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Assessing police efficiency in England and Wales using data envelopment analysis

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Summary

- Introduction and Research Questions
- Methods and Data
- Basic Empirical Study

1. Introduction and Research Questions

Background

- Crime has fallen since the mid-1990s;
- But there are new challenges in policing: new types of crime, such as cyber crime, and new priorities, such as tackling domestic violence;
- Police budgets and workforces have been falling since 2010/11.

Austerity period

- 2010/11 - 2015/16, the central government grant to police and crime commissioners and council tax grants has reduced by £2.2 billion (22%) in real terms.

- Police workforce was estimated to reduce by more than 34,000 staff (14%) by the year ending March 2015.

Motivations

- How to quantify performance of police forces in England and Wales?
- How did the police forces perform during the period of austerity?
- Are there any forces that achieved greater efficiency than others? Why?

Definitions

- Effectiveness: achieving policing outcomes regardless of expenditure;
- Efficiency: achieving given outcomes within a minimum expenditure. (Murphy, 1985)
- Value for Money: evaluate the value of police work from the perspective of expenditure. (HMIC, 1995)

Previous Research

- Efficiency: operational research with British data.

Thanassoulis (1995)

Drake and Simper (2000, 2001, 2002, 2003a, 2003b, 2004, 2005a, 2005b)

Annual HMIC PEEL Assessment

No quantitative research in England and Wales police efficiency with data from 2005 onwards.

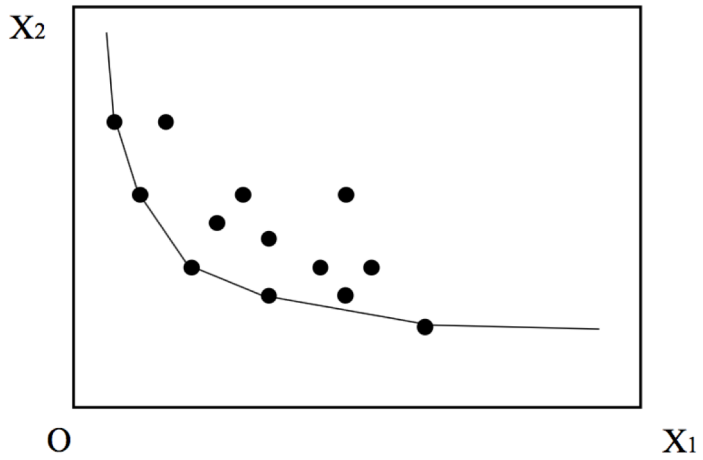
2. Methods and Data

Data envelopment analysis vs Stochastic frontier analysis

- Frontier methodologies: inputs, outputs, frontier.

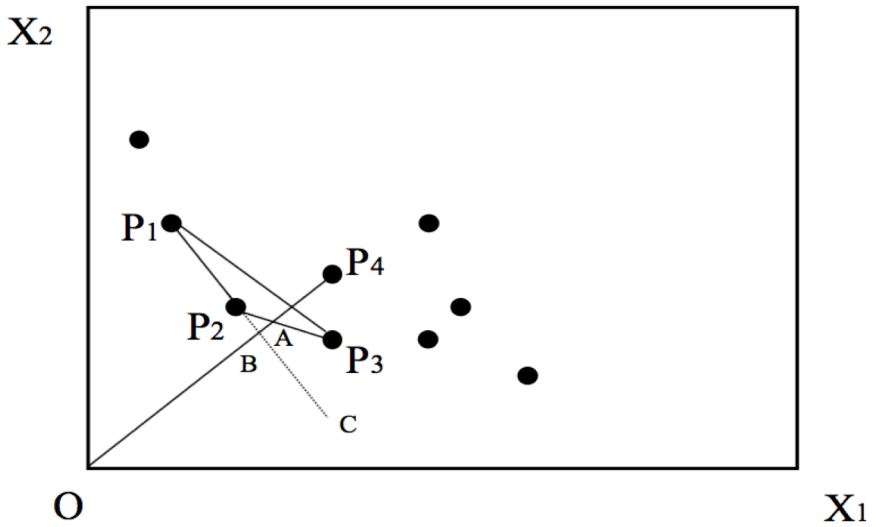
DEA	SFA
nonparametric method	parametric method
requires no assumed frontier function	requires an assumption of frontier function
linear programming problem	estimation of maximum likelihood
has no random errors	incorporates random noise

Data Envelopment Analysis
Single Input Single Output



Evaluate the frontier.

Calculate the ratio.



Data Envelopment Analysis
Multi Input and Multi Output

- Assume that there are *n* DMUs. For the *j*th decision-making unit, DMU_j, $\boldsymbol{x}_j$ and $\boldsymbol{y}_j$ represent the *m*-element input vector and the *s*-element output vector, respectively:
  $\boldsymbol{x}_j = (x_{1j}, \ldots, x_{ij}, \ldots, x_{mj})$, $\boldsymbol{y}_j = (y_{1j}, \ldots, y_{rj}, \ldots, y_{sj})$,
  for $j = 1, \ldots, n;\ i = 1, \ldots, m;\ r = 1, \ldots, s;$
  where $x_{ij} \geq 0, y_{rj} \geq 0$; and for each DMU, $\boldsymbol{x}_j, \boldsymbol{y}_j \neq \boldsymbol{0}$.
- $\boldsymbol{x}_j$ and $\boldsymbol{y}_j$ are observed data, while $\boldsymbol{u}, \boldsymbol{v}$ are vector variables, where $\boldsymbol{u} = (u_1, \ldots, u_r, \ldots, u_s)$ for outputs $\boldsymbol{y}_j$, and $\boldsymbol{v} = (v_1, \ldots, v_i, \ldots, v_m)$ for inputs $\boldsymbol{x}_j$. Elements in $\boldsymbol{u}$ and $\boldsymbol{v}$ can be seen as weights for outputs and inputs in the assessing model.

Data Envelopment Analysis
CCR Model

- Charnes, Cooper, and Rhodes, 1978
- Assumption: constant returns of scale

$$\max h_{(\,)}(\boldsymbol{u},\boldsymbol{v}) = \sum\nolimits_r u_r\, y_{r(\,)} / \sum\nolimits_i v_i\, x_{i(\,)},$$

subject to

$\sum_r u_r\, y_{rj} \,/\, \sum_i v_i\, x_{ij} \le 1$ for $j = 1, \ldots, n,$

$\sum_i v_i\, x_{i(\,)} = 1,$

and $u_r, v_i \ge 0$ for all *r* and *i*.

Data Envelopment Analysis Solution

- $\theta^* = \min \theta$
  subject to $\sum_j x_{ij}\lambda_j \leq \theta x_{i(\,)}$
  $\sum_j y_{rj}\lambda_j \geq y_{r(\,)}$, and
  $\lambda_j \geq 0$ for all j.

- The solution of $\theta^* (\leq 1)$ is the efficiency score of $DMU_{(\,)}$.
- DMUs with $\theta^* = 1$ are boundary points, which mean efficient, and those with $\theta^* < 1$, are inefficient points.

Data Envelopment Analysis
BCC Model

- Banker, Charnes and Cooper, 1984
- Assumption: variate returns of scale
- Adding a constraint:

$$\sum_j \lambda_j = 1$$

Data for Efficiency Modelling

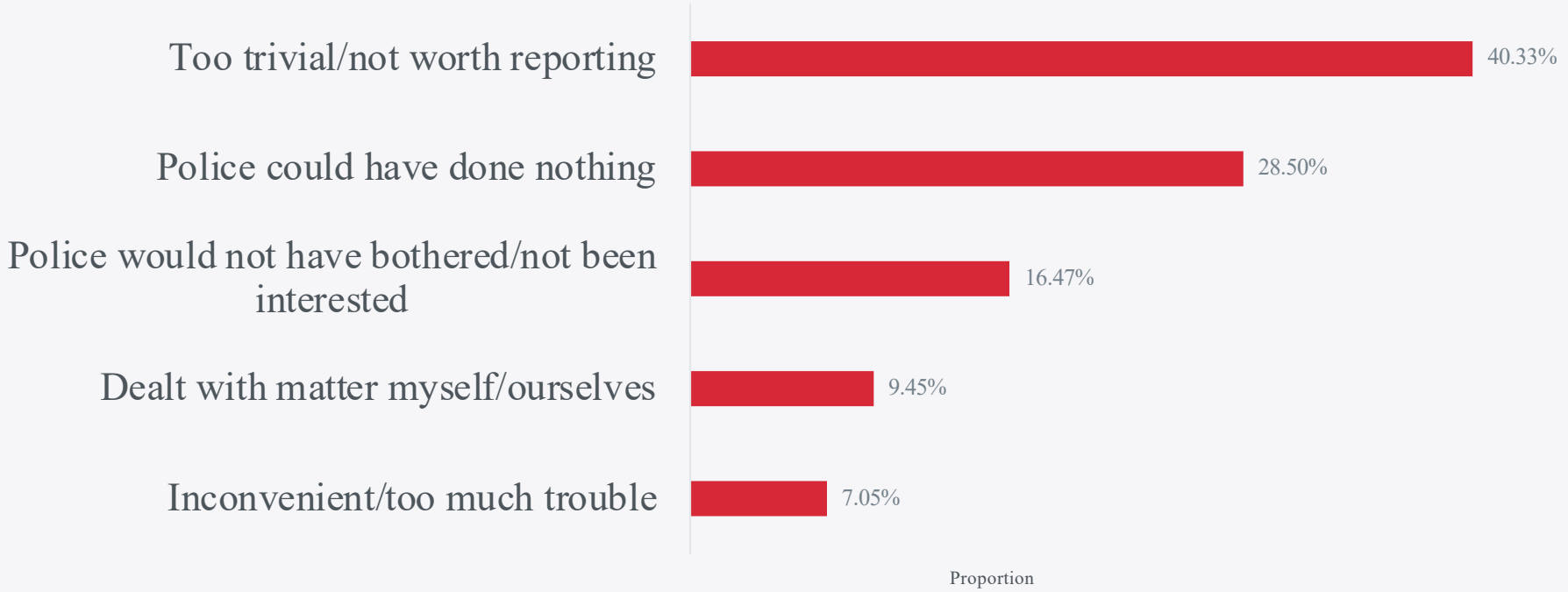
- Crime data (police recorded crime from ONS, crime survey data from CSEW)
- Administrative data (operational data, financial data, workforce data)
- Socio-demographic data (population, education, economics, etc.)

Official Recorded Data vs CSEW Data

- Asked to all victims: did the police come to know about the matter? (Crime Survey in England and Wales, 2015/16）

- Among 10594 incidents in England and Wales, the police came in only 31% cases but were absent in 48% cases.

Official Recorded Data vs CSEW Data



Most frequent five answers to "Why didn't the police come", England and Wales, 2015/16.

Official Recorded Data vs CSEW Data

Crime rates (in 1000 population) estimation of sexual offences

3. Basic Empirical Study

Question and Data

- **How did 43 police forces perform in efficiency from 2011/12 to 2017.18?**
- Crime survey in England and Wales, Secured Access, lower geographic data, 2011-2018.
- Inputs: 1. frontline workforce; 2. support workforce; 3. non-staff cost
- Outputs: 1. household crime rate; 2. personal crime rate; 3. clear up rate

Output Variables

- **household crime rate**: total crime rate in household property categories
- **personal crime rate**: total crime rate in personal property and violence categories

- **clear up rate:**

  Did the police come to know about the matter? [yes; no]

  Did the police find out or know who did it? [yes; no; not yet; not know]

DEA Results

- DEA scores are relative efficiency scores
- Constant returns of scale assumption: overall efficiency
- Variate returns of scale assumption: pure technical efficiency
- Scale efficiency = overall efficiency / pure technical efficiency

- An example from recorded crime data, not CSEW due to a delay of output

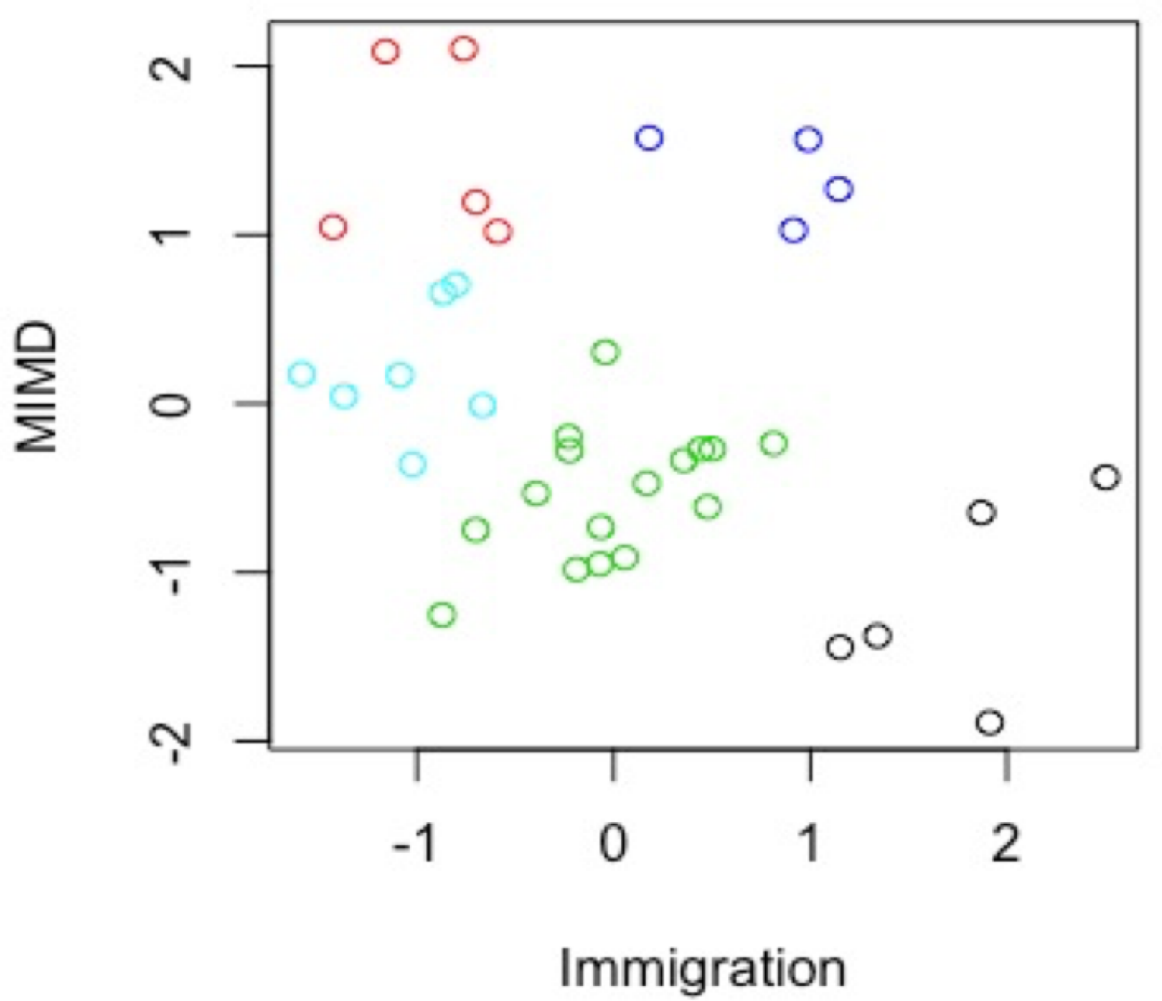
Police forces	Overall efficiency	Pure technical	Scale efficiency
Cambridgeshire	1.000	1.000	1.000
Cleveland	1.000	1.000	1.000
Essex	1.000	1.000	1.000
Hampshire	1.000	1.000	1.000
Greater Manchester	0.955	1.000	0.955
South Yorkshire	0.950	0.985	0.965
Staffordshire	0.940	1.000	0.940
West Yorkshire	0.937	1.000	0.937
Dorset	0.900	1.000	0.900
Humberside	0.877	0.885	0.991
Hertfordshire	0.865	0.867	0.998
Avon and Somerset	0.856	0.893	0.959
Lincolnshire	0.835	0.986	0.848
Northumbria	0.833	0.851	0.979
Kent	0.825	0.828	0.996
Suffolk	0.813	0.925	0.879
Leicestershire	0.811	0.819	0.990
Nottinghamshire	0.801	0.811	0.988
Bedfordshire	0.793	0.906	0.876
Lancashire	0.785	0.793	0.989
Northamptonshire	0.779	0.876	0.889
Thames Valley	0.773	0.801	0.965

Police forces	Overall efficiency	Pure technical	Scale efficiency
Warwickshire	0.768	1.000	0.768
South Wales	0.765	0.773	0.990
West Mercia	0.764	0.814	0.939
West Midlands	0.761	0.805	0.945
Durham	0.747	0.908	0.823
Merseyside	0.747	0.769	0.972
Sussex	0.733	0.739	0.991
Gwent	0.724	0.888	0.815
Wiltshire	0.723	0.911	0.794
Gloucestershire	0.722	0.981	0.736
Derbyshire	0.708	0.708	1.000
Metropolitan Police	0.660	1.000	0.660
Cheshire	0.643	0.674	0.954
Norfolk	0.640	0.771	0.830
Surrey	0.635	0.660	0.961
Cumbria	0.609	1.000	0.609
North Yorkshire	0.606	0.706	0.859
Devon and Cornwall	0.561	0.600	0.935
North Wales	0.558	0.721	0.774
Dyfed-Powys	0.446	0.896	0.497
London, City of	0.169	1.000	0.169

Police force family

- Clustering analysis with two dimensions

- Index of Multiple deprivation 2015 (excludes the crime domain)
- Immigration (non-UK born estimates) / (residual population)



- Police force clustering.

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Thank you!

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