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MEASUREMENT OF TECHNICAL EFFICIENCY IN MARINE FISHING

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The economic efficiency in a production process is divided into two components. Technical efficiency and pricing / allocative efficiency. Allocative efficiency is the ability of a farm to use inputs in optimal proportions, given their respective prices. A farmer is said to be price efficient if he maximises the profit. Technical efficiency is the effectiveness with which a given set of inputs is used to produce an output. A firm is said to be technically efficient if a firm is producing the maximum output from the minimum quantity of inputs. It is the ratio between actual and technically maximum possible output at a given level of resources. Farrell (1951) defined the economic efficiency by the product of technical efficiency and allocative efficiency.

Methods of technical efficiency analysis

Several methods are used to measure technical efficiency. The parametric approach consists of many econometrical techniques and non-econometrical ones estimating the production or cost frontier parameters (Cobb-Douglass, CES, Translog, etc.). The non-parametric approach is used when the production process cannot be identified by a functional form. Data Envelopment Analysis (DEA) helps to estimate the parametric approach of the production frontier. The mathematical program planning helps to estimate the nonparametric approach frontiers.

Measuring efficiency in Deterministic Frontier production function

$$Y = b_0 + b_1X_1 + b_2X_2 + \cdots b_nX_{n+e}$$

Where Y is the log of output

X_1 .... X_n are the log values of inputs and e is the random error term

The equation can be rewritten as $Y_t = \hat{y}_t + e_t$

To be an efficient frontier $\sum_{i=0}^{n} b_i\ X_{it} = \hat{y}_t > y_t$

The efficient farm satisfies the conditions of $e_t=0$ or $\hat{y}_t = y_t$

Stochastic frontier production function

The commonly used approach in measuring the TE is the stochastic frontier approach. Initially the frontier model is estimated, usually by maximum likelihood approach and then the estimated model is used to construct measures of inefficiency or efficiency. The model was originally developed by Aigner, Lovell, and Schmidt (1977).

In the stochastic frontier production function, the error term was decomposed into two parts, the symmetric component permits random variation of the frontier across firms and captures the effect of measurement errors, other statistical noises and random shocks outside the firm. A one-sided error term captures the effects of inefficiency relative to the stochastic frontier. The technical efficiency shows the farms' ability of maximizing output with a set of given input. The range of TE is 0 to 1. TE = 1 implies that the farm is producing on its production frontier and is said to be technically efficient. Hence, (1–TE) represents the gap between actual production and optimum attainable production that can be achieved by moving the firm towards the frontier through read justing inputs (Chaves and Aliber, 1993).

Stochastic frontier models are superior to deterministic models because they include a separate symmetric component of the variation which takes care of measurement error, mis-specification of the model and exogenous shocks and one sided error term which takes care of inefficiency.

A stochastic frontier model is given as

Y=f (X_1, X_2, X_3.........) + (v±u)

Where v is the symmetric error component and $u_i{}'s$ the one sided error component. The function can be estimated by maximum likelihood techniques.

With the assumptions of a half normal distribution of u_i and normal distribution of v_i the frontier model is written as Y= f (X_1, X_2, X_3.........)) ± (v-u)

Where u ~ N (0, σ2u) and v~ N(0,σ2v).

The parameter of gamma distribution of u, λ=σ2u/ σ2v.

The estimates of λ and σ are provided by software packages like LIMDEP/SHAZAM/SAS etc.

The technical inefficiency is given by v_i / f (X_1, X_2, X_3.........) where the denominator represents the estimated frontier and v_i are the upward /downward inefficiencies of individual firms

Mean technical efficiency =1- σu (2/π) 1/2

Empirical example: Technical efficiency analysis of trawlers in Tuticorin fishing harbor using stochastic frontier production function using SAS

The technical efficiency of single-day trawlers operating in Tuticorin fishing harbour was analysed using stochastic frontier production function. In the stochastic frontier production function, a stochastic component that describes random shocks affecting the production process is added. Since marine fish production is very much affected by several external factors, landings of fishing units showed variability among seasons, fishing units, fishing grounds, etc. and hence stochastic frontier models are more suitable. The data is usually collected following a multi-stage random sampling method covering all the seasons in a year to obtain the annual landings of craft. For technical efficiency analysis, multistage sampling covering the various fishing trips of the same fishing unit for at least a year including the lean and peak seasons will give better results.

SAS codes for stochastic frontier analysis

In SAS, The QLIM (qualitative and limited dependent variable model) procedure supports the stochastic frontier production function estimation. The explanatory variables (inputs) used in the model were fuel (FL), ice (IC) and labour (LB) used per fishing trip (log values) and the output was expressed as the log of fish produced per fishing trip (LQ).

The following statements create the dataset:

```
title1 'Stochastic Frontier Production Model'; data TE;

input FL IC LB LQ;

datalines;
```

7.0901	2.8904	3.218876	6.9565
6.9565	2.8904	3.218876	7.1053
6.9565	2.8904	3.178054	6.981
7.2793	2.8904	3.218876	7.0926
6.3969	2.8904	2.890372	6.9324

... more lines ...

/*-- Stochastic Frontier Production Model --*/ proc qlim data=TE; model LQ=FL LB IC; endogenous LQ ~ frontier (type=exponential production); run;

Results: Parameter estimates of stochastic frontier production function: mechanised trawlers in Tuticorin fishing harbour

Parameter Estimates					
Parameter	DF	Estimate	Standard Error	t Value	Approx Pr > |t|
Intercept	1	6.176947	0.133628	46.22	<.0001
Diesel(FL)	1	0.262065	0.047809	5.48	<.0001
Ice(IC)	1	0.037303	0.037695	0.99	0.3224
Labour(LB)	1	-0.261055	0.074543	-3.50	0.0005
_Sigma_v	1	0.358410	0.012364	28.99	<.0001
_Sigma_u	1	0.128539	.	.	.

Technical efficiency analysis of single-day trawlers in Tuticorin fishing harbor (TFH) in 2014 using stochastic frontier production function in SAS showed that diesel consumption had positive and significant influence on quantity of fish landed and labour use had negative influence on fish production. Mean Technical efficiency calculated from the estimated parameters was 71 % which indicated that 29% of boat operations were inefficient and hence there is scope to increase the technical efficiency of fishing units by efficient resource use.

Suggested reading

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