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Research Article

Estimating the technical efficiency for the backward integration of tapioca crop inTamil Nadu

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SUMMARY : This paper attempts to estimate the technical efficiency for the production tapioca (*Manihot esculenta*) in Tamil Nadu. India records 9th place among the area and production of tapioca in the world. In India, major tapioca cultivating states are Tamil Nadu, Kerala, and Andhra Pradesh. There are different value added products from tapioca in India like starch, sago, wafers, animal feed etc. In case of technical efficiency, the variables such as human labor, machine power, fertilizers and planting material (sets) were found to be significantly influencing the yield in both the irrigated and rainfed conditions. The animal power was found to be significantly influencing the yield only among rainfed farmers. The overall technical efficiency ratings were higher in irrigated farms compared to rainfed farms.

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KEY WORDS :
Tapioca crop, Technical efficiency, Frontier production function, Rainfed, Irrigated condition

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BACKGROUND AND OBJECTIVES

Tapioca (*Manihot esculenta*) is a perennial vegetable crop and family belongs to Euphorbiaceae. It originated in the regions of west-central Brazil. It is being produced all over the world particularly in the tropical and sub-tropical regions. Tapioca is an important and upcoming trade with high potential both in domestic as well as in export markets. About 70 per cent of the total tapioca production is used as food either directly or in processed form. Though the processing and production centers for different value added products from tapioca like starch, sago, alcohol, animal feed, wafers are concentrated in South India. Tamil Nadu State stands first in respect of processing of tapioca into starch and sago. In India, sago was produced first in Salem in 1943-44. About seven decades ago, sago production was started on a cottage industry in India. It was processed by pulping the tapioca roots, filtering the milk-extract and after settling the milk, forming globules and roasting these globules. Tapioca root is the basic raw material for sago and starch. Indian tapioca root contains about 30 to 35 per cent of starch content. About 650 to 700 units are engaged in tapioca processing in Salem district in Tamil Nadu.

Top ten important tapioca producing countries are Nigeria, Brazil, Indonesia, Thailand, Democratic Republic of the Congo, Ghana, Viet Nam, India, and Mozambique.

India ranked 9th place among the total world production of tapioca in the year 2011-12. In case of global scenario, tapioca cultivation area was under 19.64 million hectares and production of 252.2 million tonnes in 2012 (Anonymous, 2012).

In Tamil Nadu, Tapioca is cultivated at 1.24 lakh hectares. Among the various districts in Tamil Nadu, this crop was grown widely in western part of Tamil Nadu. The area under tapioca in various districts over four year period is presented in Table A.

Objective :

–To analyze the technical efficiency for

Table A: Area under tapioca in Tamil Nadu

Sr. No.	Districts	Area (Hectares)					
		2005-06	2006-07	2007-08	2008-09	2009-10	Average
1.	Salem	22425	29096	30370	25891	23057	26167.8
2.	Namakkal	17399	25520	28445	28312	26856	25306.4
3.	Dharmapuri	18357	29091	26585	23189	22779	24000.2
4.	Villupuram	10954	14219	13798	11378	11013	12272.4
5.	Erode	4771	8958	8345	8395	8670	7827.8
6.	Kanniyakumari	7795	8015	7614	7658	6202	7456.8
7.	Trichy	5685	6744	7493	7490	5232	6528.8
8.	Other districts	14696	17985	17442	11988	14832	15388.6
	Total	102082	139628	140092	124301	118641	124948.8

Source: Season and crop report of Tamil Nadu, (various volumes), directorate of economics and statistics, Government of Tamil Nadu

tapioca production in Salem and Namakkal.

Based on the past studies, the efficiency could be related to (a) operation of farm business as a whole, (b) any individual phase of the business line of production or enterprise, (c) the use of various factors of production or resource (land, labour, capital) or (d) to any single input (fertilizer, seeds, machines) (Johl and Kapur, 1981).Kalirajan and Shand (1997) measured technical efficiency as the ratio of observed output to potential output. Dixit *et al.* (2000) defined technical efficiency as, an ability of a farm to obtain maximum output from a given set of inputs. Dhondyal (1989) defined production function as the technical relationship between physical output of a farm or firm.Kumar *et al*. (2004) defined frontier production function as potential output that can be produced by a farm or firm with given level of inputs and technology. Mishra (1991) measured the efficiency in rice by fitting Cobb-Douglas production function separately to the farms who used fertilizers and those who did not use fertilizers. He compared the marginal returns with marginal cost and concluded that much differences was not observed in the efficiency of resources between users and non-users.

RESOURCES AND METHODS

A multi-stage random sampling technique was used to select the sample respondents. Based on time and resource constraints of the investigator, in the first stage, among the various districts in Tamil Nadu, Salem and Namakkal districts were selected. These two districts constituted 41 per cent of the area under tapioca cultivation in the state. In the second stage, two taluks from each district *viz.*, Salem district (Attur and Vazhappadi) and Namakkal district (Namakkal and Rasipuram) were selected based on the proportionate area under tapioca crop. In the third stage, in each taluk, three blocks were selected, again based on the proportionate area under the tapioca crop.

Besides the sample farmers, 20 market intermediaries namely local-trader (7), commission agent (7) and wholesaler (6) who were involved in the value chain were selected at random. This organization was also studied and their linkages in the value chain were analyzed.

Analytical framework :

Technical efficiency :

Technical efficiency (TE) refers to the proper choice of production function among all those actively in use by farms in the agriculture. A farmer is said to be more technically efficient than another if he consistently produces larger quantities of output from the same quantities of measurable inputs.

Farrell (1957) introduced the concept of efficiency, using the frontier production function approach. This represents the potential output that can be produced with a given bundle of inputs under a given technology.

Stochastic frontier model :

Aigner *et al.* (1977) developed a stochastic frontier model. They decomposed the error term into two parts under what is called the composed error model. Aggregating the effects of exogenous shock with the effects of measurement and inefficiency into a single one-side error term is a questionable assumption. To overcome this difficulty, composed error models have been proposed which are otherwise known as stochastic frontier models. The essential idea behind the stochastic frontier model is that the error term is composed of two independent elements *i.e.* a symmetric, normally distributed component permits random variation of the frontier across firms and captures the effect of measurement error, other statistical noises and random shocks outside the firm's control and one sided error component captures the effect of inefficiency relative to the stochastic frontier. The term v_i is the symmetric component and permits random variation in output due to factors like weather and plant diseases. It is assumed to be identically and independently distributed as $v_i \sim N(0,\sigma^2 v)$. A one sided component (ui>= 0) reflects technical efficiency relative to the stochastic frontier. Thus, $u_i = 0$ for any farm lying on the frontier, while $u_i>0$ for any farm lying below the frontier. Hence, expression u_i represents the amount by which the frontier exceeds realized output. Assuming that u_i is identically and independently distributed as $u_i \sim N(\sigma,^2 u)$, that is the distribution of u is half-normal. Thus, u_i takes the value zero when the farm produce on its outer-bound production function (realizing all the technical efficiency potential) and is less than zero when the farm produces below its outer bound production function (not realizing fully its technical efficiency potential). This might happen due to a number of factors, such as risk aversion, self-satisfaction, information problems, which may prevent the farm from achieving its full potential.

$$Y = f(X_1, X_2 .....X_n) + (\nu \pm u)$$

ν is the symmetric error component causing the deterministic component of the production frontier f $(X_1,X_2...X_n)$ to vary across the firms. Technical efficiency relative to the stochastic production frontier is captured by the one-side error component ($\pm$ u depending on whether one specifies a production or cost frontier),$u\geq 0$. Given the density functions for u and ν, the frontier function defined above may be estimated by maximum likelihood estimates (MLE) techniques. The statistical estimation of the frontier model combining both u and ν, usually leads to the estimation of average technical efficiency of the sample observations. However, individual observation specific technical efficiency measures are more useful from a policy viewpoint. The approach to identifying firm specific technical efficiency requires some estimators that allow for separating the effects of the one-side error term u from the combined effect of u and ν using the estimated frontier functions. In effect, the problem is to predict u_i under the assumption that $u_i+\nu_i$ is known. The best predictor of an unknown random variable (u_i) under the value of the combined random variable $u_i+\nu_i$ is the minimum mean square error predictor given by the conditional expectation of u_i. Assuming a half normal distribution for u_i and normal distribution for ν_i , the frontier model becomes :

Y=f $(X_1,X_2....X_n)$ ⍰EMBED Equation.3 ⍰⍰⍰(¬-u)

where,

⍰ EMBED Equation.3 ⍰ ⍰ ⍰ and ⍰
EMBED Equation.3 ⍰ ⍰ ⍰ ~ N
[0,(u⍰EMBED Equation)] and ν~N[ν ⍰EMBED Equation, 3.⍰ ⍰⍰]

The components of the disturbance are assumed to be independent and the frontier is assumed to be linear in the above case. Now, the firm or observation specific u_i can be estimated as :

$$E\{u_1 i/(u_1 i+v_1 i)\} = -\sigma \downarrow u\sigma_1 v/([f(.)/(1-F(.)$$
$$-\{(u \downarrow i + v_1 i)/()\{r/(1-r)\} \uparrow (1/2)]$$

where, f (.) and F (.) are standard normal density and distribution functions evaluated at

$$\{(u_i+v_i)/()\{r/(1-r)\}''1/2'',$$

$$\gamma = \frac{\sigma_u^2}{\sigma_v^2}$$

where, γ is an indicator of relative variability of U_i and V_i that differentiates that actual yield from the frontier. When σ_v^2 tends to zero, it implies that U_i is the predominant error, then $\gamma = 1$. This means yield difference is mainly due to non-adoption of best practice or technique. When σ_u^2 tends zero, it implies that the symmetric error term, V_i is the predominant error and γ will be tending to zero. This means that yield differences from the frontier yield is mainly due to either statistical error or external factors that are not included in the model.

$$(''2'' = (u''2'' + (v''2''$$

where,

The term (“2” is the variance parameter that denotes the total deviation from the frontier, (“2” is the deviation from the frontier due to in efficiency and σ_u^2 is the deviation from the frontier due to stochastic noise.

In the present study, the following assumptions were made which underline the specification of a stochastic frontier:

–Variations in the technical efficiency of individual firms are due to factors completely under the control of farmers.

–The stochastic frontier production function of the Cobb-Douglas type was specified for the study. The model used was:

$$InY + \beta_1 + \sum_{i+1}^{5} \beta_1 lnX_i + v_i - u_i$$

where,

Y = Tapioca yield (tonnes/hectare)
X_1 = Human labor (man days/hectare)
X_2 = Setts (Nos/hectare)
X_3 = Machine power (Hours/hectare)
X_4 = Animal (Hours/hectare)
X_5 = Fertilizers (Rs/hectare)
B_0 - intercept
β_1, β_2,β_3.........β_5- co-efficients to be estimated
u_i = Farm specific technical efficiency related factor
v_i = Random variable

From the residual, the farm specific technical efficiency was estimated.

OBSERVATIONS AND ANALYSIS

The experimental findings obtained from the present study have been discussed in following heads:

Technical efficiency in tapioca production :

Efficiency is very important concept in production, where resources are meagre and opportunities for developing better technologies (cultivation practices) are competitive. In order to understand the technical efficiency of such farmers, a stochastic frontier production function was fitted. The results are presented in Table 1.

Table 1: Results of the frontier production function

Variables	Irrigated (n=87)	Rainfed (n=33)
Constant	0.5540 (0.777)	0.2804 (0.788)
Human labor (man days/ha)	0.3064*** (4.823)	0.1760** (2.278)
Setts/ha	0.1244** (2.002)	0.2984***(2.173)
Machine power (Hours/ha)	0.1328*** (3.351)	0.1622** (2.053)
Animal (Hours/ha)	0.0841(1.257)	0.1830*** (3.397)
Fertilizers (Rs./ha)	0.1260** (2.007)	0.1418** (2.173)
Sigma-square	0.1711	0.2033
Gamma	0.8704	0.1740
Mean technical efficiency	0.8063	0.7797

Figures in parentheses indicate estimated t ratio)
** Indicate significanceof value at P=0.5 and 0.01, respectively

It could be seen from the Table 1 that the variables such as human labor, machine power, fertilizers and planting material (sets) were found to be significantly influencing the yield in both the irrigated and rainfed conditions. The animal power was found to be significantly influencing the yield only among rainfed farmers.

It is also evident from the analysis that the irrigated farmers were technically efficient than the rainfed farmers as, the mean technical efficiency (MTE) was 80.63 per cent for the irrigated farmers in tapioca cultivation and 77.97 per cent for rainfed farmers.

The distribution of technical efficiency ratings for tapioca farms was calculated and presented in Table 2 .

The results in Table 2 showed that about 54 per cent of farmers cultivating tapioca under irrigated conditions were in the 70-90 per cent of class interval of efficiency as against only about 27 per cent of farmers cultivating the crop under rainfed condition. Accordingly, only about 29 per cent of the farmers cultivating tapioca under irrigated condition were rated with an efficiency of 50 to 70 per cent as against 49 per cent under rainfed cultivation. In case of above 90 level of efficiency ratings, only 8 per cent of the farmers under irrigated cultivation and but as high as 18 per cent of the farmers under rainfed condition were classified as very high performers. However, the overall technical efficiency ratings were higher in irrigated farms compared to rainfed farms.

Table 2: Frequency distribution of technical efficiency rating of tapioca farmers

Sr. No.	Efficiency ratings (Class interval in per cent)	Irrigated	Rainfed	Classification
1.	30-50	8 (9.20)	2(6.06)	Low
2.	50-70	25 (28.78)	16 (48.48)	Medium
3.	70-90	47 (54.02)	9 (27.27)	High
4.	Above 90	7 (8.05)	6 (18.18)	Very high
	Total	87 (100.00)	33 (100.00)	

Figures in parentheses indicate percentage to total

Conclusion :

Thus, it could be concluded that from the above technical analysis, variables such as human labor, machine power, fertilizers and planting material (sets) were found to be significantly influencing the yield in both the irrigated and rainfed conditions. The animal power was found to be significantly influencing the yield only among rainfed farmers. The irrigated farmers were technically efficient than the rainfed farmers as, the mean technical efficiency (MTE) was 80.63 per cent for the irrigated farmers in tapioca cultivation and 77.97 per cent for rainfed farmers. The overall technical efficiency ratings were higher in irrigated farms compared to rainfed farms.

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