Measuring the comparative performance of Nigeria police using Data Envelopment Analysis

A.A. Maidamisa[1] and S.S. Abdulkadir[2]

June 2, 2015

[1,2] Department of Statistics & Operations Research School of Pure and Applied Sciences Modibbo Adama University of Technology P.M.B. 2076, Yola; 640001, Adamawa State, Nigeria. E-mail: alidmu@yahoo.com; and ssauta@yahoo.com;

Abstract

The aim of this paper is to assess the performance of Nigerian police commands and to compare their achievements for the year 2010. This was achieved using data envelopment analysis methodology and mixture model. The results shows ranking of these commands from the most efficient performer to the least inefficient performer. The result peers inefficient performer with efficient performers. Peers are efficient commands with performance score 100 percent and all slack zero.

***Keywords**: Police force, Data envelopment analysis, Performance assessment.*

1 Introduction

Data envelopment analysis (DEA), as proposed by Charnes, Cooper and Rhodes (Charnes et al., 1978) involves the derivation of efficiency scores of a set of comparable decision making units (DMUs), relative to one another.

When assessing the performance of DMUs, DEA combines performances of operating units in terms of several desirable and undesirable attributes into a single scalar measure, called the efficiency score. DMUs that register unit efficiency scores are considered efficient in that they have the highest values of desirable attributes and the lowest values of undesirable attributes. Units with efficiency scores less than 1 may be considered to operate sub-optimally for a given set of attributes (Ramanathan, 2006). The paper adopt DEA output oriented envelopment model with the no- tion that crime level are largely outside the control of the police management therefore, an efficient operation should at least in the short run result to high arrest of armed robbers; high prosecution offenders and high car recovery rather than lower crime level. The assessment of police performance in this paper is similar to that in (Thanassoulis, 1995; Levitt and Joyce, 1987) in that the focus is on the reducing crime level.

The objective of this paper is to evaluate the performance of the state police command in Nigeria using an interstate comparison of productivity growth. In doing so, the assessment was run assuming constant return to scale hold in converting crimes to proportional reduction. This assumption is likelyto be safe if there is no reason to believe that the proportion of harder to clear crime depends on the actual proportion of crime cleared. To the best of our knowledge, DEA has not been employed to study the performance of states command of the Nigerian police force. The paper therefore helps to provide a comparative picture of performance of various command.

The paper is organized as follows: In section 2, the methodology is presented. In section 3, data was presented and summarized. In section 4, results are presented and discussion. The determinant of efficiency is analyzed. In section 5, policy implication is drawn and finally, in section 6, the conclusions are drawn.

2 Methodology

2.1 Data Envelopment Analysis

The Data Envelopment Analysis (DEA) is based upon the economic notion of Pareto optimality which states that a given decision making unit (DMU) is inefficient if some other DMU, or some combination of other DMUs, can produce at least the same amounts of all outputs with less of some resource input and not more of any other resource. Conversely a DMU is said to be efficient if the above is not possible(Aliyu, 2012). The technique employed in this paper adopts the DEA output oriented envelopment model, that attempts to maximize output while using no more than the observed amount of any input (Cooper et al., 2007).

$$\left.\begin{array}{l} \text{Objective} \equiv \max \phi \\ \text{subject to} \\ \sum_{j=1}^{37} \lambda_j x_{ij} \leq x_{i0}, \quad i = 1, \ldots, m \\ \sum_{j=1}^{37} \lambda_j y_{rj} \geq \phi y_{r0}, \quad r = 1, \ldots, s \\ \lambda_j \geq 0, \qquad j = 1, \ldots, n \end{array}\right\} \quad (1)$$

In linear programming terminology, the objective function is to maximize the sum of all specific national development goals subject to minimizing specific resource availability indicators. These goals are observations measured and represented as outputs and denoted by yrj(r = 1,...,s). The resource availability indicators are observations measured and represented as inputs and denoted by *xij(i = 1,...,m)*. Let: s – i be an input slack; k+ r be an out- put surplus and λj be a set of unknown weights (decision variables), where *j* = *1*,...,n corresponding to each DMU*j*.

There is a need to run DEA model (1) 37 times, one for each DMU (state) in order to determine whether we can find a set of weights so that the convex combination of these 37 states perform better than one of the 37 states. If the answer is yes then the targeted state (DMU0) is inefficient, otherwise if the answer is no then the targeted state (DMU0) is efficient.

2.2 Parametric Formulation of Mixture Model

In many applications, the components (groups) densities $f_i(y_i)$ are specified to belong to some parametric family. In this case, the component densities fi(yi) are specified as $f_i(y_i;\lambda_i)$, where λ*i* is the vector of unknown parameters in the postulated form for the ith component density in the mixture. The mixture density $f_i(y_i)$ can then be written as

$$f(y_i;\Psi) = \sum_{i=1}^{k} \Pi_i f_i(y_i;\lambda_i)$$

where the vector Ψ containing all the known parameters in the mixture model can be written as $\Psi = (\pi^1,...,\pi k\text{-}1;\varepsilon^1)^1$ where ε is the vector containing all parameters in λ1,...,λk known a priori to be distinct (McLachlan and Peel, 2000). We assumed Poisson distribution for the component densities, fi(yi;λi) of the fitted mixture model and inferred number of components (groups) from the data collected on stolen vehicles as well as armed robbers arrested in 2010. The non-parametric maximum likelihood estimation was employed to determine the number of components (groups) for the data via EM al-gorithm. For classification of data into components, posterior probabilities are computed. A state is classified on the basis of data into a component in which it has the higher posterior probability.

3 Data

In this paper, five measures were employed for assessment. They are:

- **Inputs** ($i = 1, 2; m = 2$)
  1. Policemen (Includes: senior police officers, inspectors, and rank and files)
  2. Police Stations (excluding outpost)

Input one is the total number of policemen in Nigeria police by state commands. Input two is the number of police stations in Nigeria by state commands.

- **Outputs** ($r = 1, 2, 3; s = 3$)
  1. Armed robber arrested/killed
  2. Stolen vehicles recovered
  3. Total number of cases prosecuted by police.

Output one is the number of persons arrested or killed for armed robbery. Output two is the total number of stolen vehicles that were recovered by the police. Output three is the total number of cases prosecuted by the police.

- Decision making units.
  1. State command (including Abuja). ($j = 1, \ldots, 37; n = 37$)

These data were adopted from the Annual abstract of statistics (National Bureau of Statistics, 2011). Thirty six (36) states Police command and Fed- eral Capital Territory (FCT) were utilized as decision making units. The analysis assumes Constant Return to Scale (CRS). CRS is said to prevail when an increase in all input by 100% leads to corresponding increase in all output by 100% (Golany and Thore, 1997). The reason is obvious, that CRS measures technical efficiency and efficiency loss when the DMU does not operate in its most productive scale size.

Table 1: Descriptive Statistics on Input and Output Data

	Policemen	Stations	Arrest	Recovered	Prosecution
Max	25,882	128	537	1,108	1,970
Min	2,948	3	8	1	46
Average	7,081.459	44.405	79.838	53.568	454.460
SD	4,139.663	29.244	97.885	182.429	397.785

Table 1 shows the data summary in descriptive form. Measures of central tendency such as mean, measures of dispersion such as standard deviation, maximum and minimum values are shown against their respective input and output variables. Table 2, shows the result obtained from the correlation analysis.

After selecting input and output variables, the correlation coefficient is tested to ascertain whether these variables have isotonic relationship, i.e. decreasing input increase efficiency and increasing output increase efficiency. As shown in

Table 2, all the variables selected are positively correlated

Table 2: Correlation

	Policemen	Stations	Recovered	Prosecution
Policemen	1.000	0.798	0.187	0.574
Stations	0.798	1.000	0.011	0.452
Recovered	0.187	0.011	1.000	0.740
Prosecution	0.574	0.452	0.740	1.000

4 Result and Discussion

Data Envelopment Analysis solver professional version 5.0 software was used for computation. The result indicates 6 best performing Police command. These are Abuja, Abia, Sokoto, Ogun, Lagos, and Kano. These DMUs are rank top on the list of efficient frontier. The remaining 29 DMU (state) are inefficient with performance score less than 100%. The ranking was done in accordance with preference position. The least is Kaduna state command with performance score of 12.39%. Targets were earmark for inefficient DMU in order to achieve efficiency.

For instance Kaduna, which rank least can reduce the number of police stations by 35%(from 59 to 38), increase the number of arrest by 707.17% (from 36 to 291), increase the number of car recovered by 707.17% (from 23 to 186), increase prosecution of cases by 707.17% (from 182 to 1,469) having done that will project the command to become efficient. Similar analysis can be apply to project the remaining 29 inefficient commands. The details projections are not presented in the paper.

Table 3 column 6, gives information about peer(s) for state command considered inefficient in the analysis. Peer(s) are efficient command with a performance score of 100% and all slacks at zero level (Cook and Zhu, 2008). For example Bauchis peer is Kano, meaning that Bauchi can try to emulate Kano by achieving better values of attributes that would result in an efficiency score of 100%. The analysis further shows that non-parametric maximum likelihood estimate consists of three support points (components). The weight of the three components is 0.73, 0.03 and 0.24 with parameters 4.5926, 255.00 and 1108.00 respectively with log-likelihood -98.85. This implies that the first components consists of 73% of the states with an average stolen vehicles of 4.5926, the second consists of 3% with an average stolen vehicles of 255, while the third consists of 24% of the states in Nigeria with an average stolen vehicle of 1,108. A cursory look on the raw data shows that Ogun and Lagos states correspond to the first two component and the remaining 35 states have similar criminal art in terms of stolen vehicle. A similar analysis was carried out using Armed Robber Arrested/Killed data for 37 states include federal Capital Territory. The non parametric maximum likelihood estimation consists of 5 supports (groups). The weights for the 5 components are 0.41, 0.46, 0.08, 0.03 and 0.03 with the parameters 24.3931, 69.4913, 186.9986, 312.9982, and 537.00 respectively. The log-likelihood is -210.1062. The components can be link to groups of states.

Table 3: Distribution of scores, rank and peers in overall Performance

No.	DMU	Score	Rank	1/score	Peer(s)
1.	Abia	100.0	1	1	
2.	Adamawa	73.96	7	1.352	Abia, Kano
3.	Akwa Ibom	13.39	36	7.468	Abia, Kano
4.	Anambra	26.01	32	3.845	Abia, Kano, Lagos
5.	Bauchi	62.76	11	1.593	Kano
6.	Bayelsa	27.65	29	3.616	Abia, Kano
7.	Benue	26.69	30	3.747	Abia, Kano
8.	Borno	62.23	13	1.607	Abia, Kano
9.	Cross River	35.99	24	2.778	Abia, Kano
10.	Delta	34.86	25	2.869	Abia, Kano
11.	Ebonyi	61.73	14	1.620	Abia, Kano
12.	Edo	72.11	9	1.386	Kano, Lagos
13.	Ekiti	28.83	28	3.469	Abia, Kano
14.	Enugu	72.94	8	1.371	Abia, Sokoto
15.	Gombe	60.36	15	1.657	Abia, Kano
16.	Imo	50.40	18	1.984	Abia, Kano
17.	Jigawa	62.65	12	1.596	Kano, Lagos
18.	Kaduna	12.39	37	8.071	Abia, Kano, Lagos
19.	Kano	100.0	1	1	
20.	Katsina	14.46	35	6.915	Abia, Kano
21.	Kebbi	19.88	34	5.029	Kano
22.	Kogi	45.82	19	2.182	Abia, Kano
23.	Kwara	26.45	31	3.781	Abia, Kano, Abuja
24.	Lagos	100.0	1	1	
25.	Nassarawa	21.53	33	4.644	Abia, Kano
26.	Niger	41.66	22	2.401	Abia, Kano
27.	Ogun	100.0	1	1	
28.	Ondo	36.50	23	2.740	Abia, Kano
29.	Osun	59.56	16	1.679	Kano
30.	Oyo	66.06	10	1.514	Abia, Kano, Lagos
31.	Plateau	31.50	26	3.174	Abia, Kano
32.	Rivers	45.66	20	2.190	Abia, Kano, Ogun
33.	Sokoto	100.0	1	1	
34.	Taraba	51.67	17	1.935	Abia, Kano
35.	Yobe	29.56	27	3.383	Abia, Kano
36.	Zamfara	42.54	21	2.351	Abia, Kano
37.	FCT.Abuja	100.0	1	1	

5 Policy Implication

The result of this study has interesting policy implications for the development of Nigerian police. The researcher wish to stress here that the findings of this study are critically based on the choice of attributes (data) and hence, the policy implications discussed below should be considered within this perspective. This study revealed that 16.67% of the 37 DMUs studied are efficient. The smallest CRS efficiency score is 12.39%, which is Kaduna state. This is a significant result highlighting the wide disparity in socio-economic status amongst commands in Nigeria police force. We recommend that police should pay more attention to the two states, Lagos and Ogun, in terms of stolen vehicles.

6 Summary and Conclusion

In conclusion, we identified two states (Lagos and Ogun) are highly sensitive area of stolen vehicles while the remaining 35 states have similar.

The paper attempted to look into issues related to the assessment of police force in Nigeria for the year 2010. The problem is assess 37 DMUs, using two attributes and three undesirable attributes. DEA output oriented model with constant return to scale was used to evaluate the problem. There is no inappropriate data with respect to the chosen model. The average efficiency score, standard deviation, maximum, minimum scores are 51.83%, 0.2723, 100%, and 12.39% respectively. The overall performance shows that 16.67% of 37 command are efficient while 83.33% did not exhibit good performance. Furthermore, the frequency of references to other DMUs are as follows: Abia 26, Kano 30 Lagos 5, Ogun 1, Sokoto 1, and FCT, Abuja 2, all these are achieved in a total of 202 simplex iterations.

In assessing services, the inefficiency in performance is actually caused by an excess input rather than a deficit in output. DEA provides efficient input and output targets for reducing the excess and improving the deficits. As for future developmental plans, forecasts of inputs and output values can be included in a DEA analysis so that decision makers can determine which factors negatively or positively affect estimation and therefore adjust the economic development policies. DEA is a method that can be used for monitoring, planning and improvement in the performance of a system.

References

Aliyu, A. M. (2012). Evaluating excess and shortfalls in prison services. Global Journal of Mathematical Sciences. 11(2): 15–19.

Charnes, A., Cooper, W. and Rhodes, E. (1978). Measuring the efficiency of decision making units. European Journal of Operations Research. 2(6): 429–444.

Cook, W. and Zhu, J. (2008). Data Envelopment Analysis: Modeling op- erational processes and measuring productivity.1st Edition. Canada: Springer Science.

Cooper, W., Seiford, L. and Tone, K. (2007). Data Envelopment Analysis: A Comprehensive Text with Models Applications. 2nd Edition. New York: Springer Science.

Golany, B. and Thore, S. (1997). The economic and social performance of nations: efficiency and returns to scale. Socio Economic Planning Sciences. 31(3): 191–204.

Levitt, M. and Joyce, M. (1987). The Growth and Efficiency of Public spend- ing. 1st Edition. Cambridge: Cambridge University Press.

McLachlan, G. and Peel, D. (2000). Finite Mixture Models. 1st Edition. USA: John Wiley and Sons Inc.

National Bureau of Statistics (2011). Annual Abstract of Statistics. Retrieved on June 10, 2014 from www.nigerianstat.gov.ng.

Ramanathan, R. (2006). Evaluating the comparative performance of countries of the middle east and north africa: A dea application. Socio Economic Planning Sciences. 40: 156–167.

Thanassoulis, E. (1995). Assessing police forces in England and Wales using data envelopment analysis. European Journal of Operations Research. 87: 641–657.