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**Streamlining the Applied Mathematics Studies
at Faculty of Science of Palacký University in Olomouc
CZ.1.07/2.2.00/15.0243**

International Conference
Olomoucian Days of Applied Mathematics

ODAM 2011

Department of Mathematical analysis
and Applications of Mathematics
Faculty of Science
Palacký University Olomouc

AHP model for ranking of efficient units in DEA models

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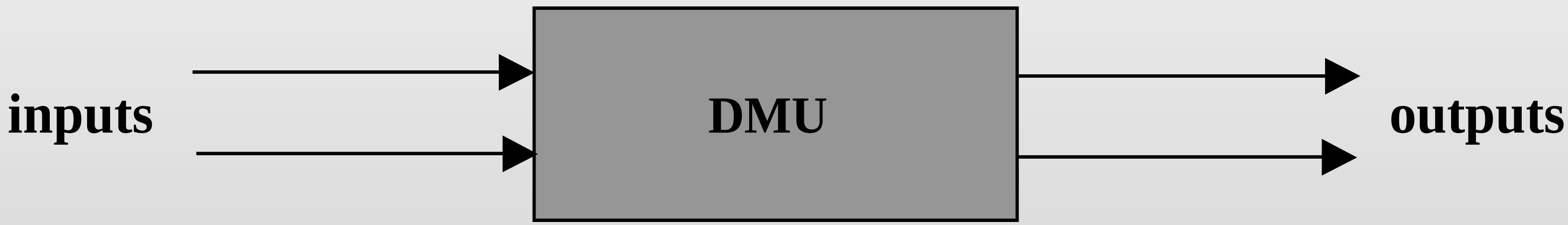
Outline

- Introduction
- Data envelopment analysis (DEA) models
- Review of ranking methods in DEA
  - Andersen and Petersen model
  - Super SBM model – Tone
  - Super SBM goal programming model
  - Cross efficiency evaluation
  - Optimistic and pessimistic efficiency concept
- AHP model
- Numerical illustration
- Software support and conclusions

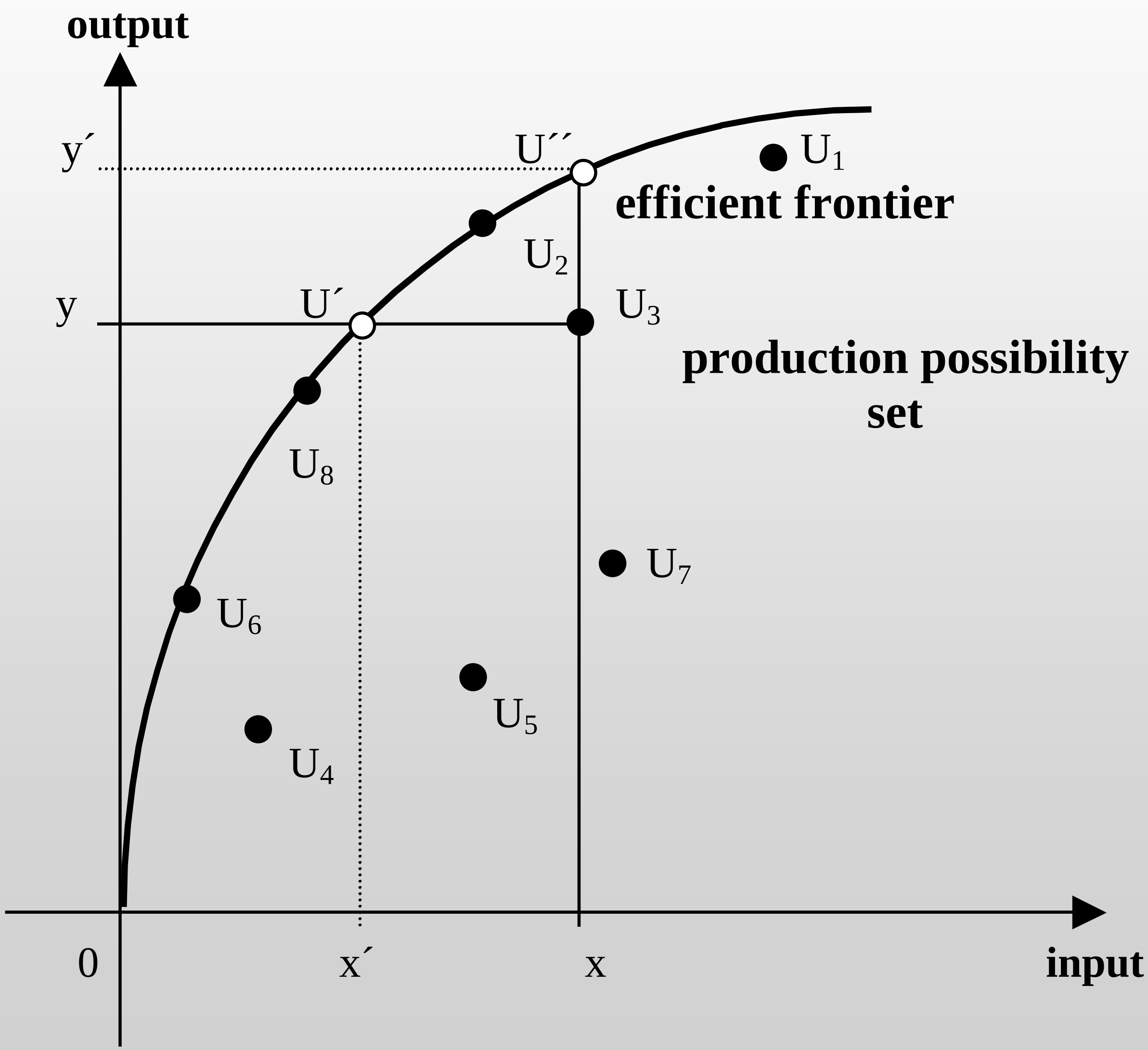
Data envelopment analysis

- **Decision making units – U_1, U_2, …, U_n**
- **Inputs (resources) – X = {x_{ij}, i=1,2,…,m, j=1,2,...,n}**
- **Outputs (effects) – Y = {y_{kj}, k=1,2,…,r, j=1,2,...,n}**



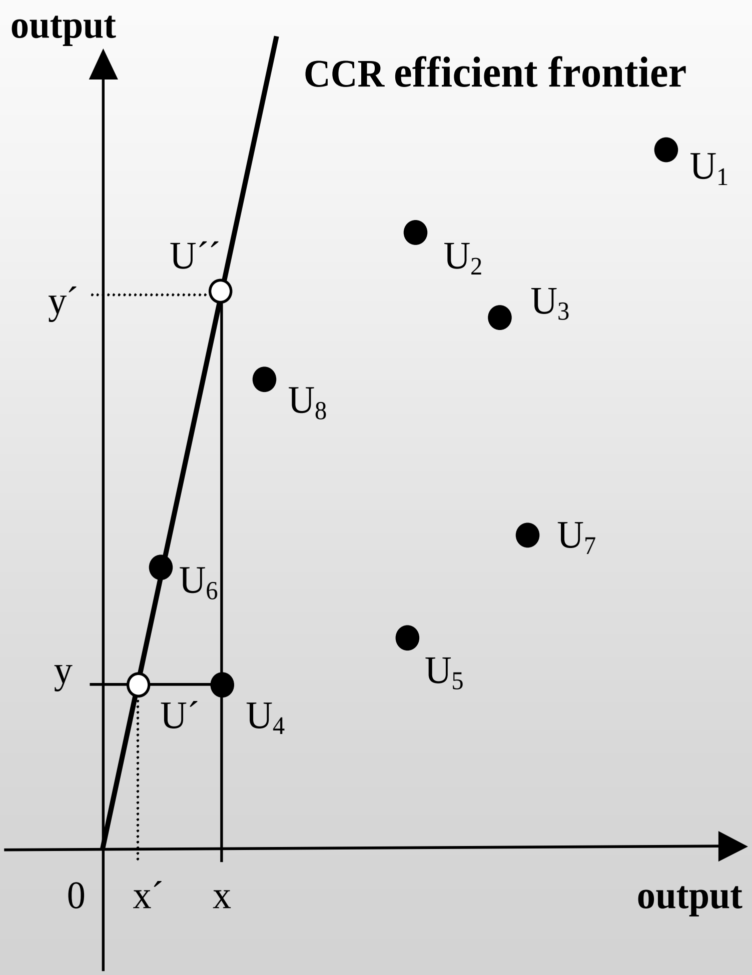
- **Measure of efficiency – outputs/inputs**

DEA – Data envelopment analysis



CCR (Charnes, Cooper, Rhodes) model

constant returns to scale (conical frontier)



maximise $$\frac{\sum_k u_k y_{kq}}{\sum_j v_j x_{jq}}$$

subject to $$\frac{\sum_k u_k y_{kj}}{\sum_i v_i x_{ij}} \leq 1,$$

$$j = 1,2,\ldots n,$$

$$u_k > \varepsilon, v_i > \varepsilon$$

CCR (Charnes, Cooper, Rhodes) model

Primal model:

maximise	$z = u^T y^q$
subject to	$v^T x^q = 1$,
	$u^T Y - v^T X \le 0$,
	$u \ge \varepsilon,\ v \ge \varepsilon$.

Dual model:

min	$f = \theta - \varepsilon(e^T s^+ + e^T s^-)$,
s.t.	$Y\lambda - s^+ = y^q$,
	$X\lambda + s^- = \theta x^q$,
	$\lambda,\ s^+,\ s^- \ge 0.$

U_q is efficient:

1. **Radial scalar variable $\theta = 1$,**
2. **All the slack variables s^+ and s^- equal to 0.**

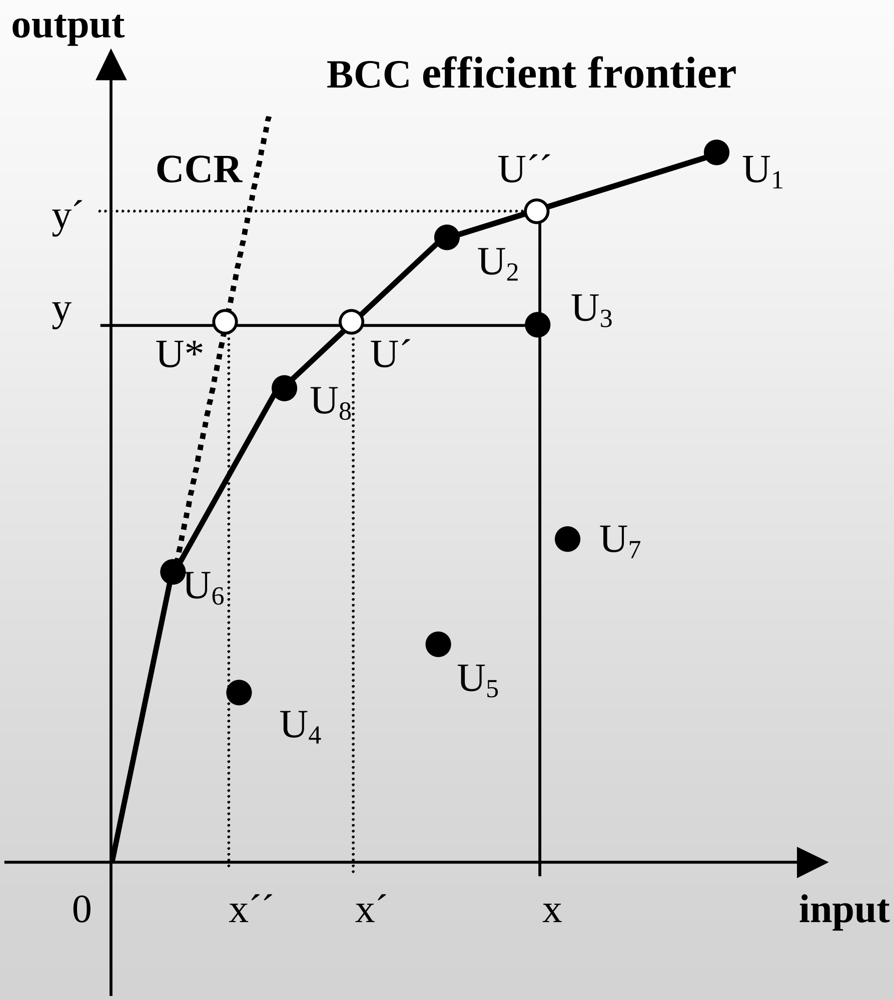
Virtual unit (target values of inputs and outputs):

$x'^q = X\lambda^*$,

$y'^q = Y\lambda^*$, **where λ^* are optimal variable values of dual model**

BCC (Banker, Charnes, Cooper) model

variable returns to scale (convex frontier)



maximise

$$g = \phi + \varepsilon(e^T s^+ + e^T s^-)\ ,$$

subject to

$$Y\lambda - s^+ = \phi y^q\ ,$$

$$X\lambda + s^- = x^q\ ,$$

$$e^T\lambda = 1\ ,$$

$$\lambda, s^+, s^- \geq 0.$$

Basic DEA models

(envelopment models)

$$\min \quad z = \theta_q - \varepsilon\left(\sum_{i=1}^{m} s_i^- + \sum_{k=1}^{r} s_k^+\right) \qquad\qquad \max \quad g = \phi_q + \varepsilon\left(\sum_{i=1}^{m} s_i^- + \sum_{k=1}^{r} s_k^+\right)$$

$$st \quad \sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = \theta_q x_{iq} \qquad\qquad st \quad \sum_{j=1}^{n} \lambda_j y_{kj} - s_k^+ = \phi_q y_{kq}$$

$$\sum_{j=1}^{n} \lambda_j y_{kj} - s_k^+ = y_{kq} \qquad\qquad \sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = x_{iq}$$

$CRS \quad \sum_{j=1}^{n} \lambda_j - free,$

$VRS \quad \sum_{j=1}^{n} \lambda_j = 1,$

$NDRS \quad \sum_{j=1}^{n} \lambda_j < 1$

$NIRS \quad \sum_{j=1}^{n} \lambda_j > 1$

SBM DEA models

$$\max \quad g = \sum_{i=1}^{m} s_i^- + \sum_{k=1}^{r} s_k^+$$

$$st \quad \sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = x_{io}$$

$$\sum_{j=1}^{n} \lambda_j y_{kj} - s_k^+ = y_{ko}$$

$CRS \quad \sum_{j=1}^{n} \lambda_j - free,$

$VRS \quad \sum_{j=1}^{n} \lambda_j = 1,$

$NDRS \quad \sum_{j=1}^{n} \lambda_j < 1$

$NIRS \quad \sum_{j=1}^{n} \lambda_j > 1$

Models with uncontrollable measures

$$\min \quad z = \theta - \varepsilon\left(\sum_{i=1}^{m} s_i^- + \sum_{k=1}^{r} s_k^+\right)$$

$$st \quad \sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = \theta x_{iq}, i \in CI$$

$$\sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = x_{iq}, i \in NI$$

$$\sum_{j=1}^{n} \lambda_j y_{kj} - s_k^+ = y_{kq}$$

$$\max \quad g = \phi + \varepsilon\left(\sum_{i=1}^{m} s_i^- + \sum_{k=1}^{r} s_k^+\right)$$

$$st \quad \sum_{j=1}^{n} \lambda_j y_{kj} - s_k^+ = \phi y_{kq}, k \in CO$$

$$\sum_{j=1}^{n} \lambda_j y_{kj} - s_k^+ = y_{kq}, k \in NO$$

$$\sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = x_{iq}$$

$CRS \quad \sum_{j=1}^{n} \lambda_j - free,$

$VRS \quad \sum_{j=1}^{n} \lambda_j = 1,$

$NDRS \quad \sum_{j=1}^{n} \lambda_j < 1$

$NIRS \quad \sum_{j=1}^{n} \lambda_j > 1$

Models with undesirable characteristics

$$\min \quad z = \theta - \varepsilon\left(\sum_{i=1}^{m} s_i^- + \sum_{k=1}^{r} s_k^+\right)$$

$$st \quad \sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = \theta x_{iq}, i \in DI$$

$$\sum_{j=1}^{n} \lambda_j x'_{ij} + s_i^- = \theta x'_{iq}, i \in UI$$

$$\sum_{j=1}^{n} \lambda_j y_{kj} - s_k^+ = y_{kq}$$

$$\max \quad g = \phi + \varepsilon\left(\sum_{i=1}^{m} s_i^- + \sum_{k=1}^{r} s_k^+\right)$$

$$st \quad \sum_{j=1}^{n} \lambda_j y_{kj} - s_k^+ = \phi y_{kq}, k \in DO$$

$$\sum_{j=1}^{n} \lambda_j y'_{kj} - s_k^+ = \phi y'_{ko}, k \in UO$$

$$\sum_{j=1}^{n} \lambda_j x'_{ij} + s_i^- = \theta x'_{iq}, i \in UI$$

$CRS \quad \sum_{j=1}^{n} \lambda_j - free,$

$VRS \quad \sum_{j=1}^{n} \lambda_j = 1,$

$NDRS \quad \sum_{j=1}^{n} \lambda_j < 1$

$NIRS \quad \sum_{j=1}^{n} \lambda_j > 1$

Solving of DEA models / 1

n (100)DMUs, m (4) inputs, r (4) ouputs

n LP problems with

(n+r+m+1) variables and (m+r) constraints

109 variables and 8(9) constraints

OR

one LP problems with

n(n+r+m+1) variables and n(m+r) constraints

10900 variables and 800 constraints

Solving of DEA models / 2

minimise $$\sum_{q=1}^{n}\left(\theta_q - \varepsilon\left(\sum_{k=1}^{r} s_{kq}^{+} + \sum_{i=1}^{m} s_{iq}^{-}\right)\right)$$

s.t.

$$\sum_{j=1}^{n} y_{kj}\lambda_{jq} - s_{kq}^{+} = y_{kq}, \qquad k = 1,2,\ldots,r,\ \text{q} = 1,2,\ldots,\text{n},$$

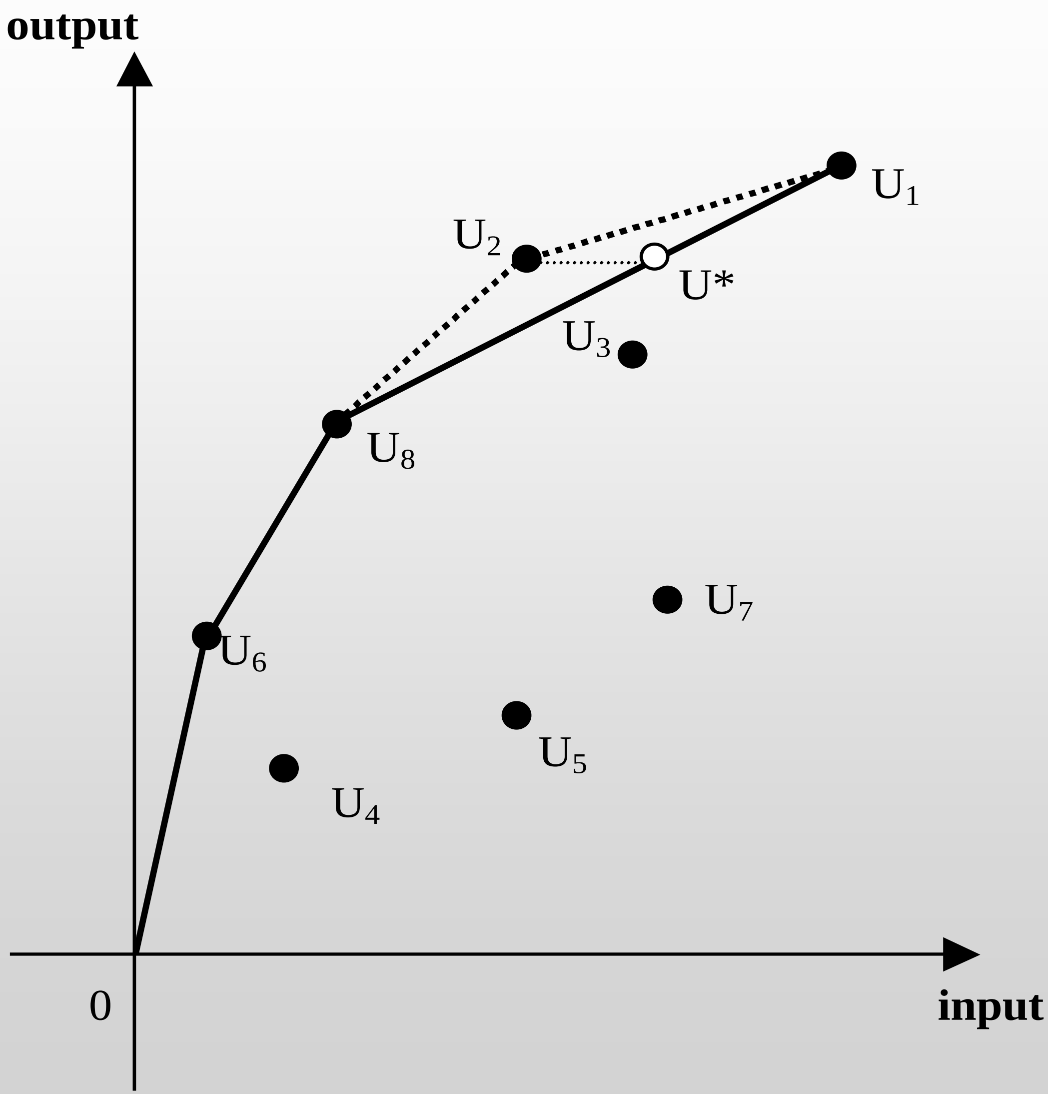
$$\sum_{j=1}^{n} x_{ij}\lambda_{jq} - s_{iq}^{-} = \theta_q x_{iq}, \qquad i = 1,2,\ldots,m,\ \text{q} = 1,2,\ldots,\text{n},$$

$$\lambda_{jq} \geq 0, s_{kq}^{+} \geq 0, s_{iq}^{-} \geq 0, \theta_q \geq 0.$$

Ranking models in DEA

- Super-efficiency DEA models
  - Andersen and Petersen model
  - Super SBM model – Tone
  - Super SBM goal programming model
- Cross-efficiency evaluation
- Optimistic and pessimistic concept
- AHP model

Super-efficiency DEA models



Super-efficiency DEA models

(Andersen and Petersen model)

$$\min \quad z = \theta_q^{AP} - \varepsilon\left(\sum_{i=1}^{m} s_i^- + \sum_{k=1}^{r} s_k^+\right) \qquad\qquad \max \quad g = \phi_q^{AP} + \varepsilon\left(\sum_{i=1}^{m} s_i^- + \sum_{k=1}^{r} s_k^+\right)$$

$$st \quad \sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = \theta_q^{AP} x_{iq} \qquad\qquad st \quad \sum_{j=1}^{n} \lambda_j y_{kj} - s_k^+ = \phi_q^{AP} y_{kq}$$

$$\sum_{j=1}^{n} \lambda_j y_{kj} - s_k^+ = y_{kq} \qquad\qquad \sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = x_{iq}$$

$$\lambda_q = 0$$

$$CRS \quad \sum_{j=1}^{n} \lambda_j - free,$$

$$VRS \quad \sum_{j=1}^{n} \lambda_j = 1,$$

$$NDRS \quad \sum_{j=1}^{n} \lambda_j < 1$$

$$NIRS \quad \sum_{j=1}^{n} \lambda_j > 1$$

Super-efficiency DEA models

(Super SBM – Tone's model)

$$\min \quad \theta_q^{SBM} = \frac{\frac{1}{m}\sum_{i=1}^{m} x_i^* / x_{iq}}{\frac{1}{r}\sum_{k=1}^{r} y_k^* / y_{kq}},$$

$$\begin{aligned}
s.t. \quad & \sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- = x_{iq}, && i = 1,2,\ldots,m, \\
& \sum_{j=1}^{n} y_{kj}\lambda_j - s_k^+ = y_{kq}, && k = 1,2,\ldots,r, \\
& x_i^* \geq x_{iq}, \quad y_k^* \leq y_{kq}, \\
& \lambda_q = 0
\end{aligned}$$

The super SBM model returns optimal objective value greater or equal 1. The optimal efficient score is greater than 1 for efficient DMUs – higher value is assigned to more efficient units. All the SBM inefficient units reach in the super SBM model optimal score 1.

Super-efficiency DEA models

(Super SBM GP model)

$$\min \quad \theta_q^G = 1 + t\gamma + (1-t)\left(\sum_{i=1}^{m}\left[s_{1i}^{+} / x_{iq}\right] + \sum_{k=1}^{r}\left[s_{2k}^{-} / y_{kq}\right]\right),$$

$$s.t. \quad \sum_{j=1}^{n} x_{ij}\lambda_j + s_{1i}^{-} - s_{1i}^{+} = x_{iq}, \qquad i = 1,2,\dots,m,$$

$$\sum_{j=1}^{n} y_{kj}\lambda_j + s_{2k}^{-} - s_{2k}^{+} = y_{kq}, \qquad k = 1,2,\dots,r,$$

$$s_{1i}^{+} \le \gamma, \quad s_{2k}^{-} \le \gamma,$$

$$t \in <0,1>, \quad \lambda_q = 0$$

In this model the distance between the unit DMU_q and a virtual unit DMU* is measured by positive and negative deviational variables - s_{1i}^{-}, s_{1i}^{+} for inputs and s_{2i}^{-}, s_{2i}^{+} for outputs. Objective function of the model contains just positive deviations for inputs and negative deviations for outputs because it measures the distance in undesirable way only – undesirable values are higher inputs and lower outputs.

Cross-efficiency evaluation

The basic idea of this concept is evaluation of each DMU using optimal weights of inputs and outputs given by standard DEA models Cross efficiency of the unit DMU_q by using optimal weights given by standard envelopment model in evaluation the unit DMU_j is defined as follows:

$$E_{qj} = \frac{\sum_{k}^{r} u_{kj} y_{kq}}{\sum_{i}^{m} v_{ij} x_{iq}}, \qquad q = 1,2,\ldots,n,\ j = 1,2,\ldots n.$$

It is clear that $E_{qq} = \theta_q$ and $E_{qj} \leq 1$ for DEA input oriented models. Average cross efficiency φ_q is defined as follows:

$$\varphi_q = \frac{\sum_{j=1}^{n} E_{qj}}{n}, \quad or \qquad \varphi_q = \frac{\sum_{j=1, j \neq q}^{n} E_{qj}}{n-1}, \qquad q = 1,2,\ldots,n.$$

Optimistic and pessimistic efficiency concept

Optimistic efficiency score (θ_q) is computed by standard envelopment models. Optimistic super-efficiency (θ^{AP}_q) can be given e.g. by Andersen and Petersen model. Pessimistic efficiency score (θ^P_q) is given as the optimal value of the following model (input oriented form) :

$$
\begin{aligned}
\max \quad & \theta_q^P \\
s.t. \quad & \sum_{j=1}^{n} x_{ij}\lambda_j \geq \theta_q^P x_{iq}, \qquad i = 1,2,\ldots,m, \\
& \sum_{j=1}^{n} y_{kj}\lambda_j \leq y_{kq}, \qquad k = 1,2,\ldots,r, \\
& \lambda_j \geq 0, \quad j = 1,2,\ldots,n.
\end{aligned}
$$

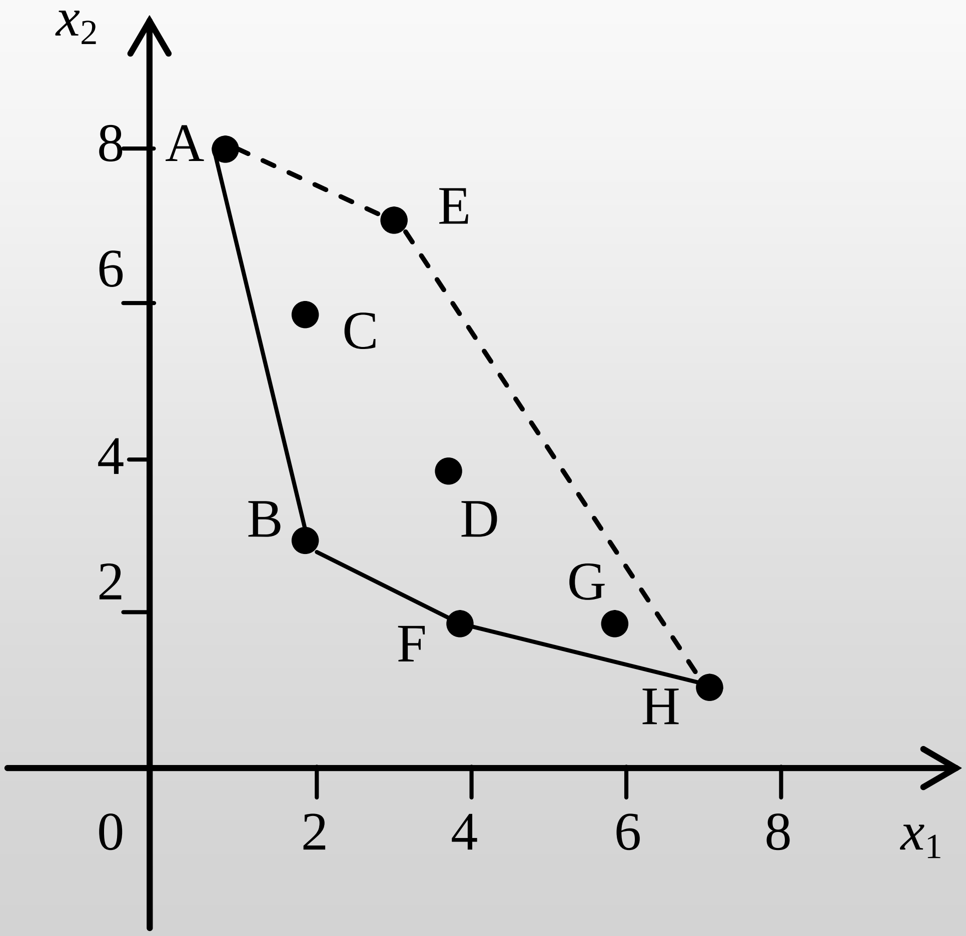
Pessimistic super efficiency score (θ^{APP}_q) can be given by simple modification of the model above ($\lambda_q = 0$)

Optimistic and pessimistic efficiency concept (2)

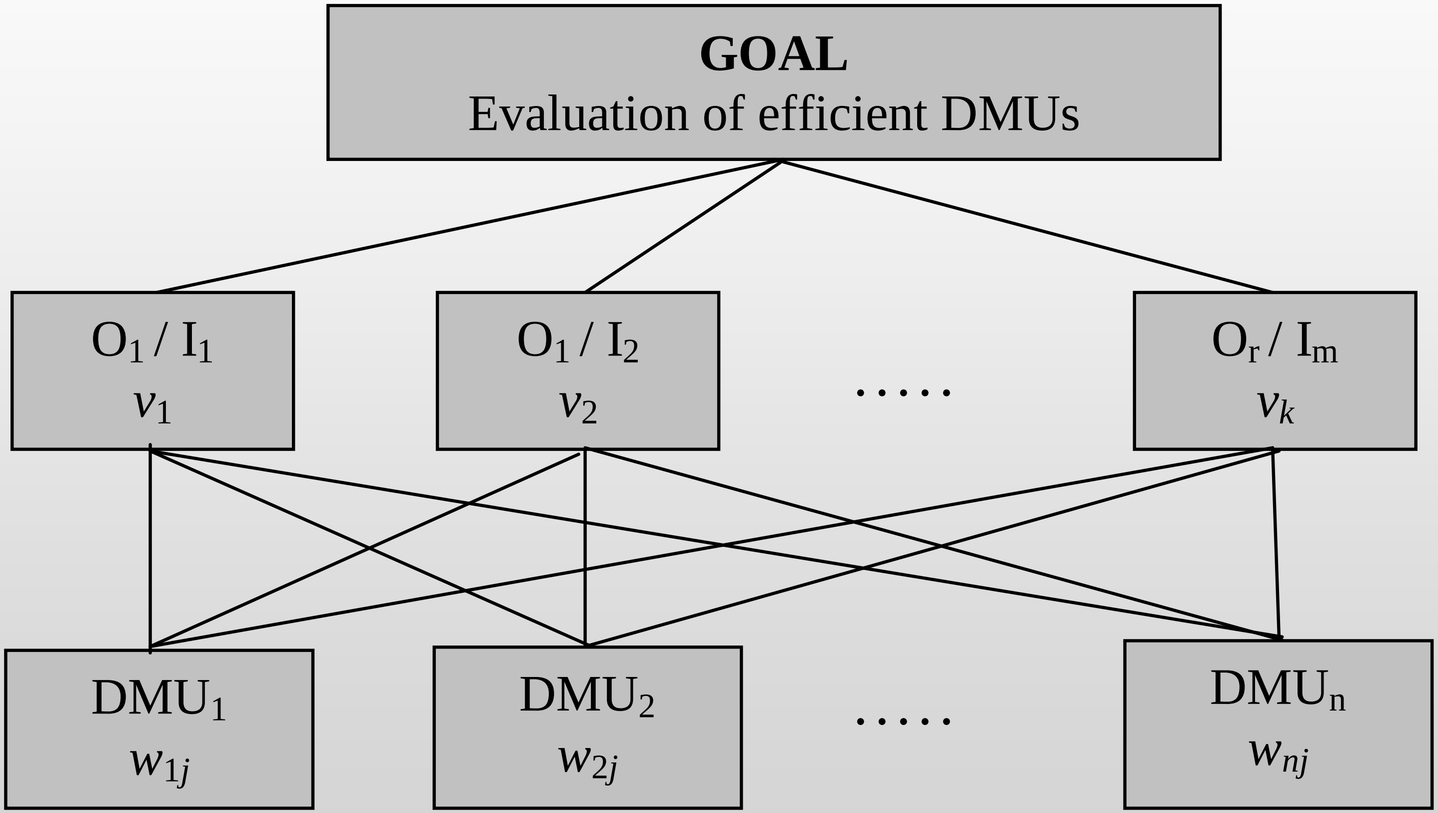
The following simple procedure for complete ranking of the DMUs can be applied:

- Compute optimistic and pessimistic efficiency scores (θ_q and $\theta^P{}_q$) and their geometric average ω_q
- Rank the DMUs according to ω_q *values*
- For the units that are optimistic and pessimistic efficient (their ω_q=1) compute their optimistic and pessimistic super-efficiency scores ($\theta^{AP}{}_q$ and $\theta^{APP}{}_q$), and compute their geometric average ψ_q.
- Rank the optimistic and pessimistic efficient units by ψ_q.

Numerical example (2)



AHP model (1)


GOAL
Evaluation of efficient DMUs
O_1 / I_1
v_1
O_1 / I_2
v_2
.....
O_r / I_m
v_k
DMU_1
w_{1j}
DMU_2
w_{2j}
.....
DMU_n
w_{nj}

AHP model (2)

Weights of particular efficiency measures:

•M1 - average weights of inputs and outputs of all DMUs given by a DEA model,

•M2 - average weights of inputs and outputs of all efficient DMUs recognized by a DEA model,

•M3 – optimal weights of particular efficient DMUs.

Numerical illustration (1)

194 bank branches, 3 inputs, 2 outputs

I_1 – total operational costs in thousands of CZK per year,
I_2 – the number of inhabitants within the region of the branch,
I_3 – the number of employees,

O_1 – value of credits in millions of CZK,
O_2 – the total number of accounts.

NI (2) – data set

DMU	I_1	I_2	I_3	O_1	O_2
26	142646	64146	7.0	128.7	22592
28	182884	85271	5.0	148.6	26214
37	141578	314102	4.0	133.3	18958
71	204665	33192	7.0	118.2	27274
79	274904	24999	6.5	143.0	26142
82	156228	7605	5.0	72.0	15854
83	132690	12677	5.0	72.5	16414
105	136572	47678	6.0	110.8	20340
133	167716	17481	6.0	113.9	19448
147	85666	801	3.0	32.3	6322
182	251608	43544	7.0	201.4	29328
184	52238	2914	2.0	21.4	6182

NI (3) – Ranking of DMUs

	AP model		Super SBMT		OPT/PES		CROSS	
	θ_q^{AP}	Rank	θ_q^{SBM}	Rank	ω_q	Rank	φ_q	Rank
26	1.103	6	1.035	9	3.057	7	0.838	7
28	1.227	2	1.100	3	3.829	2	0.843	6
37	1.153	3	1.069	4	4.026	1	0.339	12
71	1.067	9	1.033	10	2.963	8	0.912	3
79	1.093	7	1.040	7	3.269	4	0.836	8
82	1.088	8	1.054	6	2.721	10	0.818	9
83	1.020	11	1.008	11	2.750	9	0.893	4
105	1.005	12	1.003	12	3.071	6	0.866	5
133	1.066	10	1.037	8	3.099	5	0.928	2
147	4.274	1	2.043	1	2.349	12	0.636	11
182	1.134	4	1.112	2	3.740	3	0.972	1
184	1.129	5	1.058	5	2.401	11	0.814	10

NI (4) – Ranking of DMUs

	SBMG t = 0		SBMG t = 1		DEA/AHP M1		DEA/AHP M2	
	θ_q^G	Rank	θ_q^G	Rank	$u()$	Rank	$u()$	Rank
26	**1.035**	**9**	**1.049**	**6**	**0.213**	**4**	**0.176**	**7**
28	**1.091**	**3**	**1.102**	**3**	**0.243**	**3**	**0.219**	**3**
37	**1.065**	**4**	**1.071**	**4**	**0.197**	**5**	**0.176**	**8**
71	**1.031**	**10**	**1.033**	**10**	**0.164**	**10**	**0.154**	**11**
79	**1.040**	**7**	**1.044**	**7**	**0.173**	**9**	**0.190**	**6**
82	**1.053**	**6**	**1.042**	**8**	**0.243**	**2**	**0.276**	**2**
83	**1.008**	**11**	**1.010**	**11**	**0.156**	**12**	**0.164**	**10**
105	**1.003**	**12**	**1.003**	**12**	**0.178**	**7**	**0.147**	**12**
133	**1.036**	**8**	**1.037**	**9**	**0.161**	**11**	**0.170**	**9**
147	**1.751**	**1**	**1.620**	**1**	**0.311**	**1**	**0.350**	**1**
182	**1.106**	**2**	**1.110**	**2**	**0.177**	**8**	**0.193**	**5**
184	**1.057**	**5**	**1.060**	**5**	**0.194**	**6**	**0.205**	**4**

NI (5) – Modified data set

DMU	O_1/I_1	O_1/I_2	O_1/I_3	O_2/I_1	O_2/I_2	O_2/I_3
26	0.902	2.006	18.380	0.158	0.352	3227.429
28	0.813	1.743	29.720	0.143	0.307	5242.800
37	0.942	0.424	33.325	0.134	0.060	4739.500
71	0.577	3.561	16.884	0.133	0.822	3896.286
79	0.520	5.722	22.008	0.095	1.046	4021.846
82	0.461	9.472	14.406	0.101	2.085	3170.800
83	0.546	5.715	14.490	0.124	1.295	3282.800
105	0.811	2.324	18.465	0.149	0.427	3390.000
133	0.679	6.514	18.979	0.116	1.113	3241.333
147	0.377	40.369	10.779	0.074	7.893	2107.333
182	0.800	4.624	28.764	0.117	0.674	4189.714
184	0.410	7.353	10.714	0.118	2.121	3091.000

NI (6) – Evaluation scale – AHP with absolute measurement

	Excell.	VG	Good	Poor	VP	p_i
Excellent	1	3	5	7	9	0.5100
Very good	1/3	1	3	5	7	0.2638
Good	1/5	1/3	1	3	5	0.1296
Poor	1/7	1/5	1/3	1	3	0.0636
Very poor	1/9	1/7	1/5	1/3	1	0.0329

M1 - average weights of inputs and outputs of all DMUs;
v = (0.1023, 0.2321, 0.0679, 0.1519, 0.3448, 0.1009);

M2 – average weights of inputs and outputs of efficient DMUs ;
v = (0.0702, 0.3013, 0.0863, 0.0831, 0.3568, 0.1022).

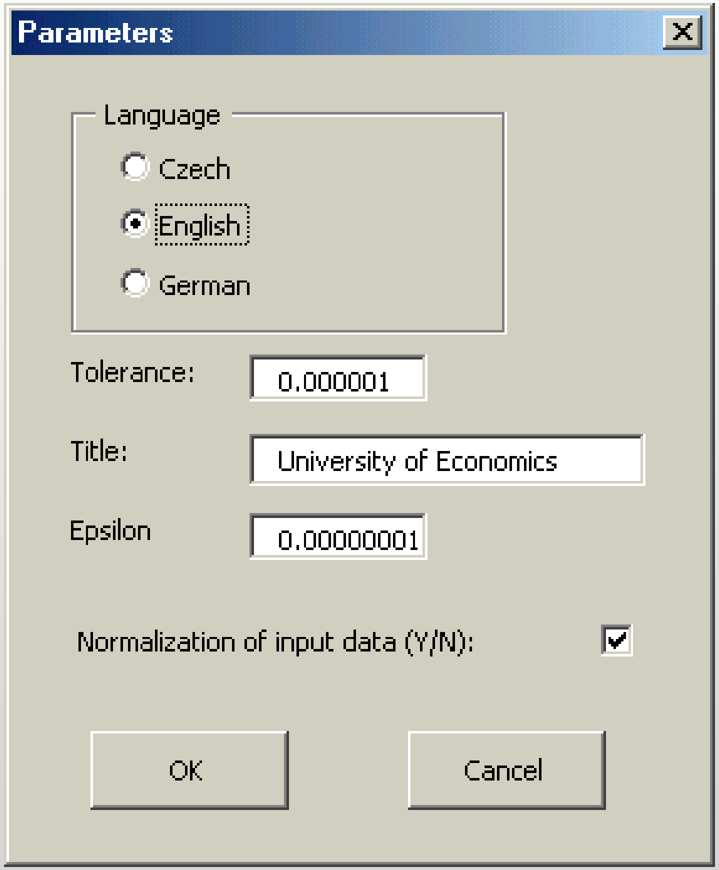
NI (7) – AHP with absolute measurement

DMU	O_1/I_1	O_1/I_2	O_1/I_3	O_2/I_1	O_2/I_2	O_2/I_3
26	0.5100	0.1296	0.2638	0.5100	0.0636	0.1296
28	0.2638	0.1296	0.5100	0.5100	0.0636	0.5100
37	0.5100	0.0329	0.5100	0.2638	0.0329	0.5100
71	0.1296	0.1296	0.1296	0.2638	0.1296	0.2638
79	0.1296	0.2638	0.2638	0.0636	0.1296	0.2638
82	0.0636	0.5100	0.0636	0.0636	0.2638	0.1296
83	0.1296	0.2638	0.0636	0.1296	0.1296	0.1296
105	0.2638	0.1296	0.1296	0.5100	0.0636	0.1296
133	0.1296	0.2638	0.1296	0.1296	0.1296	0.1296
147	0.0329	0.5100	0.0329	0.0329	0.5100	0.0636
182	0.1296	0.2638	0.5100	0.1296	0.0636	0.2638
184	0.0636	0.2638	0.0329	0.1296	0.2638	0.1296

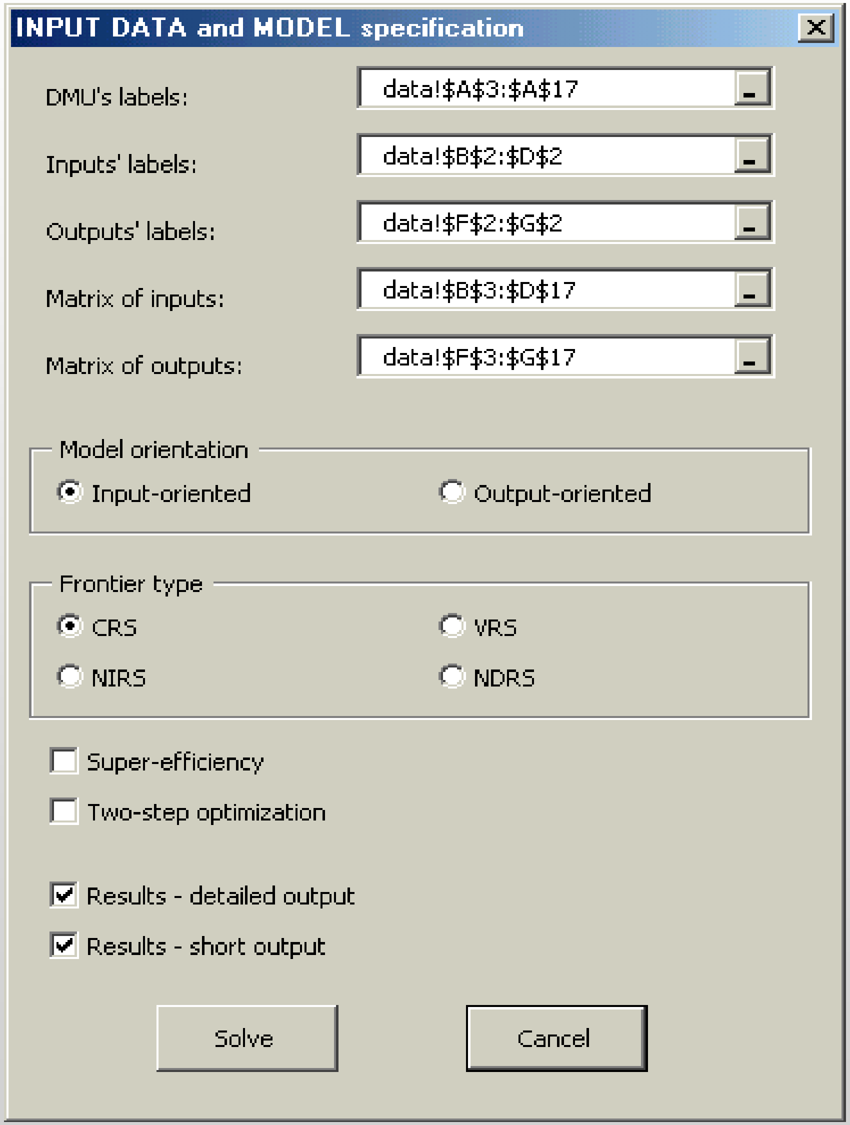
NI (8) – Correlation coefficients of rankings

	SBMT	OPTPES	CROSS	SBMG 0	SBMG 1	DEA M1	DEA M2
AP model	**0.916**	**0.154**	**-0.510**	**0.916**	**0.972**	**0.671**	**0.748**
SBMT		**0.126**	**-0.385**	**1.000**	**0.951**	**0.587**	**0.825**
OPT/PES			**0.231**	**0.126**	**0.154**	**-0.175**	**-0.238**
CROSS				**-0.385**	**-0.392**	**-0.678**	**-0.497**
SBMG 0					**0.951**	**0.587**	**0.825**
SBMG 1						**0.608**	**0.769**
DEA M1							**0.741**

MS Excel DEA system (1)



MS Excel DEA system (2)



Numerical example – input data

Microsoft Excel - test.xls

DMU	Assets (Inputs)	Equity (Inputs)	Employees (Inputs)	Revenue (Outputs)	Profit (Outputs)
Mitsubishi	91920.6	10950.0	36000.0	184365.2	346.2
Mitsui	68770.9	5553.9	80000.0	181518.7	314.8
Itochu	65708.9	4271.1	7182.0	169164.6	121.2
General Motors	217123.4	23345.5	709000.0	168828.6	6880.7
Sumitomo	50268.9	6681.0	6193.0	167530.7	210.5
Marubeni	71439.3	5239.1	6702.0	161057.4	156.6
Ford Motor	243283.0	24547.0	346990.0	137137.0	4139.0
Totota Motor	106004.2	49691.6	146855.0	111052.0	2662.4
Exxon	91296.0	40436.0	82000.0	110009.0	6470.0
Royal Dutch/Shell Group	118011.6	58986.4	104000.0	109833.7	6904.6
Wal-Mart	37871.0	14762.0	675000.0	93627.0	2740.0
Hitachi	91620.9	29907.2	331852.0	84167.1	1468.8
Nippon Life Insurance	364762.5	2241.9	89690.0	83206.7	2426.6
Nippon Telegraph & Telephone	127077.3	42240.1	231400.0	81937.2	2209.1
AT&T	88884.0	17274.0	299300.0	79609.0	139.0

Numerical example – results

Microsoft Excel - test.xls

CRS_I model

	DMU	Eff. score	Virtual inputs Assets	Virtual inputs Equity	Virtual inputs Employees	Virtual outputs Revenue	Virtual outputs Profit	Pears --->			
1	Mitsubishi	0.662832	60927.89101	7258.007526	23861.94255	184365.20000	346.20000	3(.184)	4(.017)	5(.893)	11(.00
2	Mitsui	1.000000	68770.90000	5553.900000	80000.00000	181518.70000	314.80000	2(1)			
3	Itochu	1.000000	65708.90000	4271.100000	7182.00000	169164.60000	121.20000	3(1)			
4	General Motors	1.000000	217123.40000	23345.500000	709000.00000	168828.60000	6880.70000	4(1)			
5	Sumitomo	1.000000	50268.90000	6681.000000	6193.00000	167530.70000	210.50000	5(1)			
6	Marubeni	0.971967	69436.58086	5092.230409	6514.12040	161057.40000	156.60000	3(.547)	5(.408)	9(.001)	
7	Ford Motor	0.737166	179340.03064	18095.221335	255789.33683	137137.00000	4139.00000	3(.253)	4(.305)	9(.233)	13(.20
8	Totota Motor	0.524558	55605.31008	26065.979415	77033.90820	111052.00000	2662.40000	5(.382)	9(.371)	11(.066)	
9	Exxon	1.000000	91296.00000	40436.000000	82000.00000	110009.00000	6470.00000	9(1)			
10	Royal Dutch/Shell Gro	0.841424	99297.75563	49632.446893	87508.06801	109833.74168	6904.60000	9(1.067)			
11	Wal-Mart	1.000000	37871.00000	14762.000000	675000.00000	93627.00000	2740.00000	11(1)			
12	Hitachi	0.386057	35370.91374	11545.873253	128113.87429	84167.10000	1468.80000	5(.312)	9(.145)	11(.169)	
13	Nippon Life Insurance	1.000000	364762.50000	2241.900000	89690.00000	83206.70000	2426.60000	13(1)			
14	Nippon Telegraph & Te	0.348578	44296.33241	14723.963371	80660.91520	81937.20000	2209.10000	4(.012)	5(.247)	9(.291)	11(.06
15	AT&T	0.270382	24032.61346	4670.552157	80925.16857	79609.00000	139.00000	5(.467)	11(.015)		