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Crime, Deterrence – Performance of Criminal Justice System in 28 Indian States – A DEA Based Study

KEYWORDS: Deterrence, Criminal Justice System, Data Envelopment Analysis, Directional Distance Functions and Super Efficiency

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ABSTRACT Crime is an undesirable output of human behavior. The level of crime reflects public ethics, state's economic strength, people's pleasure and communal harmony. Crime is governed by economic, deterrent and psychic factors. Crime can be controlled by sufficiently stimulating deterrence. The Criminal Justice System (CJS) is founded on deterrence whose components are certainity, severity and celerity. The activity of police, judiciary and correction homes deter crime. We have postulated a macro production function with one input (crime rate) and two outputs, conviction rate (police output) and criminal courts' case clearance rate (judiciary output). For 28 Indian states fraction of the crime rates compatible with current CJS outputs; the CJS outputs required to meet the current crime; CJS activity expansion to contract crime rate through enhancement of deterrence effect are estimated by means of Data Envelopment Analysis (DEA) under Free disposable Hull (FDH) frame work. Evaluating Super efficiency for extremely efficient states, the criminal justice system of various states are ranked.

1. INTRODUCTION:

This study aims at examining the performance of Criminal Justice System (CJS) in 28 Indian States, grouped into six provinces. The criminal justice system is founded on deterrence; certainity, severity and celerity are the components of deterrence (Thomas Hobbs, 1996; Beccaria, C, 1963; Bentham 1948). Humans who participate in crime are rational, the choice between legitimate and illegitimate activities is made comparing utilities associated with them (Gray S. Decker, 1968; Issac Ehrlich, 1973). The risk associated with crime is apprehension and punishment, whose consequences are deterioration of wealth, forfeing legitimate earnings and freedom, and attaining social stigma. The classical Deterrence Theorists believed that punishment deters crime. Hobbs opinioned that punishment imposed for a crime committed should outweigh the benefit derived out of it. Baccario believed that such punishments whose severity exceed what is necessary to achieve deterrence were not justified. That is, punishment should be proportional to the crime, severity beyond necessity may possibly result in increased number of crimes. Bentham argues that punishment in excess to essential is unjustified. Mere specification of punishment against a crime can not deter crime unless the CJS is swift in action and punishment is certain.

In 20the century crime was viewed in and lytic perspective (Gary S, baker, 1968; Issac Ehrlich, 1973; Davis, Michel, L, 1998; Jost, Peter J, 2001; Levitt, Steven D, 1998; Fender, John, 1999; Seigal, 2001; Oliver, 2003). Becker believed that individual's decision to participate crime is based on costs and benefits and probatrility of attaining positive net benefits induces crime participation. Even large net benefits would defer crime if probability of attaining it is small enough. Becker postulated CJS activity production function.

$$A = f(m, r, c)$$

where A is CJS activity that can be numerically measured; m, r and c are respectively man power, material and Capital. But, cost is associated with this activity, denoted by C(A). Deterrence is associated with this cost for which,

$$\frac{dC(A)}{dA} \geq 0$$

Larger CJS activity to deter crime requires larger investments in man power, material and capital, there by the activity cost is enhanced. Ehrlich (1973) views CJS Activity is related to crime rate and public demand to repress crime.

Several researchers studied crime deterrence and police efficiency implementing Becker's cost-benefit approach (Darough and Haineke, 1979; Drake and Simpler, 2000; Nithan and martin, 1999; Foulas et.al, 2005; Drake et.al, 2009; Chohen, M, 2000; Welsh and Farrington, 2000).

Ehrilich (1973) argues that conviction rate and severity of punishment the two components of deterrence may not be exogenous variables, since they are being determined by public demand and funds. If the crime rate is high, public raise their voice for protection. Consequently, more spending on CJS will take place to combat crime.

If crime rate in a period $t-1$ goes high, due to public demand for safety, there will be a rise in CJS expenditure and in period t conviction rate (p) and length of punishment (f) will improve to bring crime rate to a tolerance limit. Lagged crime rate is recommended to add as an explanatory variable in regression studies. Lagged crime rate influences current CJS activity cost. Becker's cost function can now take be form,

$$C_t = C(M_t, r_t, c_t, u_{t-1})$$

where u_{t-1} is crime rate at t-1

Conviction rate (probability of conviction) is viewed as police output. Ehrlich (1973) postulated a Cobb-Douglas type production function for which output rate is the conviction rate:

$$P = B\left(\frac{E}{N}\right)^{\beta_1}\left(\frac{Q}{N}\right)^{\beta_2} Z^{\delta} e^{\xi}$$

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where P is probability of capture and consequent punishment; $\frac{E}{N}$ and $\frac{Q}{N}$ are expenditure rate on police and crime rate respectively. Z represents measurable environmental variables. B and ξ are intercept and statistical disturbance term respectively Votey and Philips (1973) postulated a production function

$$CR_t = Ke^{\lambda t} O_t^{\alpha} E_t^{\beta}$$

and a crime supply function,

$$O_t = Ae^{\theta t} \left(CR_t\right)^r \left(\mu ps\right)^{\delta}$$

where CR : clearance rate

O: rate of offences

E: environmental factors.

μp : product of unemployment and participation rates.

Several studies do exist that are production function based while law environment performance was examined, some of which are (Ehrlich, 1973; Philips and Votey, 1973; Thanssoulis, 1995; Carrington et.al, 1993; Darke and Simpler 2002, Almer and Gosechi, 2011).

Some of the studies of crime were based on econometric modelling and some other were based on Data Envelopment Analysis, (Thanassoulis, 1995; Drake and Simpler 2000, 2002a, 2002b, 2002c; Nyhen and Martin, 1979)

All the crime studies were invariably founded on deterrence theory governed by certainty, severity and celerity. 'Celerity' refers to the speed with which punishment is administered, which depends on the performance of judiciary. The ability to quicker disposable of the cases by the justice department reveals the swiftness with which punishment is administered to the offender. 'Certainity' refers to the probability of conviction which reveals the quality of police services and depth of police investigation. But, several studies referred above chose police clearance rate as output of police.

2. DATA ENVELOPMENT ANALYSIS:

(a) Data envelopment analysis is a linear programming tool, used to measure efficiency scores of decision making units (DMUs). Efficiency measurement seeks a frontier of the production possibility set built by sample data and a suitable distance function that helps to project an inefficient production interior to the production possibility set to land on its surface. The distance covered to reach the frontier provides an efficiency score and the coordinates of the surface point attained by virtue of projection provides targets to the inefficient producer. Charness, Cooper and Rhodes (CCR, 1978) postulated a fractional programming problem that seeks maximation of the ratio of weighted sum of outputs to the weighted sum of inputs, constraining such ratios of all the decision making units, including that of test DMU less than or equal to unity. This can be transformed into a linear programming problem. This optimization problem is called as CCR multiplier problem. Its dual is called CCR envelopment problem. CCR envelopment frontier yielding production possibility set can be obtained by the postulates of inclusion, free disposability, convexity, ray expansion and minimum extrapolation. CCR problem can now distinguish returns to scale differences among decision making units. Banker, Charnes and Cooper (BCC, 1984) generalized CCR approach to allow returns to scale to vary. CCR/BCC efficiency measures are radial. Both these measures seek maximal input contraction under input orientation and maximal output expansion under output orientation, holding the input / output mix invariant. BCC production possibility set is built on the postulates: inclusion, free disposability, convexity and minimum extrapolation. The BCC efficiency targets are shorter than the CCR targets.

(b) Dropping the convexity postulate Deprins et.al (1984) proposed Free Disposable hull (FDH). The FDH envelopment frontier may be viewed as ex post production frontier and

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BCC radial measure implemented on FDH-frontier provide short run targets to the inefficient decision making units. To implement FDH-BCC efficiency measurement there is no need to solve linear (or) integer linear programming problems. Tulkens (1993) provided closed form expressions to evaluate input/output radial efficiency scores. These formulae reduce computational labour, do not require computer support for small data sets.

$$\lambda_{j_0}^{FDH} = \underset{j\in D}{Min}\,\underset{i\in M}{Max}\left(\frac{x_{ij}}{x_{ij_0}}\right) \quad ..... (2.1)$$

$$j\in D \Rightarrow y_j \geq y_{j_0}$$

$$0 < \lambda_{j_0}^{FDH} \leq 1$$

$$\theta_{j_0}^{FDH} = \underset{j\in D}{Max}\,\underset{r\in S}{Min}\left(\frac{y_{rj}}{y_{rj_0}}\right) \quad ..... (2.2)$$

$$j\in D \Rightarrow x_j \leq x_{j_0}\,;\ \theta_{j_0}^{FDH} \geq 1$$

where $\lambda_{j_0}^{FDH}$ and $\theta_{j_0}^{FDH}$ respectively stand for FDH input and output technical efficiency scores. x_j and y_j are m and s componented input and output vectors of j[th] decision making unit. DMU_{j_0} is the test DMU for which input/output technical efficiency is sought.

(c) DEA suffers from lack of discriminating power since it can not differentiate the unit-efficiency score-attained efficient decision making units. Andersen and Petersen (1993) resolved the issue as 'Super Efficiency' among the efficient decision making units can be used to break the tie. Super efficiency problems under CCR frame work are always feasible for positive inputs and outputs. But BCC Super Efficiency Problems are not always feasible (Seiford and Zhu, 1998). Under FDH-BCC frame work super efficiency can be evaluated using the following expressions:

$$\lambda_{FDH}^{Super}\left(j_0\right) = \underset{j\in D_0}{Min}\,\underset{i\in M}{Max}\left(\frac{x_{ij}}{x_{ij_0}}\right) \quad ...... (2.3)$$

$$j\in D_0 \Rightarrow y_j \geq y_{j_0}\,,\ j \neq j_0$$

$$\lambda_{FDH}^{Super} > 1$$

$$\theta_{FDH}^{Super}\left(j_0\right) = \underset{j\in D_0}{Max}\,\underset{r\in S}{Min}\left(\frac{y_{rj}}{y_{rj_0}}\right) \quad ......(2.4)$$

$$j\in D_0 \Rightarrow x_j \leq x_{j_0}\,,\ j \neq j_0$$

$$\theta_{FDH}^{Super} < 1$$

(d) For the purpose of ranking of DMUs, due to infeasibility of BCC-SE problems, BCC-SE approach is not recommended. The directional distance functions approach can enhance the discriminating power of DEA, since under simultaneous input expansion and output contraction, the DDF-SE problems are always feasible (S. Ray, 2004; Seiford and Zhu, 1996, Cooper et.al 2007), in particular if direction of projection is the direction of observed input and output vector. Under FDH-BCC frame work, the directional efficiency scores can be evaluated using the following expressions:

$$\beta_{j_0}^{FDH} = \underset{j\in D}{Max}\,\underset{i,r}{Min}\left\{\frac{x_{ij_0}-x_{ij}}{x_{ij_0}}, \frac{y_{rj_0}-y_{rj}}{y_{rj_0}}\right\} \quad ... (2.5)$$

$$j\in D \Rightarrow x_j \leq x_{j_0} \ and \ y_j \geq y_{j_0}$$

$$0 \leq \beta_{j_0}^{FDH} < 1$$

$$\beta_{FDH}^{Super}\left(j_0\right) = \underset{j\in D_0}{Max}\ \underset{i,r}{Min}\left\{\frac{x_{ij_0}-x_{ij}}{x_{ij_0}},\ \frac{y_{rj_0}-y_{rj}}{y_{rj_0}}\right\} \quad \text{….. (2.6)}$$

$$j \in D_0 \Rightarrow x_j \le x_{j_0},\ y_j \ge y_{j_0},\ j \ne j_0$$

$$\beta_{FDH}^{Super}\left(j_0\right) < 0$$

To resolve tie among efficient DMUs, super Efficiency scores yielded by (2.6) can be implemented.

3. PRESENT STUDY:

The study investigates performance of Criminal Justice System (CJS) of Indian States. Under production function approach. The study aims at (i) estimating CJS outputs needed to meet the given crime rate (ii) estimating the fraction CJS outputs (iii) evaluating maximum CJS activity levels and minimum crime rate levels which lead to optimal environmental (iv) ranking CJS of Indian states basing on their distance between the prevailing and optimal environment.

4. THE PRODUCTION FUNCTION:

Specification of the production function is heavily constrained by the data availability. The data are secondary collected from Crime in India-2013, published by Govt of India. The input of production function is “Crime rate” measured as ratio of number of crimes committed to one lakh population ‘Conviction Rate’ is choosen as Police Output. Alternatives to Conviction Rate as Police output are number of arrests and police clearance rates. Ehrlich (1973) postulated a Cobb-Douglas type production function for which probability of apprehension and consequent punishment (Conviction Rate) as output. “Conviction Rate” reflects certainity component of Deterrence Theory.

Percentage of cases disposed off by the criminal courts choosen as judiciary output, which reflects the celerity component of Deterrence Theory.

$$O_s = F\left(CR_s,\ J_s\right)$$

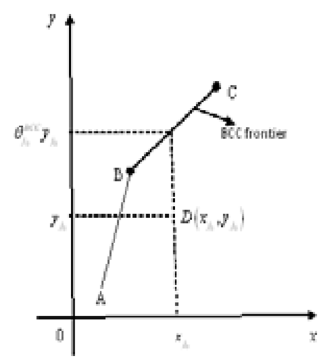
where O_s : offence rate in state S

CR_s : Conviction rate in State S

J_s : Judiciary clearance Rate in state S

5. EMPIRICAL ANALYSIS:

(i) Given the crime rate we wish to estimate potential CJS outputs needed to combat the crime in each of the Indian States.



The above figure narrates one input and one output production process. The BCC frontier production function is determined by the extremely efficient decision making units A, B and C. The test DMU D is inefficient. It employs input x_{j_0} and produces output y_{j_0} if x_{j_0} is crime rate and y_{j_0} is police output reflecting police activity, then to meet the given crime rate the police activity requirement is $\theta_{j_0}^{BCC} y_{j_0}$ where $\theta_{j_0}^{BCC}$ is output technical efficiency measure of BCC which cannot be less than one. The interpretation is similar to FDH production frontier. The police activity enhancement is possible via increase in police personnel, capital and material which in turn results in cost enhancement,

$$C\left(\theta_{j_0}^{FDH} y_{j_0}\right)$$

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Change of cost: $$\frac{C\left(\theta_{j_0}^{FDH} y_{j_0}\right)-C\left(y_{j_0}\right)}{C\left(y_{j_0}\right)} > 0$$

where C is police cost function.

NORTH EASTERN INDIA:

S.No	Name of the State	FDH-BCC output technical efficiency θ_{FDH}^{BCC}
1	Arunachal Pradesh	1.7323
2	Assam	3.4686
3	Manipur	1.9195
4	Meghalaya	2.0516
5	Mizoram	1.0
6	Nagaland	1.0
7	Sikkim	1.0
8	Tripura	2.5576
	Mean	1.8412

Mizoram, Nagaland and Sikkim are efficient. Crime and CJS activity among them are optimal. The most CJS-activity-insufficient state among North Eastern Indian States is Assam. This state needs to enhance its CJS outputs by 247 percent more than the current outputs. On the average, the North East Indian province should expand its CJS outputs by 85 percent.

NORTH INDIAN STATES:

S.No	Name of the State	θ_{FDH}^{BCC}
1	Punjab	2.0773
2	Haryana	1.72
3	Uttar Pradesh	1.5725
4	Bihar	4.0952
5	Uttaakhund	1.5725
6	Himachal Pradesh	3.9573
7	Jammu and Kashmir	1.8376
8	Rajasthan	1.3424
	Mean	2.2719

Bihar and Himachal Pradesh experience CJS activity extreme shortage among North Indian States. To meet the given crime rate Bihar should increase its CJS outputs by 310 percent more than its current outputs. Himachal Pradesh should expand its CJS outputs by 296 percent more to combat the current offences. On the average, the North Indian province needs to enhance its CJS outputs by 127 percent more than the outputs currently produced.

SOUTH INDIAN STATES:

S.No	Name of the State	$\theta_{j_0}^{FDH}$
1	Andhra Pradesh & Telangana	1.6475
2	Karnataka	1.5580
3	Kerala	1.2189
4	Tamilnadu	1.2216
	Mean	1.4115

All the South Indian States are among the top 10 high-crime states. Inspite of this, these states need to enhance their CJS outputs at smaller scale than rest of Indian States. Top most crime occurred in Kerala (502.2 crimes per one lakh population). But, this state needs to increase its CJS outputs by 22 percent more than the current level. On the average, South Indian province requires to enhance its CJS outputs by 41 percent to meet the current crime rate.

WESTERN INDIAN STATES:

S.No	Name of the State	$\theta_{j_0}^{FDH}$
1	Goa	2.8104
2	Gujarat	2.0666
3	Maharstra	4.8314
	Mean	3.2361

To combat current crime Maharastra needs to expand its CJS outputs by 383 percent more than its current production. On the average, CJS output expansion needed to take place in this province is 224 percent more.

EASTERN INDIAN STATES:

S.No	Name of the State	$\theta_{j_0}^{FDH}$
1	West Bengal	5.7986
2	Jharkhand	1.7450
3	Odisha	6.3245
	Mean	4.6224

Among all the Indian provinces eastern Indian province needs to enhance its CJS outputs the

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most. On the average, this province needs to enhance its outputs by 362 percent.

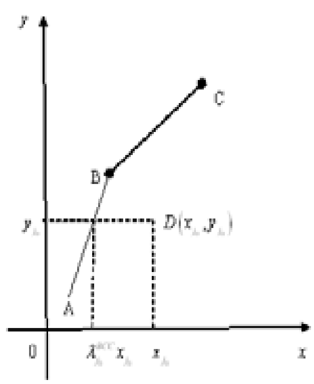
CENTRAL INDIAN STATES:

S.No	Name of the State	$\theta_{j_0}^{FDH}$
1	Madhya Pradesh	1.6801
2	Chattisgarh	2.0773
	Mean	1.8787

Central Indian province needs to enhance its outputs by 88 percent to combat current crime and to perform in optimal environment.

(ii)

S.No	Name of the Provice	Mean fraction of crime rate
1	NORTH EASTERN INDIA	0.5746
2	NORTH INDIA	0.3277
3	SOUTH INDIA	0.1810
4	WESTERN INDIA	0.2313
5	EASTERN INDIA	0.3143
6	CENTRALs INDIA	0.2023



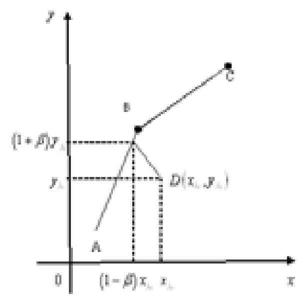
If x_{j_0} and y_{j_0} represent crime rate and CJS output rate, then the current CJS ouput y_{j_0} is sufficient to meet the crime rate $\lambda_{j_0}^{BCC} x_{j_0}$.

For South Indian province the current CJS activity is sufficient to meet 18.1 percent of the crime that occurs currently. Central Indian states are among top 10 high-crime states. The CJS outputs of central Indian province are sufficient to meet only 20 percent of the crime that occurs in this part of the country.

(iii) Votley and Philips (1973) through their schematic diagram explain that crime Generation Process (CGP) is governed by

(a) Economic conditions, (b) attitudes and (c) deterrence effect.

It is via stimulating deterrence effect that crime can be controlled.



This problem seeks one percent crime rate reduction in response to one percent CJS output expansion.

S.No	Name of the Provirce	FDH-DDF Mean efficiency Score
1	NORTH EASTERN INDIA	0.4095
2	NORTH INDIA	0.5463
3	SOUTH INDIA	0.3731
4	WESTERN INDIA	0.7687
5	EASTERN INDIA	0.5968
6	CENTRAL INDIA	0.7103

Inspite of high crime being observed in South Indian States, expanding its outputs, there by contracting crime rate by 37 percent the South Indian

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province can perform in optimal environment. Western India is far away from optimal environment compared to other provinces. Western Indian province is far away from optimality, since it needs CJS output expansion by 77 percent to attain reduction of crime rate by the same percent.

(iv) SUPER EFFICIENCY – RANKING CJS INDIAN STATES:

S.No	Name of the Efficient State	FDH-DDF Super efficiency β_{FDh}^{Super}
1	MIZORAM	-0.0605
2	NAGALAND	-0.7662
3	SIKKIM	-0.3952

Smaller values of FDH DDF Super efficiency values reveal greater ability to remain efficient under input expansion and output contraction. Among the three extremely efficient Indian States Nagaland attains first rank, Sikkim and Mizoram respectively secure second and third ranks.

RANKING OF CRIMINAL JUSTICE SYSTEMS

S.No	Name of State	Rank
1	Andhra Pradesh	12
2	Arunachal Pradesh	20
3	Assam	28
4	Bihar	19
5	Chattisgarh	25
6	Goa	26
7	Gujarat	27
8	Haryana	16
9	Himachal Pradesh	23
10	Jammu and Kashmir	22
11	Jharkhand	8
12	Karnataka	10
13	Kerala	6
14	Madhya Pradesh	17
15	Maharstra	24
16	Manipur	15
17	Meghalaya	13
18	Mizoram	3
19	Nagaland	1
20	Odisha	18
21	Punjab	14
22	Rajasthan	7
23	Sikkim	2
24	Tamilnadu	5
25	Tripura	9
26	Uttar Pradesh	11
27	Uttarakhand	4
28	West Bengal	21

6. FINDINGS:

(i) South Indian States and Central Indian States are worst hit by crime. Police and Judiciary activity is highly insufficient to meet crime in any Indian state.

(ii) Inspite of the high crime rates prevailing in South Indian states, these states need smaller CJS output expansion than rest of India to combat crime.

(iii) Western and Eastern Indian states need huge CJS output expansion to dispose crime effectively that occur in these states.

(iv) In South Indian states the opportunity of crime deterrence is more found than in the rest of the states.

(v) Inspite of high crime rate, the South Indian province is found closer to optimal environment than rest of India, that can be achieved by expanding CJS outputs bu 37 percent, simultaneously contracting crime rate by the same percent via deterrence effect.

(vi) Using FDH-DDF based efficiency scores all the 28 Indian States are ranked according to their CJS efficiency. Nagaland, Sikkim and Mizoram have secured first, second and third ranks respectively, basing on their Super efficiency. These three states belong to North Eastern Indian States.

(vii) Goa, Gujarat and Assam have secured 26, 27, and 28th ranks respectively.

(viii) Western and Eastern Indian states performance is far away from optimal environment compared to other Indian Provinces.

APPENDIX:

(i) Data

(ii) Scores

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(i) DATA

S.No	STATE	Input Crime Rate	Police Output Conviction Rate	Judiciary output percentage of the cases disposed off by criminal courts
1	Andhra Pradesh	252.1	32.8	26.1
2	Arunachal Pradesh	217.9	48.2	2.2
3	Assam	277.3	8.6	20.5
4	Bihar	166.3	13.4	10.5
5	Chattisgarh	227.3	38.8	20.7
6	Goa	228.8	24.1	15.3
7	Gujarat	258.8	40.8	7.7
8	Haryana	273.0	31.3	25
9	Himachal Pradesh	198.2	21.1	9.8
10	Jammu and Kashmir	210.5	30.5	23.4
11	Jharkhand	148.4	25.1	29.3
12	Karnataka	224.7	32.5	27.6
13	Kerala	502.2	68.5	16.3
14	Madhya Pradesh	303.8	49.7	24.2
15	Maharstra	201.7	13.3	8.9
16	Manipur	126.3	43.5	2.4
17	Meghalaya	121.1	40.7	2.7
18	Mizoram	165.6	83.5	43
19	Nagaland	52.6	82.1	40.4
20	Odisha	172.5	10.3	6.8
21	Punjab	129.2	36.4	20.7
22	Rajasthan	279.2	62.2	15.8
23	Sikkim	135.3	43.8	71.1
24	Tamilnadu	297.6	58.8	35.2
25	Tripura	167.2	15.9	27.8
26	Uttar Pradesh	108.4	53.1	17.0
27	Uttarakhand	92.9	70.2	20.6
28	West Bengal	185.5	14.4	0.6

		Crime Rate λ_{FDH}	Proportion θ_{FDH}^{Super}	expansion and crime rate contraction rate
1	Andhra Pradesh	0.2086	1.6475	0.5878
2	Arunachal Pradesh	0.2414	1.7323	0.7033
3	Assam	0.1897	3.4683	0.9709
4	Bihar	0.3163	4.0752	0.6837
5	Chattisgarh	0.2314	2.0775	0.7686
6	Goa	0.2299	2.8104	0.7101
7	Gujarat	0.2033	2.0666	0.7968
8	Haryana	0.1927	1.72	0.617
9	Himachal Pradesh	0.2654	3.9573	0.7346
10	Jammu and Kashmir	0.2499	1.8376	0.7265
11	Jharkhand	0.3544	1.7450	0.3788
12	Karnataka	0.2341	1.5580	0.4638
13	Kerala	0.1047	1.2189	0.2190
14	Madhya Pradesh	0.1731	1.6801	0.6519
15	Maharstra	0.2608	4.8314	0.7392
16	Manipur	0.4165	1.9195	0.5835
17	Meghalaya	0.4344	2.0516	0.5656
18	Mizoram	1.0	1.0	0
19	Nagaland	1.0	1.0	0
20	Odisha	0.3049	6.3235	0.6951
21	Punjab	0.4071	2.0773	0.5829
22	Rajasthan	0.1884	1.3424	0.3424
23	Sikkim	1.0	1.0	0
24	Tamilnadu	0.1767	1.2216	0.2216
25	Tripura	0.3146	2.5576	0.4532
26	Uttar Pradesh	0.4052	1.5725	0.5148
27	Uttarakhand	0.5662	1.1895	0.1695
28	West Bengal	0.22835	5.7986	0.7164

(ii) SCORES

S.No	STATE	Fraction	Potential Output	CJS output

8

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