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How to Apply DEA to Real Problems: A Panel Discussion

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Joseph C. Paradi, PhD., P.Eng. FCAE
Executive Director - CMTE
University Of Toronto

The Mission of the Centre

- *Our corporate members are major Financial institutions: The Royal Bank, TD Bank and CIBC, plus the major Canadian Telecommunications carrier: Bell Canada.*
- *The Centre focuses on the Financial Services Industry. Specifically, we work in software and operations studies of productivity, efficiency, effectiveness and other targeted projects. Part of this process is a continuous improvement program.*
- *The FSI is changing rapidly and technology is playing a major part in this process. The CMTE plays an important role in keeping an eye on emerging technology that may impact the Centre's supporters.*
- *Thus we have excellent cooperation and data and managers are vitally interested in the outcomes.*

DEA Projects

- *Retail Branch Study - this was a manpower study on the Ontario branches of a large Canadian Bank*
- *Commercial Branch Study - a two part effort:*
  - profitability based on input minimisation
  - sales potential study for improvement
- *Temporal analysis of the 6 Canadian Banks over a 15 year time frame & Malmquist Index evaluation of the window analysis results.*
- *Software Development Teams' productivity.*
- *Engineering Teams' Productivity at a Bell Canada*
- *Credit Union study in Ontario, failure prediction goals.*
- *Stock market listed company failures study*
- *Mutual funds performance study*
- *P&C Insurance companies in Canada*

The Concept When Applying DEA

- *For many services, we claim we have no metrics that are FAIR and EQUITABLE*

- *"If we can't measure it, we can't manage it"*

- *But, if we can COMPARE them, we can "measure" them*

- *Part of this process is a continuous improvement program*

- *But, we need a "base-line" for comparisons*

- *DEA provides the "Benchmark" for improvement*

DEA Model Orientation

- *In planning an application of DEA, "believability" is all important. Managers must "see" the reasons for the model and that it accurately reflects real life.*
- *Orientation is key here. What is the most appropriate orientation for the DEA models?*
  - can output orientation be useful in all cases?
  - if minimising inputs only, can these be damaging to the firm if focused on exclusively?
  - the reality is most often that a mixture of the two is the real option
  *- If the result and the targets are not **perceived** to be both FAIR and EQUITABLE, managers will reject it*
- *They also need simple and "usable" results that can be implemented without DEA expertise*

Some Realities in Implementation

- *Typically, results can be realised in three parts:*
  - low hanging fruit - easy to harvest ~ 30-40%
  - need a ladder - worth while effort ~ 30-40%
  - top of tree - cost more than worth

- *Technical efficiency. We can answer the question:*
  "Are we doing things right?"

- *Also: **"Are we doing the right things?"** to get a sense of effectiveness - if we have price data*

- *How to deal with the push-back of the "measured"*

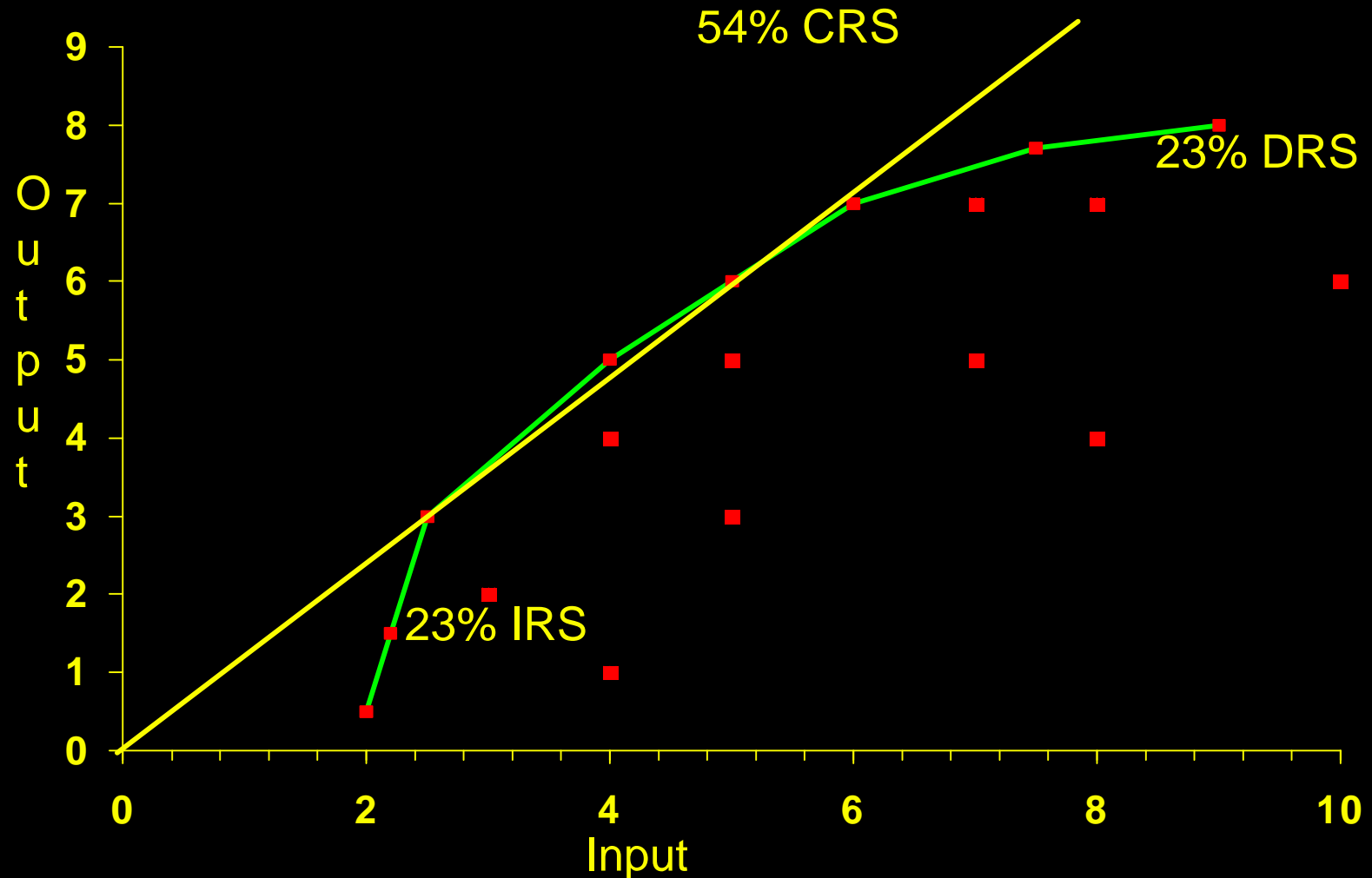- *On-going "production" use of DEA.*

Communication of the results

- *The most challenging effort is to explain the results across the organisation*

- *Manager push back is a real impediment*

- *What to do about this problem?*

  - present the results in a non-threatening manner

  - provide individual reports for each manager

  - create gap maps to show a clear picture

  - offer "negotiation" on targets

Retail Branch Study

- *The firm was one of the 5 large Canadian Banks*
- *DEA formulations depend on managerial needs:*
  - inputs to be decreased
  - technology investment to reduce costs
  - work redistribution
- *The study's objective was to evaluate manpower deployment in retail branches*
  - reduction in headcount was the goal
  - can some back-office work move to regional centres
- *Almost 300 branches were examined in one Province*
- *Comparisons were made to the Bank's own performance measurement system*
- *Returns to Scale is a fundamental issue:*
  - is the banking industry inherently CRS?
  - can IRS and DRS units be moved to CRS?
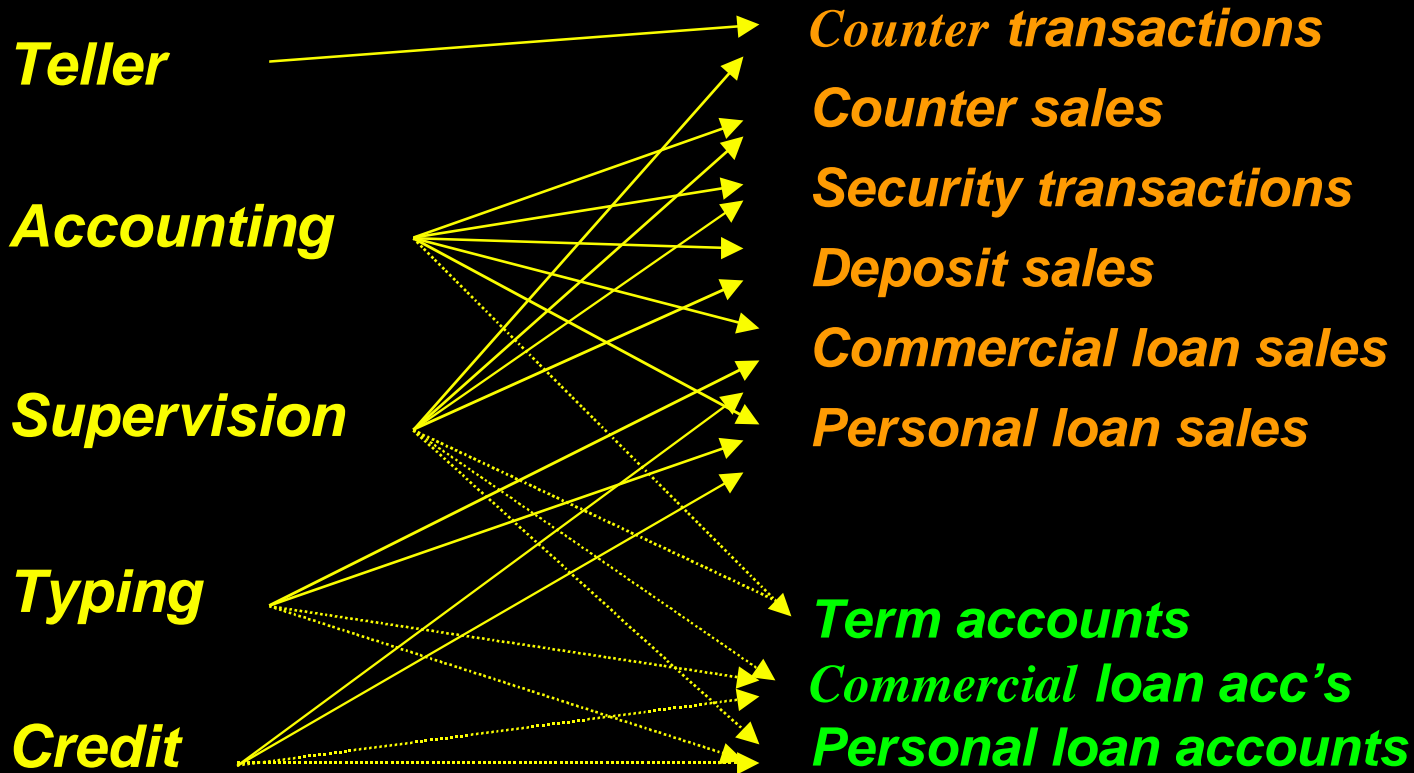
Scale Efficiency

- *Scale distribution of efficient units in a real case*

54% CRS

23% DRS

23% IRS

Output

Input

Retail bank branch work flow

INPUTS (PERSONNEL)

OUTPUTS (TRANSACTIONS)

Teller

Accounting

Supervision

Typing

Credit

Counter transactions

Counter sales

Security transactions

Deposit sales

Commercial loan sales

Personal loan sales

Term accounts

Commercial loan acc's

Personal loan accounts

FACE - TO - FACE

BACK OFFICE

General Results

- *Input oriented models were constructed because the nature of the model (outputs are transactions) did not lend itself to output maximisation*

- *Both VRS and CRS models were examined*

- *Weight constraints were applied as we refined the models*
  - output weights were the resource units
  - input weights were staff salary values

- *For the full model using all 9 outputs, and constraints, we concluded that:*
  - 10% were efficient, mean score = 0.807

Individual results

Branch XYZ: score = 0.90

Inputs			TARGET
Tellers	2.2		2.0
Typing	0.05		0.04
Accounting	1.45	**x 0.90 - excess**	0.81
Supervision	0.6		0.53
Credit	1.27		1.14
Outputs			
CtrTrans	5763		7943
CtrSales	130		143
SecTrans	0		4
DepSales	132	**+ shortage**	132
PlnSales	23		34
ClnRevs	15		15

The target is made up of a combination of efficient peers:

$$0.35B_8 + 0.25B_{82} + 0.19B_{61} + 0.13B_{40} + 0.04B_{64} + 0.04B_{64}$$

The Bank's Own Results

- *The bank has, as all Canadian banks do, a substantial group of people whose goals are to measure internal performance*

- *They use traditional methodologies:*
  - averages
  - regression analysis
  - curve fits
  - scatter graphs, etc.

- *They do calculate, using a combination of different measures, an "efficiency" figure for each branch*

- *- We converted their ratings to a 0.0 - 1.0 scale*

DEA to Bank results Comparisons

- *If both productivity results are expressed as efficiency values on a scale of 0.0 to 1.0, with the efficient ones at 1.0, θ (Theta) values for DEA, then:*
  - we can compare the two sets of numbers
  - the comparison will show how well each method operates when considering:
    - DMU (branch) scale size
    - consistency with each other
    - over/under scoring

- *Clearly, it is important that the bank does not attempt to "improve" a branch that is already efficient while ignoring a branch that is inefficient, due to measurement problems (scale efficiency for ex.)*

Small Personal Banking Branch


Smallest Branches - Group 1
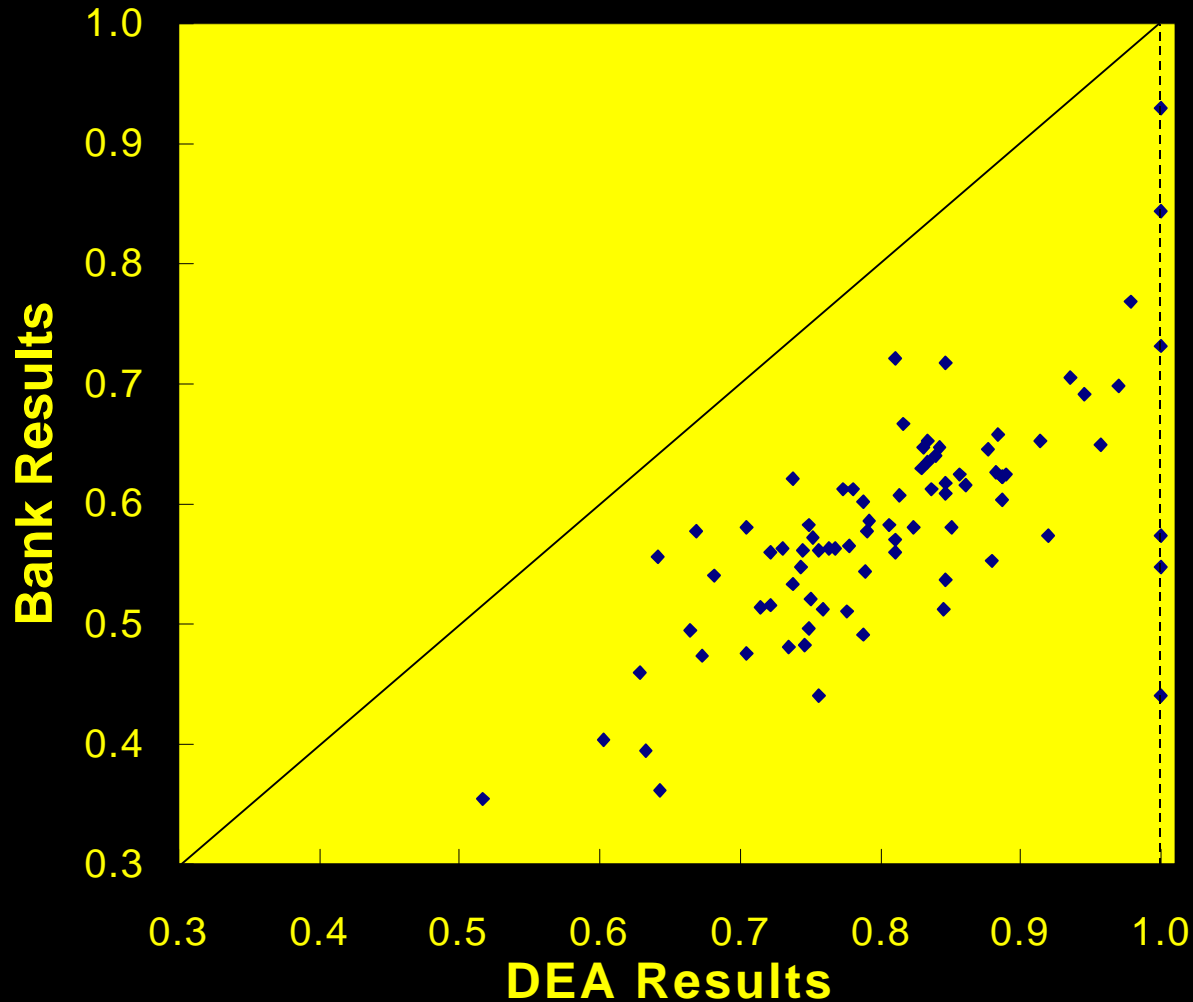
What is Remarkable here?

- *The general trend is quite close*
  - the 45 ^{0} line is essentially parallel to the results
  - the bank line could be shifted to the 45 ^{0} line easily
  - we conclude that the bank and DEA are quite close in finding better or worse candidates

- *There is general agreement on who is "good" and who is "bad"*
  - there are no DEA inefficient branches that the bank deems efficient
  - however, there are DEA efficient branches that the bank scored quite low

- *In small branches, the agreement is acceptable*

Largely Commercial Branch

Largest Branches - Group 4
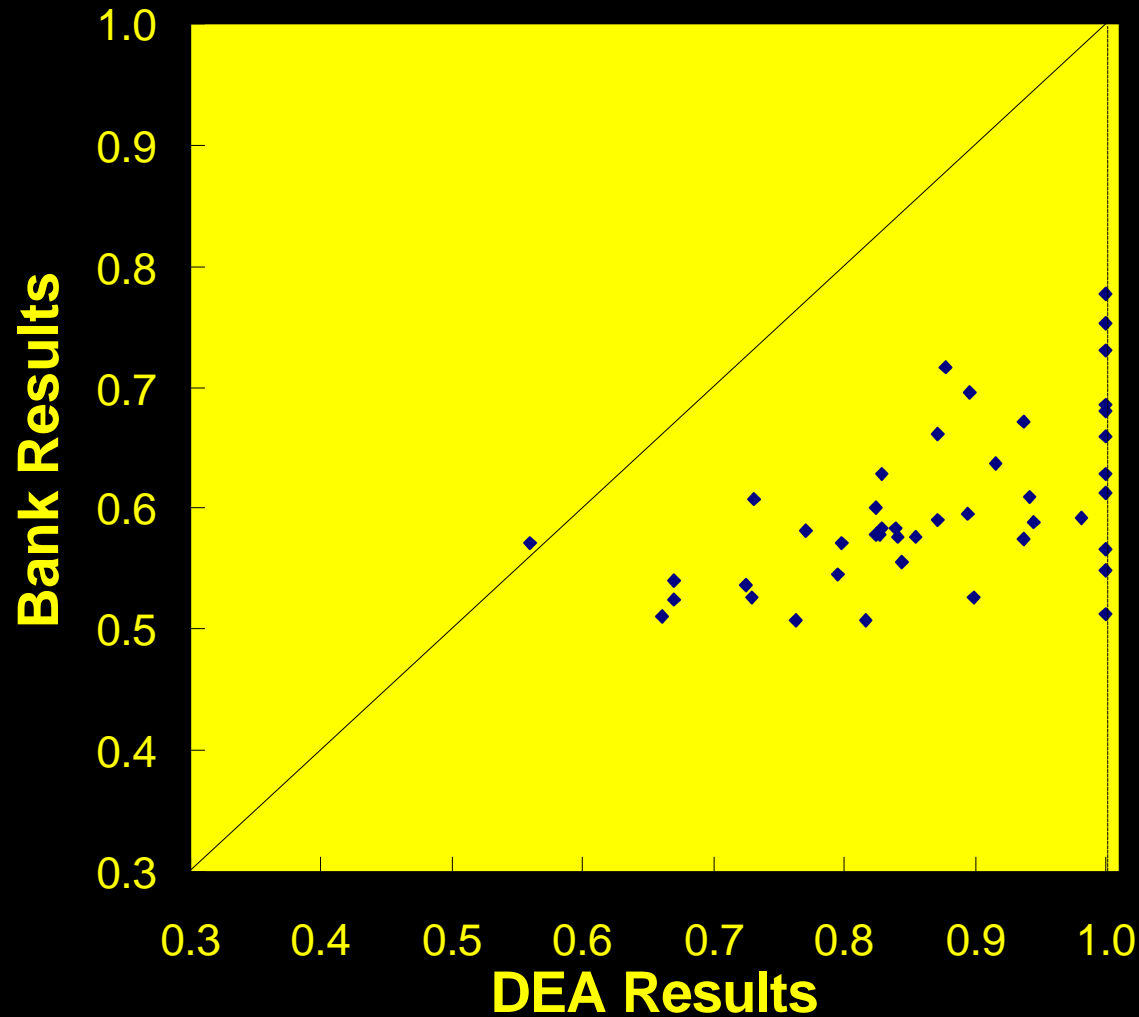
Some Comments

- *Larger branches cause more problems to the bank's evaluation methods as the diverging trend shows*
- *But, the simple statistics show that the differences between all four groups are about the same:*
- *<u>Average Efficiency</u>   <u>Bank</u>   <u>DEA</u>*

Average Efficiency	*Bank*	*DEA*
- Group 1	*0.58*	*0.81*
- Group 2	*0.61*	*0.78*
- Group 3	*0.58*	*0.80*
- Group 4	*0.60*	*0.87*

- *Looking at the outliers is very important to establish the reasons - and learn from them or remove the unit*
- *There are glaring problems with DEA efficient branches being scored very low by the bank, especially in the larger branch size group.*

Significant Differences

- *We see that DEA does not need the size based segmentation that the Bank's methods require*
- *The bank's measurement system does not assign even a single perfect score, i.e. 1.0*
- *DEA's discriminating power is much more acceptable by management because it clearly shows "how they are doing" and that there are 100% efficient branches to be used as examples to improve.*
- *DEA discriminates (difference between lowest and highest score) much better than the bank's system at the very large branch level (the bank's Group 4)*
- *- DEA spread = 0.44 and the Bank spread = 0.27*
- *DEA spread is remarkably constant for all four groups (0.48, 0.42, 0.44, 0.44 respectively)*

Conclusions of this Study

- *DEA is a significant improvement on the bank's current system because:*
  - it is more consistent
  - gives better results at the high end
  - takes into account many variables at the same time
  - provides 100% efficient branches
  - offers targets for inefficient branches
  - it can be shown to be FAIR and EQUITABLE
  - peers can be examined for guidance to improve
  - using DEA, no size based groupings are needed

- *The Bank system has some benefits too, in that it is simple and certain traditional values are retained*

- *DEA should be used to augment the bank's systems*

The Commercial Branch Study

- *Canada-wide commercial branch network*

- *Total sample: 91 branches*

- *More than 8 distinct geographical areas*

- *The data used was from 1995 bank records*

- *Senior management was the driver*

- *Findings were validated against bank findings*

The "Production" Model

INPUTS

Staff (5 types)
IT expense
Rent
Other NIE

Commercial Branch

OUTPUTS

$ Deposits
$ Loans
$ Fee Income
Connections
A   -
B   -
C   -
D   -
E   -

Environmental: *Growth factor*

The "Strategic" Model

INPUTS

Staff (5 types)
IT expense
Rent
Other NIE
Non-Accrual Loans

Commercial Branch

OUTPUTS

$ Fee Income
Deposit spread
Loan Spread
$ Deposits
$ Loans
Quality
- employee
- Customer
(satisfaction)

Environmental: *Growth factor* and **BRR**
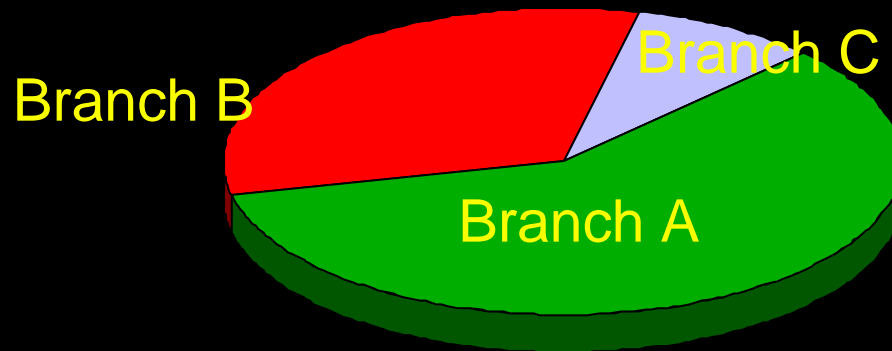
Environment and Performance

- *Important to capture relevant environmental factors:*
  - *- **socio-economic** factors:*
  - *- <u>retail branches</u>: demographical information such as average income in the neighbourhood*
  - *- <u>commercial branches</u>: business prospects*
  - *- **competition index**: number of competing branches in the vicinity*
- *Choice of path to move towards the frontier*
- *Location with good potential to attract more business*
  - *- output-augmentation to increase market share*
  - *- Output enhancement difficult because of low growth area, high competition*
- *Cost-minimisation target*

Individual reports
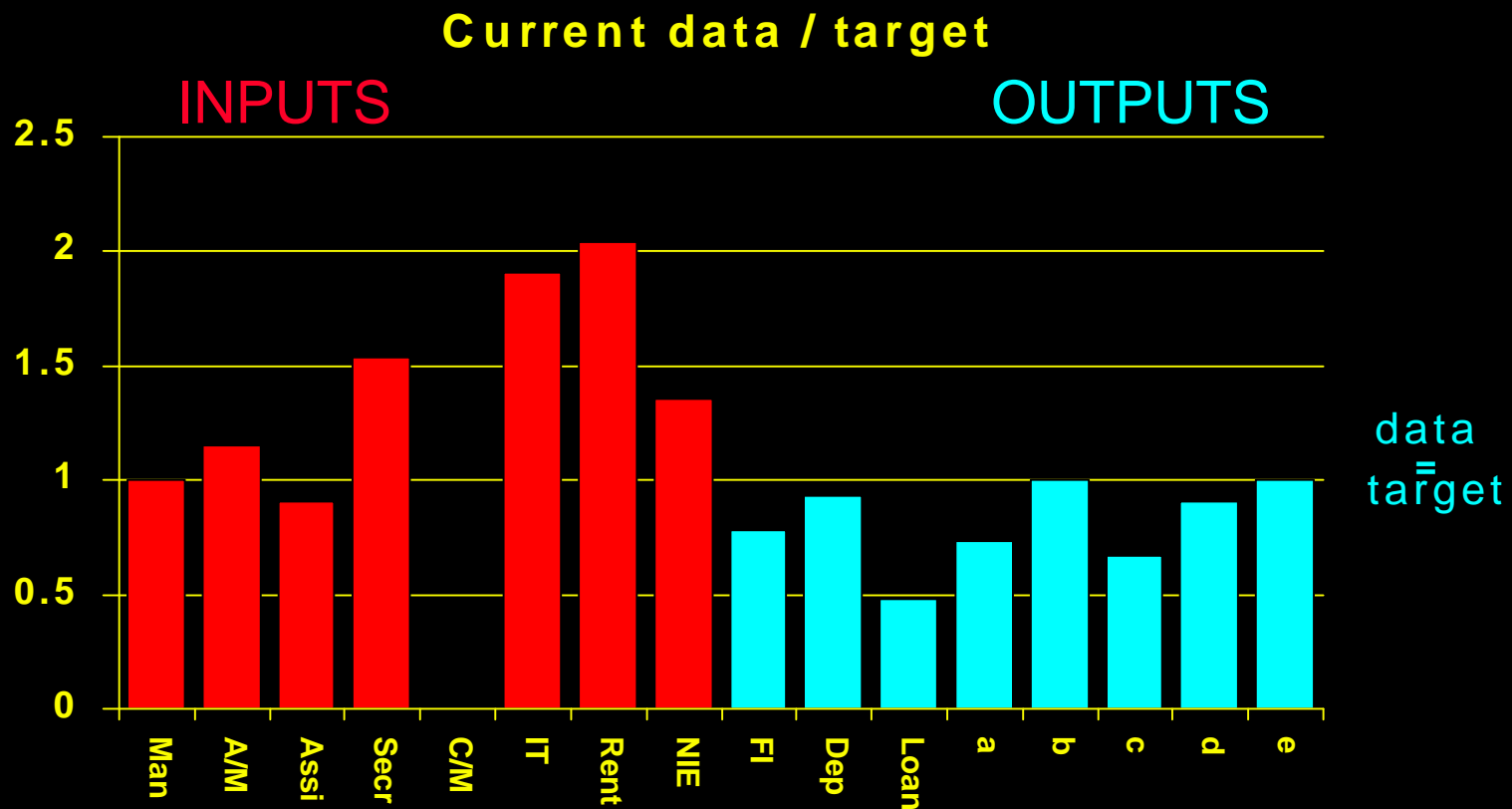
Branch #6   *Cost-efficiency: 0.78*

	Data	Target	Peer 1 Branch A	Peer 2 Branch B
A/M	6	5	3	10
Secretaries	2	1.3	1	7
…				
Deposits	42	81	25	180
Loans	46	169	50	927

Branch B

Branch C

Branch A

Individual Reports

Branch #6   **Cost Efficiency = 0.78**

Current data / target

INPUTS   OUTPUTS

data
=
target

Temporal Study of Can. Banks

- *Objective: "To analyse **Cost Efficiency, Organisational Efficiency** and **Productivity changes** of Six largest Canadian Schedule I Banks during the period 1981 to 1996"*
- *Data was from published sources and from private communications with the banks*
- *The outcome has been very good for us because the banks can relate well to the findings*
- *We can point to the dates when the firms had a major event in their corporate lives*
- *The results "grab" senior management because it is simple and makes sense to them*
- *The methodology gains credibility because they can validate the results for themselves*

Production Model

- **To Measure Cost Efficiency**

Inputs

- *Interest Expenses ($s)*
- *Number of Employees*
- *Physical Capital, equipment & furniture ($s)*
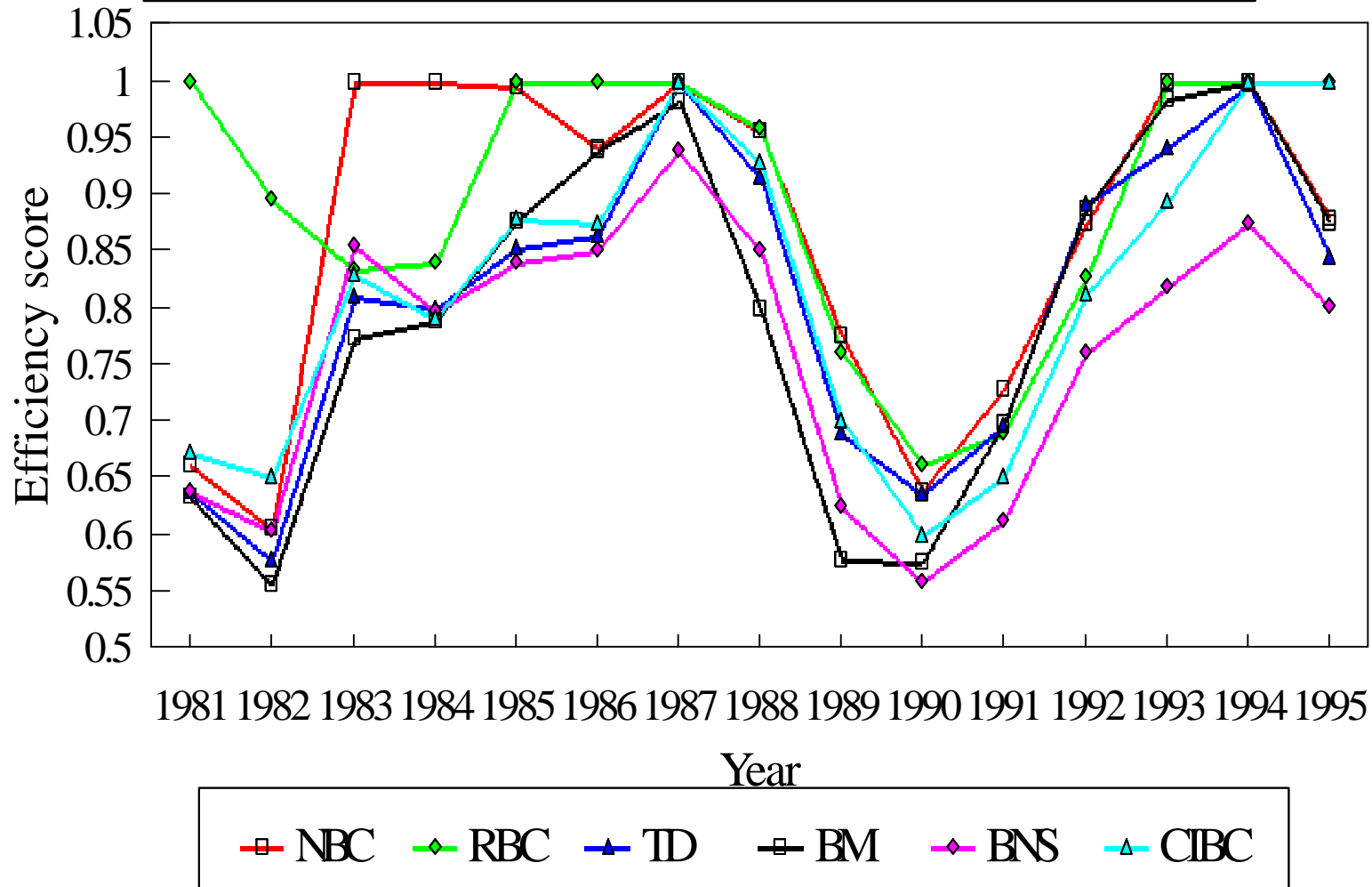- *Non-interest expenses ($s)*

BANK

Outputs

- *Deposits ($s)*
- *Loans ($s)*
- *Securities ($s)*
- *Deposits with banks other than BOC ($s)*
- *Non-interest income ($s)*

Results - Production Model

Overall Efficiency of Six banks from 1981 to 1995

Intermediation Model

- **To Measure Organisational Efficiency**

Funds borrowed

Resources

Inputs

- Deposits ($s)
- Debentures ($s)
- Other liabilities ($s)
- Shareholder's Equity ($s)

- Number of Employees
- Physical Capital ($s)
- Non-interest expenses ($s)

BANK

Outputs

- Loans ($s)
- Securities ($s)
- Deposits with banks other than BOC ($s)
- Deposits with BOC & other non-interest earning assets ($s)
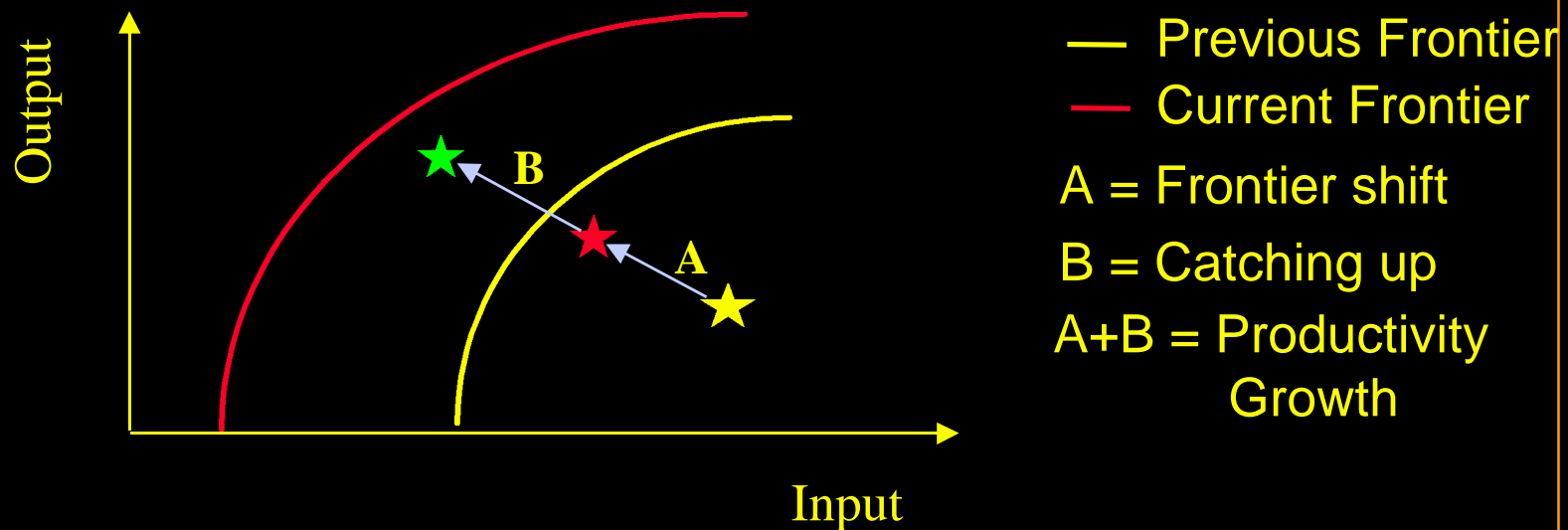- Non-interest income ($s)
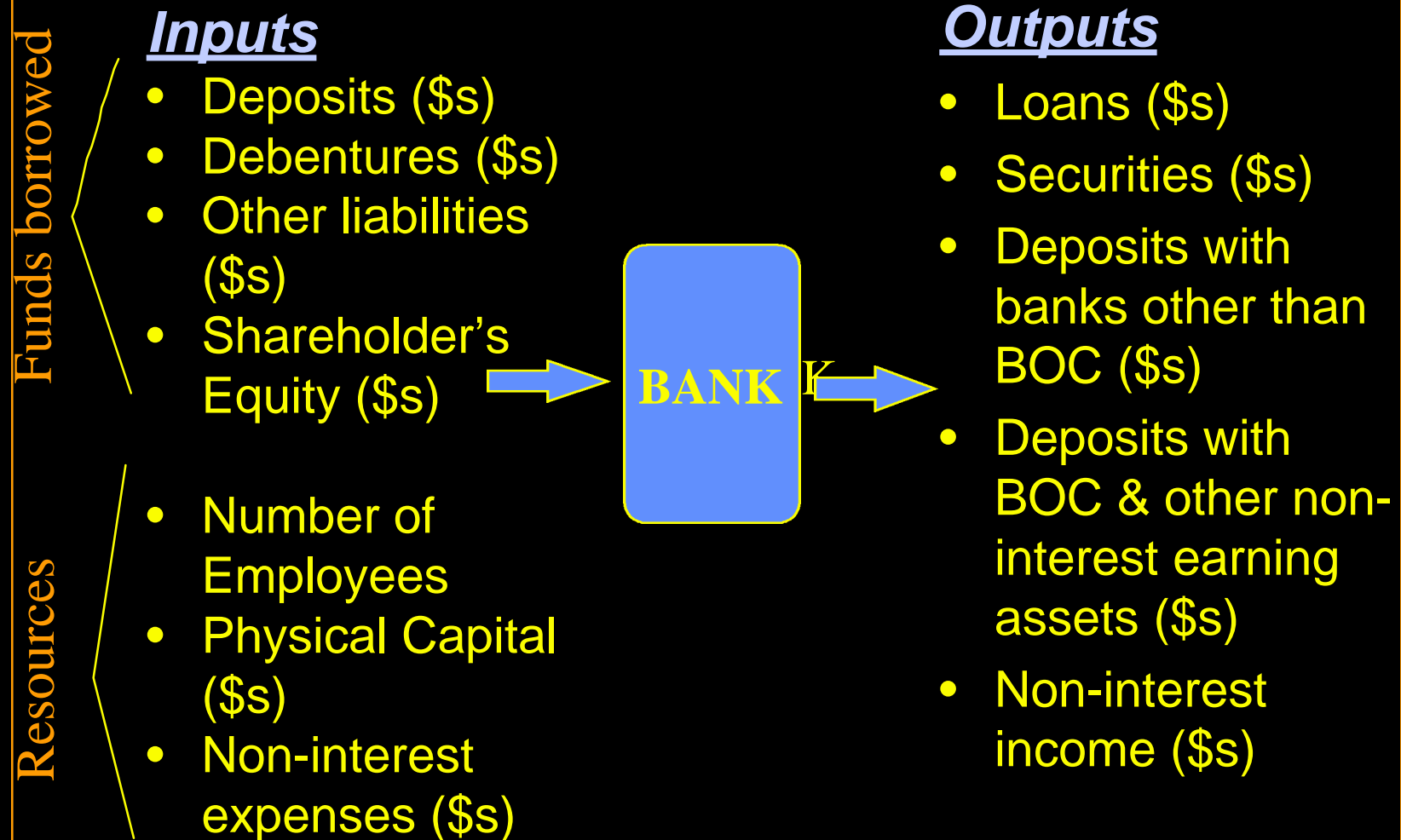
Window Analysis

- *What is Window Analysis?*
- *Works on the principle of moving average*
- *An organisation in separate time periods in a window is treated as separate organisations*

1989   1990   1991   1992   1993   1994   1995

Four year Window
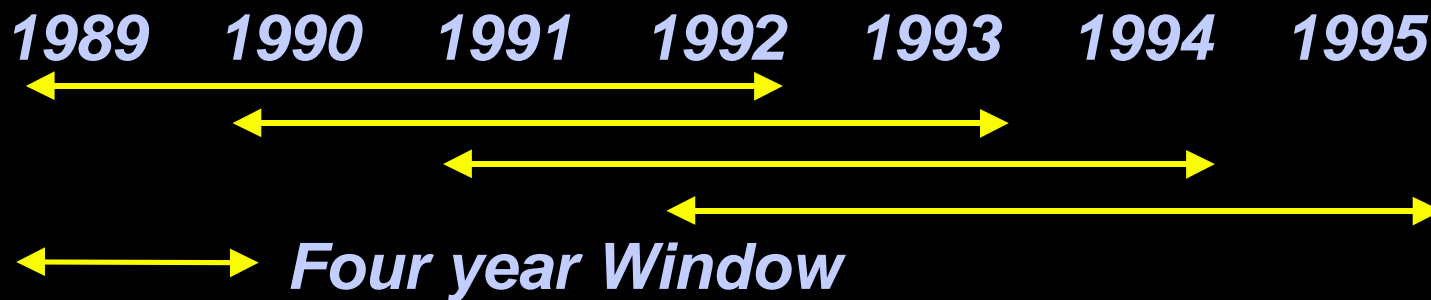
- *Why is it used?*
- *Increases the number of DMUs for otherwise few DMUs*
- *Helps analyse Performance trends over time*

Productivity Growth - Malmquist Index

- *Helps analyse **productivity changes** from one time period to another*

- *Separates **two components** of productivity change*
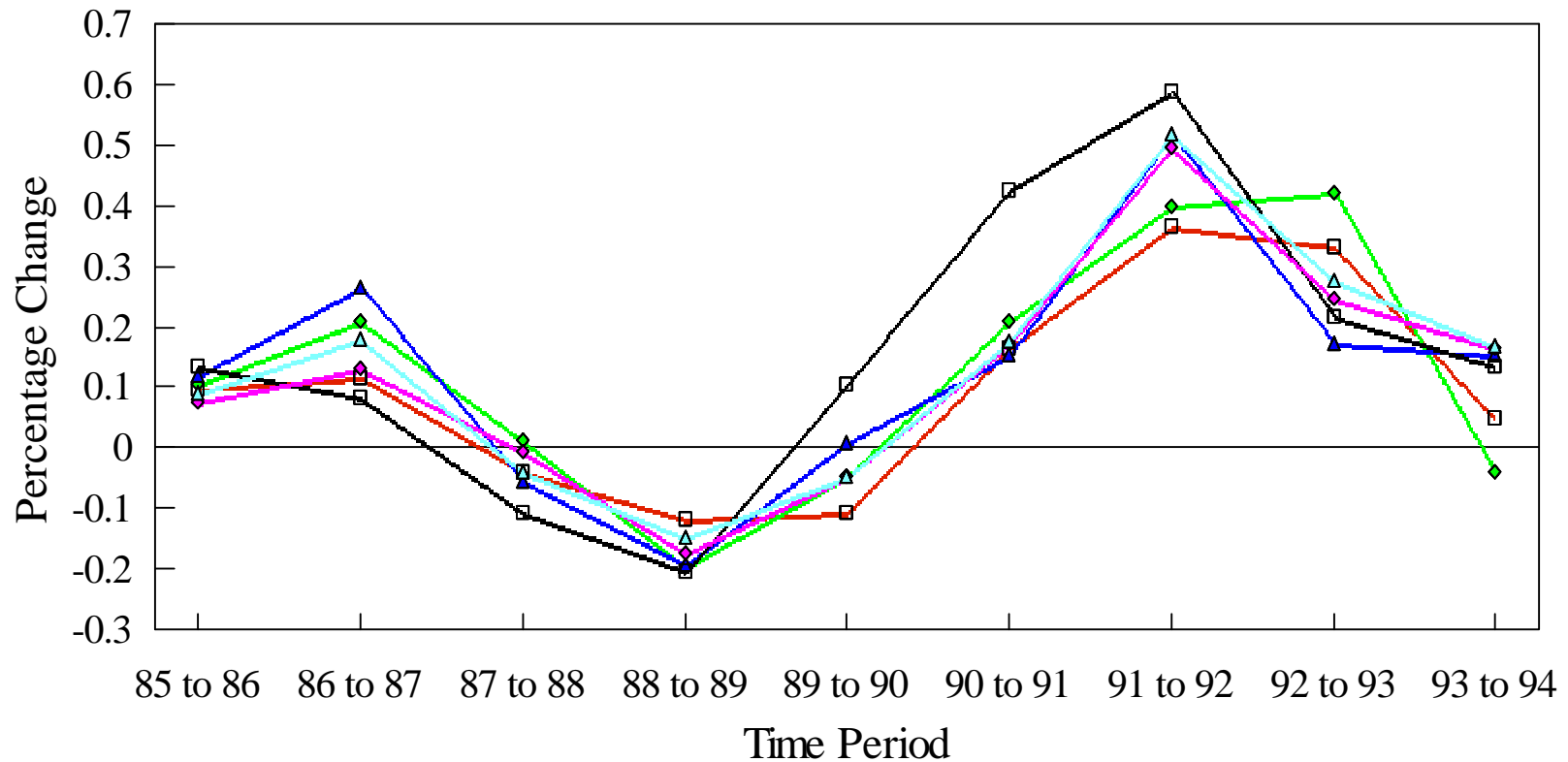 - *catching up*
  - *shift in Efficient Frontier*

— Previous Frontier
— Current Frontier
A = Frontier shift
B = Catching up
A+B = Productivity
        Growth

Results - Malmquist Index

Productivity Growth

Malmquist Index: Productivity Change from one Period to another
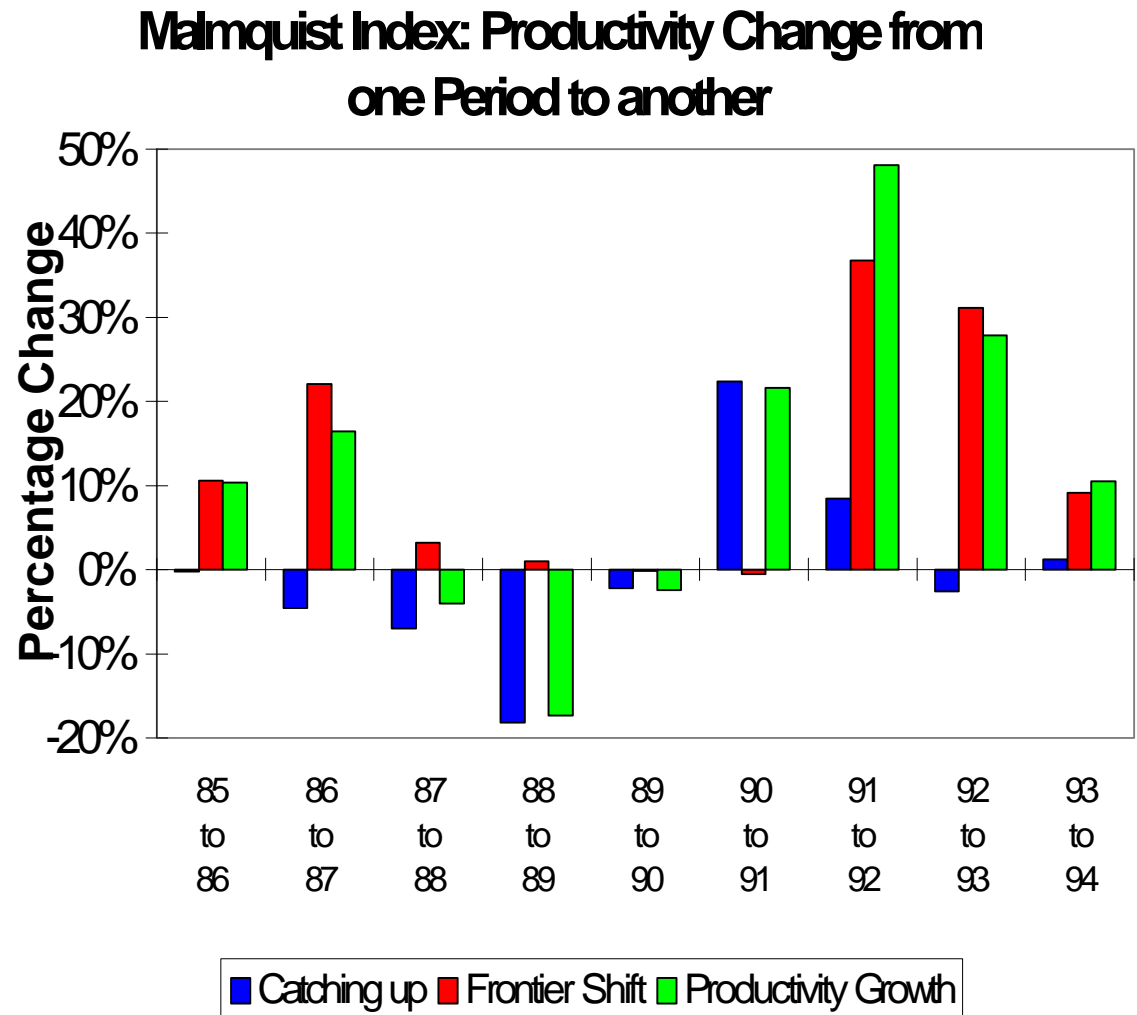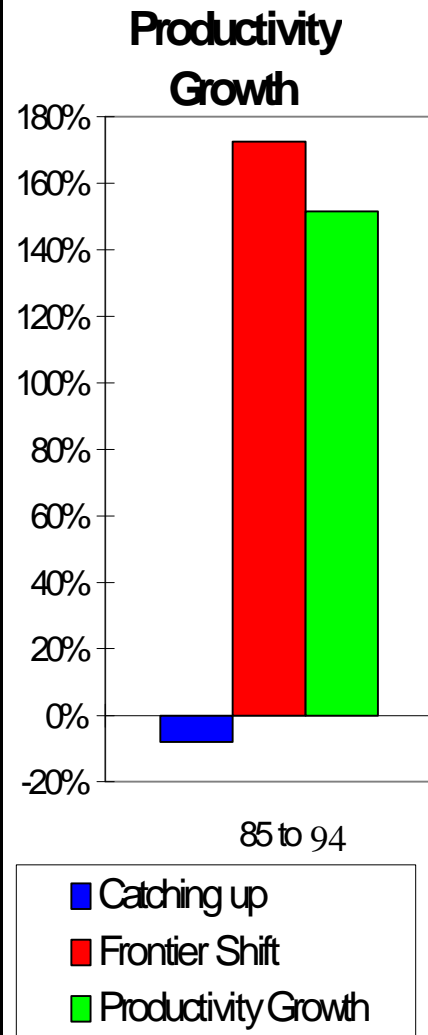
Results - Malmquist Index

Productivity Growth from one period to the other

Summary of Results

- *Banks' performance was highly affected with the **economic conditions** in Canada*
  - *two recession periods and collapse of loans and real estate markets had a negative impact on the performance*
  - *Periods of economic growth affected the banks' efficiency in a positive manner*

- ***Productivity** of six banks as a group - increased by about **160%** from 1985 to 1994*
  - *mainly due to a significant technological growth, especially from 1991 onwards.*

- *This was an excellent sales opportunity to the banks' top management*

P&C Insurance Study

- *To develop models that capture the insurance business from two perspectives:*
  - *Operational performance*
  - *Investment performance*
- *To provide to management, brokers, agents, and other participants DEA results including:*
  - *Set of "best performers"*
  - *Peer group analysis of inefficient DMUs*
  - *Potential savings when projected onto the frontier*
- *To determine factors that may affect performance*
  - *Organizational form*
  - *Insurer type*
  - *Type of Ownership*
- *To identify trends that may exist in the industry*
- *Relationships with total assets, reinsurance etc*

Operational Performance Model

Inputs

- *Salary expenses*
- *Operating expenses*
- *Acquisition expenses*
- *Claims incurred and adjustment expenses*
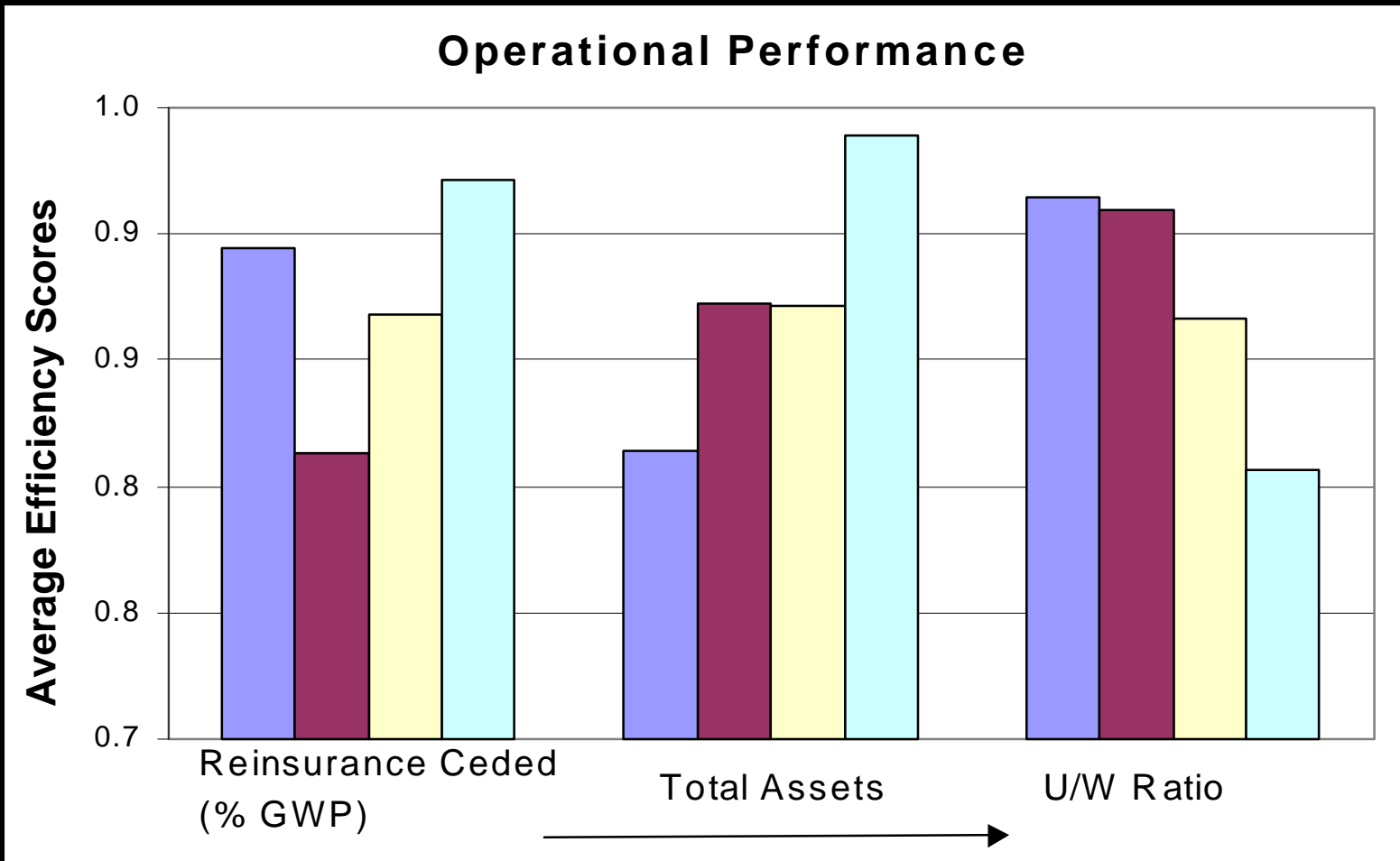
120

DMUs

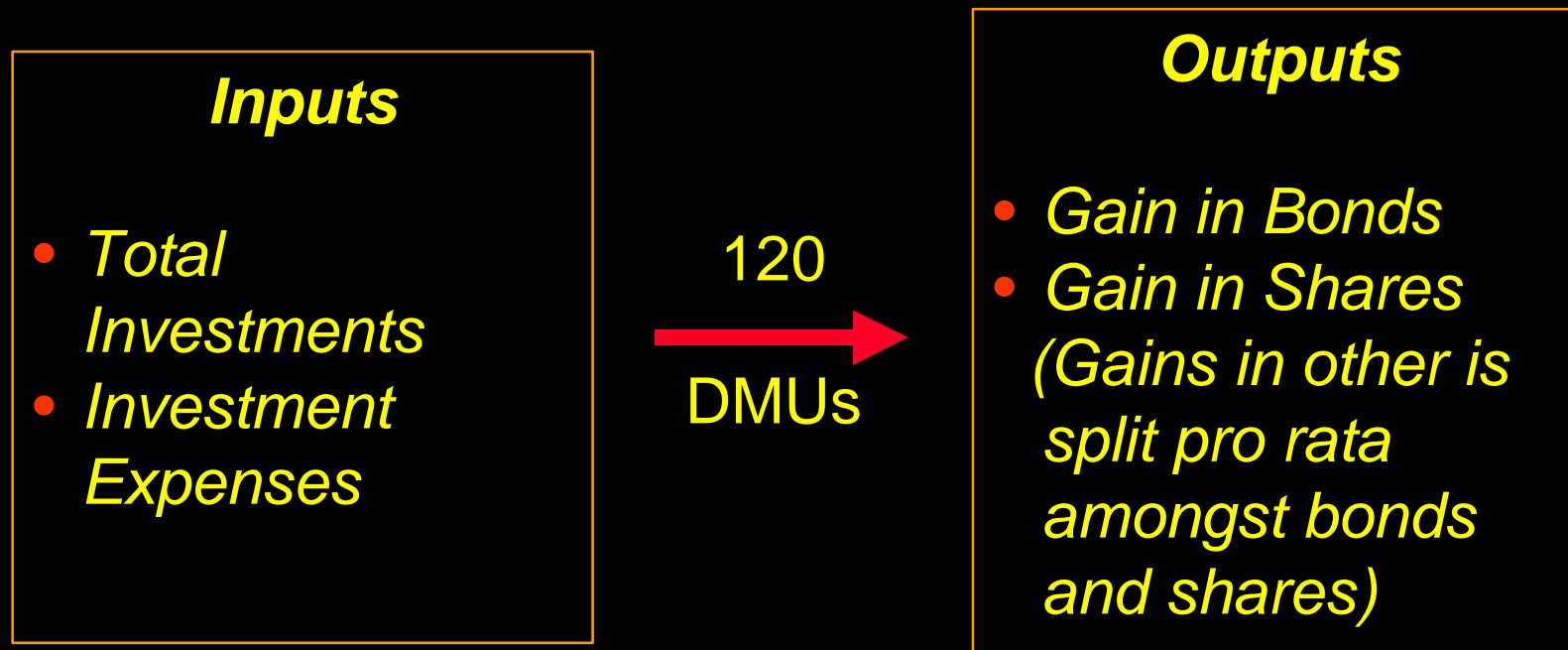## Outputs

- *Net Written Premiums*
- *Commission Income*

CCR & BCC Models with Input Orientation

Results - Insurer Characteristics

- *Bars represent Quartiles of population*

Operational Performance

Average Efficiency Scores (y-axis): 0.7, 0.8, 0.8, 0.9, 0.9, 1.0

Categories: Reinsurance Ceded (% GWP), Total Assets, U/W Ratio

Investment Performance Model

Inputs

- *Total Investments*
- *Investment Expenses*

120

DMUs

Outputs

- *Gain in Bonds*
- *Gain in Shares (Gains in other is split pro rata amongst bonds and shares)*

CCR & BCC Models with Output Orientation

Results - Insurer Characteristics

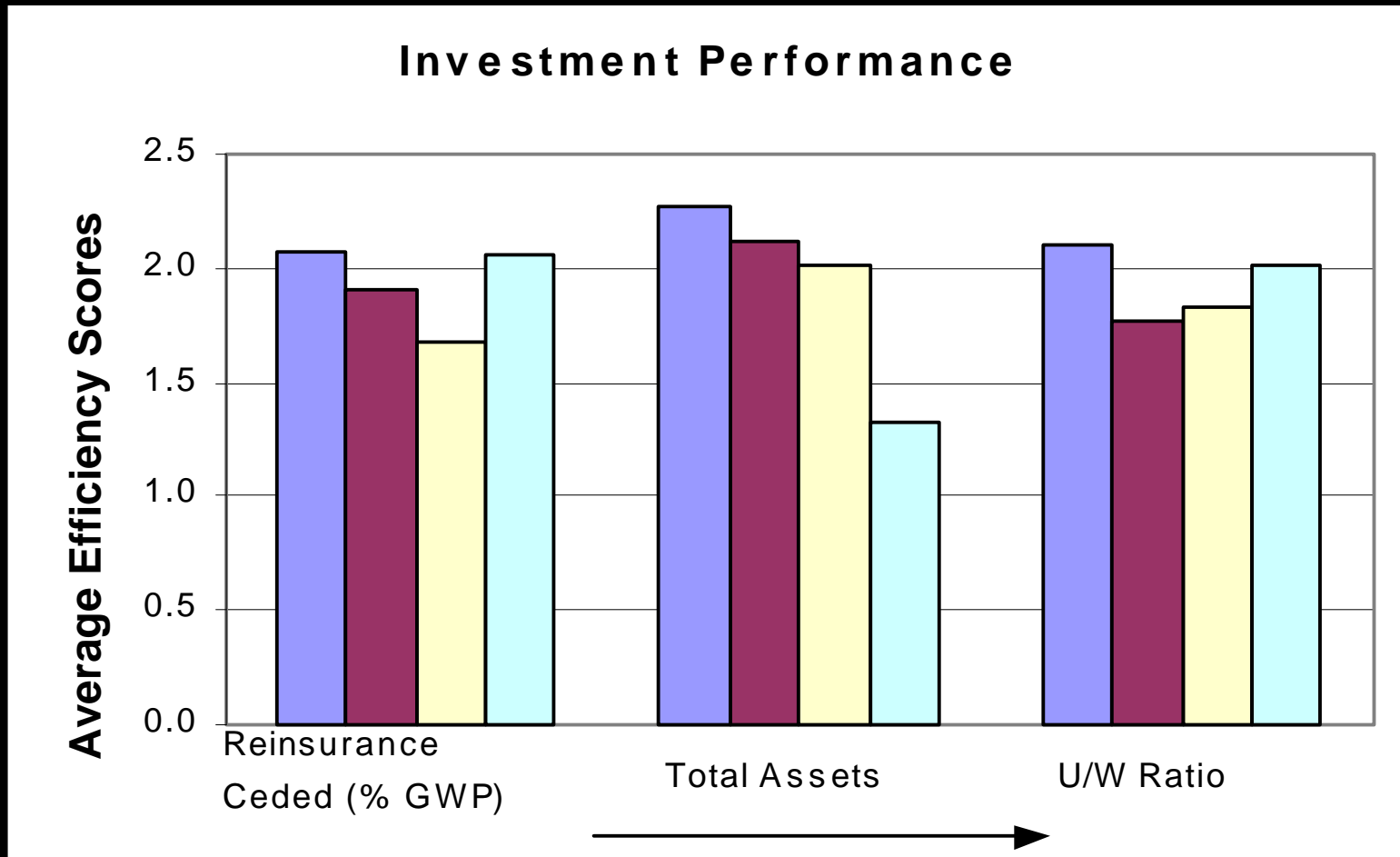- *Bars represent Quartiles of population*

Investment Performance

Other Projects

- *Software Development Teams' productivity.*
  - Two studies, both to provide team improvements
  - A third at present is examining Year 2000 efforts
- *Engineering Teams' Productivity at a Bell Canada*
  - Interesting study of network design teams
  - Conclusion is that redrawing geographical boundaries would make large improvements
- *Credit Union study in Ontario, failure prediction goals.*
  - DEA results are not much better than the complex set of ratios they use
- *Stock market listed company failures study*
  - Very exciting results - 3 year forward projections
- *Mutual funds performance study*
  - DEA is not a lot of help here

Final Comments

- *DEA is a powerful tool, it overcomes the limitations of traditional techniques for **benchmarking** and **productivity** measurement*
- *DEA provides much more than efficiency measures for multiple input/output processes*
  *- specific information on **best practices***
  *- specific, **achievable targets** for inefficient DMUs*
  *- quantified **potential savings** - most profitable ways to improvement*
  *- realistic info for **planning and costing***
- *The analyst must pay a lot of attention to **managers' behaviour** and fears*
- *The form of results **presentation is crucial***
- ***Simple explanation** of what DEA is necessary*