Number of samples (unit)	31	13	40
Coefficient of variances in samples (%)	46.75	35.28	50.88

The following conventional Cobb-Douglas production function was used in order to determine the relation between the gross production values obtained as a result of production of the selected products and the inputs used.

$$Q = Al^{\alpha}K^{\beta}T^{\gamma} \quad (2)$$

If conventional Cobb-Douglas production function is used for estimation of TFP, the following equation can be used (McCloskey, 1972).

$$TFP = A = \frac{Q}{L^{\alpha}K^{\beta}T^{\gamma}} \quad (3)$$

When the Eq. 2 given above is transformed into log linear form, the parameters can be estimated. The linear form in Eq. 4 was obtained by running logarithm on both sides of the equation.

$$InQ = InA+\alpha InL+\beta InK+\gamma InT \quad (4)$$

The model used in this study is given in Eq. 5, which is the revised form of conventional Cobb-Douglas production function in order to estimate TFP.

$$InQi = InA+\beta_1 InX_1+\beta_2 InX_2+\beta_3 InX_3+\beta_4 InX_4+\varepsilon \quad (5)$$

In Eq. 5, Q represents the production level (gross production value), A represents TFP coefficient, X represents the inputs used and α, β, γ and δ are the partial flexibility coefficients. Running logarithm at both sides of the equation ensures that inputs can be split easily. During logarithmic transformation, in case of variables including zero, one was added to such variables and transformation was accomplished in this way (Socal and Rohls, 1969).

The independent variables used in the model were taken as the port used by the farms (X_1), fuel (X_2), other variable inputs (X_3) and labor (X_4); dependent variable was taken as the gross production value of the farms (Q). ε refers to the error term in the formula.

It is also expressed by many other researchers that Cobb-Douglas type production function equations are appropriate for the functional analysis intended for the agricultural activities. In addition, it is preferred since it provides easy calculation, ability to test production flexibilities statistically and to obtain sufficient number of degree of freedom even where data is very few etc.

With Cobb-Douglas production function, the production flexibilities can be determined and thereby it facilitates calculation of the input use rates of the enterprises. In addition, it is also effective in determination of income based on scale. Thus, it introduces a different point of view about the productivity concept of the enterprises and determines the input use efficiency putting forth the function of the outputs obtained based on the inputs used.

RESULTS AND DISCUSSION

It was endeavored to determine some basic characteristics that may influence the productivity of the enterprises as a result of the interviews conducted with the enterprises. Such characteristics are given in Table 2.

In the functional analysis of the agricultural products considered in Aydin province, descriptions of the variables considered in the relation between the gross production value and the inputs used and the average and standard deviations of the variables are given in Table 3.

When the coefficients in Table 4 are examined, TFP increase by the increase in the size of the farm. This TFP coefficient was found significant only in the third group enterprises. This situation reveals that the increase income in small enterprises can be achieved by orienting to ecological production or good agricultural practices rather than increase of inputs. In addition, it is possible to talk about a income that decreases in Group I based on the scale and increases in Groups II and III based on scale.

The affect of the plot on the Gross Production Value is negative in Group I and positive in Groups II and III. However, this is important only in case of Group II. Because a labor-intensive production is prevailing in Group I enterprises. This is supported by the negative affects of the labor input and the fact that it is significantly significant. The affects of gasoline input is also significant and negative in Group I. Other inputs are positive and significant in Groups I and III. It is observed that the technological developments may be effective in enterprises in Group I and III.

Table 2: Some characteristics of enterprises

Characteristics	Group I	Group II	Group III
Average age of farmers	51.77	54.54	56.75
Average education time of farmers (year)	5.35	5.23	5.90
Experience of farmers (year)	28.10	34.85	33.65
Average land size of enterprises (da)	17.00	62.15	237.55
Number of tractor per enterprises (unit)	0.16	0.77	1.30
Population per enterprises (unit)	1.81	2.15	2.83

Table 3: Description of variables

	Variables	Group I Ort.	Group I Std. Dev.	Group II Ort.	Group II Std. Dev.	Group III Ort.	Group III Std. Dev.
Q	Total gross production value (NTL-New Turkish Lira)	6486.13	4868.87	15214.12	11351.09	63079.40	81650.60
X_1	Total land use (decare)	17.00	7.95	62.00	22.06	237.55	255.76
X_2	Gasoline (lt)	313.33	338.11	1550.71	1085.83	4802.59	6093.48
X_3	Value of other inputs (Fertilizer, seed, chemical etc.) (NTL)	1426.85	1724.92	6893.58	7160.61	28889.84	37662.36
X_4	Labour (Man-Work Unit)	25.20	19.16	102.74	66.62	352.22	352.71

Table 4: The coefficient estimates of variables

Variables	Group I	Group II	Group III
Constant (ln TFP)	0.443(0.84)	1.763(0.45)	2.426(3.42**)
ln X_1 (Land)	-0.139(-0.63)	1.682(2.46*)	0.184(1.63)
ln X_2 (Labour)	-0.610(-7.45***)	0.134(0.48)	0.018(0.21)
ln X_3 (Gas)	-0.346(-6.99***)	0.099(0.72)	-0.012(-0.43)
ln X_4 (Other variable inputs)	1.574(29.69***)	-0.023(-0.04)	0.741(6.28***)
R^2	0.985	0.665	0.892
F	402.30***	3.97*	70.38***

(t-values are in the parenthesis) * $p<0.05$, ** $p<0.01$ and *** $p<0.001$

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