Branch Bank Efficiency
Past, Present and Future

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5/31/2004
Outline

- Past
  - <1978: Profit measures, Operational efficiency
  - 1978-1998: Data Envelopment Analysis

- Present considerations
  - Too many factors (DEA-PCA)
  - Balancing strategic objectives (DEA-BSC)
  - Multi-stage systems

- Future
  - Drivers of change
  - Will branches disappear?
Pre-1978 Measures

- Industrial Engineering
- Accounting
- Economic
- Econometric
- Ad-hoc measures
Industrial Engineering Approach

- **Efficiency** = actual / standard

- **Problems**
  - How to aggregate
  - Expensive to construct
  - Difficult to maintain
  - Limited scope
  - Identical standards

Kotha, Barnum, Bowen, Interfaces 96
Accounting Approach

- Revenues, costs, profits w.r.t base year
- Problems
  - Internal comparison
  - Relevance of base year
  - Limited scope

Camanho and Dyson, JORS 99
Economic Approach

- Assume a certain production function, estimate its parameters, explain differences in performance through economic considerations

Problems

- Justifying the assumed production function
- How to update
- Everybody is efficient?

Evanoff and Israelevich, Federal Reserve Bank 92
Econometric Approach

- Fit a stochastic frontier using statistical tools, measure distance to
- Problems
  - Need for large data sets
  - Differentiating “noise” from inefficiency
  - Average vs. excellent performance

Ferrier and Lovell, J. of Econometrics, 90
Ad-hoc Approaches

- Share and compare
- SWOT maps
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Data Envelopment Analysis  
- A Simple Description -

- DEA measures relative efficiency of decision-making units with multiple inputs and outputs but no obvious production function to aggregate data i.e. non-parametric

Charnes, Cooper & Rhodes, EJOR 1978
DEA Formulation

- Relative efficiency is defined as the ratio of total weighted output to total weighted input.
- By comparing \( n \) units with \( s \) outputs denoted by \( y_{ja}, j=1,...,s \) and \( r \) inputs denoted by \( x_{ia}, i=1,...,r \), the efficiency measure for DMU \( a \) is:

\[
Max_{w_j, v_i} e_a = \frac{\sum_{j=1}^{s} w_j y_{ja}}{\sum_{i=1}^{r} v_i x_{ia}}
\]

**Decision variables:**
- \( w_j \) output weights
- \( v_i \) input weights
A constraint requires that the same weights, when applied to all DMUs do not provide any unit with efficiency greater than one.

\[
\sum_{j=1}^{s} w_j y_{jm} \leq 1 \quad \text{for } m = 1, \ldots, n
\]

\[
\sum_{i=1}^{r} v_i x_{im}
\]
DEA Results

- Result of DEA is determination of hyperplanes defining an envelope surface or Pareto frontier
- DMUs lying on envelope are deemed efficient whilst remainder deemed inefficient
- DEA can be translated into a linear program, which can be solved relatively easily
- a complete DEA must solve $n$ LPs, one for each DMU
Additive DEA Model

Primal Additive:

Max \( \lambda, s, \sigma \) \( e^t s + e^t \sigma \)

s.t. \( Y\lambda - s = Y^a \)

\(-X\lambda - \sigma = -X^a \)

\( \lambda, s, \sigma \geq 0 \)

Dual Additive:

Min \( v, u \) \( VX^a - UY^a \)

s.t. \( VX - UY \geq 0 \)

\( V \geq e \)

\( U \geq e \)

Charnes, Cooper, Golany, Seiford and Stutz, 1985
Some DEA Applications to Banking

- Parkan: **Canada** (ECPE 87)
- Athanassopoulos, Giokas: **Greece** (Interfaces 00)
- Sherman, Ladino: **USA** (Interfaces 95)
- Camanho, Dyson: **Portugal** (JOR 99)
- Golany, Storbeck: **USA** (Interfaces 99)
- Kantor, Maital: **Israel** (Interfaces 99)
- Soteriou, Zenios: **Cyprus** (Mg Sc 99)
- Chen: **Taiwan** (JOR 02)
- Paradi, Schaffnit: **Canada** (EJOR 04)
- Many more …
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Too Many Factors

- In a typical evaluation of bank branches, DEA suffers from excess variables compared to decision-making units.
- Principle Component Analysis (PCA) can reduce the dimensions with minimal loss of information.

Adler and Golany, JORS 2002
Principal Component Analysis - A Simple Description -

- PCA explains variance structure of matrix of data through linear combinations of variables, thus reducing data to a few PCs, generally describing 80 to 90% of the variance in the data.
Let random vector $X = [X_1, X_2, ..., X_p]$ have correlation matrix $C$ with eigenvalues $\beta_1 \geq \beta_2 \geq ... \geq \beta_p \geq 0$ and normalized eigenvectors $l_1, l_2, ..., l_p$.

$$X_{PC_i} = l_i^T X = l_{i1} X_1 + l_{i2} X_2 + ... + l_{ip} X_p$$

$$\text{Var}(X_{PC_i}) = l_i^T V l_i, \quad i=1,2, ..., p$$

$$\text{Cor}(X_{PC_i}, X_{PC_k}) = l_i^T V l_k, \quad i=1,2, ..., p, k=1,2, ..., p$$

PCs are the uncorrelated linear combinations ranked by their variances in descending order.
PCA-DEA Formulation

\[ \text{Min } V_o X_o^a + V_{PC} X_{PC}^a - U_o Y_o^a - U_{PC} Y_{PC}^a \]

s.t. \[ V_o X_o + V_{PC} X_{PC} - U_o Y_o - U_{PC} Y_{PC} \geq 0 \]
\[ V_o \geq e \]
\[ U_o \geq e \]
\[ V_{PC} L_x \geq e \]
\[ U_{PC} L_y \geq e \]
\[ V_{PC}, U_{PC} \text{ free} \]

**Data:**

- \( X_0 \) original inputs and \( X_{PC} \) PC inputs
- \( Y_0 \) original outputs & \( Y_{PC} \) PC outputs

**Decision variables:**

- \( V_o \) & \( V_{PC} \) weights on inputs
- \( U_o \) & \( U_{PC} \) weights on inputs
3 PCA-DEA constrained models

- PCA-DEA partially constrained model
  \[ V_{PCi} - V_{PCi+1} \geq 0 \]
  \[ U_{PCi} - U_{PCi+1} \geq 0 \]

- Complete PCA-DEA constrained model
- Maximum discrimination in the PCA-DEA formulation
Complete PCA-DEA constrained model

\[\begin{align*}
\text{Min} & \quad VX^a - UY^a \\
\text{s.t.} & \quad VX - UY \geq 0 \\
& \quad V \geq e \\
& \quad U \geq e
\end{align*}\]

\[\begin{align*}
\text{Min} & \quad V_{PC} X_{PC}^a - U_{PC} Y_{PC}^a \\
\text{s.t.} & \quad V_{PC} X_{PC} - U_{PC} Y_{PC} \geq 0 \\
& \quad V_{PC} L_x \geq e \\
& \quad U_{PC} L_y \geq e \\
& \quad V_{PC_i} - V_{PC_{i+1}} \geq 0 \\
& \quad U_{PC_i} - U_{PC_{i+1}} \geq 0
\end{align*}\]
Maximum discrimination in the PCA-DEA constrained formulation

\[
\begin{align*}
\text{Max} & \quad \varepsilon_2 \\
\text{s.t.} & \quad V_{PC} X_{PC} - U_{PC} Y_{PC} \geq 0 \\
& \quad V_{PC} L_x \geq e \\
& \quad U_{PC} L_y \geq e \\
& \quad V_{PCI} - V_{PCI+1} \geq \varepsilon_2 \\
& \quad U_{PCI} - U_{PCI+1} \geq \varepsilon_2 \\
& \quad V_{PC_1} = 1
\end{align*}
\]
University Departments Example
Wong & Beasley (1990)

Compared 7 university departments over 6 variables:

**Inputs:**
- # of academic staff
- Academic staff salaries
- Support staff salaries

**Outputs:**
- # of undergraduate students
- # of postgraduate students
- # of research papers
## PCA Illustration

### Table: Outputs (L_y) and Inputs (L_x)

<table>
<thead>
<tr>
<th></th>
<th>PC1</th>
<th>PC2</th>
<th>PC3</th>
<th>PC1</th>
<th>PC2</th>
<th>PC3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inputs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L_x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PC1</td>
<td>0.017</td>
<td>0.049</td>
<td>-0.9986</td>
<td>0.796</td>
<td>-0.601</td>
<td>0.0679</td>
</tr>
<tr>
<td>PC2</td>
<td>0.974</td>
<td>0.225</td>
<td>-0.0277</td>
<td>0.488</td>
<td>0.704</td>
<td>-0.5157</td>
</tr>
<tr>
<td>PC3</td>
<td>0.226</td>
<td>-0.973</td>
<td>0.044</td>
<td>0.358</td>
<td>0.378</td>
<td>-0.8541</td>
</tr>
<tr>
<td>variance explained</td>
<td>98.145</td>
<td>1.854</td>
<td>0.0002</td>
<td>95.548</td>
<td>3.169</td>
<td>1.2819</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>DMU</th>
<th>additive original data</th>
<th>3 PCs on each side + constr</th>
<th>2 PCs on each side + constr</th>
<th>1 PC on each side</th>
<th>CCR (eff. = 1)</th>
<th>Subj. constr</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0.1254</td>
<td>0.2121</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.863</td>
<td>0.995</td>
<td>0.862</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>2.024</td>
<td>1.0141</td>
<td>1.5803</td>
<td>0.691</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>202.5909</td>
<td>1.1506</td>
<td>0.4512</td>
<td>1.0834</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>0</td>
<td>1.3016</td>
<td>2.3188</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>3.346</td>
<td>1.9975</td>
<td>3.6997</td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>
## Results of maximum discrimination model

### Rank

<table>
<thead>
<tr>
<th>Rank</th>
<th>DMU</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DMU 6</td>
</tr>
<tr>
<td>2</td>
<td>DMU 2</td>
</tr>
<tr>
<td>3</td>
<td>DMU 1</td>
</tr>
<tr>
<td>4</td>
<td>DMU 3</td>
</tr>
<tr>
<td>5</td>
<td>DMU 5</td>
</tr>
<tr>
<td>6</td>
<td>DMU 7</td>
</tr>
<tr>
<td>7</td>
<td>DMU 4</td>
</tr>
</tbody>
</table>

### Weights on original inputs

<table>
<thead>
<tr>
<th></th>
<th>weights on original inputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>#of academic staff</td>
<td>1</td>
</tr>
<tr>
<td>academic salaries</td>
<td>1</td>
</tr>
<tr>
<td>support salaries</td>
<td>1.1807</td>
</tr>
</tbody>
</table>

### Weights on original outputs

<table>
<thead>
<tr>
<th></th>
<th>weights on original outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>undergrads</td>
<td>1.0077</td>
</tr>
<tr>
<td>postgrads</td>
<td>1.0074</td>
</tr>
<tr>
<td>papers</td>
<td>1</td>
</tr>
</tbody>
</table>
DEA-PCA: Conclusions

- Combining PCA & DEA can improve discriminatory power of model
- Assurance regions and cone-ratio constraints require additional preferential information, PCA-DEA constrained formulation does not
- PCA-DEA constrained formula can improve discrimination with little to no loss of information, depending on model
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- **Future**
  - On-line banking
  - Supply chain approach
The Balanced Score Card

• A set of measures that provide top management a fast and comprehensive view of the business – focus on strategy, not control.

• Balanced presentation of both financial measures (past performance) and operational measures (future performance)

• Minimize information overload by limiting the number of measures used

• focus on the most critical measures

The BSC Concept

How do the customer see us?

Financial Perspective

GOALS | MEASURES

How Do we Look to Stakeholders?

Customer Perspective

GOALS | MEASURES

How do the customer see us?

Internal Business Perspective

GOALS | MEASURES

What must we excel at?

Innovation and Learning Perspective

GOALS | MEASURES

Can we continue to improve and Create Value?
A BSC-DEA Model

\[ \max_{u,v} S_0 = \left( \sum_r u_r y_{r0} \right) \left/ \left( \sum_i v_i x_{i0} \right) \right. \]

\[ \left( \sum_r u_r y_{rj} \right) \left/ \left( \sum_i v_i x_{ij} \right) \right. \leq 1, \quad \forall j \]

\[ L_{C_k} \leq \left( \sum_{i \in C_k} u_i y_{i0} \right) \left/ \left( \sum_{i \in C_0} u_i y_{i0} \right) \right. \leq U_{C_k}, \quad k = 1, \ldots, \bar{k} \]

\[ u_r \geq \varepsilon, \quad r = 1, \ldots, s \]

\[ v_i \geq \varepsilon, \quad i = 1, \ldots, m \]
• A node represents a card (or a group of measures)
• The single measures are the leaves of the graph
• Lower and upper bounds are attached to each node
An LP formulation of the BSC-DEA Model

\[
\max_{u,v} \quad s_0 = \sum_r u_r y_{r0}
\]

\[s.t.\]

\[
\sum_i v_i x_{i0} = 1
\]

\[
\sum_r u_r y_{rj} - \sum_i v_i x_{ij} \leq 0 \quad \forall j
\]

\[- \sum_{r \in C_k} u_r y_{r0} + L_{C_k} \sum_{r \in C_0} u_r y_{r0} \leq 0 \quad k = 1, \ldots, \bar{k}
\]

\[
\sum_{r \in C_k} u_r y_{r0} - U_{C_k} \sum_{r \in C_0} u_r y_{r0} \leq 0 \quad k = 1, \ldots, \bar{k}
\]

\[
u_i \geq \varepsilon
\]

\[
u_i \geq \varepsilon
\]

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Feasible Region for the Upper and Lower Bounds

Possible

Not Possible

\[ L_i \geq 0 \]
\[ U_i \leq 1 \]
\[ L_i \leq U_i \]
**BSC-DEA: Illustrations**

**Figure 1:** Two-dimensional expected output including 51 enveloping branches

**Figure 2:** Scores attained by the DEA-BSC model for the enveloping branches on *curve a* for two sets of balancing limits
A Decision Support Model

Budget Reallocation among Branches

- Apply relative balanced scoring model on all active and candidate branches
- Generate relative scoring table for each review period $t$
- Close some branches as a function of:
  - Pre-determined relative thresholds on critical factors, group of indicators or total scoring
  - Scoring trends of branches over time periods
  - Other managerial considerations
- Compute the amount of free resources $R$

Golany, Phillips, Rousseau *IIE Transactions* 93
Parameters and Variables

- **Sets** $P(C)$: Set of (candidate) active branches.
- **Scores** $S_j$: Score of branch $j$ (score of candidate branch $j$)
- **Bounds** $\text{Max (min) budget allocation for branch } j$
- **Other parameters** $R$: remaining budget (after canceling non-attractive branches, $N_{\text{max}}$: max no. of branches.
- **Variables** $X_j$: budget allocation to branch $j$, $u_j$: zero one “selector” of branch $j$. 

A Decision Support Model...2
A Decision Support Model...3

**IP Formulation**

\[
\begin{align*}
\text{Max} & \quad \sum_{j \in P} s_j x_j + \sum_{j \in C} \hat{s}_j x_j \\
\text{s.t.} & \quad \sum_{j \in N} x_j \leq R, \\
& \quad x_j \leq b_j^{\max} u_j, \quad j \in N \\
& \quad x_j \geq b_j^{\min} u_j, \quad j \in N \\
& \quad \sum_{j \in N} u_j \leq n_{\max}, \quad j \in N \\
& \quad u_j \in \{0,1\}, \quad j \in N \\
& \quad x_j \geq 0, \quad j \in N
\end{align*}
\]
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The Conventional Approach

A branch with some inputs and outputs… one of n such branches

Efficiency = sum of weighted outputs divided by a sum of weighted inputs

Golany, Hackman, Passy, AOR 04
DEA Input Efficiency: A Numerical Example

\[ K_2 = 100 \]
\[ I = 40 \]
\[ L_2 = 100 \]
\[ F = 300 \]
\[ \theta^*_2 = 0.6 \Rightarrow \]

\[ K_2 = 60 \]
\[ I = 24 \]
\[ L_2 = 60 \]
\[ F = 300 \]
Technical inefficiency ($P_1$ & $P_2$):
- too much resources for the given output, or
- too little output for the given resources, or
- both

Allocative inefficiency (aggregate unit):
- inappropriate allocation of $K$ & $L$ to the two processes
Aggregate Efficiency: Classical DEA

The weighting model

\[\text{Max} \quad \frac{\pi_F \cdot F_0}{\pi_K \cdot K_0 + \pi_L \cdot L_0} \quad \pi_F \cdot F_j \quad \pi_K \cdot K_j + \pi_L \cdot L_j \leq 1\]

The envelopment model

\[\theta_A^{(CL)} = \text{Min} \quad \theta_A \quad \sum_j \lambda_j \cdot K_j \leq \theta_A \cdot K_0 \]
\[\sum_j \lambda_j \cdot L_j \leq \theta_A \cdot L_0 \]
\[\sum_j \lambda_j \cdot F_j \geq F_0\]
Disaggregate Efficiency

\[
\theta_A^{(DA)} = \text{Max}\left\{ \left[ \frac{K_{10}}{K_0} \cdot \theta_1^* + \frac{K_{20}}{K_0} \cdot \theta_2^* \right], \left[ \frac{L_{10}}{L_0} \cdot \theta_1^* + \frac{L_{20}}{L_0} \cdot \theta_2^* \right] \right\}
\]

\[
\theta_1^* = \text{Min} \theta_1 \\
\sum_j \lambda_{1j} \cdot K_{1j} \leq \theta_1 \cdot K_{10} \\
\sum_j \lambda_{1j} \cdot L_{1j} \leq \theta_1 \cdot L_0 \\
\sum_j \lambda_{1j} \cdot I_j \geq 0
\]

\[
\theta_2^* = \text{Min} \theta_2 \\
\sum_j \lambda_{2j} \cdot K_{2j} \leq \theta_2 \cdot K_{20} \\
\sum_j \lambda_{2j} \cdot L_{2j} \leq \theta_2 \cdot L_{20} \\
\sum_j \lambda_{2j} \cdot I_j \leq \theta_2 \cdot I_0 \\
\sum_j \lambda_{2j} \cdot F_j \geq F_0
\]
Aggregate Efficiency: Complete Transferability of Resources

\[
\begin{align*}
\text{Max} & \quad \frac{\pi_F \cdot F_0}{\pi_K \cdot K_0 + \pi_L \cdot L_0} \\
& \quad \frac{\pi_I \cdot I_j}{\pi_K \cdot K_{1j} + \pi_L \cdot L_{1j}} \leq 1 \\
& \quad \frac{\pi_F \cdot F_j}{\pi_K \cdot K_{2j} + \pi_L \cdot L_{2j} + \pi_I \cdot I_j} \leq 1
\end{align*}
\]

\[
\theta_A^{(CT)} = \text{Min} \quad \theta_A \\
\sum_j \lambda_{1j} \cdot K_{1j} + \sum_j \lambda_{2j} \cdot K_{2j} \leq \theta_A \cdot K_0 \\
\sum_j \lambda_{1j} \cdot L_{1j} + \sum_j \lambda_{2j} \cdot L_{2j} \leq \theta_A \cdot L_0 \\
\sum_j \lambda_{1j} \cdot I_j - \sum_j \lambda_{2j} \cdot I_j \geq 0 \\
\sum_j \lambda_{2j} \cdot F_j \geq F_0
\]
Allocative Efficiency

\[ \theta_A^{(AE)} = \frac{\theta_A^{(CT)}}{\theta_A^{(DA)}} \]
Consistent Pricing Model: Analysis of $P_1$

$$\text{Max} \quad \frac{\pi_i \cdot I_0}{\pi_K \cdot K_{10} + \pi_L \cdot L_{10}}$$

$$\frac{\pi_i \cdot I_j}{\pi_K \cdot K_{1j} + \pi_L \cdot L_{1j}} \leq 1$$

$$\frac{\pi_F \cdot F_j}{\pi_K \cdot K_{2j} + \pi_L \cdot L_{2j} + \pi_i \cdot I_j} \leq 1$$

$\pi^*_F = 0 \implies$ separability
Consistent Pricing Model: Analysis of $P_2$

\[\begin{align*}
\text{Max} & \quad \frac{\pi_F \cdot F_0}{\pi_K \cdot K_{20} + \pi_L \cdot L_{20} + \pi_I \cdot I_0} \\
& \quad \frac{\pi_I \cdot I_j}{\pi_K \cdot K_{1j} + \pi_L \cdot L_{1j}} \leq 1 \\
& \quad \frac{\pi_F \cdot F_j}{\pi_K \cdot K_{2j} + \pi_L \cdot L_{2j} + \pi_I \cdot I_j} \leq 1
\end{align*}\]

\[\begin{align*}
\theta_2^{(os)} &= \text{Min} \quad \theta_2 \\
& \quad \sum_j \lambda_{1j} \cdot K_{1j} + \sum_j \lambda_{2j} \cdot K_{2j} \leq \theta_2 \cdot K_{20} \\
& \quad \sum_j \lambda_{1j} \cdot L_{1j} + \sum_j \lambda_{2j} \cdot L_{2j} \leq \theta_2 \cdot L_{20} \\
& \quad - \sum_j \lambda_{1j} \cdot I_j + \sum j \lambda_{2j} \cdot I_j \leq \theta_2 \cdot I_0 \\
& \quad \sum_j \lambda_{2j} \cdot F_j \geq F_0
\end{align*}\]
Interpretation Through an Outsourcing Option

- $P_2$ has an option to allocate a portion of its capital ($K$) and labor ($L$) to an efficient (composite) stage 1 that will produce with it some intermediate factor ($I$).

- It may be worth doing so if the $P_1$ composite unit is very efficient in producing $I$ and there is an efficient composite $P_2$ that can use the extra $I$ with relatively little $K$ and $L$ to produce more $F$. 
Outsourcing Option: Numerical Example

Observed Unit

$K_2 = 100$
$I = 40$
$L_2 = 100$

Composite Units

$K_1 = 20$
$L_1 = 25$

$F = 300$
$I = 26$

$\theta^*_2 = 0.6 \Rightarrow$

$K_2 = 60$
$I = 24$
$L_2 = 60$

$F = 300$
$I = 50$
$L_2 = 35$

$K_2 = 40$
$L_2 = 60$

Outsourcing Option:

$K = 26$
$L = 80$

I = 26
F = 300

θ = 40
Efficiency Tradeoffs:
Analysis of $P_1$ given $P_2$'s efficiency

\[
\begin{align*}
\text{Max} \quad & \frac{\pi_I \cdot I_0}{\pi_K \cdot K_{10} + \pi_L \cdot L_{10}} \\
& \quad \frac{\pi_I \cdot I_j}{\pi_K \cdot K_{1j} + \pi_L \cdot L_{1j}} \leq 1 \\
& \quad \frac{\pi_F \cdot F_j}{\pi_K \cdot K_{2j} + \pi_L \cdot L_{2j} + \pi_I \cdot I_j} \leq 1 \\
& \quad \frac{\pi_F \cdot F_0}{\pi_K \cdot K_{20} + \pi_L \cdot L_{20} + \pi_I \cdot I_0} \geq T_2
\end{align*}
\]

$\delta = 0 \gg \lambda_{2j}^* = 0 \gg$ the program reduces to the ordinary envelopment of $P_1$

$\theta_1^{(AQ)} = \text{Min} \quad \theta_1$

$\sum_j \lambda_{1j} \cdot K_{1j} + \sum_j \lambda_{2j} \cdot K_{2j} \leq \theta_1 \cdot K_{10} + \delta \cdot T_2 \cdot K_{20}$

$\sum_j \lambda_{1j} \cdot L_{1j} + \sum_j \lambda_{2j} \cdot L_{2j} \leq \theta_1 \cdot L_{10} + \delta \cdot T_2 \cdot L_{20}$

$\sum_j \lambda_{1j} \cdot I_j - \sum_j \lambda_{2j} \cdot I_j \geq I_0 - \delta \cdot T_2 \cdot I_0$

$\sum_j \lambda_{2j} \cdot F_j \geq \delta \cdot F_0$
Interpretation Through an Acquisition Option

- A composite $P_2$ is constructed using $T_2$ and a scale factor $\delta$
- $P_1$ acquires the resources of $P_2$, scaled down by the product of $T_2$, and $\delta$, promising to supply the scaled output $\delta F$.
- $P_1$ allocates part of its own K and L together with $\delta T_2 K_2$, $\delta T_2 L_2$ to two efficient composites of $P_1$ and $P_2$
- The composite $P_1$ produces more I than is required by the composite $P_2$
- The composite $P_2$ produces the promised F.
- The unused amount $\delta T_2 I$ plus the unused portion of I from the composite $P_1$ equal the output I of the observed $P_1$
- The unused portion of K,L from $P_1$ represents its inefficiency
Outline

- **Past**
  - <1978: Profit measures, Operational efficiency
  - 1978-1998: Data Envelopment Analysis

- **Present considerations**
  - Too many factors (DEA-PCA)
  - Balancing strategic objectives (DEA-BSC)
  - Multi-stage systems

- **Future**
  - Drivers of change
  - Will branches disappear?
Drivers of change

- Increased competition from non-traditional institutions
- New information technologies
- Erosion of product and geographic boundaries
- Less restrictive governmental regulations
Fundamental Financial Functions

- Making payments
- Pooling resources
- Transfer economic resources
- Managing risks
- Price information
- Handle incentive problems
To specialize or not to specialize?

- **Moving towards one-stop shopping**
  - Mutual funds offer check-writing privileges
  - NationsBank Corp. broadens its product line

- **Moving towards specialization**
  - State Street Bank & Trust to focus only on servicing financial assets
  - Bankers Trust shed its retail banking business
  - Signet Bank drops its credit card business
Inherent inefficiency in branches

- Provider's perspective
  - Expensive real-estate
  - Low utilization of expensive servers
- Customer perspective
  - Transportation difficulties
  - Restricted hours of operation
Will branches disappear?

- **Restructuring**: few major branches, multiple “satellite” branches (some in supermarkets or malls)
- **Remote control**: use internet sites, call centers, ATMs for most transactions, employ dispatching service when necessary
- **Outsource**: a single “branch service” company serves multiple banks
- **Do-it-yourself**: large corporations provide their own guarantee of credit, do their own foreign exchange trading, etc.