INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
1560–8530/2007/09–5–788–790
http://www.fspublishers.org

Short Communication

Measuring Returns to Scale for Onion, Tomato and Chilies Production in Sindh Province of Pakistan

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ABSTRACT

A production technology may exhibit constant, increasing or decreasing returns to scale. This paper estimates production function to measure the degree of returns to scale for onion, tomato and chilies using primary data collected from three districts of Sindh, namely Hyderabad, Thatta and Mirpurkhas. Functional form of the production function was specified as Cobb-Douglas function with three inputs: land, labor and capital. Sum of the coefficients on these inputs measures the degree of homogeneity, which determines whether the production function is constant, increasing or decreasing returns to scale. Ordinary least square method was used for estimating the production function. The t-test was applied for testing the null hypothesis that degree of homogeneity equals 1. Null hypothesis was maintained at 5% significance level for each of onion, tomato and chilies crops. These results indicated that the production function has constant returns to scale for these crops.

Key Words: Returns to scale; Production function; Cobb-douglas; Onion; Tomato; Chilies

INTRODUCTION

Farm production is a function of farm inputs including land, labor, capital, management practices and other inputs. In the short run some inputs are fixed, while in the long run all inputs are variable. Returns to scale refers to the change in output when all inputs are changed proportionately (Varian, 1992; 2005). For a given proportional increase of all inputs, if output is increased by the same proportion, there are constant returns to scale; if output is increased by a larger proportion, the firm enjoys increasing returns to scale and if output is increased by a smaller proportion, there are decreasing returns to scale (Varian, 1992; 2005).

Measuring the degree of returns to scale in agriculture is of significant importance for understanding the structure of agriculture sector and for investigating the implications of fragmentation or concentration of farmland and other long-run changes in the structure. Furthermore it is useful for making policies that affect the welfare of the whole society, such as those concerning land reforms and government support services.

Returns to scale can be measured by estimating production function. In Cob-Douglas production function, the coefficients on inputs also represent the production elasticity and their sum measures whether the production function is constant, increasing, or decreasing returns to scale (Heady, 1961; Palanisami *et al.,* 2002). In this study, production function is estimated to test the null hypothesis of constant returns to scale.

Although there have been many studies in Pakistan on production function estimation and input-output analysis, very few studies have paid attention to returns to scale in agriculture. Bakhsh *et al.* (2006) estimated production function for individual contribution of different factors in radish cultivation in Punjab province of Pakistan and found that the seed, fertilizer and labor were important factors affecting the yield of radish. Oad *et al.* (2001) in his study on economics of Papaya performed input-output analysis by calculating the input-output ratio and marketing margins. Hussain (1991) estimated production function for measuring the degree of returns to scale in Peshawar valley. However, Sindh province has different structure of agriculture as compared to other provinces. Farm size distribution in Sindh indicated that there were 82% small farms (having total holding less than 5 hectares), 10% medium farms (5 - 10 hectares) and 8% large farms (10 hectares or above), while in Pakistan there were 85.68% small farms, 9% medium size farms and 5.56% large farms during the year 2000 (Government of Pakistan, 2003). There was a need of current analysis on measuring the degree of returns to scale as there have been continuous changes in agriculture structure due to fragmentation of farmland, technological growth, credit availability and market structure.

Among agricultural products, onion, tomato and chilies are most common vegetables in Pakistan and other countries of South Asia. These vegetables are co-cooked with other vegetables and meat in addition to consumed as salad. Therefore the demand of these vegetables is relatively inelastic in Pakistan (Lohano & Mari, 2005). On the supply side, onion, tomato and chilies are important crops. These crops provide high profits to farmers and employment opportunities to rural laborers as these crops require more labor inputs as compared to other crops.

The objective of this study was to measure the degree of return to scale by estimating Cobb-Douglas production function for onion, tomato and chilies in the Sindh province of Pakistan.

MATERIALS AND METHODS

For this study, primary data were collected from farmers by conducting surveys in three districts of Sindh, namely Hyderabad, Thatta and Mirpurkhas. Hyderabad was selected for onion crop, Thatta for tomato crop and Mirpurkhas for chilies for primary data collection. Hyderabad was selected for onion, because area under onion is highest in Hyderabad among all distrcits of Sindh (Government of Sindh, 2004). Similarly Thatta district is major tomato producer and Mirpurkhas is major chilies producing district in Sindh (Government of Sindh, 2004). Sixty farmers for each vegetable were randomly selected from these districts so the total sample size was 180 farmers for this study. Data were collected by survey method using a pre-tested questionnaire.

Production function was estimated for measuring the returns to scale for each of the vegetables, namely onion, tomato and chilies. The functional form of the production function is specified as Cobb-Douglas function (Varian, 2005):

$$y = Ax_1^{\beta_1} x_2^{\beta_2} x_3^{\beta_3} e^{\varepsilon} \qquad (1)$$

Where

y is output, x_1, x_2, x_3, are inputs, A, β_1, β_2, β_3, are coefficients to be estimated and ε is the error. The error term represents all other variables, which may affect output. Both output and inputs were measured in value terms. Furthermore, output and inputs were measured for the whole farms of the selected vegetables. Output y is value of production in rupees. Input x_1 is the cost in rupees on labor input for farm operations including plowing, leveling, weeding, irrigating and other activities up to harvesting the crop. Input x_2 is the cost in rupees on capital input incurred for the purchase of fertilizers, pesticides and seed. Input x_3 is the cost in rupees on land input, which includes land rent and land tax.

The coefficients of the model in Equation (1) are the measures of production elasticity for each input. Coefficient β_1 is the percent change in output resulting from a one percent change in the input x_1. Similarly, the coefficient on each input is the percent change in output resulting from a one percent change in the input. In a Cobb-Douglas production function, the sum of these coefficients, $\beta_1 + \beta_2 + \beta_3$, is the degree of homogeneity, which measures whether the production function is constant, increasing, or decreasing returns to scale. Three possibilities exist:

(1) If $(\beta_1 + \beta_2 + \beta_3) = 1$, there are constant returns to scale.

(2) If $(\beta_1 + \beta_2 + \beta_3) < 1$, there are decreasing returns to scale.

(3) If $(\beta_1 + \beta_2 + \beta_3) > 1$, there are increasing returns to scale.

In order to test the significance of $(\beta_1 + \beta_2 + \beta_3)$, we rearrange the terms of the model in Equation (1). Multiplying and dividing it by $x_3^{\beta_1} x_3^{\beta_2}$ will keep the model un-changed, because we can multiply by 1:

$$y = Ax_1^{\beta_1} x_2^{\beta_2} x_3^{\beta_3} e^{\varepsilon} \frac{x_3^{\beta_1} x_3^{\beta_2}}{x_3^{\beta_1} x_3^{\beta_2}} \qquad (2)$$

Rearranging the terms of Equation (2) yields:

$$y = A\left(\frac{x_1}{x_3}\right)^{\beta_1}\left(\frac{x_2}{x_3}\right)^{\beta_2} x_3^{\beta_1+\beta_2+\beta_3} e^{\varepsilon} \qquad (3)$$

Let $h = \beta_1 + \beta_2 + \beta_3$, then Equation (3) can be written as:

$$y = A\left(\frac{x_1}{x_3}\right)^{\beta_1}\left(\frac{x_2}{x_3}\right)^{\beta_2} x_3^{h} e^{\varepsilon} \qquad (4)$$

The model in Equation (4) can be used for estimating the degree of homogeneity directly and for testing its statistical significance.

For estimating the model, Equation (4) is transformed into linear equation by taking natural logarithm:

$$\ln y = \beta_0 + \beta_1 \ln\left(\frac{x_1}{x_3}\right) + \beta_2 \ln\left(\frac{x_2}{x_3}\right) + h \ln x_3 + \varepsilon \qquad (5)$$

Where

The constant $\beta_0 = \ln(A)$. The ordinary least square (OLS) method is used for estimating Equation (5) with standard assumptions of the classical regression model (Greene, 2003).

RESULTS AND DISCUSSION

Production function is estimated using the model specified in Equation (5). The regression results are presented in Tables I, II and III for onion, tomato and chilies, respectively. The tables present coefficient estimates, their standard error, t statistics, p-values for testing the significance and the coefficient of determination (R^2). The R-squared of these regressions are 0.988 for onion, 0.979 for tomato and 0.980 for chilies, which indicate that about 98% of the variation in the dependent variable has been explained in estimating these models.

The 5% critical value of Student's t distribution for sample size of 60 was 2.00. First, the t-statistics are presented for testing the null hypothesis that the coefficients are zero. As the t-statistics are greater than 2.00, the test rejects the null hypothesis, thus the coefficients are different from zero at 5% significance level for each case. The estimated values degree of homogeneity (h) are 0.989, 0.986 and 0.978 for onion, tomato and chilies, respectively. For testing that the production function is constant returns to scale, we also tested the null hypothesis that $h = 1$. In this

Table I. Regression results for onion production function

Coefficient	Coefficient Estimate	Standard Error	t-statistics	p-value	R^2
β_0	2.043	0.171	11.922	0.000	0.988
β_1	0.531	0.108	4.924	0.000	
β_2	0.262	0.118	2.229	0.030	
h	0.989	0.015	67.237 (-0.715)*	0.000 (0.600)*	

* *t* statistic and p value given in parentheses are for the null hypothesis that the coefficient is equal to 1. The remaining *t* statistics and p values are for the null hypothesis that coefficient is zero

Table II. Regression results for tomato production function

Coefficient	Coefficient Estimate	Standard Error	t-statistics	p-value	R^2
β_0	2.491	0.197	12.631	0.000	0.979
β_1	0.262	0.104	2.515	0.015	
β_2	0.256	0.059	4.329	0.000	
h	0.986	0.021	46.215 (-0.651*)	0.000 (0.518*)	

* *t* statistic and p value given in parentheses are for the null hypothesis that the coefficient is equal to 1. The remaining *t* statistics and p values are for the null hypothesis that coefficient is zero

Table III Regression results for chilies production function of chilies

Coefficient	Coefficient Estimate	Standard Error	t-statistics	p-value	R^2
β_0	2.051	0.203	10.115	0.000	0.980
β_1	0.392	0.098	3.983	0.000	
β_2	0.594	0.105	5.628	0.000	
h	0.978	0.019	50.482 (-1.135*)	0.000 (0.261*)	

* *t* statistic and p value given in parentheses are for the null hypothesis that the coefficient is equal to 1. The remaining *t* statistics and p values are for the null hypothesis that coefficient is zero

case, the *t* statistic and p-value are presented in parentheses. As the *t*-statistic in absolute terms is less than 2.00, the test maintains the null hypothesis, thus the coefficient *h* is equal to 1 by this test. As described in methodology, $h = \beta_1 + \beta_2 + \beta_3$, these results showed that the production function for onion, tomato and chilies exhibit constant returns to scale as reported by Hussain (1991) The estimated returns to scale parameter found by Hussain (1991) was 0.991 (P > 0.01).

CONCLUSION

In this paper, Cobb-Douglas production function was estimated to measure the returns to scale for onion, tomato and chilies producing farms. The results showed that the production of onion, tomato and chilies exhibits constant returns to scale. These results indicate that if all inputs are increased proportionately, the output is increased by the same proportion. For the future study, it is suggested that the degree of returns to scale be measured for different crops as well as for aggregate agricultural production in Pakistan.

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(Received 07 February 2007; Accepted 30 June 2007)