

# TENANCY EFFICIENCY IN PADDY CULTIVATION: A STUDY OF WEST BENGAL

Subrata Kundu\*

*This study takes into account the size-class differences among owners and tenants in the context of measuring sharecropping efficiency using Data Envelopment Approach. The present study is based mainly on primary cross-section data. The primary data on various aspects were collected through the personal interview method using suitably designed pre-tested schedule/questionnaire for the year 2009-2010. This analysis shows that the small-sized farms belonging to both owner and tenant categories are more efficient than others. The average efficiency levels are 86 per cent for owner cultivators and 90 per cent for tenant-cultivators. This result indicates that there exists some scope to improve the productivity levels with the existing level of input use and with the available technology. This study can prove useful to policy makers and researchers in evaluating the performance of West Bengal agriculture.*

**Keywords :** Underdeveloped Economy, Technical Efficiency, Sharecropping Efficiency Data Envelopment Analysis,

## INTRODUCTION

The efficiency of resource-use under different types of tenure is a subject of discussion which received considerable attention, theoretically as well as empirically, among the economists of both Marshallian and non-Marshallian tradition. In the early stages of discussion most writers, concerning the subject of resource allocation patterns, argued that share tenancy is inefficient compared to the alternatives of cash tenancy and owner cultivation [Johnson 1950; Cheung 1969; Bardhan and Srinivasan 1971; Koo 1973; Stiglitz 1974; Sen 1975; Bell and Zusman 1976; Reid Jr. 1976; Newbery 1977; Bell 1977; Swamy 1988; etc.]. Their argument supports the view that outputs being shared with the landlord, a share tenant gets only a portion of what he or she produces. Hence, the tenant does not have the incentive to cultivate efficiently on share-rented land and the tenant can be expected to undersupply resources. Consequently, the output per hectare would be greater for a purely owner operated farm and for a fixed rent tenant operated farm than for a tenant operated sharecropping farm. The challenge to the poor opinion of sharecropping was exemplified from the very beginning by a small group of economists [Cheung 1968, 69; etc]. They held that sharecropping in fact could be an efficient way of organising agricultural production provided the landlord was able to induce efficiency in share tenancy by monitoring inputs.

So far, only a few studies have attempted to measure the efficiency of resource use under different types of tenure in West Bengal agriculture. A study was carried out by Chattopadhyay (1979). He used a sample of 808 farms selected from 12 villages of Sriniketan in Birbhum district of West Bengal during 1976-77. The study indicated that owner-cultivators cultivate their land more intensively than the tenant-cultivated farms of the corresponding class of holdings except the biggest one. In fact, the large tenant cultivators behave more or less in the same fashion as owner cultivators in so far as intensities of different types of inputs as well as productivity of land are concerned. The evidence thus did not indicate inefficiencies in the use of land under large tenant cultivators. This, however, was not true in the case of small tenants.

Similar attempts were made by some other researchers (e.g., Bhaumik, 1993; Chattopadhyay and Sarkar, 1997) to study tenurial efficiency in different regions of India. Bhaumik's (1993) sample consisted of 224 households spread over four blocks of Midnapore district of West Bengal during 1986-87. He examined the differences in performances of the households across various plots of land in terms of the value of

\* Dept. of Economics, Vivekananda Satavarshiki Mahavidyalaya, Manikpara, Paschim Medinipur, West Bengal

output per acre and the intensity of input use (bullock labour, human labour and material inputs) per acre. He divided the sample of farmers into three categories: owners, share-croppers and fixed-rent tenants and compared the performances of these three types of tenure. The study was conducted for a number of crops (such as aman paddy, boro paddy, potato and sugarcane). He observed that only for paddy, share-cropped plots showed greater degree of efficiency than the owned plots. On the other hand, the intensity of resource use as well as land productivity appeared to be invariant between owned and fixed-rent plots.

Chattopadhyay and Sarkar (1997) studied the problem with reference to 150 farming households situated in North 24 Parganas district in West Bengal. Using the variables capturing output productivity and intensity of input use, they observed that there was no remarkable difference in the utilization of different types of inputs (human labour, bullock labour, material inputs etc.) and output per unit of land among the groups of tenants and owners. A multiple regression set-up using a number of variables suggested that fertilizer and irrigation are the most important variables in explaining the variations in agricultural output as well as yield per acre for the region under study<sup>1</sup>.

A more recent study was done by Chattopadhyay and Sengupta (2001). They have used farm-level disaggregate data pertaining to the year 1989-90 for West Bengal. They used data envelopment approach which involves no assumptions whatsoever about relation between dependent and independent variables of the production function. Their analysis shows that the medium-size farms belonging to both owner and tenant categories are efficient. Among the factors that help them to be efficient, the availability of irrigation seems to be very important. Use of machine has no positive role while non-irrigation material cost provides very little support.

One of the important measures of overall resource use efficiency is technical efficiency. The ratio between the actual and the potential outputs is defined as a measure of technical efficiency of an economic decision-making unit in the literature and the production environment in which a farm/firm operates (socio-economic characteristics) determines the variations in the efficiency levels of the firm household [Kalirajan and Shand (1994)]. Improving Technical efficiency is important to reap the potential benefits of the existing technology, rather than searching for new technology [Kalirajan *et al.* (1996)]. This study attempts to measure the farm-specific technical efficiency for paddy cultivation of different types of tenure in West Bengal agriculture. In the present study, we employ the Data Envelopment Approach (DEA). For estimation of technical efficiency, parametric approaches like the Stochastic Frontier Approach are also available. However, we have used DEA mainly because of two reasons:

- In case of DEA one is not required to assume any specific functional form describing the output-input relationship.
- The DEA approach (unlike its parametric counterpart) can easily handle multiple outputs.

The paper proceeds as follows. First, we give a brief description of the data used. Then the next Section provides methodological framework. DEA approach for measuring efficiency is elaborated in this section and after that the empirical results are provided. Finally the study is concluded.

## DATA DESCRIPTION

The present study is based mainly on cross-section data. The required information meant for the study was collected from the primary source. The primary data on various aspects relating to the inputs of production of the sample farms were collected through the personal interview method using suitably designed pre-tested schedule/ questionnaire for the year 2009-2010. These sample households were

---

<sup>1</sup> They used variables such as the size of operational holdings, percentage of area irrigated, fertilizer cost per acre, percentage of leased-in area to total cultivated area etc.

selected from six blocks located in Paschim Medinipore district in West Bengal. Paschim Midnapur district was purposively selected since it had varying socio-economic and geographical features. Total 160 sample households were selected for collecting the required information for the study. The selected households were stratified into Owner operator and tenant. Thus 110 households from the owner operator and 50 from the tenant were selected for the purpose of study.

This data set supplies information on various inputs like human labour, bullock labour, fertilizer, manure, machine and output of all the crops cultivated both in value and quantitative terms. For our efficiency estimates we have taken several inputs namely Labour (human labour), Capital<sup>2</sup>, Intermediate input<sup>3</sup> which presumably explain production of most of the crops very well. All these variables are measured in per unit area. The time period is one year. Information is also provided for other items of farm expenditure as well.

## MEHTODOLOGICAL FRAMEWORK

### Concept of Technical Efficiency

In judging the performance of a production unit, one commonly examines whether or not the unit is efficient and/or productive. However, the terms efficient and productive are not synonymous. In production theory, productivity refers to the output produced per unit of input while efficiency/inefficiency of a production unit means the comparison between the observed and the potential/optimal output or input. The comparison can take the form of the ratio between observed and optimal level of output for a given input set, the ratio between observed and optimal level of input set for a given output, or combination of the two. Efficiency of production units can be technical, allocative, scale or economic. Technical efficiency refers to a farm's ability to obtain the maximum possible output from a given set of inputs. There are, however, two major alternative approaches towards defining technical efficiency: the Pareto-Koopmans approach and the Debreu-Farrell approach.

Koopmans (1951) provided a formal definition of technical efficiency: a producer is technical efficient if an increase in any output requires a reduction in at least one other output or an increase in at least one input, and if a reduction in any input requires an increase in at least one other input or a reduction in at least one output. Thus, a technically inefficient producer could produce the same output with less of at least one input, or could use the same inputs to produce more of at least one output. Because of its Paretian implication, this approach is known as Pareto-Koopmans approach.

Debreu (1951) and Farrell (1957) introduced a measure of technical efficiency. Their measure is defined as one minus the maximum equi-proportionate reduction in all inputs that still allows continued production of given outputs. A score of unity indicates technical efficiency because no equi-proportionate input reduction is feasible, and a score less than unity indicate the severity of technical inefficiency. In some circumstances, it is desirable to convert the Debreu-Farrell measure to equi-proportionate output expansion with given inputs; the conversion is straightforward.

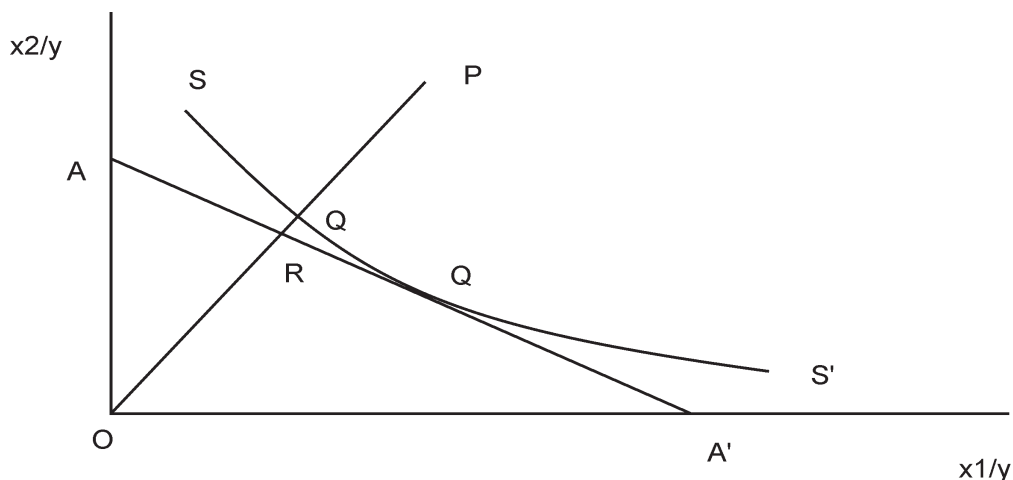
The Debreu-Farrell approach yields a radial measure of technical efficiency, as efficiency is measured along a ray from the origin to the observed production point. Consequently, the efficiency measure hold the relative proportions of inputs (or outputs) constant.

<sup>2</sup> For capital we have used the capital expenses (expenditure of machinery, implements, bullock, irrigation expenses etc.). In rural India, irrigation claims the lion's share in the cost of capital. Creating channels for canal irrigation or buying tube wells are costly. Even operating and maintenance cost may also make the difference. Irrigation costs also include cost of fuels such as electricity, petroleum etc.

<sup>3</sup> Following the suggestion of Ball, Hallahan and Nehring (2004), we have treated fertilizer and pesticides as the main intermediate inputs.

A comparison of the two approaches shows that the Pareto-Koopmans approach is stricter than the Debreu-Farrell approach. In the radial approach, radial expansion (contraction) of output (input) can give rise to output (input) slacks. The Pareto-Koopmans does not allow the existence of any such slacks if a firm is to be declared technically efficient. The two definitions of efficiency are same only when the underlying production technology which comprises only properly enveloped units is efficient for each output. In the present paper, we have followed the Debreu-Farrell approach.

**Figure 1: Technical Efficiency**



Farrell illustrated his ideas using a simple example involving firms, which used two inputs ( $x_1$  and  $x_2$ ) to produce a single output ( $y$ ), under the assumption of constant return to scale.<sup>4</sup> Knowledge of the unit isoquant of fully efficient firms,<sup>5</sup> represented by  $SS'$  in Figure 1, permits the measurement of technical efficiency. If a given firm uses quantities of inputs, defined by the point  $P$ , to produce a unit of output, the technical inefficiency of that firm could be represented by the distance  $QP$ , which is the amount by which all inputs could be proportionally reduced without a reduction in output. This is usually expressed in percentage terms by the ratio  $QP/OP$ , which represents the percentage by which all inputs need to be reduced to achieve technically efficient production. The technical efficiency (TE) of a firm is most commonly measured by the ratio  $TE_i = OQ/OP$ , which is equal to one minus  $QP/OP$ .<sup>6</sup> It will take a value between zero and one, and hence provides an indicator of the degree of technical inefficiency of the firm. A value of one indicates the firm is fully technically efficient. For example, the point  $Q$  is technically efficient because it lies on the efficient isoquant.

Traditionally the Stochastic Frontier Approach (SFA) is used to measure the technical efficiency given the technology and prices. However, this econometric approach requires the specification of production function technology. Recently, mathematical programming approaches, such as Data Envelopment Analysis (DEA) are developed to measure technical efficiency by combining the firm's production to the best production frontier (Seiford and Thrall, 1990). Coelli (1995), among many others indicated that

<sup>4</sup> The assumption of constant returns to scale allows the technology to be represented using the unit isoquant. Farrell also discussed the extension of his method so as to accommodate more than two inputs, multiple outputs, and non-constant return to scale.

<sup>5</sup> The production frontier of fully efficient firms is not known in practice, and thus must be estimated from observations on a sample of firms in the industry concerned.

<sup>6</sup> The subscript "i" is used on TE to indicate that it is an input-orientated measure.

DEA approach has two main advantages in estimating the efficiency scores. First, it does not require the assumption of functional form to specify the relationship between inputs and outputs. Second, it does not require the distributional assumption of the inefficiency term.

### Data Envelopment Approach

Data Envelopment Analysis is a non-parametric mathematical programming technique used for assessing/evaluating and comparing the relative performances of economic units with minimal prior assumption on input-output relation. The DEA method is a generalization of Farrell's single input-single output technical efficiency measure to the multiple input-multiple output case. The methodology was originally developed by Charnes, Cooper, and Rhodes (1978) and was later further extended by Banker, Charnes and Cooper (1984).

The DEA approach forms the efficiency frontier out of piecewise linear stretches thereby forming a convex production possibility set. In DEA frontier, efficient observations are those for which no other decision making unit or linear combination of units has as much or more of every output (given inputs) or as little or less of every input (given outputs). The DEA approach is now describe in brief.

Let us consider a productive unit producing a scalar output  $Y$  from bundles of  $m$  inputs  $x = (x_1, x_2, x_3, \dots, x_m)$ .

Let  $(x^j, y^j)$  be the observed input-output bundle of firm  $j$  ( $j=1, 2, 3, \dots, n$ ). The technology is defined by the production possibility set.

$$P_s = \{(x, y) : y \text{ can be produced from } x\}$$

An input-output combination  $(x^0, y^0)$  is feasible if and only if  $(x^0, y^0) \in P_s$ . The underlying assumptions are as follows:

All observed input-output combinations are feasible. Thus  $(x^j, y^j) \in P_s$  ( $j=1, 2, 3, \dots, n$ ).

The production possibility set  $P_s$  is convex. Hence, if  $(x^1, y^1) \in P_s$  and  $(x^2, y^2) \in P_s$  then  $\{\omega x^1 + (1 - \omega) x^2, \omega y^1 + (1 - \omega) y^2\} \in P_s$ . i.e., weighted averages of feasible input-output combinations are also feasible.

Inputs are freely disposable. Hence, if  $(x^0, y^0) \in P_s$  and  $x^1 \geq x^0$  then  $(x^1, y^0) \in P_s$ .

Output is freely disposable. Hence, if  $(x^0, y^0) \in P_s$  and  $y^1 \leq y^0$  then  $(x^0, y^1) \in P_s$ .

#### Computation of Technical Efficiency Using DEA

The production possibility set can be represented by the two alternatives but equivalent ways in terms of the input and output set. For any output bundle  $y^0$  the input requirement set is

$$V(y^0) = \{x : (x, y^0) \in P_s\}$$

Similarly for any input bundle  $x^0$ , the producible output set is

$$P(x^0) = \{y : (x^0, y) \in P_s\}$$

There are accordingly three alternative ways of computing technical efficiency: the revenue maximization approach, the output maximization approach and the cost minimization approach. In this paper output maximization approach has been followed.

In the output maximization approach, the farm seeks to maximize output given the input bundle. As per the Banker, Charnes, and Cooper (1984) orientation (under the assumption of the variable returns to scale) the problem is,

$$\text{Max } \phi$$

$$\text{s. t. } \phi Y^0 \leq \lambda Y$$

$$X0 \geq \lambda X$$

$$\sum \lambda_j = 1 \quad \lambda_j \geq 0$$

In case we assume the operation of constant returns to scale then the condition  $\sum \lambda_j = 1$  is dropped. The calculation of Technical Efficiency is contingent on the assumption about returns to scale. If one assumes constant returns to scale then the productive units are penalized more as compared to the case where the units are assumed to exhibit variable returns to scale. The ratio of VRS and CRS technical efficiency scores gives us the scale efficiency for the respective units.

## EMPIRICAL RESULTS

In Table 1 we present the frequency distribution of farmers by efficiency level derived from the values of  $E_i$ . From this table one can draw some interesting conclusions regarding the nature of efficiency of farmers. The table shows that there are very few farms with efficiency level less than 0.75. The highest number of farms belongs to the efficiency group 0.95 - 1.00 per cent. It implies that the empirical distribution of efficient farms is asymmetrical in nature.

**Table 1: Frequency Distribution of Farmers by Level of Efficiency ( $E_i$ )**

Obtained From DEA Analysis

Levels of Technical Efficiency	Farms
Up to 0.75	20
0.75 - 0.80	22
0.80 - 0.85	16
0.85 - 0.90	26
0.90- 0.95	14
0.95 - 1.00	62
Sample Size	160

In Table 2 we present frequency distributions of the farms categorized as “efficient” and “inefficient” by types of tenure i.e., owners and tenants<sup>7</sup>. This table shows that out of 110 owner-cultivated farms 76 are efficient and out of 50 tenant-cultivated farms 43 are efficient. Thus, the preponderance of efficient farms seems to be larger among the tenants in our study. Obviously, our findings seem to contradict the basic neoclassical logic of inherent inefficiency of tenant farms as propounded by Marshall (1920).

Table 3 shows the summary statistics of the efficiency measures for the sample farmers. Technical efficiency of owner operators ranged between 66 and 96 per cent with an average of 86 percent. This analysis indicates that the output can be raised by 14 per cent by following efficient crop management practices without having to increase the level of application of input. In case of tenant-cultivated farms Technical efficiency ranged between 74 and 99 per cent with an average of 90 percent. This analysis indicates that the output can be raised by 10 per cent by following efficient crop management practices without having to increase the level of application of input.

<sup>7</sup> We have treated farms with efficiency scores greater than 0.8  $E_i \geq 0.8$  as efficient and others as inefficient.

**Table 2: Frequency Distribution of Efficient and Inefficient**

Farms by Types of Tenure

Type of Tenure	Efficient ( $E_i \geq 0.8$ )	Inefficient ( $E_i < 0.8$ )	Total
Owners	76	34	110
Tenants	43	7	50
All	119	41	160

**Table 3: Summary Statistics of the Efficiency Measures**

Variable	Owners	Tenants
Mean	0.86	0.90
Standard Error	0.01	0.03
Median	0.88	0.92
Standard Deviation	0.07	0.09
Minimum	0.66	0.74
Maximum	0.96	0.99
Sample Size	110	50

**Table 4: Frequency Distribution of Efficient and Inefficient Farms  
By Size-Classes of Holdings and Types of Tenure**

Size Classes Of Holdings (hectare)	Efficient Farms		Inefficient Farms		Total
	Owners	Tenants	Owners	Tenants	
Marginal (bellow 1 hect.)	12	9	5	1	27
Small (1 - 2 hect.)	34	16	8	3	61
Medium (2 - 4 hect.)	21	13	9	3	46
Large (above 4 hect.)	9	5	12	0	26
Total	76	43	34	7	160

We now present data on the distribution of farms separately for efficient and inefficient categories by size-classes of holdings<sup>8</sup> and types of tenure in Table 4. The table shows that majority of efficient farms, irrespective of any tenancy type; belong to the small-sized farms. It is also seen from this table that the number of inefficient farms increases with the increase in size-class of holdings particularly among the owner-operated farms. Thus, our empirical observations are show greater efficiency of small-sized farms in West Bengal.

<sup>8</sup> We have used the categorization developed by the West Bengal government.



## CONCLUSION

This study takes into account the size-class differences among owners and tenants in the context of measuring sharecropping efficiency. For this study we have used Data Envelopment Approach. Data are collected from the primary source for the year 2009-2010. This analysis shows that the small-sized farms belonging to both owner and tenant categories are more efficient than others. The average efficiency levels are 86 per cent for owner cultivators and 90 per cent for tenant-cultivators. This result indicates that there exists some scope to improve the productivity levels with the existing level of input use and with the available technology.

## References

- Ball V E, C Hallahan, R Nehring (2004), "Convergence of Productivity: An Analysis of the Catch-up Hypothesis within the Panel of States", *American Journal of Agricultural Economics*, Vol. 86; pp. 1315-1321.
- Banker R D, A Charnes, W W Cooper (1984), "Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis", *Management Science*, 30(9); pp. 1078-1092.
- Bardhan P, T N Srinivasan (1971), "Crop-sharing Tenancy in Agriculture: A Theoretical and Empirical Analysis", *American Economic Review*, 61(1); pp. 48-64.
- Bell C. (1977), "Alternative Theories of Share-cropping: Some Tests Using Evidence from North-East India", *Journal of Development Studies*, Vol. 13, No. 4; pp. 346.
- Bell C, P Zusman (1976), "A Bargaining Theoretic Approach to Crop-sharing Contracts", *American Economic Review*, 66(4); pp. 578-588.
- Bhaumik S K. (1993), *Tenancy Relations and Agrarian Development: A Study of West Bengal*, Sage Publications, New Delhi.
- Charnes A, W W Cooper, E Rhodes (1978), "Measuring the Efficiency of Decision Making Units", *European Journal of Operation Research*, Vol. 2, No. 6; pp. 429-444.
- Chattopadhyay M (1979), "Relative Efficiency of Owner and Tenant Cultivation: A Case Study", *Economic and Political Weekly*, 14(39); pp. 93-96.
- Chattopadhyay M, A Sengupta (2001), "Tenancy Inefficiency – A Study Based on West Bengal Agriculture", *Economic and Political Weekly*, February; pp.3-10.
- Chattopadhyay M, D Sarkar (1997), "A New Look at the Old Bottle: A Study on Land Tenure and Farm Productivity", *Indian Journal of Labour Economics*, 36(2); pp. 201-207.
- Cheung S N S (1968), "Private Property Rights and Sharecropping", *Journal of Political Economy*, Vol.76; pp.107-122.
- Cheung S N S (1969a), *The Theory of Share Tenancy*, Chicago University.
- Coelli T J, (1995), "Recent Developments in Frontier Modeling and Efficiency Measurement", *Australian Journal of Agricultural Economics*, Vol. 39; pp. 219-245.
- Debreu G (1951), "The Coefficient of Resource Utilisation", *Econometrica*, 19(3); pp.273-292.
- Farrell M J, (1957), "The Measurement of Productive Efficiency", *Journal of the Royal Statistical Society, Series A*, 120(3).
- Johnson D G, (1950), "Resource Allocation under Share Contracts", *Journal of Political Economy*, 58(2); pp.111-123.
- Kalirajan K P, R T Shand (1994), *Economics in Disequilibrium: An Approach from the Frontier*, Macmillan India Limited, New Delhi.
- Kalirajan K P, M M Obwona, S Zhao (1996), "A Decomposition of Total Factor Productivity Growth: The Case of Chinese Agricultural Growth Before and After Reforms", *American journal of Agricultural Economics*, Vol. 78; pp. 331-338.



- Koo A Y C. (1973), "Towards a More General Model of Land Tenancy and Reform", *Quarterly Journal of Economics*, 87(4); pp.567-580.
- Koopmans T C, (1951), An Analysis of Production as an Efficient Combination of Activities, in T.C. Koopmans eds., *Activity Analysis of Production and Allocation*, New York Cowles Commission for Research in Economic, Monograph No. 13, John Wiley and Sons.
- Marshall, A. (1920), *Principles of Economics*, London, Macmillan.
- Newberry D M G, Stiglitz, J E (1979), "Sharecropping, Risk-sharing, and the Importance of Imperfect Information", in J.A. Roumasset, J.M. Boussard, and I. Singh (eds). *Risk, Uncertainty, and Agricultural Development*, Agricultural Development Council, New York.
- Reid J D (Jr.) (1976), "Share-cropping and Agricultural Uncertainty", *Economic Development and Cultural Change*, 24(3); pp.549-576.
- Seiford L, R Thrall (1990), "Recent Development in DEA: The Mathematical Approach to Frontier Analysis", *Journal of Econometrics*, Vol.46; pp.7-38.
- Sen A K (1975), *Employment, Technology and Development*, Oxford University Press, London.
- Stiglitz J E (1974), "Incentives and Risk Sharing in Sharecropping", *Review of Economic Studies*, Vol.41; pp.219-255.
- Swamy D S (1988), "Agricultural Tenancy in the 1970's", *Indian Journal of Agricultural Economics*, 43(4); pp.555-568.