IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

# Slack Based DEA Method For Performance Evaluation of State Police of India-2019

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## ABSTRACT

This paper focuses on the issue of measuring the efficiency of police in India by using Data Envelopment Analysis that is a relative efficiency measuring technique. As DEA not only give us the result for efficient and inefficient DMU's it also provides us the targets that are for the inefficient Units to become the efficient one, so major cause of concern after analysing the relative efficiency scores of the state police units would be regarding the identification of reasons behind the inefficiencies of some of the units as compared to the other units which have turned out to be efficient in the analysis.

**Key words**: Data Envelopment Analysis, Relative efficiency, Police efficiency.

## INTRODUCTION

This paper is application of the technique of Data Envelopment Analysis (DEA) which is a relative efficiency measuring technique to police-work-related data from India. This application of DEA on police work related data provides a rationale for identifying good performance. This also helps in generating the targets of performance, the optimum levels of operations, role models that inefficient units can emulate and the extent to which improvements can be made over a period. The paper measures the performances of State police units in India and infers the ways in which inefficient State police departments can improve their overall efficiency. It is vital for the Police Department to secure the effective and efficient provision of police inspection and repairs. However, due to the difficulty of Police operations, conventional performance measurement methods have not been efficient in recognizing and allocating best practices all over the Police force. A main objective of DEA is to measure the efficiency of a Decision-Making Unit (DMU) by a scalar measure, ranging between zero (the worst) and one (the best). This scalar value is measured through a linear programming model. DEA model deals with the ratio of multiple inputs and outputs to gauge the relative efficiency of the DMUs. This fractional program is solved by transforming it into an equivalent linear program. The optimal objective value ($\theta*$) is called the ratio (or radial) efficiency of the DMU.

Estimation of efficiency regarding police precincts or units can also be classified as studies (till late 1980s and early 1990s) being based on non-frontier econometric models, prominent among them being Hirsch,1968; Swimmer, 1974; Carr-Hill and Stern, 1977; Levitt and Joyce, 1987; Gyapong and Gyimah-Brempong, 1988; Cameron,1989 and Jackson 1992. After this, there has been efficiency estimation using DEA no parametric frontier methodology to analyse efficiency of n parametric frontier techniques (Tannassoulis,1995; Carrigton et al, 1997; Nyhan and Martin, 1999; and Stone,2002). Most of the above studies are of advanced economies like USA and UK. Ticio and Mancebon,2002 also used DEA methodology to analyse efficiency of National Research in areas of public safety rather. **Shinn Sun (2000)** has evaluated the relative efficiency of Police precincts in Taipei city in Taiwan Data envelopment analysis

was applied to obtain the relative efficiencies. **Drake & Simper (2000)** has focused on measuring the productivity of the England and Welsh forces using the Data envelopment analysis and multiple discriminant analysis. **Drake, Leigh and Simper, Richard (2001)** emphasised the fact that the new Labour government recently instigated an initiative to establish whether English and Welsh police forces should be ranked into groups based on an efficiency measure. **Carlos Pestana Barros (2006)** estimated the efficiency of the Lisbon Police force area using two stages DEA. They were gauging the Data Envelopment Analysis efficiency scores and match up to the areas with one another. Authors rank the areas as indicated by their efficiency for the period of 2000-2002. **Verma & Garvineni (2006)** focused on the estimation of the Police effectiveness in India using DEA the study tenders the opinion for making out best performance practices in the Police department. The data mentioned further has been collected for the analysis of the efficiency of State police:

**Total Police Expenditure (TPE)** Total Police Expenditure in Crores in India made during 2019. Police expenditures are one the important input to improve the Police efficiency in the provinces. **Transport Facilities (TF)** Transport Facilities, transport facilities play a major role to detect the criminals and it will be helpful to control the crime rates in the country. Therefore, here considered one of the inputs. **Number of Police Officers (NPO)** Number of Police Officers in particular State. Crimes cannot be controlled or detected without the appropriate number of Police officers. As a result, it is considered as one of the important inputs. **Number of Disposal Cases (NDC)** Number of Disposal cases, this is the output of Police units after the case filled. NDC indicated here number of cases disposed against number of cases filed. This is one of the main outputs in study. **Number of Cases Charge sheeted (NCC)** Shows that Number of Cases Charge sheeted, this is the important output to measure the Police efficiency. NCC indicates here number of charge sheet against number of cases filed.

As we know that the DEA gives targets to the inefficient units to become the efficient unit. The gap that is to be fulfilled by the inefficient unit to be efficient one is called as **Slack in DEA**. The slacks basically provide the information related to the variables (Input/Output) which needs improvement for the decision-making unit. Mathematically, slacks are such non-negative quantities which are needed to convert inequality to equality. In the study there are the slacks calculated which needed to be improved for becoming a in efficient unit efficient DMU's.

## METHODS AND MATERIAL

### I. DATA

The study was mainly depending upon secondary data. The data chosen for the research work in this paper was mainly state police units in India. The data for the study were collected from the **National Crime Record Bureau**, **State Budget Documents** etc., The data collected were analysed and tabulated very carefully. Also, the collected data were mined further and consolidated to know its suitability for the purposes of analysis. This study is pertaining for the period of 2019.

### II. METHODOLOGY

**a) Data envelopment analysis** approach is a linear programming-based method to assess the relative efficiencies of DMUs wherein many inputs and outputs can be simultaneously considered to not only identify relatively efficient DMUs but also identifies the peer group of the referent DMU from which the best practices can be transferred.

Suppose there are $n$ States denoted as decision making units (DMUs). $DMU_j$ $(j=1,...,n)$ consume $m_1$ variable inputs $x_{i_1 j}$ $(i_1=1,\ldots,m_1)$ and fixed output $x_{i_2 j}$ $(i_2=1,\ldots,m_2)$ to generate $k_1$ variable outputs $y_{r_1 j}$ $(r_1=1,\ldots k_1)$ and $k_2$ fixed outputs $y_{r_2 j}$ $(r_2=1,\ldots, k_2)$.

Then we can evaluate the performance of given DMU, say $DMU_d$ by following slack based measure DEA model:

$$Min\ \theta = \frac{1 - \frac{1}{m_1}\sum_{i_1=1}^{m_1} \frac{s_{i_1}^-}{x_{i_1 d}}}{1 - \frac{1}{K_1}\sum_{r_1=1}^{k_1} \frac{s_{r_1}^+}{y_{r_1 d}}}$$

s. t.

$$\sum_{j=1}^{n} x_{i_1 j}\,\lambda_j + s_{i_1}^{-} = x_{i_1 d}, \qquad (i_1=1,\ldots,m_1)$$

$$\sum_{j=1}^{n} x_{i_2 j}\,\lambda_j = x_{i_2 d}, \qquad (i_2=1,\ldots,m_2)$$

.

$$\sum_{j=1}^{n} y_{r_1 j}\,\lambda_j - s_{r_1}^{+} = y_{r_1 d}, \qquad (r_1=1,\ldots,k_1)$$

$$\sum_{j=1}^{n} y_{r_2 j}\,\lambda_j = y_{r_2 d}, \qquad (r_1=1,\ldots,k_2)$$

$$x_{i_1 d} - s_{i_1}^{-} \geq L_{i_1} x_{i_1 d}\ \forall i_1$$

$$y_{r_1 d} - s_{r_1}^{+} \geq U_{r_1} y_{r_1 d}\ \ \forall r_1,$$

$$\lambda_i \geq 0\ \forall j.$$

The optimum solution of model (1) is denoted as $(\theta^*, \lambda_j, s_{i_1}^{-*}, s_{r_1}^{+*})$. In the model (1), the performance of $DMU_d$ can be improved by letting

$$\hat{x}_{ij}=x_{i_1 d} - s_{i_1}^{-*}\ \forall i_1$$

$$\hat{y}_{r1d}=y_{r_1 d} + s_{r_1}^{+*}\ \ \forall r_1,$$

are the optimal improved variable input and variable output respectively.

**Table 1: Efficiency and Inefficiency of DMUs**

| S.no. | DMU's | Objective Value | Efficient |
|---|---|---|---|
| 1 | **Andhra Pradesh** | 0.627 | No |
| 2 | **Arunachal Pradesh** | 0.589 | No |
| 3 | **Assam** | **1.000** | **Yes** |
| 4 | **Bihar** | 0.711 | No |
| 5 | **Chhattisgarh** | 0.702 | No |
| 6 | **Goa** | 0.807 | No |
| 7 | **Gujarat** | **1.000** | **Yes** |
| 8 | **Haryana** | 0.793 | No |
| 9 | **Himachal Pradesh** | **1.000** | **Yes** |
| 10 | **Jharkhand** | 0.579 | No |
| 11 | **Karnataka** | 0.478 | No |
| 12 | **Kerela** | 0.751 | No |
| 13 | **Madhya Pradesh** | 0.819 | No |
| 14 | **Maharashtra** | **1.000** | **Yes** |
| 15 | **Manipur** | 0.834 | No |
| 16 | **Meghalaya** | 0.875 | No |
| 17 | **Mizoram** | 0.806 | No |
| 18 | **Nagaland** | 0.919 | No |
| 19 | **Odisha** | 0.719 | No |
| 20 | **Punjab** | 0.547 | No |
| 21 | **Rajasthan** | 0.767 | No |
| 22 | **Sikkim** | 0.909 | No |
| 23 | **Tamil Nadu** | **1.000** | **Yes** |
| 24 | **Telangana** | 0.709 | No |
| 25 | **Tripura** | 0.739 | No |
| 26 | **Uttar Pradesh** | **1.000** | **Yes** |
| 27 | **Uttarakhand** | 0.734 | No |
| 28 | **West Bengal** | 0.549 | No |
| 29 | **A&N Island** | 0.513 | No |
| 30 | **Chandigarh** | 0.755 | No |
| 31 | **D&N Haveli+Daman & Diu** | **1.000** | **Yes** |
| 32 | **Delhi** | **1.000** | **Yes** |

| | | | |
|---|---|---|---|
| 33 | **Jammu and Kashmir** | 0.514 | No |
| 34 | **Ladakh** | **1.000** | **Yes** |
| 35 | **Lakshadweep** | **1.000** | **Yes** |
| 36 | **Puducherry** | 0.784 | No |

**b) Slacks In DEA:**

The optimal solution reveals the existence, if any, of a surplus in inputs and a shortage in outputs (called slacks). A DMU with the full ratio efficiency, $\theta * = 1$, and with no slacks in any optimal solution is called efficient. Otherwise, the DMU has a disadvantage against the DMUs in its reference set. Therefore, in discussing total efficiency, it is important to observe both the ratio efficiency and the slacks

**Table 2: Input/Output Slacks**

| | Input Slack | | | Output Slack | |
|---|---|---|---|---|---|
| **State** | **Total Expenditure on Police** | **Transport facilities** | **Number of police officers** | **Number of Disposal Cases** | **Number of Cases Charge sheeted** |
| **Andhra Pradesh** | 2642.45 | 6.06 | 22210.94 | 0.00 | 0 |
| **Arunachal Pradesh** | 888.34 | 10.64 | 59062.00 | 102095 | 236686 |
| **Assam** | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **Bihar** | 4543.23 | 3.15 | 26546.45 | 0 | 0 |
| **Chhattisgarh** | 2740.47 | 1.69 | 19040.66 | 1929 | 55432 |
| **Goa** | 99.11 | 1.77 | 1523.53 | 1534.66 | 2311.23 |
| **Gujarat** | 0 | 0 | 0 | 0 | 0 |
| **Haryana** | 3598.17 | 1.74 | 10772.36 | 0 | 23470.55 |
| **Himachal Pradesh** | 0 | 0 | 0 | 0 | 0 |
| **Jharkhand** | 4483.26 | 3.37 | 27333.63 | 0 | 13744.14 |
| **Karnataka** | 3084.34 | 7.98 | 43493.7 | 0 | 0 |
| **Kerela** | 1839.77 | 3.14 | 13390.56 | 0 | 0 |
| **Madhya Pradesh** | 1115.6 | 2.17 | 17992.88 | 0 | 40681.99 |
| **Maharashtra** | 0 | 0 | 0 | 0 | 0 |
| **Manipur** | 184.12 | 1.14 | 4890.27 | 26622.32 | 36020.49 |
| **Meghalaya** | 95.06 | 1 | 1838.54 | 7987.4 | 13617.09 |
| **Mizoram** | 174.8 | 1.78 | 1567.51 | 2807.91 | 3527.05 |
| **Nagaland** | 235.01 | 0.49 | 2287.65 | 27377.85 | 50663.1 |
| **Odisha** | 2288.93 | 2.82 | 16446.55 | 0 | 10584.89 |
| **Punjab** | 3706.82 | 3.12 | 38892.71 | 23896.99 | 46010.75 |
| **Rajasthan** | 4730.4 | 1.81 | 22214.32 | 0 | 64575.3 |
| **Sikkim** | 149.41 | 0.76 | 517.82 | 3117.15 | 3539.48 |
| **Tamil Nadu** | 0 | 0 | 0 | 0 | 0 |
| **Telangana** | 2144.01 | 5.97 | 14244.96 | 0 | 0 |
| **Tripura** | 337.19 | 2.26 | 5958.98 | 11953.23 | 20213.78 |
| **Uttar Pradesh** | 0 | 0 | 0 | 0 | 0 |
| **Uttarakhand** | 532.76 | 2.36 | 5622.91 | 2534.67 | 0 |
| **West Bengal** | 5647.17 | 6.29 | 44125.97 | 0 | 0 |
| **A&N Island** | 215.29 | 7.44 | 2094.91 | 310.41 | 383.41 |
| **Chandigadh** | 107.34 | 2.42 | 1887.18 | 2321.58 | 2093.09 |
| **D&N Haveli+Daman & Diu** | 0 | 0 | 0 | 0 | 0 |
| **Delhi** | 0 | 0 | 0 | 0 | 0 |
| **Jammu and Kashmir** | 5837.96 | 4 | 39336.69 | 35776.06 | 80780.52 |

| | | | | | |
|---|---|---|---|---|---|
| **Ladakh** | 0 | 0 | 0 | 0 | 0 |
| **Lakshadweep** | 0 | 0 | 0 | 0 | 0 |
| **Puducherry** | 97.87 | 3.15 | 740.85 | 0 | 0 |

The above table basically have the two categories one in **Input slacks** and other one is the **Output slacks**.

**Table 3: The Statistical measures for the State Police Units:**

| Statistical measure | All State Police Units | Efficient State Police Units | Inefficient State Police Units |
|---|---|---|---|
| **N** | 36 | 10 | 26 |
| **Mean** | 0.7925 | 1 | 0.7127 |
| **Std. Deviation** | 0.16866 | 1 | 0.1263 |
| **Minimum** | 0.48 | 1 | 0.48 |
| **Median** | 0.7885 | 1 | 0.735 |
| **Maximum** | 1 | 1 | 0.92 |
| **Avg. Overall Technical Inefficiency** | 0.79242 | 1 | 0.734 |

## RESULTS

- From Table 1 it will be concluded that among all the 36 DMU's there are 10 DMU's which are efficient and 26 are inefficient DMU's. State police of **Assam, Gujarat, Himachal Pradesh, Maharashtra, Tamil Nadu, Uttar Pradesh, D&N Haveli/Daman & Diu, Delhi, Ladakh and Lakshadweep** are the efficient states whereas State police of **Andhra Pradesh, Arunachal Pradesh, Bihar, Chhattisgarh, Goa, Haryana, Jharkhand, Karnataka, Kerela, Madhya Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Odisha, Punjab, Rajasthan, Sikkim, Telangana, Tripura Uttarakhand, West Bengal, A&N Island, Chandigarh, Jammu and Kashmir** and **Puducherry** are inefficient DMU's.
- From the same Table 1 above we can easily interpret that the Police of **Nagaland** and **Sikkim** has to make less efforts to be the Efficient States whereas there are some states namely **Arunachal Pradesh**, **Jharkhand**, **Karnataka**, **Punjab**, **West Bengal**, **A&N Island** and **Jammu and Kashmir** has very poor police efficiency that is why these stats has to much more to gain the efficient position.
- From Table 2 we conclude that in Input Orientated Models, input slacks give us the information about the improvement that are to be made in inputs. Inputs are those resources that are provided to a DMU to complete some task and slacks in input tell us how inefficiently the resources are utilized. Basically, the input slacks provide the information how much Inputs are to be reduce for best utilization or the given inputs for completing the given task efficiently. For example, in above table the **Andhra Pradesh** must reduce the **Total Expenditure on Police** by 2642.45**, Transport facilities** by 6.06**, Number of police officers** by 22210.94 for completing a task with optimum outputs. We can draw similar conclusions for the rest of the State Police Units as well.
- From the Table 2 we can interpret that in Output Oriented Models, Output variables are considered. The output slacks give us the information how much an output variable must be increased to make efficient utilization of the resources provided. For example, above table, Arunachal Pradesh must increase **Number of Disposal Cases** to **102095** and **Number of Cases Charge sheeted** to **236686**. We can draw similar conclusions for the rest of the State Police Units as well.
- The slack values for the efficient state police units turn out to be zero, indicating no change in the outputs or Inputs.

  **Note:** There are two options that are of reducing the inputs in the model for same level of output or increase in the number of outputs for same level of input. If we have used the output-oriented model for our analysis, the DMU rather should go in for increase in output with same level of inputs to

improve efficiency, and if we have used the input-oriented model we should reduce the inputs with same level of output to improve the efficiency.

## CONCLUSION:

This study conducted for measuring the relative efficiency of Indian Police which covers 36 states and Union territories. The results of the study of technical efficiency of state police unit during 2019 revealed that only 10 states are efficient on production frontier that are **Assam, Gujarat, Himachal Pradesh, Maharashtra, Tamil Nadu, Uttar Pradesh, D&N Haveli/Daman & Diu, Delhi, Ladakh and Lakshadweep** under the constant return of scale assumption. This implies the need to invest in human capital by training the staff properly and equipping the Police with modern equipment and machinery, so that States can operate at the optimal level.

## SUGGESTIONS:

- The results of the study reveal that most of the states are operating below efficient level. Therefore, it is good to make yearly efficiency targets for each state and work hard to achieve them.
- The Police department set the targets in coordination with the society and collectively they can ensure better law and order situation and improve efficiency.
- After setting targets, incentives should be announced for achieving the targets.

## LIMITATIONS:

- The results of the study are sensitive to the selection of inputs and outputs.
- High efficiency values can be obtained by being truly efficient or having a niche combination of inputs/outputs
- The number of efficient State Unit on the frontier increases with the number of inputs and output variables.

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