Impact of automation in improving Technical Efficiency of a farming sector

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Abstract

The success of business at the farm level mainly depends on the economic efficiency of the farm. Several farms do not realize the full potential of technology due to factors such as their managerial skills and differences in production environments. The present study was undertaken to quantify and measure technical efficiency so as to know the relative efficiency of different farms, variations in efficiency among the farms and to analyse the policy implications for improving the efficiency. To measure technical efficiency in turmeric production, data from 180 sample farms in northwestern region of Tamil Nadu were collected and analyzed using Translog Normal Half Normal Stochastic Frontier Model (TNHNSFM). The significant level of the parameter resulted in the presence of technical inefficiency. The estimate of γ, which is the ratio of the variance of farm-specific performance of technical efficiency to the total variance of output was 0.77, indicating that the difference between the observed and frontier output was primarily due to the factors which were 77 per cent under the control of farms. Expenditure on human labour to be reduced to improve profit as the data showed cost on labour is very high compared to machine cost. The significant level of the parameter λ (λ= 1.84) showed that there exists sufficient evidence to suggest the presence of technical inefficiency.

Key words: Technical Efficiency, Maximum Likelihood Estimates, Stochastic Frontier Production Function, Translog normal-half normal Stochastic Frontier Model.

Introduction

The efficiency of a production unit may be defined as how effectively it uses variable resources for the purpose of profit maximization, given the best production technology available. The concept of efficiency is further divided into two components technical efficiency and allocative efficiency. Traditionally, researchers have concentrated on the study of allocative efficiency based on the assumption that entrepreneurs operate on technical production functions with full technical efficiency. However, in recent literature, it is seen that the above assumption is weak and several farmers do not realize the full potential of technology due to several factors such as their managerial skills and differences in the production environment. The importance of differentiating technical progress from technical efficiency in production function analysis was first highlighted by Farrell (1957), who introduced the concept of frontier production function representing production technology with full technical efficiency (TE). Many agricultural scientists and farm experts have endorsed the view that the performance of agriculture is yet to reach its potential level. Available evidences in the last few years revealed that technological package via its efficient utilization may accelerate the pace of agricultural development in India and so in raising the living standards of the rural population (Battese, 1991 and Jai Singh et al., 2002). However, there are large variations in input practices and output levels among farms in different regions within the country. Therefore, an analysis at the farm level is desirable to have a clear understanding of the existence of the gap between actual output and potential output of agricultural crops in different regions as well as within the same region of the country (Debnarayan and Sudpita, 2004 ; Mythili and Shanmugam, 2000).

Data and Analytical framework

In India, Tamil Nadu is one of the major producers of turmeric with a total area of 16181 ha. and the production of about 67250 tonnes. In the northwestern region of Tamil Nadu, two major turmeric growing districts viz., Erode and Coimbatore were considered for the study. Erode and Coimbatore districts were purposely selected because they occupy nearly 47 per cent of the turmeric area and 60 per cent of the turmeric production in Tamil Nadu.

Techniques of Efficiency Measurement

The stochastic production frontier incorporates producer specific random shocks into the analysis (Bhavani, 1991), which is accomplished as, $y = f(x;\beta)e^{v}e^{-u}$, where $\left(f(x;\beta)e^{v}\right)$ is the stochastic production frontier, v_i is the two sided noise component, u_i is the non-negative technical inefficiency component of the error term. The noise component v_i is assumed to be independently and identically distributed and symmetric as $N\left[0,\sigma_v^2\right]$, distributed independently of of u_i which is distributed as $N^{+}[0,\sigma_u^2]$. The error term $\varepsilon = v_i - u_i$ is not symmetric, since $u_i \geq 0$. In the present study, the structure of production of farms has been modelled using translog production function (Christensen *et al.,* 1973), $\ln y = \beta_0 + \sum_{i=1}^{7}\beta_i \ln x_i + \frac{1}{2}\sum_{i=1}^{7}\sum_{j=1}^{7}\beta_{ij} \ln x_i \ln x_j$ considering seven inputs seed (x_1), human labour (x_2) machinery (x_3), manure (x_4), fertilizer (x_5), pesticide (x_6), post harvest expenditure (x_7) as inputs.

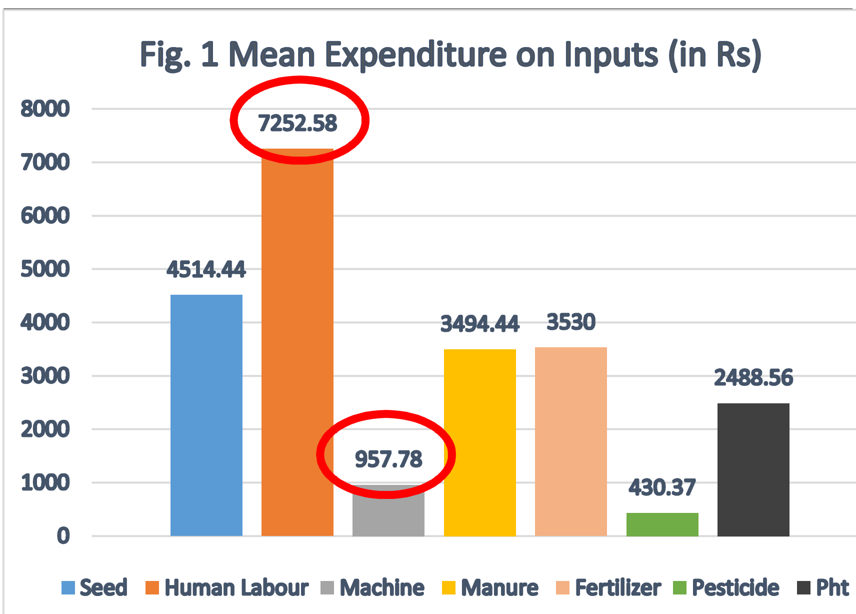
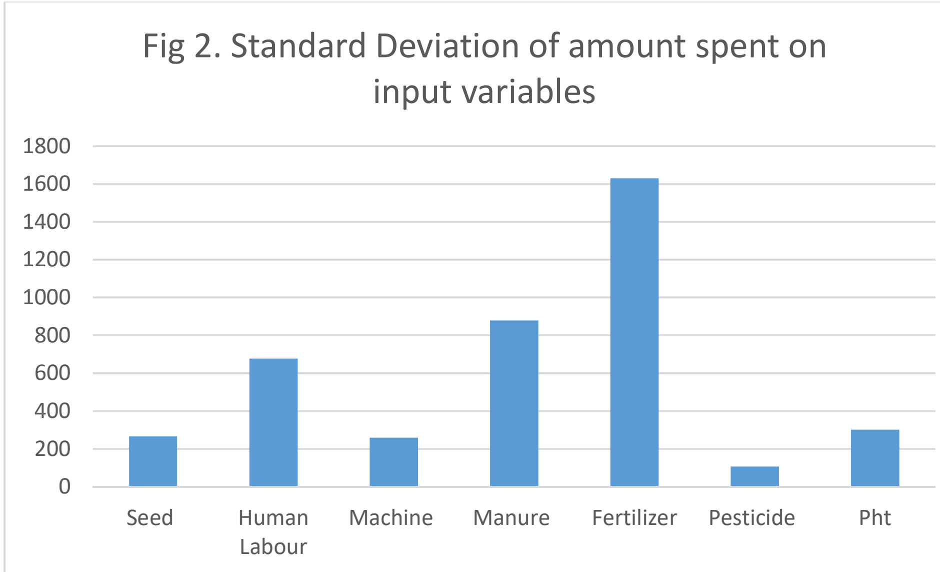


Fig 1, shows the expenditure of inputs used for an average production of 2423 Kg. Surprisingly, expenditure on human labour is the maximum of all other expenditures. Alternative to improve the profit might be to introduce automative tools for weeding, monitoring, watering and, harvesting. Skilled labours are in demand to improve productivity, to minimize cost and hence the livelihood of farmers.

Fig 2. Shows the variability on practicing the input variables, fertilizer on top followed by manure, usage of these two inputs has to be given utmost care to minimize cost.



The results of the analysis are presented based on Translog Normal Half-Normal Stochastic Frontier Model (TNHNSFM)

Results and Discussion

The translog production function model considered for the study involved a total of 35 independent variables. Ordinary Least Square (OLS) estimates of the parameters of stochastic frontier model, which show the average performance of the 180 sample farms, are presented in Table 1. With the R^2 value of 0.73, the inputs used in the model were able to explain 73 per cent of the variations in the turmeric production using translog normal half-normal stochastic frontier model.

Table 1 Ordinary Least Square Estimates of Average Performance Using Translog Normal Half-Normal Stochastic Frontier Model

Variables	Parameters	Coefficients
Constant	β_0	266.506
ln_{Sed}	β_1	-38.949
ln_{Hum}	β_2	-9.841
ln_{Mac}	β_3	-6.133
ln_{Man}	β_4	0.087*
ln_{Fer}	β_5	0.382
ln_{Pes}	β_6	4.238
ln_{Pht}	β_7	-11.765
ln_{Sed} x ln_{Sed}	β_{11}	2.378
ln_{Hum} x ln_{Hum}	β_{22}	-0.767
ln_{Mac} x ln_{Mac}	β_{33}	-0.320

$ln_{Man} \times ln_{Man}$	β_{44}	-0.688**
$ln_{Fer} \times ln_{Fer}$	β_{55}	-0.074
$ln_{Pes} \times ln_{Pes}$	β_{66}	-0.111
$ln_{Pht} \times ln_{Pht}$	β_{77}	-0.192
$ln_{Sed} \times ln_{Hum}$	β_{12}	0.739
$ln_{Sed} \times ln_{Mac}$	β_{13}	0.098
$ln_{Sed} \times ln_{Man}$	β_{14}	-0.308
$ln_{Sed} \times ln_{Fer}$	β_{15}	0.006
$ln_{Sed} \times ln_{Pes}$	β_{16}	0.068
$ln_{Sed} \times ln_{Pht}$	β_{17}	1.761
$ln_{Hum} \times ln_{Mac}$	β_{23}	0.559
$ln_{Hum} \times ln_{Man}$	β_{24}	0.666
$ln_{Hum} \times ln_{Fer}$	β_{25}	0.106
$ln_{Hum} \times ln_{Pes}$	β_{26}	-0.421
$ln_{Hum} \times ln_{Pht}$	β_{27}	0.376
$ln_{Mac} \times ln_{Man}$	β_{34}	0.100
$ln_{Mac} \times ln_{Fer}$	β_{35}	0.103
$ln_{Mac} \times ln_{Pes}$	β_{36}	0.218
$ln_{Mac} \times ln_{Pht}$	β_{37}	-0.055
$ln_{Man} \times ln_{Fer}$	β_{45}	0.126
$ln_{Man} \times ln_{Pes}$	β_{46}	0.131
$ln_{Man} \times ln_{Pht}$	β_{47}	-0.008
$ln_{Fer} \times ln_{Pes}$	β_{56}	-0.035
$ln_{Fer} \times ln_{Pht}$	β_{57}	-0.293
$ln_{Pes} \times ln_{Pht}$	β_{67}	-0.346

* Significant at 5% level $R^2 = 0.728$

** Significant at 1% level N = 180

The inputs manure, fertilizer and pesticide were of greater significance . The Ordinary Least Square (OLS) estimates discussed above were of average performance. Hence, to study about the farm specific performances, Maximum Likelihood Estimates (MLE) were obtained. The maximum likelihood estimates of the translog normal half-normal stochastic frontier model are presented in Table.2. A direct comparison of the parameters estimated for the average (OLS) and stochastic function (MLE) showed close similarity between the intercepts and input coefficients. As seen in Table 1 & Table .2 the intercept differences between the two production functions represent a neutral shift from the average production function. Further, by the specification of the likelihood function, the difference between the production function estimated by the OLS and frontier function can be statistically shown by the 5 per cent significant level of λ= 1.84. The significant level of the parameter λ showed that there exists sufficient evidence to suggest the presence of technical inefficiency. The estimates of the error variances σ_u^2 and σ_v^2 were 0.00306 and 0.00090 respectively as shown in Table 2. Therefore, it could be easily seen that the variance of one-sided error, σ_u^2 is larger than the variance of the random error, σ_v^2. Thus, the value of λ= 1.84 of more than one clearly showed the dominant share of the estimated variance of the one-sided error term, u, over the estimated variance of the whole error term.

Table .2 Maximum Likelihood Estimates of the Translog Normal Half-Normal Stochastic Frontier Model

Variables	Parameters	Coefficients	Variables	Parameters	Coefficient
Constant	β_0	288.686	$ln_{Sed} \times ln_{Fer}$	β_{15}	- 0.065
ln_{Sed}	β_1	-41.875	$ln_{Sed} \times ln_{Pes}$	β_{16}	- 0.011
ln_{Hum}	β_2	-9.926	$ln_{Sed} \times ln_{Pht}$	β_{17}	2.011
ln_{Mac}	β_3	-5.518	$ln_{Hum} \times ln_{Mac}$	β_{23}	0.502
ln_{Man}	β_4	1.605	$ln_{Hum} \times ln_{Man}$	β_{24}	0.504
ln_{Fer}	β_5	0.516	$ln_{Hum} \times ln_{Fer}$	β_{25}	0.068
ln_{Pes}	β_6	5.498	$ln_{Hum} \times ln_{Pes}$	β_{26}	- 0.489
ln_{Pht}	β_7	-17.414	$ln_{Hum} \times ln_{Pht}$	β_{27}	0.662
$ln_{Sed} \times ln_{Sed}$	β_{11}	2.912	$ln_{Mac} \times ln_{Man}$	β_{34}	0.113
$ln_{Hum} \times ln_{Hum}$	β_{22}	-0.736	$ln_{Mac} \times ln_{Fer}$	β_{35}	0.109
$ln_{Mac} \times ln_{Mac}$	β_{33}	-0.319	$ln_{Mac} \times ln_{Pes}$	β_{36}	0.217
$ln_{Man} \times ln_{Man}$	β_{44}	-0.637*	$ln_{Mac} \times ln_{Pht}$	β_{37}	- 0.073
$ln_{Fer} \times ln_{Fer}$	β_{55}	-0.050	$ln_{Man} \times ln_{Fer}$	β_{45}	0.170*
$ln_{Pes} \times ln_{Pes}$	β_{66}	-0.104	$ln_{Man} \times ln_{Pes}$	β_{46}	0.152
$ln_{Pht} \times ln_{Pht}$	β_{77}	-0.212	$ln_{Man} \times ln_{Pht}$	β_{47}	0.161
$ln_{Sed} \times ln_{Hum}$	β_{12}	0.735	$ln_{Fer} \times ln_{Pes}$	β_{56}	- 0.022
$ln_{Sed} \times ln_{Mac}$	β_{13}	0.083	$ln_{Fer} \times ln_{Pht}$	β_{57}	- 0.275
$ln_{Sed} \times ln_{Man}$	β_{14}	-0.593	$ln_{Pes} \times ln_{Pht}$	β_{67}	- 0.387*

$\lambda = \frac{\sigma_u}{\sigma_v}$		1.845*
$\sigma = \sqrt{\sigma_u^2 + \sigma_v^2}$		0.063**
Log- likelihood		305.877
Estimated variances of the underlying variables		
v		0.0009
u		0.0031
ε		0.0040
γ = Var(u)/Var (ε)		0.7750

* Significant at 5% level ** Significant at 1 % level

This further implied that greater part of the residual variation in output was associated with the variation in technical inefficiency rather than with 'measurement error', which was associated with uncontrollable factors related to the production process. Moreover, both λ and σ variables of northwestern region of Tamil Nadu entered the output of all farms positively and significantly. The estimate of γ , which is the ratio of the variance of farm-specific performance of technical efficiency to the total variance of output was 0.77, indicating that the difference between the observed and frontier output was primarily due to the factors which were 77 per cent under the control of farms.

Estimation of Technical Efficiency using TNHNSFM

The level of technical efficiency for each of the 180 sample farms was calculated using TNHNSFM by estimating the one-sided error component u_i and is presented in Table .3. The maximum estimated technical efficiency was 99.14 per cent while the minimum was 87.02 per cent using translog normal half-normal stochastic frontier model. The mean level of technical efficiency was 95.72 percent, which implied that the sample farms realized 95.72 percent of their technical abilities. According to Grabowski et al., (1990), a farm is considered technically inefficient even if the farm registered a technical efficiency of 82 per cent. By this standard, 100 per cent of farms considered technically efficient in the sample under study using translog normal half-normal stochastic frontier model as no farm has reported the technical efficiency score of less than 87 per cent.

Table .3 Farm Specific Technical Efficiency of Translog Normal Half-Normal Stochastic Frontier Model

Farms	Values	Farms	Values	Farms	Values	Farms	Values
F1	0.970	F46	0.980	F91	0.967	F136	0.955
F2	0.907	F47	0.959	F92	0.967	F137	0.965
F3	0.954	F48	0.934	F93	0.956	F138	0.991

F4	0.975	F49	0.938	F94	0.965	F139	0.901
F5	0.978	F50	0.977	F95	0.944	F140	0.975
F6	0.943	F51	0.980	F96	0.976	F141	0.975
F7	0.948	F52	0.977	F97	0.957	F142	0.934
F8	0.976	F53	0.987	F98	0.955	F143	0.956
F9	0.988	F54	0.900	F99	0.972	F144	0.928
F10	0.968	F55	0.987	F100	0.973	F145	0.984
F11	0.941	F56	0.979	F101	0.979	F146	0.962
F12	0.934	F57	0.959	F102	0.947	F147	0.963
F13	0.885	F58	0.980	F103	0.985	F148	0.951
F14	0.913	F59	0.913	F104	0.954	F149	0.953
F15	0.960	F60	0.982	F105	0.950	F150	0.979
F16	0.977	F61	0.982	F106	0.985	F151	0.975
F17	0.986	F62	0.937	F107	0.977	F152	0.961
F18	0.870	F63	0.978	F108	0.978	F153	0.956
F19	0.956	F64	0.912	F109	0.982	F154	0.958
F20	0.919	F65	0.977	F110	0.980	F155	0.956
F21	0.892	F66	0.969	F111	0.971	F156	0.973
F22	0.961	F67	0.943	F112	0.961	F157	0.963
F23	0.903	F68	0.908	F113	0.970	F158	0.969
F24	0.956	F69	0.965	F114	0.963	F159	0.959
F25	0.879	F70	0.926	F115	0.980	F160	0.940
F26	0.988	F71	0.929	F116	0.965	F161	0.973
F27	0.981	F72	0.983	F117	0.968	F162	0.975
F28	0.926	F73	0.919	F118	0.956	F163	0.963
F29	0.980	F74	0.956	F119	0.944	F164	0.978
F30	0.910	F75	0.977	F120	0.950	F165	0.960
F31	0.938	F76	0.955	F121	0.935	F166	0.974

F32	0.963	F77	0.986	F122	0.973	F167	0.975
F33	0.966	F78	0.956	F123	0.976	F168	0.965
F34	0.985	F79	0.974	F124	0.957	F169	0.976
F35	0.973	F80	0.962	F125	0.952	F170	0.968
F36	0.979	F81	0.937	F126	0.940	F171	0.928
F37	0.959	F82	0.960	F127	0.941	F172	0.963
F38	0.980	F83	0.973	F128	0.956	F173	0.950
F39	0.913	F84	0.981	F129	0.945	F174	0.946
F40	0.966	F85	0.905	F130	0.917	F175	0.955
F41	0.971	F86	0.906	F131	0.964	F176	0.953
F42	0.981	F87	0.979	F132	0.973	F177	0.920
F43	0.975	F88	0.974	F133	0.952	F178	0.980
F44	0.929	F89	0.929	F134	0.966	F179	0.964
F45	0.959	F90	0.973	F135	0.972	F180	0.950

Maximum TE = 0.9914 Minimum TE = 0.8703 Mean TE = 0.9572

However, for better indication of the distribution of individual efficiencies, a frequency distribution of predicted technical efficiencies within ranges of five using TNHNSFM is depicted in Table .4. This indicated less variations in the level of technical efficiency across farms. Results from Table .4 showed that 27 per cent of sample farms operated below a technical efficiency of 95 per cent indicating scope to increase turmeric production by 5 per cent with the efficient allocation of inputs and using the same technology.

Table .4 Frequency Distribution of Farm Specific Technical Efficiency Estimates Using Translog Normal Half–Normal Stochastic Frontier Model

Efficiency Score (per cent)	No. of Farms	Percentage
Below 85	-	-
85 – 90	4	2.22
90 – 95	44	24.45
95 – 100	132	73.33

Moreover, the highest number of farms (132) was found in the technical efficiency class of 95-100 per cent. However, the model range lies between 87.02 per cent and 99.14 per cent. No farm has reported a technical efficiency score of less than 85 per cent.

To test whether the model TNHNSFM predicted technical efficiency accurately, correlation coefficient between observed efficiency and technical efficiency has been calculated and presented in the following section.

Correlation Analysis for TNHNSFM

The strength of relationship that exists between the observed efficiency and technical efficiency using TNHNSFM is given by the correlation coefficient $r_{OE} = 0.587$. Among translog models, TNHNSFM showed highest correlation coefficient followed by TNESFM and TNTNSFM

Chi-square Test for Goodness of Fit of TNHNSFM

Table 5 Measurement of Chi-square for TNHNSFM

Farms	Observed Efficiency (O_i)	Expected Efficiency (E_i)	$\frac{(O_i - E_i)^2}{E_i}$	Farms	Observed Efficiency	Expected Efficiency	$\frac{(O_i - E_i)^2}{E_i}$
F1	1.042	0.970	0.00531	F46	1.083	0.980	0.01090
F2	0.833	0.907	0.00591	F47	1.000	0.959	0.00173
F3	0.917	0.954	0.00148	F48	0.958	0.934	0.00063
F4	0.958	0.975	0.00028	F49	1.000	0.938	0.00406
F5	1.042	0.978	0.00420	F50	1.042	0.977	0.00431
F6	0.958	0.943	0.00025	F51	1.042	0.980	0.00387
F7	1.000	0.948	0.00290	F52	1.042	0.977	0.00434
F8	1.042	0.976	0.00441	F53	1.083	0.987	0.00946
F9	1.125	0.988	0.01903	F54	0.917	0.900	0.00029
F10	1.042	0.968	0.00562	F55	1.083	0.987	0.00947
F11	0.958	0.941	0.00031	F56	1.000	0.979	0.00047
F12	0.917	0.934	0.00033	F57	1.000	0.959	0.00178
F13	0.875	0.885	0.00010	F58	1.063	0.980	0.00693
F14	0.917	0.913	0.00001	F59	0.917	0.913	0.00001
F15	0.792	0.960	0.02936	F60	1.083	0.982	0.01036
F16	0.833	0.977	0.02112	F61	1.083	0.982	0.01045
F17	1.042	0.986	0.00318	F62	1.000	0.937	0.00427
F18	0.875	0.870	0.00003	F63	1.042	0.978	0.00413

F19	0.917	0.956	0.00160	F64	0.917	0.912	0.00003
F20	0.833	0.919	0.00802	F65	1.042	0.977	0.00432
F21	0.917	0.892	0.00066	F66	1.000	0.969	0.00101
F22	0.833	0.961	0.01691	F67	0.958	0.943	0.00024
F23	0.917	0.903	0.00019	F68	0.917	0.908	0.00008
F24	0.875	0.956	0.00690	F69	1.000	0.965	0.00128
F25	0.750	0.879	0.01899	F70	1.000	0.926	0.00595
F26	0.958	0.988	0.00086	F71	0.958	0.929	0.00093
F27	0.833	0.981	0.02233	F72	1.083	0.983	0.01016
F28	0.750	0.926	0.03345	F73	1.042	0.919	0.01649
F29	0.833	0.980	0.02183	F74	1.000	0.956	0.00204
F30	0.750	0.910	0.02802	F75	1.042	0.977	0.00433
F31	0.750	0.938	0.03766	F76	1.000	0.955	0.00217
F32	1.000	0.963	0.00143	F77	1.083	0.986	0.00967
F33	1.042	0.966	0.00598	F78	1.000	0.956	0.00205
F34	1.083	0.985	0.00988	F79	1.042	0.974	0.00469
F35	1.000	0.973	0.00077	F80	1.042	0.962	0.00658
F36	1.000	0.979	0.00047	F81	1.042	0.937	0.01172
F37	1.000	0.959	0.00178	F82	1.000	0.960	0.00168
F38	1.063	0.980	0.00693	F83	1.042	0.973	0.00478
F39	0.917	0.913	0.00001	F84	1.042	0.981	0.00380
F40	1.083	0.966	0.01431	F85	0.917	0.905	0.00014
F41	0.958	0.971	0.00017	F86	0.917	0.906	0.00012
F42	1.000	0.981	0.00039	F87	1.042	0.979	0.00398
F43	1.042	0.975	0.00458	F88	1.042	0.974	0.00477
F44	0.917	0.929	0.00015	F89	0.958	0.929	0.00091
F45	1.000	0.959	0.00179	F90	1.042	0.973	0.00491

Farms	Observed Efficiency (O_i)	Expected Efficiency (E_i)	$\frac{(O_i - E_i)^2}{E_i}$	Farms	Observed Efficiency (O_i)	Expected Efficiency (E_i)	$\frac{(O_i - E_i)^2}{E_i}$
F91	1.000	0.967	0.00112	F136	1.042	0.955	0.00795
F92	1.042	0.967	0.00578	F137	1.167	0.965	0.04214
F93	1.000	0.956	0.00201	F138	1.250	0.991	0.06744
F94	1.000	0.965	0.00131	F139	0.958	0.901	0.00360
F95	1.042	0.944	0.01002	F140	1.167	0.975	0.03751
F96	1.042	0.976	0.00437	F141	1.083	0.975	0.01194
F97	1.000	0.957	0.00196	F142	1.000	0.934	0.00461
F98	1.000	0.955	0.00214	F143	1.083	0.956	0.01698
F99	1.042	0.972	0.00501	F144	1.000	0.928	0.00554
F100	1.042	0.973	0.00485	F145	1.083	0.984	0.00998
F101	1.083	0.979	0.01102	F146	1.042	0.962	0.00656
F102	1.042	0.947	0.00956	F147	1.042	0.963	0.00644
F103	1.042	0.985	0.00329	F148	0.958	0.951	0.00005
F104	0.833	0.954	0.01524	F149	1.042	0.953	0.00818
F105	0.833	0.950	0.01433	F150	1.083	0.979	0.01107
F106	1.042	0.985	0.00323	F151	1.042	0.975	0.00451
F107	1.042	0.977	0.00430	F152	1.042	0.961	0.00674
F108	1.042	0.978	0.00411	F153	1.042	0.956	0.00762
F109	1.042	0.982	0.00364	F154	1.042	0.958	0.00724
F110	1.042	0.980	0.00388	F155	1.000	0.956	0.00205
F111	1.000	0.971	0.00088	F156	1.042	0.973	0.00482
F112	1.000	0.961	0.00162	F157	1.000	0.963	0.00141
F113	1.083	0.970	0.01313	F158	1.042	0.969	0.00539
F114	1.042	0.963	0.00644	F159	1.042	0.959	0.00710
F115	1.042	0.980	0.00386	F160	1.000	0.940	0.00388
F116	1.000	0.965	0.00126	F161	1.083	0.973	0.01253
F117	1.083	0.968	0.01379	F162	1.083	0.975	0.01194
F118	1.042	0.956	0.00776	F163	1.042	0.963	0.00642
F119	1.042	0.944	0.01001	F164	1.083	0.978	0.01143
F120	1.000	0.950	0.00259	F165	1.042	0.960	0.00703
F121	1.042	0.935	0.01214	F166	1.083	0.974	0.01224
F122	1.083	0.973	0.01248	F167	1.083	0.975	0.01213
F123	1.083	0.976	0.01181	F168	1.042	0.965	0.00614
F124	1.042	0.957	0.00747	F169	1.083	0.976	0.01173
F125	1.000	0.952	0.00244	F170	1.042	0.968	0.00563
F126	1.083	0.940	0.02200	F171	1.000	0.928	0.00556
F127	1.000	0.941	0.00376	F172	1.042	0.963	0.00641
F128	1.042	0.956	0.00764	F173	1.042	0.950	0.00886
F129	1.000	0.945	0.00316	F174	1.000	0.946	0.00309
F130	1.000	0.917	0.00744	F175	1.042	0.955	0.00795
F131	1.125	0.964	0.02697	F176	1.042	0.953	0.00830
F132	1.167	0.973	0.03839	F177	1.000	0.920	0.00698
F133	1.167	0.952	0.04850	F178	1.083	0.980	0.01096
F134	1.167	0.966	0.04179	F179	1.042	0.964	0.00625
F135	1.083	0.972	0.01284	F180	1.042	0.950	0.00875

$\chi^2 = 1.4386$

Chi-square test was applied to test the Goodness of fit of translog normal half-normal stochastic frontier model in measuring technical efficiency. As could be seen in Table 4.2.5 the χ^2 value of TNHNSFM is obtained as 1.4386. Therefore, there was less difference between observed efficiency and technical efficiency using TNHNSFM.

Empirically Estimated Translog Normal Half-Normal Production Function The estimated translog normal half-normal production function (Palanisami *et al.,* (2002) is given as follows

$$\text{PROD} = (288.686)\ Sed^{-41.875}\ Hum^{-9.926}\ Mac^{-5.518}\ Man^{1.605}\ Fer^{0.516}\ Pes^{5.498}\ Pht^{-17.414}$$

$$\exp\{(2.912)(\ln Sed)(\ln Sed) + (-0.736)(\ln Hum)(\ln Hum) + (-0.319)(\ln Mac)(\ln Mac)\}\times$$

$$\exp\{(-0.637)(\ln Man)(\ln Man) + (-0.050)(\ln Fer)(\ln Fer) + (-0.104)(\ln Pes)(\ln Pes)\}\times$$

$$\exp\{(-0.212)(\ln Pht)(\ln Pht) + (0.735)(\ln Sed)(\ln Hum) + (0.083)(\ln Sed)(\ln Mac)\}\times$$

$$\exp\{(-0.593)(\ln Sed)(\ln Man) + (-0.065)(\ln Sed)(\ln Fer) + (-0.011)(\ln Sed)(\ln Pes)\}\times$$

$$\exp\{(2.011)(\ln Sed)(\ln Pht) + (0.502)(\ln Hum)(\ln Mac) + (0.504)(\ln Hum)(\ln Man)\}\times$$

$$\exp\{(0.068)(\ln Hum)(\ln Fer) + (-0.489)(\ln Hum)(\ln Pes) + (0.662)(\ln Hum)(\ln Pht)\}\times$$

$$\exp\{(0.113)(\ln Mac)(\ln Man) + (0.109)(\ln Mac)(\ln Fer) + (0.217)(\ln Mac)(\ln Pes)\}\times$$

$$\exp\{(-0.073)(\ln Mac)(\ln Pht) + (0.170)(\ln Man)(\ln Fer) + (0.152)(\ln Man)(\ln Pes)\}\times$$

$$\exp\{(0.161)(\ln Man)(\ln Pht) + (-0.022)(\ln Fer)(\ln Pes) + (-0.275)(\ln Fer)(\ln Pht)\}\times$$

$$\exp\{(-0.387)(\ln Pes)(\ln Pht)\}$$

Conclusion

The results clearly showed the existence of technical inefficiency in turmeric production. A measure of technical efficiency showed the scope for improvement in production even under current status of technology. Technical inefficiency might be due to lack of awareness, working knowledge, skill, attitude or inadequate resource supply required for the adoption of the technology. The effectiveness of extension education in diffusing technology may also be a factor. Attempts to maximize production through improvement in efficiency will not be achieved without improvement in skills of human resources. For a meaningful development of a production sector, the government should provide various incentives and stimulants necessary for the continuous expansion of the production. Mechanization might help to improve precision in farming practices which in turn improves productivity.

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