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# EFFICIENCY OF KHADI AND VILLAGE INDUSTRIES IN INDIA– DATA ENVELOPMENT APPROACH (DEA)

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## ABSTRACT

*The measurement of efficiency of an industry is important both for the economic theorist and economic policy maker. If economic planning is to concern itself with particular industries, it is important to know how far a given industry can be expected to increase its output by simply increasing its efficiency, without absorbing further resources. Past studies have shown that productivity can be raised by improving efficiency, which usually is a neglected source of productivity, without increasing the resource base or without developing new technologies.*

*The major objective of this study was to analyse technical, scale, cost and allocative efficiencies of Khadi and Village industries in India between 2000-01and 2010-11. The efficiency scores were obtained by applying Data Envelopment Approach (DEA). It could be found that for the entire period, technical, scale, cost and allocative efficient DMUs (Decision Making Units) were more under variable return to scale (VRS) than under constant returns to scale (CRS) production technology. Also it is very clear that inefficiency could be due to the existence of either increasing or decreasing returns to scale.*

## Introduction

Khadi and Village Industries have been recognised as one of the most important means for providing better economic opportunities for the people of a developing economy like India. The importance of Khadi was triggered by Gandhiji in 1908, when he perceived that the chief cause of rural poverty was destruction of spinning wheel. The ideology of Khadi and Village Industries was also popularised by Mahatma Gandhi and dawned upon the imagination of the framers of our Constitution. Promotion of Khadi and Village Industries was specially mentioned in our Constitution as one of the Directive Principles of the State Policy. It was recognised that their labour-intensive industries could mitigate unemployment and promote self-sufficiency. The First Five Year Plan, therefore, laid special emphasis on small scale industries including Khadi and Village industries with the objective of providing additional employment opportunities, mobilising resources of capital and skill and providing a more equitable distribution of income and wealth. The development of Khadi and Village Industries is emerging as a stock of paramount opportunities, diffusion of skills to the rural areas, alleviation of regional imbalances and a better distribution of national income essential to achieve the egalitarian objective of establishing a social welfare state. Village economy cannot be complete without the essential village industries.

The common characteristic found in both Khadi and Village Industries is that they are labour

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intensive in nature. In the wake of industrialisation, and the mechanisation of almost all processes, Khadi and Village industries are suited to a labour surplus country like India.Another advantage of Khadi and Village Industries is that they require little or no capital to set up, thereby making them an economically viable option for the rural poor.This is an important point with reference to India in view of its stark income, regional and rural/urban inequalities.

Efficiency is a very important factor of productivity growth especially in developing economies, where resources are scarce and opportunities for developing and adopting better technology have also started lately. Past studies showed that productivity can be raised by improving efficiency,which usually is a neglected source for productivity, without increasing the resource base or without developing new technologies. In this regard the role played by KVI should not be neglected.

Though the Khadi and Village industry has registered a significant increase in terms of production and sales even during globalisation period, it undoubtedly is facing a stiff competition in the globalisation period.In other words it has shown the signs of withstanding it without consistency. But the Khadi and Village industries has a long way to go as it suffers from too much of reliance on budgetary sources, lack of adopting new market techniques, lack of product innovativeness, could not market the brand image utilising the India's national heritage, etc. Moreover, it has the potential to solve the unemployment problem of rural India to a greater extent. If we ignore the khadi and village industry, it is at our own risk. In order to bring these industries on par with other manufacturing sectors, specifically it's efficiency level will have to be given weightage.

## Methodology

***Database of the Study :*** This study is based on secondary data.The reference period chosen for the study covers ten year period between 2000-01 and 2010-11. The data were available only up to this period while the analysis was made.The basic data source of the study includes, Annual Survey of Industries (ASI) published by Central Statistical Organisation (CSO), Government of India relating to fixed capital, net value added and number of workers. The variables- fixed capital and net value added - were normalised (excepting number of workers) by applying Gross Domestic Product (GDP) deflator in order to convert the actual figures into real terms.For this purpose, GDP at current and constant prices were obtained from various issues of Economic Survey published by Government of India, Ministry of Finance and Economic Division, New Delhi to calculate GDP deflator.

***Tools of Analysis - DEA Model :*** This study is mainly based on input oriented DEA model.In the input-based measure, the technical efficiency of the firm is evaluated by the extent to which all inputs could be proportionally reduced without a reduction in the output. The input oriented CCR model (Charnes,Cooper,Rhodes,1978) and BCC model ( Banker,Charnes and Cooper, 1984) are explained below.

### Technical Efficiency

***(i) CCR Model ( based on constant returns to scale) :*** The efficiency measure for the DMU can be calculated by solving the following mathematical programming problem:

max $h_0(u,v)$ =

$$\frac{\sum_{r=1}^{S} u_r Y_{ro}}{\sum_{i=1}^{S} v_i x_{io}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Subject to

$$\frac{\sum_{r=1}^{S} u_r Y_{rj}}{\sum_{i=1}^{m} v_i xi_j} \leq 1, \text{j} = 1, 2......, \text{j}_o, ......, \text{n}... \text{.....................................(2)}$$

$$u_r \leq 0, r = 1,2,...., s$$
.................. (3)

$$v_i \geq 0, j = 1,2,...., m \quad ...................(4)$$

where xij is the observed amount of input of the ith type of the DMU (xij> 0,

i = 1,2,......n, j = 1,2,.....n) and yrj = the observed amount of output of the rth type for the jth DMU (Yrj > 0, r = 1,2,.....s, j = 1,2,...n).

The variables $u_r$, and vi are the weights to be determined by the above programming problem. However, this problem has infinite number of solutions since if (u*, v*) is optimal then for each positive scalar α (αu*, αv*) is also optimal. Following the Charnes - Cooper transformation (1962), one can select a representative solution (u,v) for which

$$\sum_{i=1}^{m} v_i x_{io} = 1 \quad .......................... (5)$$

to obtain a linear programming problem that is equivalent to the linear fractional programming problem (1) - (4). Thus, denominator in the above efficiency measure $h_0$ is set to equal one and the transformed linear problem for DMU can be written.

$$\max z_0 = \sum_{r=1}^{S} u_r Y_{ro} \quad ........................ \quad (6)$$

Subject to

$$\sum_{r=1}^{S} u_r Y_{rj} - \sum_{r=1}^{m} v_i x_{ij} \leq 0, \; j = 1, 2, \ldots, n$$
......................(7)

$$\sum_{r=1}^{m} v_i x_{io} = 1 \quad ...................... (8)$$

$$u_r \geq 0, r = 1,2,...., s \quad ...................... (9)$$

vi 0, i = 1,2,...., m ...................... (10)

For the above linear programming problem, the dual can be written (for the given DMU) as:

$$\min z_0 = \Theta_o \quad ..................... (11)$$

Subject to

$$\sum_{j=1}^{n} \lambda_r Y_{rj} \geq y_{ro}, \; r = 1,2,...,s \quad ................ (12)$$

$$\Theta o x_{io} - \sum_{j=1}^{n} \lambda_j x_{ij} \geq 0, i = 1,2,\ldots, m$$
...................... (13)

$$\lambda_j \geq 0, \quad j = 1,2,...,n \quad ...................... (14)$$

Both of the above linear problems yield the optimal solution Θ*, which is the efficiency score (so-called technical efficiency or CCR efficiency) for the particular DMU and repeating them for each DMUj , j = 1,2,.....n efficiency scores for all of them are obtained. The value of Θ is always less than or equal unity (since when tested, each particular DMU is constrained by its own virtual input-output combination too). DMUs for which Θ* < 1 are relatively inefficient and those for which Θ* = 1 are relatively efficient, having their virtual input-output combination points laying on the frontier. The frontier itself consists of linear facets spanned by efficient units of the data and the resulting frontier production function (obtained with the implicit constant returns to scale assumption) has no unknown parameters.

***(ii) BCC Model ( based on Constant Returns to Scale ) :*** Since there are no constraints for the weights λj , other than the positivity conditions in the problem (11) - (14), it implies constant returns to scale. For allowing variable returns to scale, it is necessary to add the convexity condition for the weights, λj, i.e. to include in the model (11) - (14) the constraint:

..................... (15)

The resulting DEA model that exhibits variable returns to scale is called BCC model, after Banker, Charnes and Cooper (1984). The input-oriented BCC model for the $DMU_0$ can be written formally as:

min $z_0 = \Theta o$ ..................... (16)

Subject to

$$\sum_{j=1}^{n} \lambda_r Y_{rj} \geq Y_{ro} r = 1,2,\ldots,s$$ ..................... (17)

$$\Theta_o x_{io} - \sum_{j=1}^{n} \lambda_j x_{ij} \geq 0, i = 1,2,\ldots,m$$

..................... (18)

$$\sum_{j=1}^{n} \lambda_j = 1$$ ..................... (19)

$\lambda_j \geq 0$, j = 1,2,...,n ..................... (20)

Running the above model for each DMU, the BCC efficiency scores are obtained (with similar interpretation of its values as in the CCR model). These scores are also called "pure technical efficiency scores", since they are obtained from the model that allows variable returns to scale and hence eliminate the "scale part" of the efficiency from the analysis. Generally, for each DMU the CCR efficiency score will not exceed the BCC efficiency score, what is intuitively clear since in the BCC model each DMU is analysed "locally" (i.e. compared to the subset of DMUs that operate in the same region of returns to scale) rather than "globally".

***iii. Scale Efficiency :*** Following the scale properties of the above two models, (Cooper et al., 2000), the scale efficiency is defined as follows. For a particular DMU, the scale efficiency is defined as a ratio of its overall technical efficiency score (measured by the CCR model) and pure technical efficiency score (measured by the BCC model).

***iv. Cost Efficiency :*** The standard measure of cost efficiency is obtained via a two stage process. i) Estimate the minimum price-adjusted resource usage given technological constraints, and (ii) compare this minimum to actual, observed costs. Cost efficiency can be measured if input prices are available in addition to output and input data. Let $x = (x_1, \ldots x_k) \in R_+^k$ denotes a vector of inputs and $y = (y_1, \ldots y_m) \in R_+^m$ denote vector of outputs. Formally, the cost efficiency model can be specified as :

$\text{Min}_{z,x}$ ..................... (21)

s.t. $z.Y \leq y_0$

z.x x0

zi 0

where Y is an n x m matrix of observed outputs for n industries and x is an n x k matrix of inputs for each industry. z is a I x n vector of intensity variables and $w = (w_1, \ldots w_k) \in R_+^k$ denoted input prices. The constraints of the model (21) define the input requirement set given by :

$L(y) = (x.\ z.\ y \geq y_0,\ z\,x \leq\ x,\ z_i \geq 0,\ \sum_{i=1}^{n} z_i = 1)$ ..................... (22)

The input requirement set specifies a convex technology with Variable Returns to Scale (VRS), which is imposed by the constraint $\sum_{i=1}^{n} z_i = 1$. Leaving the constraint out of the model changes the technology to Constant Returns to Scale (CRS).

***v. Allocative Efficiency :*** Allocative efficiency is defined as a ratio of cost efficiency score to technical efficiency score. Both under CRS production technology and VRS production technology, this efficiency score was estimated for the present study.

**Results and Discussion**

The results regarding the technical efficiency estimates of the industries are presented in Table 1.

**Table 1 : Technical Efficiency (TE) Estimates**

| DMU | CRS | VRS |
|---|---|---|
| 2000-01 | 1.000 | 1.000 |
| 2001-03 | 1.000 | 1.000 |
| 2003-04 | 0.947 | 0.960 |
| 2004-05 | 0.920 | 0.962 |
| 2005-06 | 0.875 | 0.895 |
| 2006-07 | 0.401 | 0.523 |
| 2007-08 | 0.477 | 0.681 |
| 2008-09 | 1.000 | 1.000 |
| 2009-10 | 0.262 | 0.929 |
| 2010-11 | 0.794 | 1.000 |
| Average Technical Efficiency (2001-11) | 0.768 | 0.895 |
| Average Technical Inefficiency (2001-11) | 0.302 | 0.112 |
| No. of Technical Inefficient DMUs (2001-11) | 3 | 4 |

Source: Calculations are based on ASI data.

Footnote: Average technical inefficiency = 1-$\overline{X}/\overline{X}$

CRS- Constant Returns to Scale;
VRS- Variable Returns to Scale.

Under Constant Returns to Scale (CRS) production technology, the average technical efficiency score during 2001-02 to 2010-11 was 0.768. This implied that the industries needed only 76.8 per cent of the inputs. In terms of average inefficiency, it would have needed 23.20 per cent more inputs to produce the same output, which meant waste of resources to the extent mentioned above. Whereas under variable returns to scale production technology (VRS), the average technical efficiency score during the same reference period was 0.895. This again explained the fact that the industries needed only 89.5 per cent of the total inputs. In other words, it would be waste of resources for the industries to the extent of 10.50 per cent in terms average inefficiency to produce the same level output if it employs more than 89.5 per cent of total inputs for producing the same level of output.

Based on the above findings, it could be concluded that under VRS production technology, the number of inefficient DMUs exceeded the number of efficient DMUs (If the efficiency scores across the years are exactly equal to one, those years are referred to as inefficient DMUs or years, which explains the fact that there are no improvements in production). Under VRS production technology, higher average efficiency was recorded. It may be due to the reason that DMUs that were efficient under Constant Returns of Scale (CRS) production technology were accompanied by new efficient DMUs that might operate under increasing or decreasing returns to scale. Higher degree of average technical inefficiency particularly under constant return to scale production technology could be attributable to the fact that the industries may not be using the most efficient technology available to transform the inputs into output due to differences in products produced, differences in selecting best practice frontiers and relatively small regional spheres of operation of the industries might have resulted in inefficiencies and also structured problems regarding staff efficiency and operating efficiency may have prevented the firm from improving its efficiency level.

It could be concluded that though the efficiency of the firms varied considerably on account of the various reasons mentioned, all the firms were estimated to be on the frontiers at least once. In other words, both under CRS and VRS technology, the number of efficiency scores or levels during the entire period, was indicative of the fact that the efficiency of firms was not strongly influenced by the size of production.

***b. Scale Efficiency :*** The scale efficiency scores of the industries selected under the present study are presented in Table 2.

**Table 2 : Scale Efficiency (SE) Estimates**

| DMU | CRS (TE) | VRS (TE) | Scale Efficiency(SE) (CRS(TE)/VRS (TE) | RTS |
|---|---|---|---|---|
| 2000-01 | 1.000 | 1.000 | 1.000 | CRS |
| 2001-03 | 1.000 | 1.000 | 1.000 | CRS |
| 2003-04 | 0.947 | 0.960 | 0.986 | IRS |
| 2004-05 | 0.920 | 0.962 | 0.956 | IRS |
| 2005-06 | 0.875 | 0.895 | 0.978 | IRS |
| 2006-07 | 0.401 | 0.523 | 0.767 | IRS |
| 2007-08 | 0.477 | 0.681 | 0.700 | IRS |
| 2008-09 | 1.000 | 1.000 | 1.000 | CRS |
| 2009-10 | 0.262 | 0.929 | 0.282 | IRS |
| 2010-11 | 0.794 | 1.000 | 0.794 | IRS |
| Average Scale Efficiency (2001-11) | 0.768 | 0.900 | 0.846 | |
| Average Scale Inefficiency (2001-11) | 0.302 | 0.011 | 0.182 | |
| No. of Scale Inefficient DMUs (2001-11) | 2 | 4 | 3 | |

Source : Calculations based on ASI data.

Footnote : Average scale inefficiency = 1-$\overline{X}/\overline{X}$

RTS - Returns to Scale;

IRS - Increasing Returns to Scale;

CRS – Constant Returns to Scale.

DEA results applied to know the scale efficiency of industries for the entire period revealed that the industries were not operating at an optimum scale. The average scale efficiency was 84.6 per cent. In terms of average inefficiency, it could increase additional production to the extent of 15.4 per cent, by taking advantage of their scale characteristics. DEA allows to assess whether a firm lies in the range of increasing, constant and decreasing returns to scale. In other words, it revealed the scale characteristics of DMUs. If market contains firms scale, market efficiency can be increased if more DMUs attain constant returns to scale, because fewer resources are wasted. The measurement of economies of scale, therefore, helps assess at the same time whether higher market concentration should be encouraged to improve efficiency. A DMU may be scale inefficient, if it experiences decreasing returns to scale or if it has not taken full advantages of increasing returns to scale. Indeed most of the inefficient DMUs presented increasing returns to scale characteristics which indicated that industries can increase the scale to effectively improve that efficiency.

***Cost Efficiency :*** Table 3 gives details regarding cost efficiency scores of selected industries for the reference period under study.

**Table 3 : Cost Efficiency (CE) Estimates**

| DMU | CRS | VRS |
|---|---|---|
| 2000-01 | 0.975 | 1.000 |
| 2001-03 | 0.857 | 0.874 |
| 2003-04 | 0.812 | 0.827 |
| 2004-05 | 0.904 | 0.925 |
| 2005-06 | 0.867 | 0.877 |
| 2006-07 | 0.397 | 0.497 |
| 2007-08 | 0.449 | 0.642 |
| 2008-09 | 1.000 | 1.000 |
| 2009-10 | 0.201 | 0.732 |
| 2010-11 | 0.506 | 0.750 |
| Average Cost Efficiency(2001-11) | 0.697 | 0.812 |
| Average Cost Inefficiency (2001-11) | 0.435 | 0.232 |
| No. of Cost inefficient DMUs(2001-11) | 1 | 2 |

Source : Caculations are based on ASI data.
Footnote: Calculations are based on ASI data
CRS- Constant Returns to Scale;
VRS- Variable Returns to Scale;

Average cost inefficiency = $1-\overline{X}/\overline{X}$

Under Constant Returns to Scale (CRS) production technology, the industries were efficient to the extent of 69.7 per cent. Under Variable Returns to Scale (VRS) production technology the same industries were more efficient to the extent of 81.2 per cent. Considering the cost efficient DMU's, it was found to be more under VRS production technology, than under CRS production technology. The average cost inefficiency was more under CRS production technology than under VRS production technology.The average cost inefficiency of the industries under CRS and VRS production technology, respectively were 43.5

and 23.2 per cent.The number of cost inefficient DMUs exceeded the number of cost efficienct DMUs during the reference period under study.

***Allocative Efficiency :*** Allocative efficiency scores of the industries under the reference period are presented in Table 4.

**Table 4 : Allocative Efficiency (AE) Estimates**

| DMU | CRS | VRS |
|---|---|---|
| 2000-01 | 0.975 | 1.000 |
| 2001-03 | 0.857 | 0.874 |
| 2003-04 | 0.857 | 0.861 |
| 2004-05 | 0.982 | 0.962 |
| 2005-06 | 0.990 | 0.980 |
| 2006-07 | 0.992 | 0.950 |
| 2007-08 | 0.943 | 0.943 |
| 2008-09 | 1.000 | 1.000 |
| 2009-10 | 0.769 | 0.788 |
| 2010-11 | 0.637 | 0.750 |
| Average Allocative Efficiency(2001-11) | 0.900 | 0.911 |
| Average Allocative Inefficiency(2001-11) | 0.101 | 0.098 |
| No. of AllocativeInefficient DMUs(2001-11) | 1 | 2 |

Source: Calculations are based on ASI data.
Footnote: CRS- Constant Returns to Scale; VRS- Variable Returns to Scale;
Average Allocative inefficiency = 1-$\overline{X}/\overline{X}$

Estimates revealed that over the study period, the industries under CRS production technology had on an average allocative efficiency level of 90 per cent implying that the industries were 10 per cent inefficient respectively. In the case of VRS production technology, the industries had an average allocative efficiency of 91.1 per cent, implying that the industries were on an average 0.9 per cent inefficient which was negligible. More efficient DMU's were observed in VRS production technology than under CRS production technology.

## Conclusion

It could be concluded that for the entire period of analysis, technical, scale, cost and allocative efficient DMUs were more under Variable Returns to Scale (VRS) production technology than under Constant Returns to Scale (CRS) production technology.Also it is very clear that inefficiency could be due to the existence of either increasing or decreasing returns to scale. Following measures are to be implemented which is consistent ever- Reviewing existing KVI schemes and suggesting policies/ schemes for the sector for employment generation, technology upgradation/ modernisation and support for innovative products, credit, marketing, training need of entrepreneurs and monitorable annual targets for each area. For inclusive growth and sustainable development, the inefficient khadi clusters should increase their production or sales. Moreover, the khadi clusters should strengthen interrelationships relating to infrastructure, technology, procurement, production and marketing and should make use of the benefits announced by Government of India under SFRUTI (Scheme of Fund for Regeneration of Traditional Industries). The soft and hard intervention on Cluster Development Programme of Government of India will help Khadi and Village Industries Clusters in India to increase their productivity and efficiency.

Efforts must be made to improve the quality and value of khadi production by focusing upon design inputs and improving the quality of khadi cloth. The government must also provide adequate finance, tax exemptions, particularly in sales tax, octroi , purchase tax, etc., to khadi and village industries till it can stand on its own and face globalisation. When the issue of climate change is dominating the economic policies, the clean and green techniques of production have to be promoted. Hence khadi and village industries have to be promoted. Moreover, it has the potential to solve the unemployment problem of rural India to a greater extent. If we ignore the khadi and village industry it is at our own risk!. The following policy initiatives are needed for the development of these industries in the near future.

1) To come out with viable technology to reduce the cost of production of khadi and village industries products.

2) The cloth required by government departments like schools, hospitals and jails, should be purchased only from the khadi industries.

3) The government employees of all the departments should be compulsorily asked to wear khadi clothes at least twice in a week.

4) Marketing techniques should be suitably adopted .

5) Khadi and village industries should be encouraged in villages and no MNCs or big firms should be allowed to produce those products produced by Khadi & Village industries.

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