TFDEA: A New Approach for Technology Forecasting of New Product Development Targets

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Citation Details
TFDEA: A New Approach for Technology Forecasting of New Product Development Targets

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Veritas, Inc.

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Portland State University
Presentation Flow

Introduction

Tech. Forecasting

DEA

TFDEA

Application

Conclusions

Introduction

Tech. Forecasting

DEA

TFDEA

Application

General Practice

State of the Art

General Practice

Example

TPC-C
Introduction

- **GAP1**: Current quantitative technology forecasting techniques do not handle variable trade-offs.
- **GAP2**: Current DEA tools do not handle single occurrence DMUs with variable time periods.
Research Objectives

- **Methodology:**
  - Develop a methodology for technology forecasting which provides a robust means to measure the SOA and its progress by extending current temporal DEA to allow for DMUs which are introduced only once at irregular intervals.

- **Application:**
  - Apply the methodology to a straightforward real world application.
Technology Forecasting

- **What is technology forecasting?**
  - “to predict the future characteristics of a useful machine”

- **What's a machine?**
  - Not only physical devices, but tools, techniques and procedures that provide some function to an end-user.

What is technology?

*Knight '74
What is technology, really?

Machine

Structure
Element 1
Element 2
Element 3
Element 4

Technology

Function
Attribute 1
Attribute 2

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How is it currently done?

Definition
- Monitoring

Exploration
- Extrapolation
- Expert Opinion

Refinement
- Modelling and Simulation
- Scenarios

Understanding
What are the challenges?

- *It is difficult to assign a single attribute to the measurement of a technology.*
- Typically only addresses a technological approach not a single technology.
How are these challenges addressed?

- **State Of the Art (SOA)**

  “The best implemented technology as reflected by the physical and performance characteristics actually achieved during the time period in question”

  –Dodson, TFSC 1 1970
How can SOA be used?

- Given that technology is never better than State-of-the-Art, an index may be used to measure relative to the SOA.
- Over time a product's technology index will change – tracking that change will allow for future predictions.
What is the SOA?

Increasing State of the Art

Technology Approach #1

Technology Approach #2

Characteristics: #1, #2

Time: t₁, t₂
Where does SOA fit?

Definition

Exploration

Refinement

Monitoring

Extrapolation

Expert Opinion

Modeling and Simulation

Scenarios

Understanding
Steps to Forecast SOA

What does DEA measure?
Steps For DEA

- Decide Purpose
- Define DMU
- Determine I/O
- Choose DEA Model
- Collect Data
- Perform Analysis
- Examine Results
- Improve Model

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Data Envelopment Analysis

- Builds an efficiency envelope relative to its peers (extreme-point method)
How do they go together?
How do they fit together?

**Introduction**

**TEFDEA**

**Tech. Forecasting**

**DEA**

**TFDEA**

**Application**

**Conclusions**

**Gap:** General forms do not take into account the dynamic nature of trade-off surfaces.

**Attr:** DMUs are independently rated against peers which are explicitly identified by DEA.

**Gap:** Do not address the “best” available technology.

**Attr:** DEA is an extreme point method.

**Gap:** Current methods are limited to a single output.

**Attr:** DEA can handle multiple inputs and outputs simultaneously.

**Gap:** Current methods require independent attributes.

**Attr:** DEA does not require attribute independence.
How do they fit together?

Traditional DEA

- Decide Purpose
- Define a DMU
- Determine I/O Model
- Collect Data
- Perform Analysis
- Examine Results
- Improve Model
- Choose Model

Measuring SOA

- Specify Operational Definition of SOA
- Specify Parameter Selection Guidelines
- Develop Technique to Represent Surface
- Develop Prospective SOA Advances (GAP)
- Perform Analysis
- Examine Results

TFDEA

- Determine Scope of Forecast
- Define a Product
- Define SOA Characteristics
- Determine Specific Model
- Improve Model
- Collect Data
- Analyze Tech. Progress
- Examine Results
Example - RDBMS

RDBMS

Structure (INPUT)

Total Cost Of Ownership

OLTP TECH

Function (OUTPUT)

tpm-C
## TPC Data

<table>
<thead>
<tr>
<th>Product</th>
<th>Name</th>
<th>Year Released</th>
<th>Total Cost($)</th>
<th>Perf. (tpmC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Unisys Aquanta QR/6 c/s</td>
<td>1997</td>
<td>297392</td>
<td>7407</td>
</tr>
<tr>
<td>B</td>
<td>ALR Revolution 6X6 (1MB L2) c/s</td>
<td>1997</td>
<td>463821</td>
<td>1308</td>
</tr>
<tr>
<td>C</td>
<td>Compaq ProLiant 3000 6/450-512</td>
<td>1998</td>
<td>176042</td>
<td>6290</td>
</tr>
<tr>
<td>D</td>
<td>Unisys Aquanta QR/2V Server</td>
<td>1998</td>
<td>424297</td>
<td>1911</td>
</tr>
<tr>
<td>E</td>
<td>Compaq Proliant 3000-6/600-1P</td>
<td>1999</td>
<td>160643</td>
<td>8050</td>
</tr>
<tr>
<td>F</td>
<td>Compaq Proliant ML570</td>
<td>2000</td>
<td>201717</td>
<td>2020</td>
</tr>
<tr>
<td>G</td>
<td>Dell PowerEdge 6450</td>
<td>2000</td>
<td>334936</td>
<td>3123</td>
</tr>
<tr>
<td>H</td>
<td>Unisys e-@action Enterprise Server</td>
<td>2000</td>
<td>797935</td>
<td>6139</td>
</tr>
</tbody>
</table>

Source: Transaction Processing Council (TPC) [www.tpc.org](http://www.tpc.org)
Identification of the SOA
Mapping Progress

- Introduction
- Tech. Forecasting
- DEA
- TFDEA
- Application
- Conclusions
How do we represent it?

- Use the $\beta$ determined earlier:

$$\phi^t = (\beta)^t \cdot \phi^0$$

$$y^t_r = \beta^{\Delta t} \cdot y^0_r \ \forall \ r \in \{1...m\}$$

- Translation: new outputs can be multiplied by the old outputs
Forecasting the Future

Graph showing the relationship between X - Cost (US 1000s $) and Y - Performance (1000s tpmC), with various data points and lines indicating 1998 Frontier, 1999 Predicted Frontier, and 95% Confidence Interval.
Forecasting the Future
Forecasting the Future
Applications:
### TPC Results

#### Output-Oriented TFDEA

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Predicted Range</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Predicted Range</td>
<td>541</td>
<td>42.77%</td>
</tr>
<tr>
<td>ROC Predicts Lower Bound Only</td>
<td>220</td>
<td>17.39%</td>
</tr>
<tr>
<td>ROC Predicts Upper Bound Only</td>
<td>241</td>
<td>19.05%</td>
</tr>
<tr>
<td>ROC Did not Predict SOA</td>
<td>263</td>
<td>20.79%</td>
</tr>
<tr>
<td>Total</td>
<td>1265</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

#### IO-OO Output-Oriented TFDEA

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Predicted Range</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Predicted Range</td>
<td>797</td>
<td>63.00%</td>
</tr>
<tr>
<td>ROC Predicts Lower Bound Only</td>
<td>130</td>
<td>10.27%</td>
</tr>
<tr>
<td>ROC Predicts Upper Bound Only</td>
<td>338</td>
<td>26.71%</td>
</tr>
<tr>
<td>ROC Did not Predict SOA</td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>Total</td>
<td>1265</td>
<td>100.00%</td>
</tr>
</tbody>
</table>
## TPC Results

<table>
<thead>
<tr>
<th>Product</th>
<th>Date</th>
<th>$\phi_{lower}$</th>
<th>$\phi_{upper}$</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBM eServer xSeries 365 4P c/s</td>
<td>2004-03-31</td>
<td>1.23</td>
<td>1.30</td>
<td>Low</td>
</tr>
<tr>
<td>HP Integrity Superdome</td>
<td>2004-04-14</td>
<td>0.95</td>
<td>1.02</td>
<td>Target</td>
</tr>
<tr>
<td>HP rx8620</td>
<td>2004-04-15</td>
<td>1.04</td>
<td>1.07</td>
<td>Low</td>
</tr>
<tr>
<td>Unisys ES7000 Aries 420 Enterprise Server</td>
<td>2004-04-20</td>
<td>1.20</td>
<td>1.24</td>
<td>Low</td>
</tr>
<tr>
<td>HP Integrity rx5670 Cluster 64P</td>
<td>2004-04-30</td>
<td>0.82</td>
<td>0.89</td>
<td>RISK</td>
</tr>
<tr>
<td>PRIMEPOWER 2500</td>
<td>2004-04-30</td>
<td>1.64</td>
<td>1.77</td>
<td>Low</td>
</tr>
<tr>
<td>IBM eServer pSeries 690 Model 7040-681</td>
<td>2004-08-16</td>
<td>1.08</td>
<td>1.21</td>
<td>Low</td>
</tr>
<tr>
<td>IBM eServer Xseries 445 8P c/s</td>
<td>2004-08-31</td>
<td>1.44</td>
<td>1.59</td>
<td>Low</td>
</tr>
</tbody>
</table>

*HP Integrity made its debut – but it used RedHat Linux for its Operating System.*
TPC - Conclusions

- Method provides a good estimate of future trends.
- IO-OO offers additional insight.
- Still prone to disruptive technologies.