Measuring & Predicting Business Performance: AI & Optimization Techniques

Ali Emrouznejad

Professor and Chair in Business Analytics

Director, Centre for Business Analytics in Practice

Surrey Business School, University of Surrey

UK

a.emrouznejad@surrey.ac.uk

www.Emrouznejad.com

AACSB ACCREDITED

ASSOCIATION OF MBAS ACCREDITED

Athena SWAN

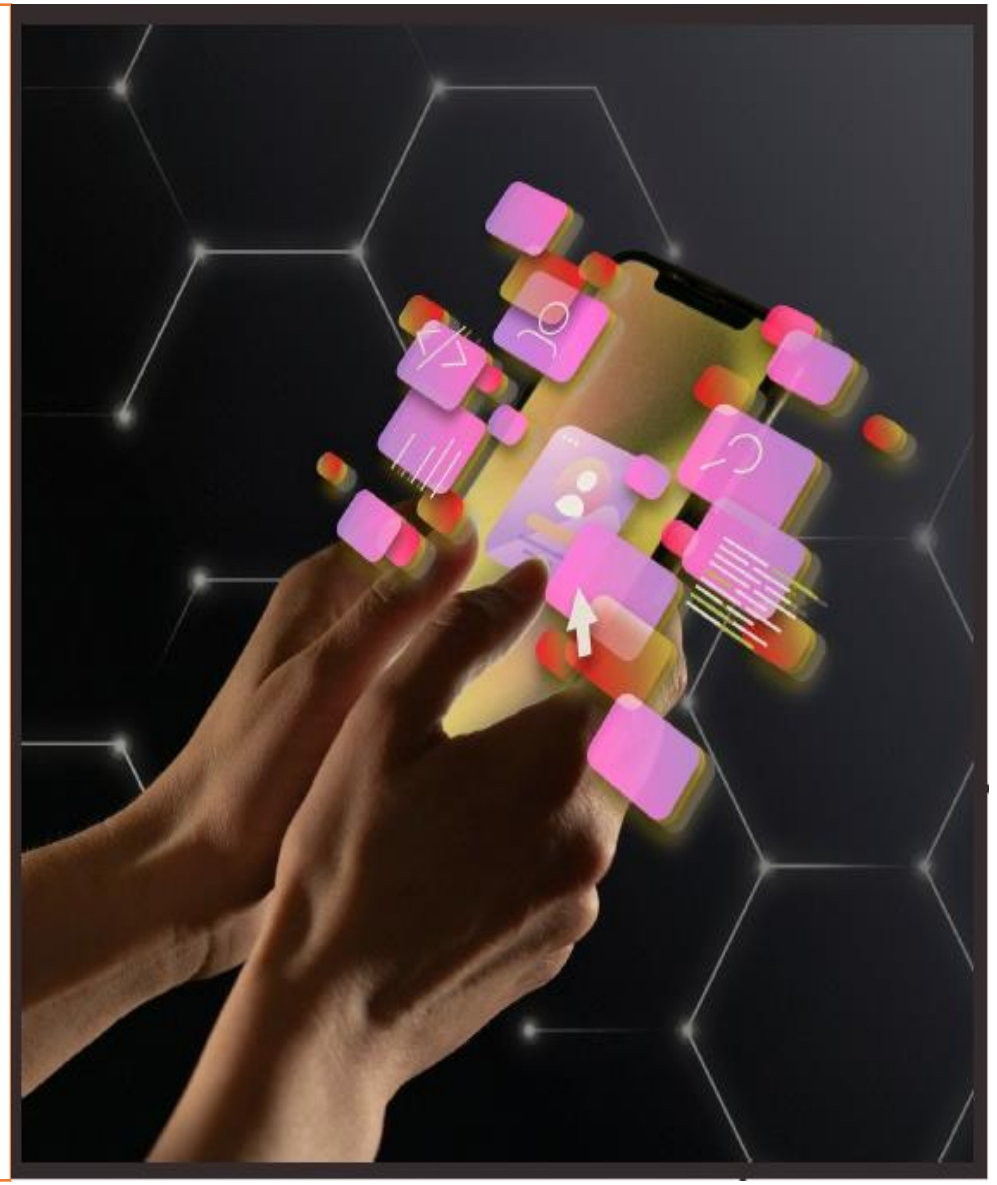
THE WORLD UNIVERSITY RANKINGS

SURREY BUSINESS SCHOOL UNIVERSITY OF SURREY


Academic links
Industry links
Institute of Sustainability
CENTRE FOR BUSINESS ANALYTICS IN PRACTICE
UNIVERSITY OF SURREY
HG & CO.
Institute of AI
Program on Sustainability Analytics and NetZero
Events / Webinars / Conferences
Contribution to Teaching
Impact cases
Projects / Funding
Publications
Supporting Staff
UNIVERSITY OF SURREY

Measuring & Predicting Business Performance
AI-driven optimization!

In this presentation, we will explore how businesses can harness the power of **optimization techniques** and **artificial intelligence** to **measure business performance** (efficiency and Productivity)



Measuring & Predicting Business Performance
AI-driven optimization!

- Driving **operational excellence** in **business performance**.
- **Data Envelopment Analysis (DEA)** enable organizations to identify inefficiencies, and areas of improvement within their processes.
  - ✓ Application of DEA in measuring the efficiency of organizations.
- Utilizing **AI algorithms** such as neural networks and clustering to further identify factors that can increase business performance.
  - ✓ Investigate how the obtained results can be used to feed AI algorithms, enabling us to identify and **explain the sources of inefficiency** and leverage these findings to predict performance.
- Empowering proactive decision-making and optimized resource allocation to **enhance productivity businesses** can streamline operations, minimize resources, and maximize outputs and ultimately achieve higher levels of operational excellence.

PI vs **AI-driven DEA**

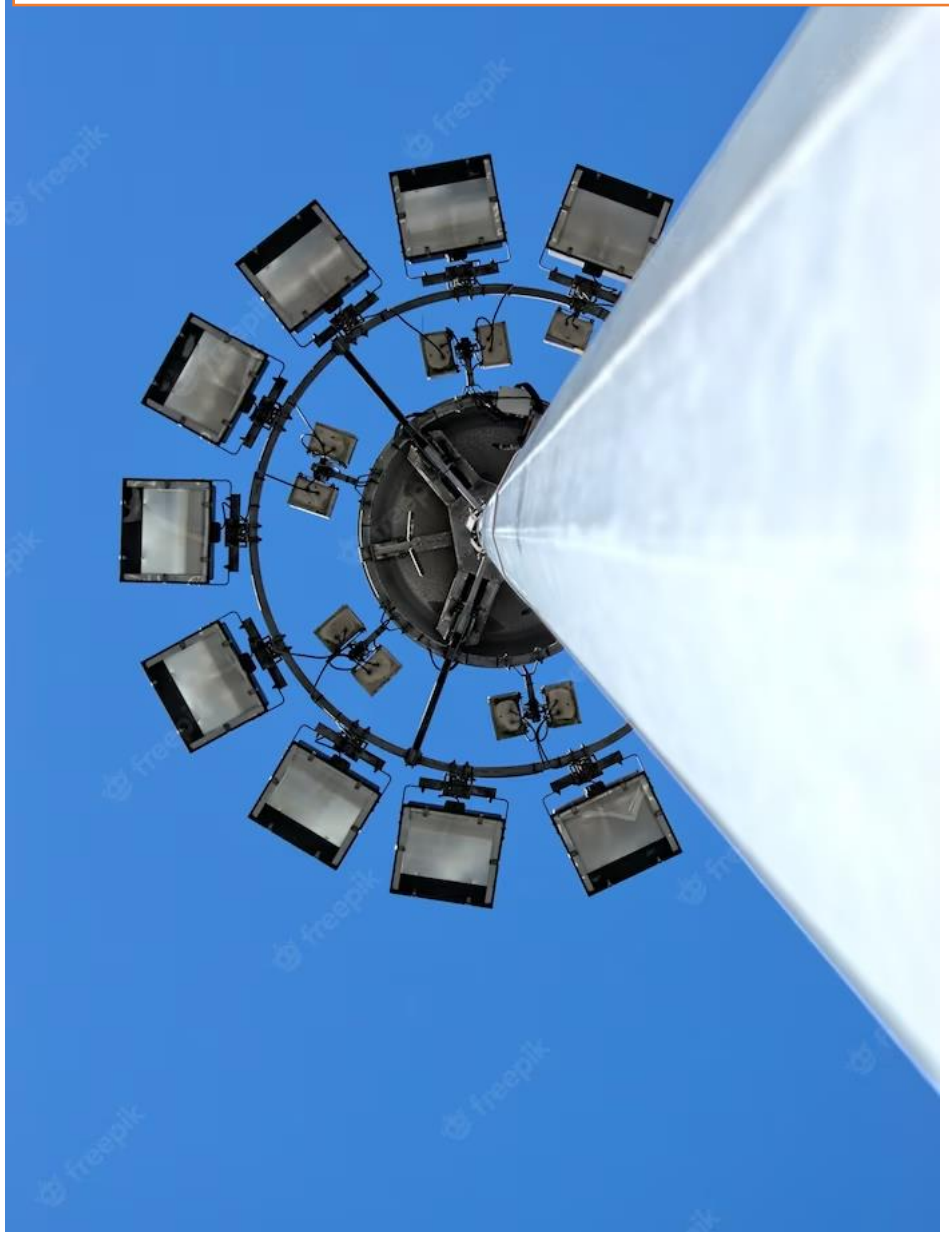
It enables organizations to **stay ahead of the competition**, adapt to market changes, and deliver personalized experiences to customers, leading to increased satisfaction and loyalty.

AI-driven Data Envelopment Analysis goes **beyond measuring performance**.

- DEA provides us opportunity to find targets and identify source of inefficiency.
- By analysing historical data and applying predictive modelling techniques, businesses can forecast future outcomes and trends.

This empowers organizations to proactively identify potential risks, seize opportunities, and make data-driven decisions to drive growth and profitability.

Choosing the Right Optimization (DEA) technique and AI model

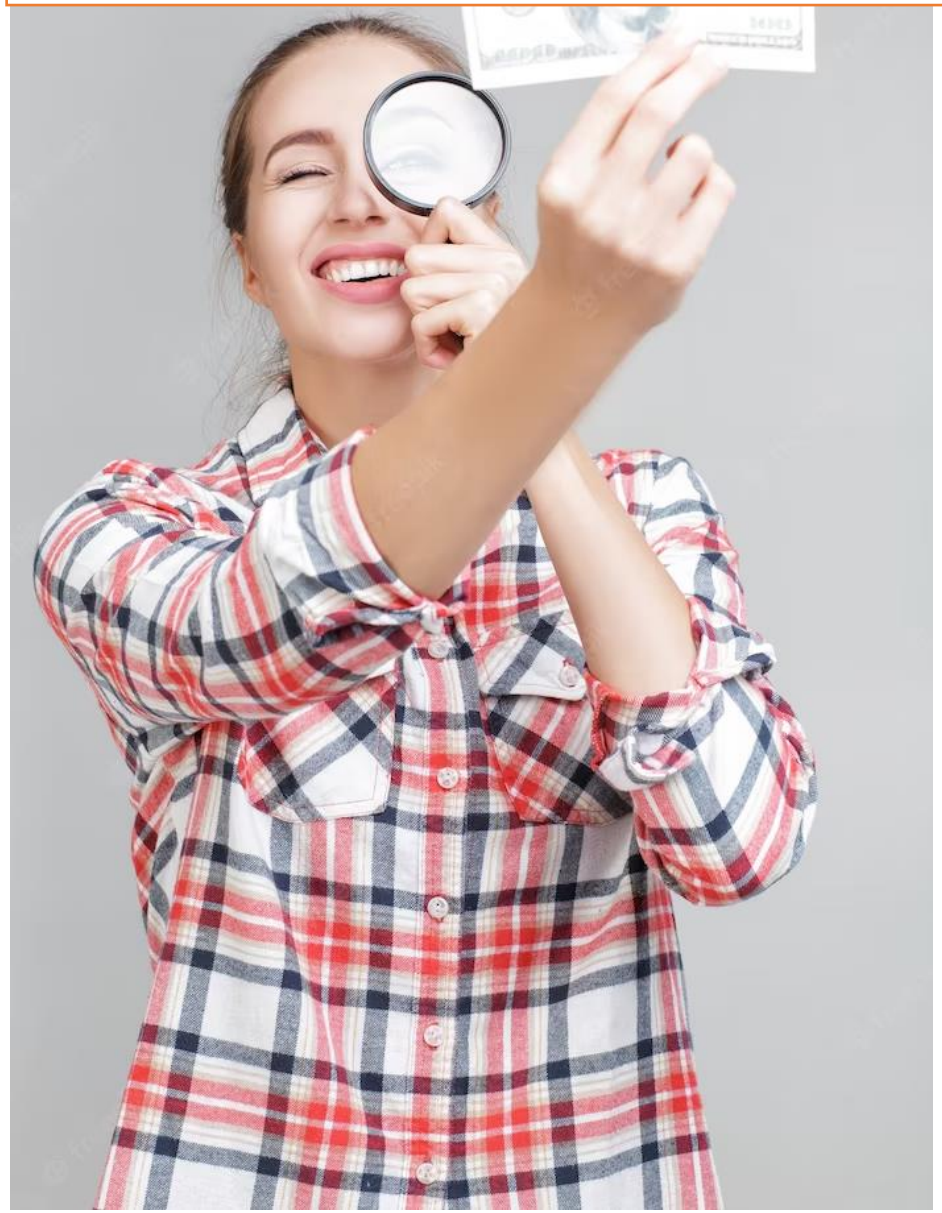


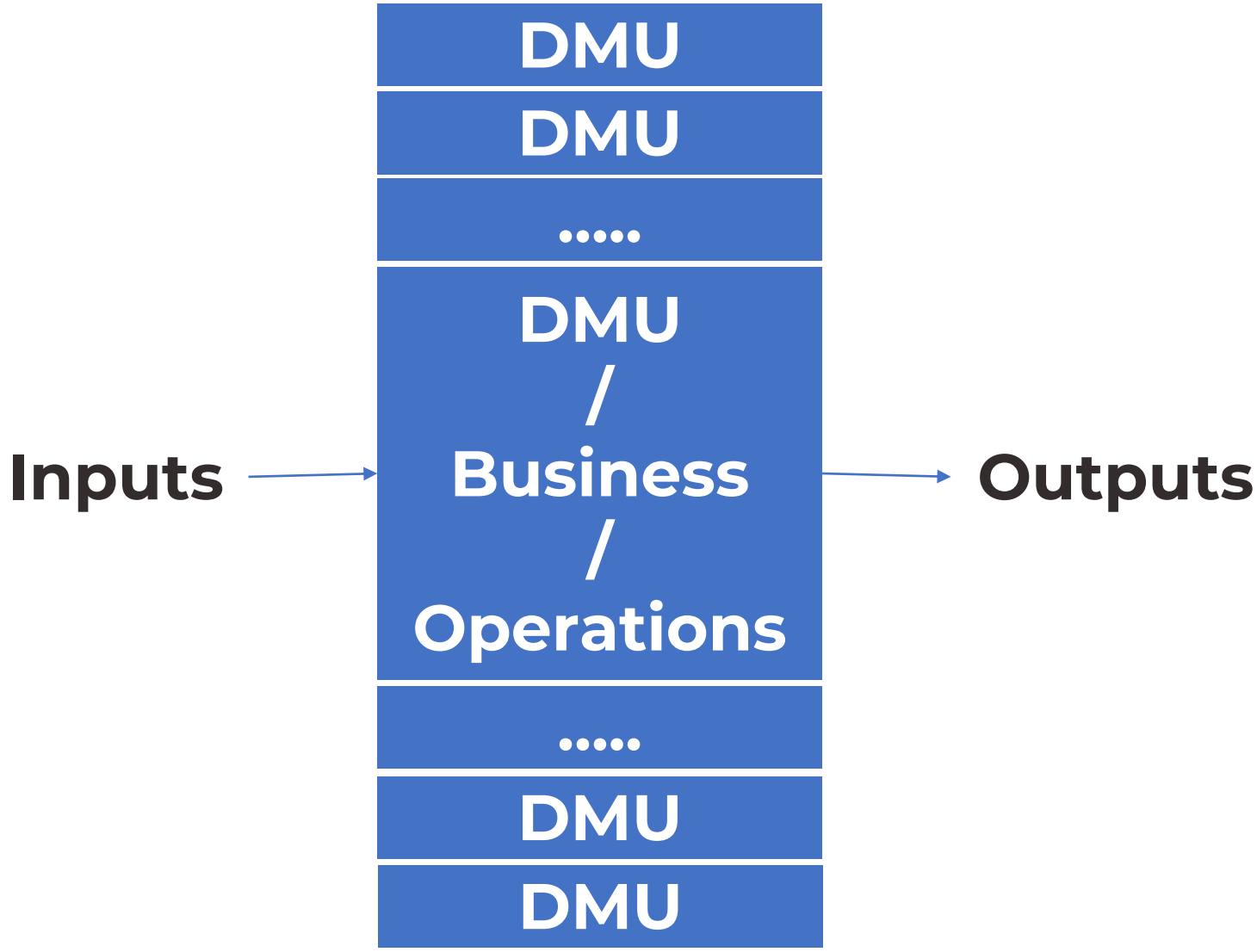
Selecting the **appropriate models** is essential to achieve accurate measure of efficiency.

DEA can be combined with a **range of popular AI models** such as regression analysis, decision trees, and neural networks, support vector machine,....

Understand the strengths and limitations of each model and how to choose the most suitable one based on **business goals** and **data characteristics**.

Decision making units / Business / Operations





Decision making units / Business / Operations

FT1000
Employee, Capital → Revenue

Hospitals
Doctors, Nurses → Inpatients, Outpatients

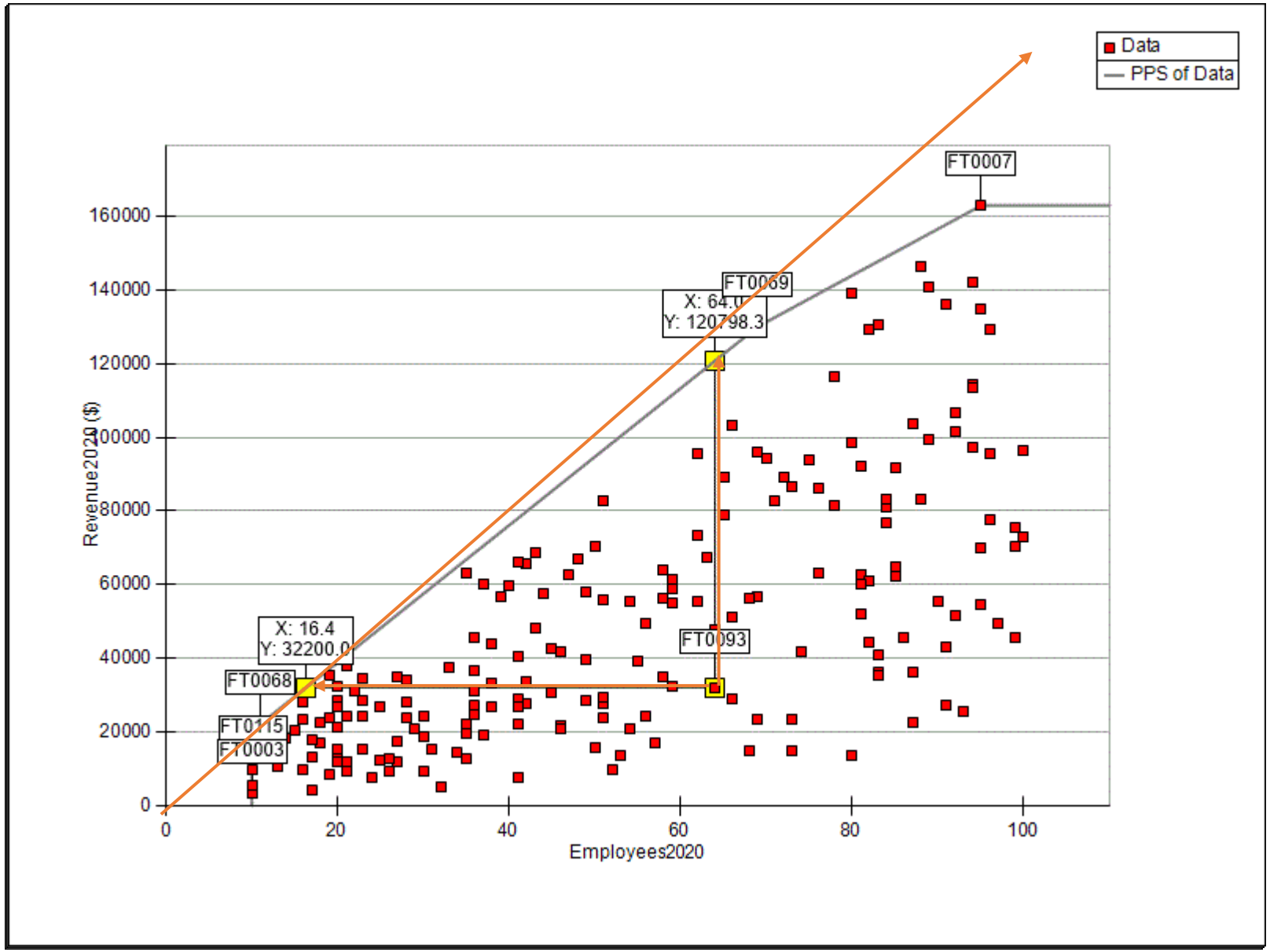
Banks
Employee, Asset → Accounts, Loan, …

…

FT1000 / Data Envelopment Analysis Performance Evaluation

Rank	The rank of the company	
Name	Company name	
Ranked2021	Is the company in the ranking in 2021?	
Ranked2020	Is the company in the 2020 ranking?	
Country	which country does the company belong to?	
Sector	Field of operation of the company	
CAGR	Compound growth rate from 2017 to 2020	
Revenue2020	Revenue 2020 in Euros (€)	**Output**
Revenue2017	2017 Revenue in Euros (€)	
Employees2020	Number of employees in 2020	**Input**
Employees2017	Number of employees in 2017	
Founding Year	The year the company was founded	
Capital	The Capital in 2020	

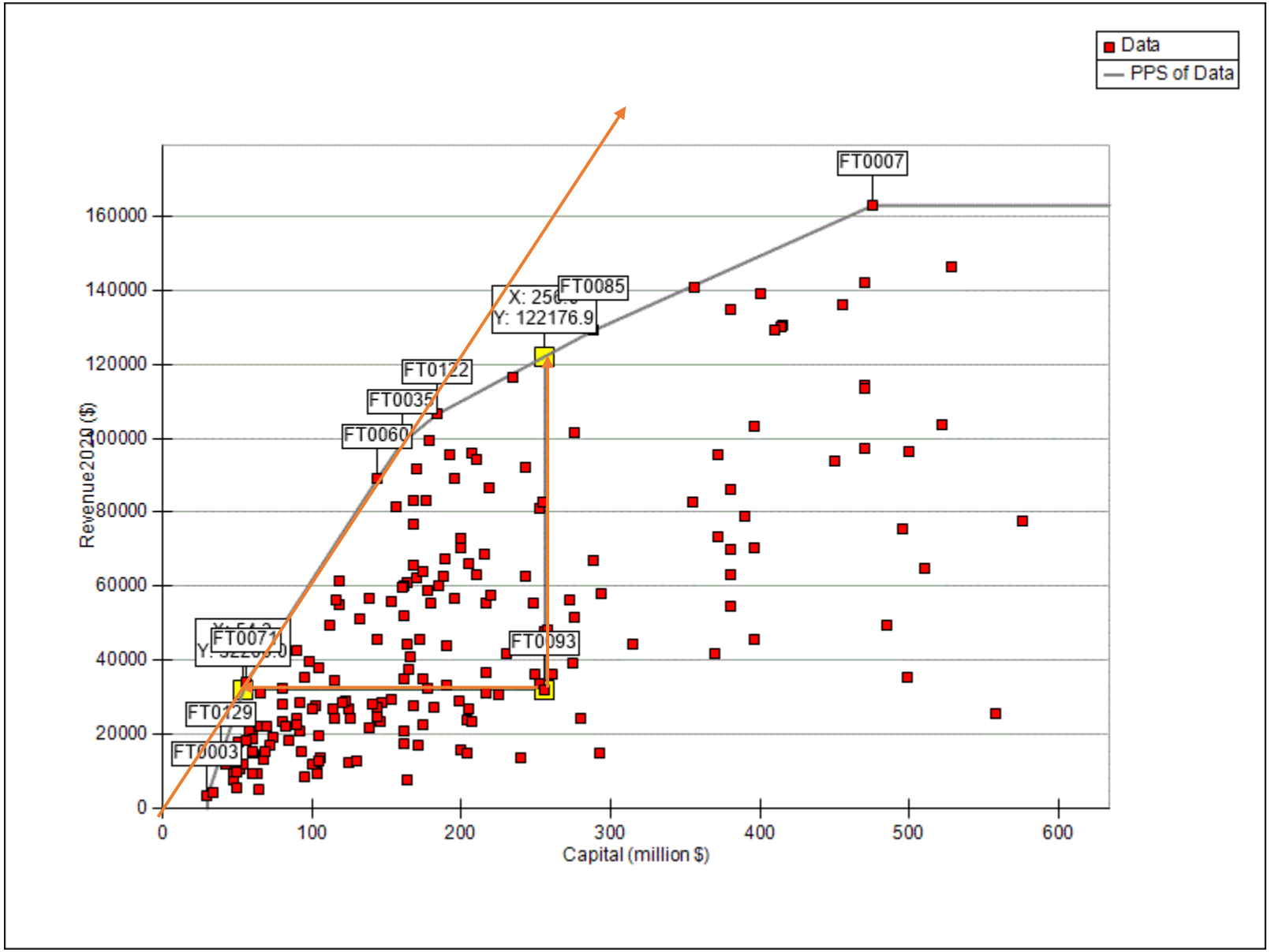
FT1000 / Data Envelopment Analysis Performance Evaluation



FT1000 / Data Envelopment Analysis Performance Evaluation

Rank	The rank of the company	
Name	Company name	
Ranked2021	Is the company in the ranking in 2021?	
Ranked2020	Is the company in the 2020 ranking?	
Country	which country does the company belong to?	
Sector	Field of operation of the company	
CAGR	Compound growth rate from 2017 to 2020	
Revenue2020	Revenue 2020 in Euros (€)	**Output**
Revenue2017	2017 Revenue in Euros (€)	
Employees2020	Number of employees in 2020	
Employees2017	Number of employees in 2017	
Founding Year	The year the company was founded	
Capital	The Capital in 2020	**Input**

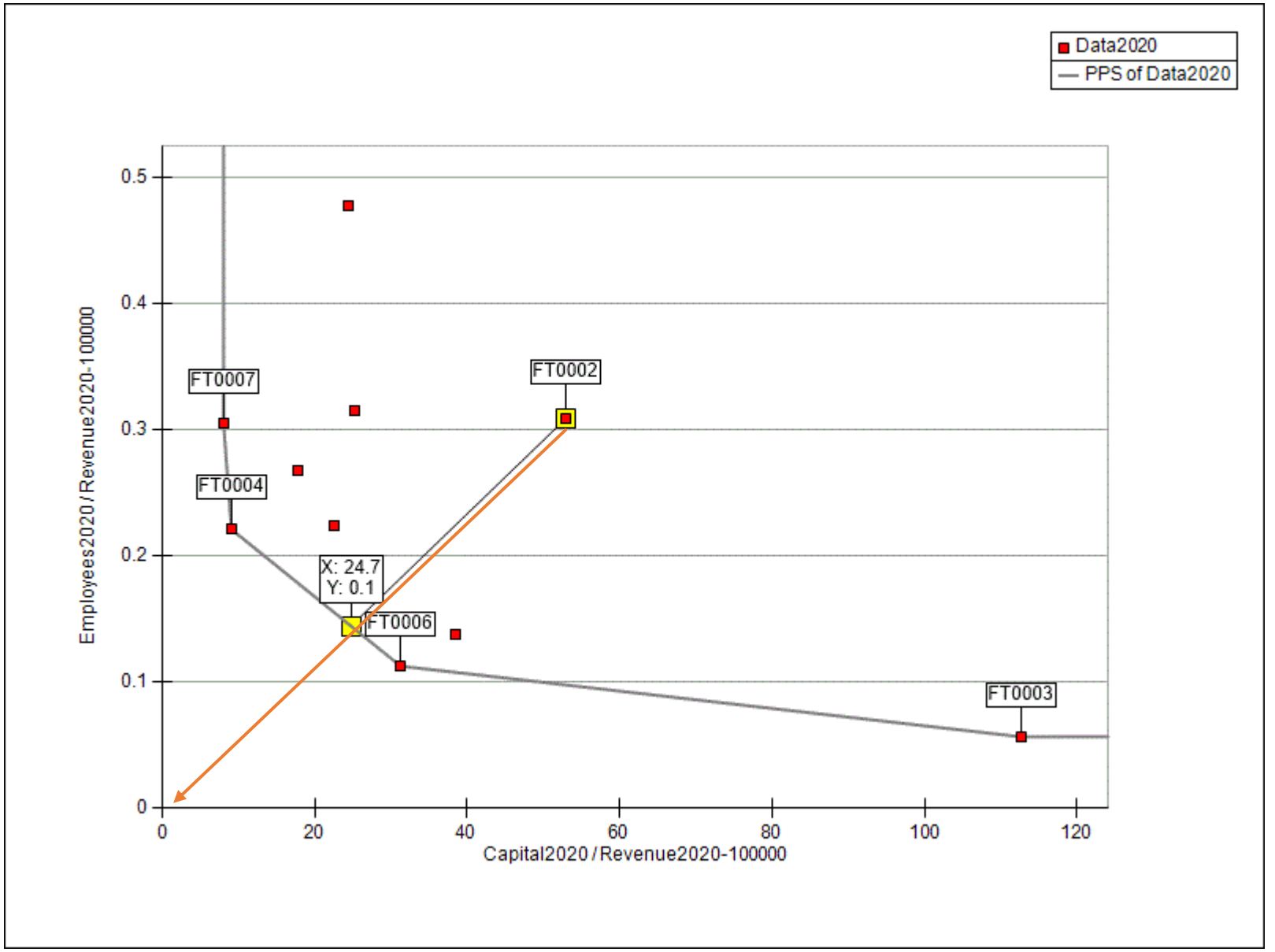
FT1000 / Data Envelopment Analysis Performance Evaluation



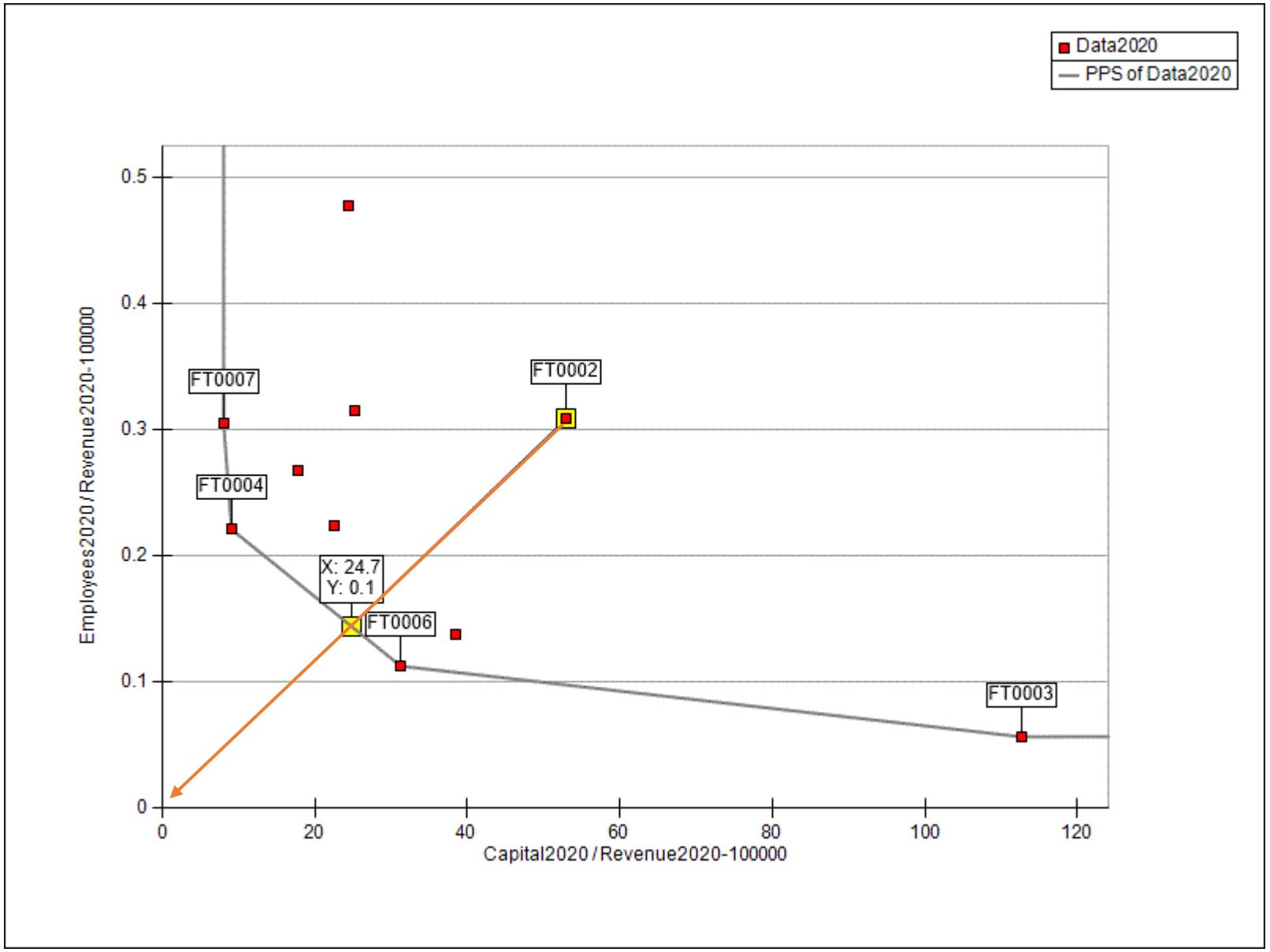
FT1000 / Data Envelopment Analysis Performance Evaluation

Rank	The rank of the company	
Name	Company name	
Ranked2021	Is the company in the ranking in 2021?	
Ranked2020	Is the company in the 2020 ranking?	
Country	which country does the company belong to?	
Sector	Field of operation of the company	
CAGR	Compound growth rate from 2017 to 2020	
Revenue2020	Revenue 2020 in Euros (€)	**Output**
Revenue2017	2017 Revenue in Euros (€)	
Employees2020	Number of employees in 2020	**Input**
Employees2017	Number of employees in 2017	
Founding Year	The year the company was founded	
Capital	The Capital in 2020	**Input**

FT1000 / Data Envelopment Analysis Performance Evaluation

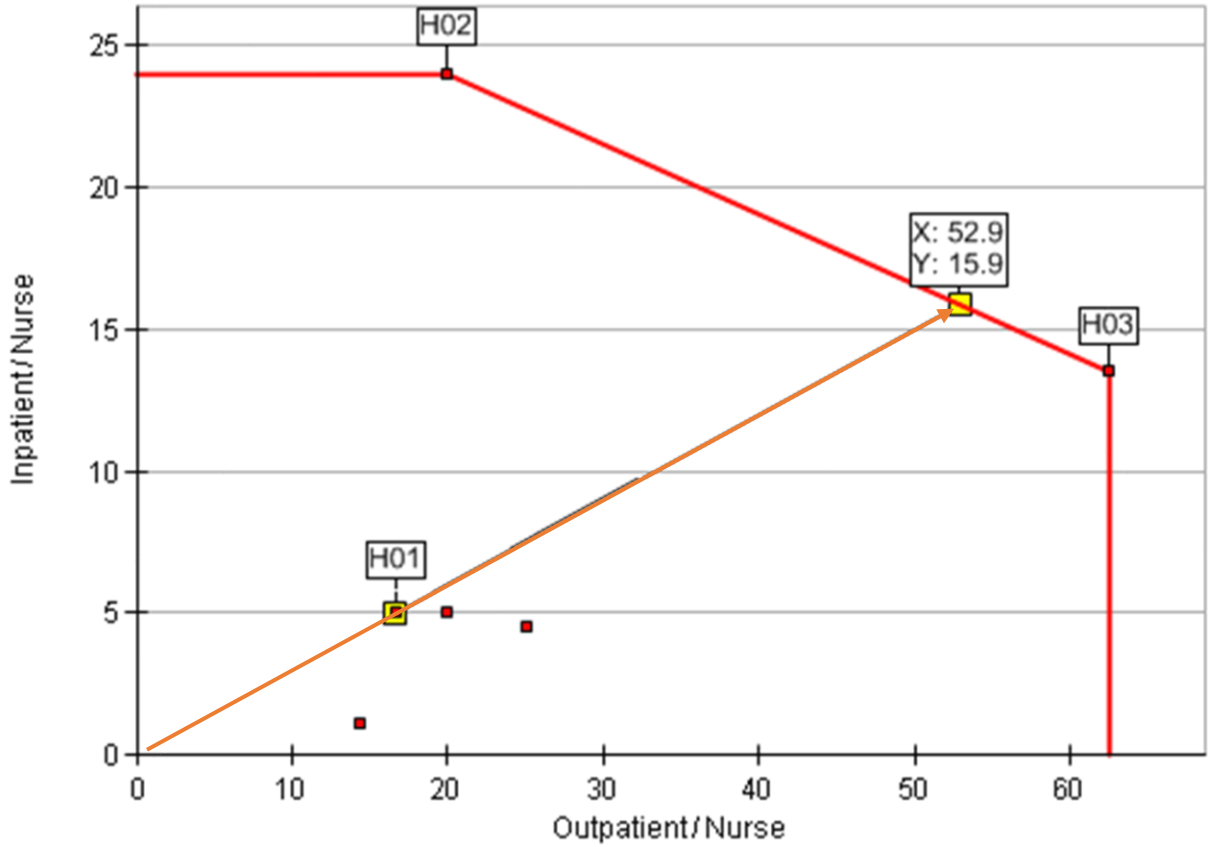


DEA / Minimization



$$\begin{aligned}
&\text{Min} \quad h \\
&\text{s.t.} \quad \sum_j \lambda_j X_{ij} \leqslant h X_{ij_0}; \quad \forall i \\
&\qquad \sum_j \lambda_j Y_{rj} \geqslant Y_{rj_0}; \quad \forall r \\
&\qquad \sum_j \lambda_j = 1. \\
&\qquad \lambda_j \geqslant 0; \quad \forall j, h \text{ free}
\end{aligned}$$

DEA / Maximization



$$\text{Max} \quad h$$

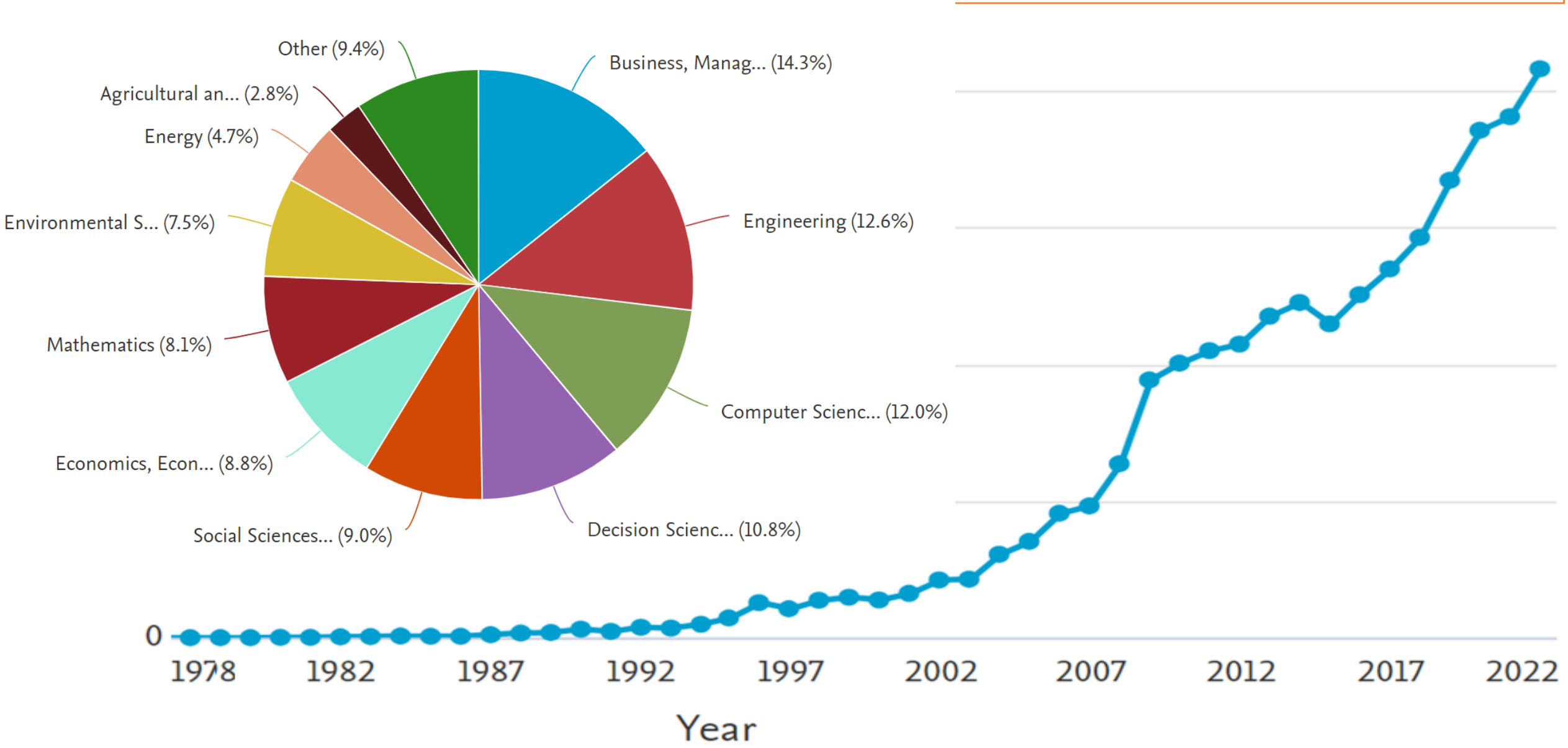
$$\text{s.t.} \quad \sum_j \lambda_j X_{ij} \leqslant X_{ij_0}; \quad \forall i$$

$$\sum_j \lambda_j Y_{rj} \geqslant h Y_{rj_0}; \quad \forall r$$

$$\sum_j \lambda_j = 1$$

$$\lambda_j \geqslant 0; \quad \forall j, h \text{ free}$$

DEA 1978-2023 (23,000) document results



DEA 1978-2023 (23,000) document results

Contents lists available at ScienceDirect

Socio-Economic Planning Sciences

journal homepage: www.elsevier.com/locate/seps

Invited paper

A survey and analysis of the first 40 years of scl DEA: 1978–2016

Ali Emrouznejad [a, *], Guo-liang Yang [b, **]

[a] Aston Business School, Aston University, Birmingham, UK
[b] Institute of Policy and Management, Chinese Academy of Sciences, Beijing 100190, China

ARTICLE INFO

Article history:
Received 22 January 2017
Accepted 23 January 2017
Available online 26 January 2017

Keywords:
Data envelopment analysis
Efficiency and productivity
Bibliography
Survey

ABSTRACT

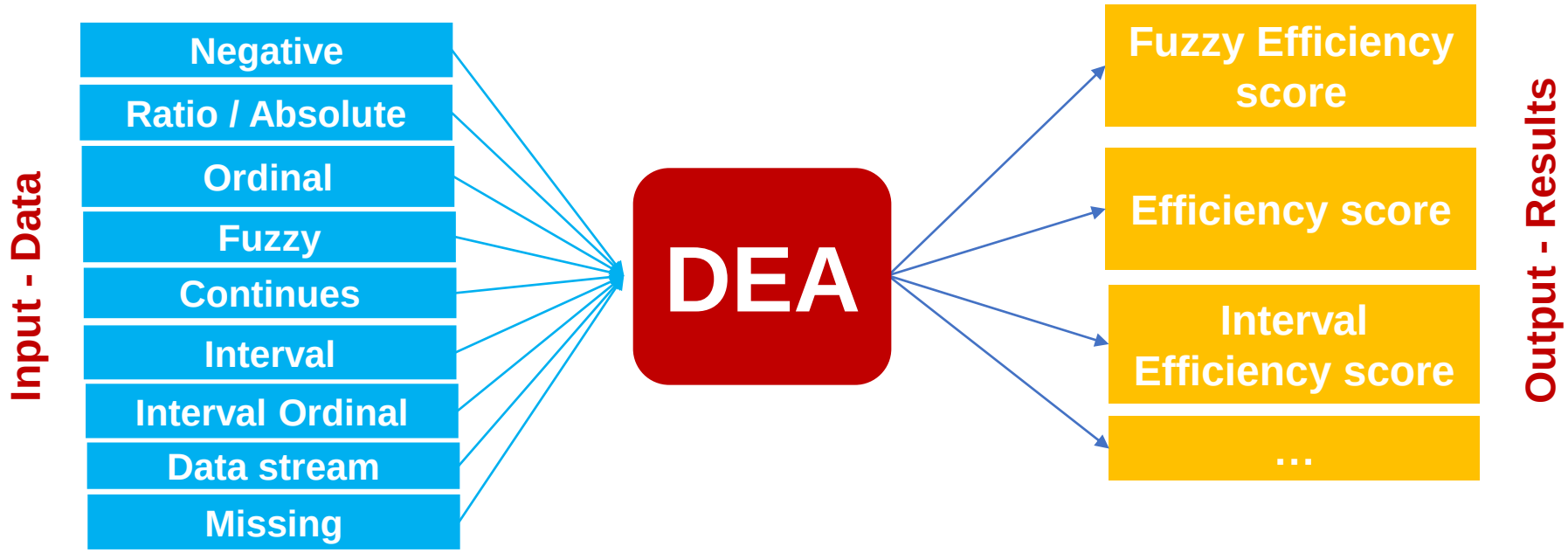
In recent years there has been an exponential growth in the number of publications relate applications of Data Envelopment Analysis (DEA). Charnes, Cooper, and Rhodes (1978) intı a tool for measuring efficiency and productivity of decision making units. DEA has imı recognized as a modern tool for performance measurement. Since then, a large and consic of articles has been appeared, including significant breakthroughs in theory and a great pı on DEA applications, both public and private sectors, to assess the efficiency and produ activities. Although there have been several bibliographic collections reported, a compreh and listing of DEA-related articles covering its first four decades of history is still missi thus, aims to report an extensive listing of DEA-related articles including theory and mı velopments and "real" applications in diversified scenarios from 1978 to end of 2016. S statistics of the publications' growth, the most utilized academic journals, authorship ana keywords analysis are also provided.

© 2017 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

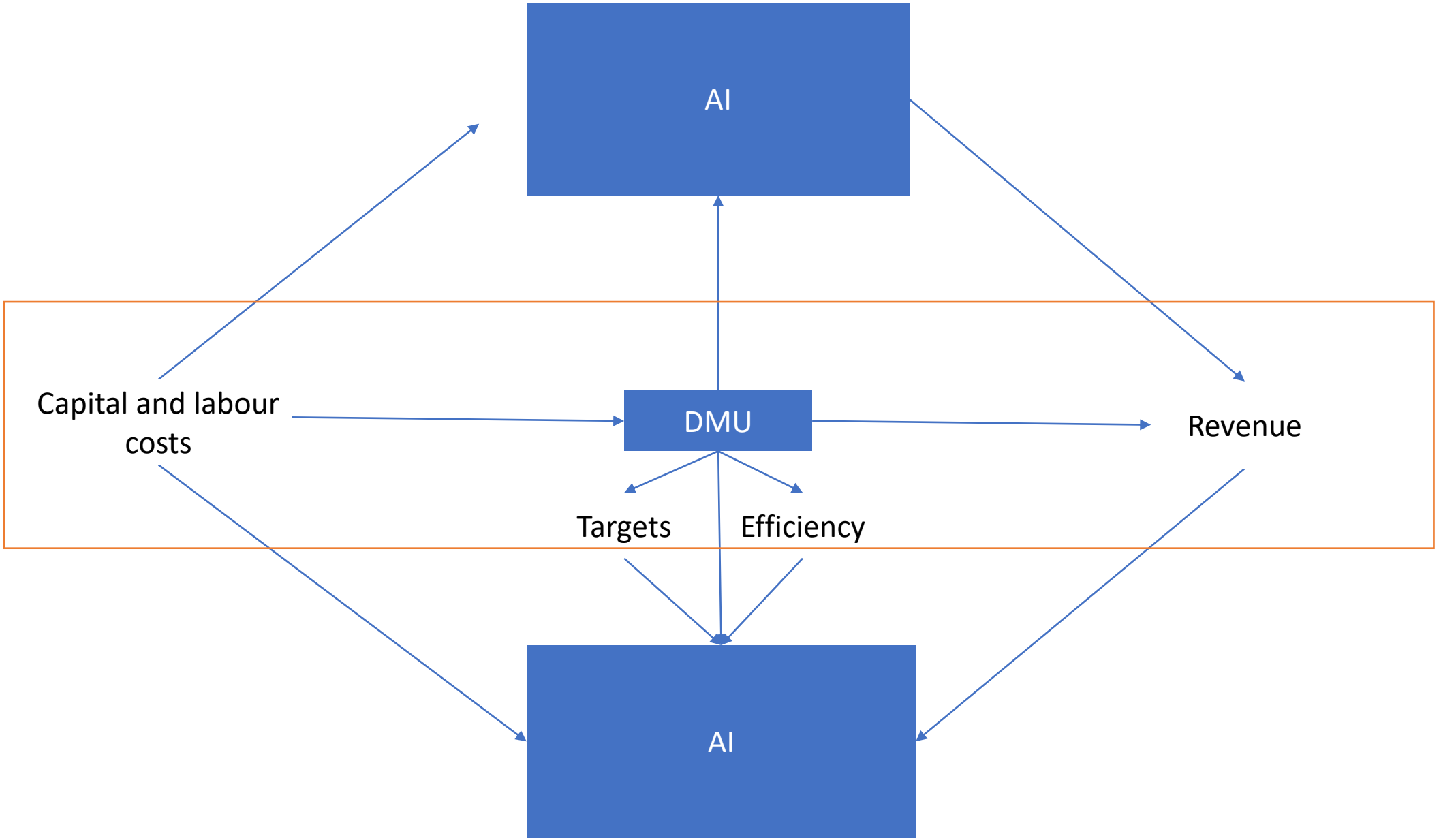
1. Ab Rahim, R., Does competition foster efficiency? Empirical evidence from Malaysian commercial banks. *Asian Academy of Management Journal of Accounting and Finance*, 2016. **12**(1): p. 1-23.
2. Abankina, I., F. Aleskerov, V. Belousova, L. Gokhberg, S. Kiselgof, V. Petrushchenko, S. Shvydun and K. Zinkovsky, From equality to diversity: Classifying Russian universities in a performance oriented system. *Technological Forecasting and Social Change*, 2016. **103**: p. 228-239.
3. Abbas, M., T. Azid and M.H.A. Hj Besar, Efficiency, effectiveness and performance profile of Islamic and conventional banks in Pakistan. *Humanomics*, 2016. **32**(1): p. 2-18.

10297. Lewin, A.Y., R.C. Morey and T.J. Cook, Evaluating the administrative efficiency of courts. *Omega*, 1982. **10**(4): p. 401-411.
10298. Banker, R.D., A. Charnes, W.W. Cooper and A.P. Schinnar, BI-EXTREMAL PRINCIPLE FOR FRONTIER ESTIMATION AND EFFICIENCY EVALUATIONS. *Management Science*, 1981. **27**(12): p. 1370-1382.
10299. Charnes, A. and W.W. Cooper, Auditing and accounting for program efficiency and management efficiency in not-for-profit entities. *Accounting, Organizations and Society*, 1980. **5**(1): p. 87-107.
10300. Charnes, A., W.W. Cooper and E. Rhodes, Measuring the efficiency of decision making units. *European Journal of Operational Research*, 1978. **2**(6): p. 429-444.

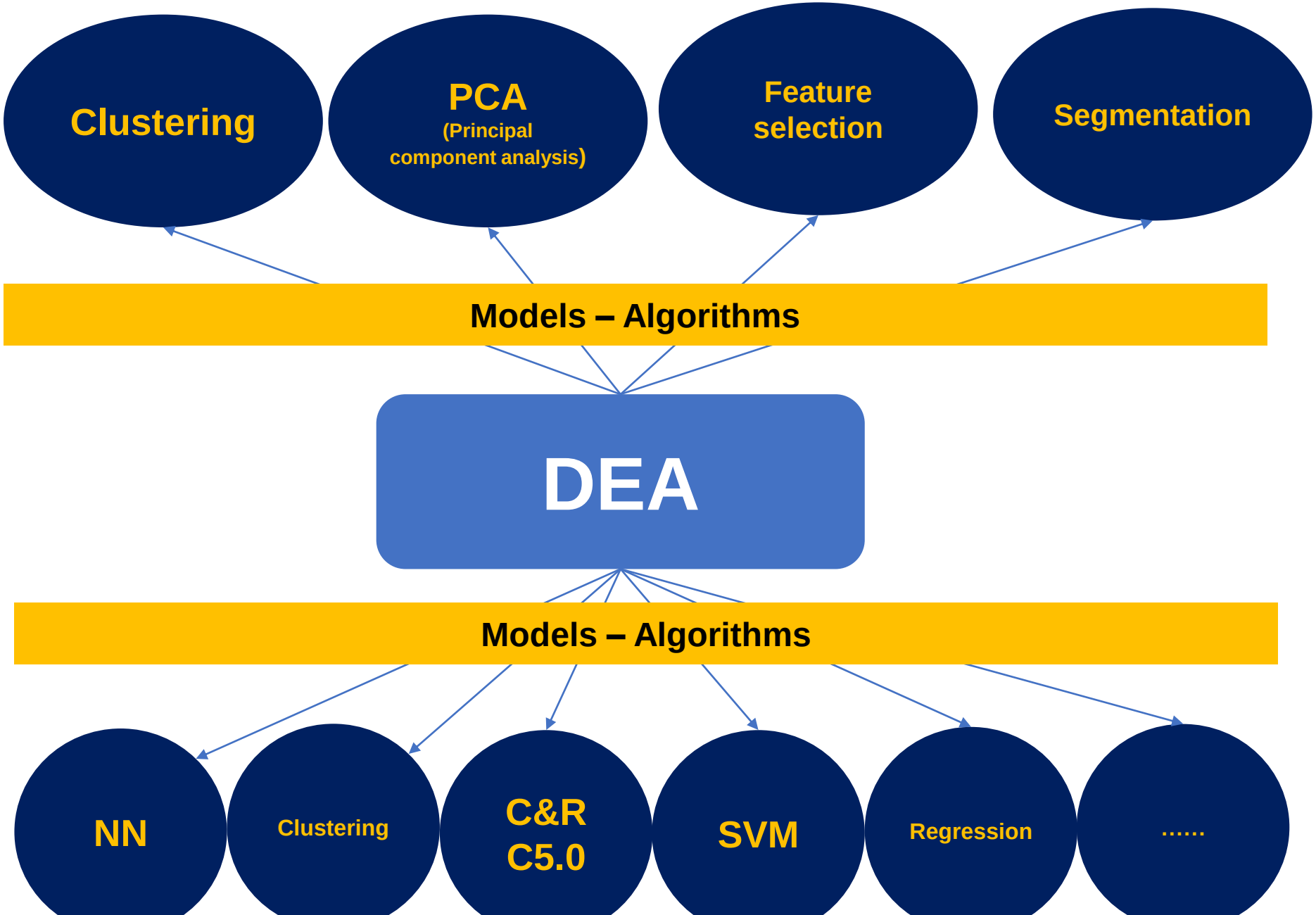
AI / ML / DM


Input - Data
Negative
Ratio / Absolute
Ordinal
Fuzzy
Continues
Interval
Interval Ordinal
Data stream
Missing
DEA
Fuzzy Efficiency score
Efficiency score
Interval Efficiency score
...
Output - Results

AI / ML (training a model) - DEA



DEA / AI


Clustering
PCA
(Principal component analysis)
Feature selection
Segmentation
Models – Algorithms
DEA
Models – Algorithms
NN
Clustering
C&R C5.0
SVM
Regression
……

AI / ML / DEA

- (2022) A Genetic Algorithm for Solving Bus Terminal Location Problem Using Data Envelopment Analysis with Multi-objective Programming. ***Annals of Operations Research***, **309**, pages259–276.

- (2021) A combined machine learning algorithms and DEA method for measuring and predicting the efficiency of Chinese manufacturing listed companies, ***Journal of Management Science and Engineering***, **6 (4)**: 435-448.

- (2021) Fuzzy Clustering of Homogeneous Decision Making Units with Common Weights in Data Envelopment Analysis, ***Journal of Intelligent & Fuzzy Systems***, **40 (1)**: 813-832.

- (2018) Finding the optimal combination of power plants alternatives: a multi response Taguchi-neural network using TOPSIS and fuzzy best-worst method, ***Journal of Cleaner Production***, (**203**): 210-223.

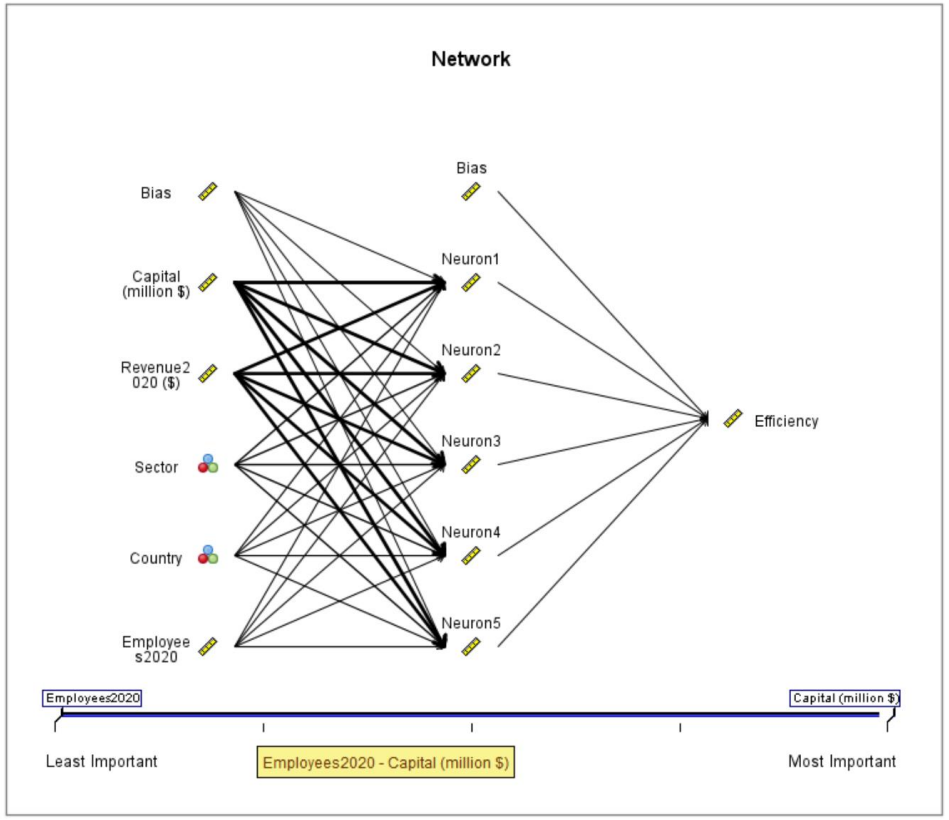
- (2015) Evaluation efficiency of large-scale data set with negative data: an artificial neural network approach, ***Journal of Supercomputing***, **71(7)**: 2397-2411**.**

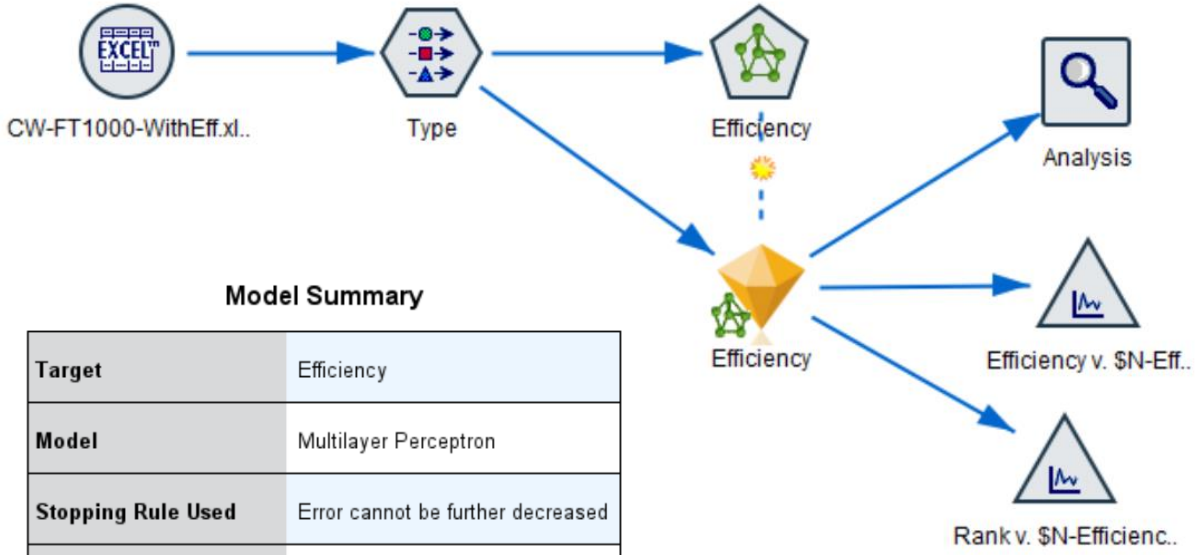
- (2014), Neural Network DEA for Measuring the Efficiency of Mutual Funds, ***International Journal of Applied Decision Sciences***, **7 (3)**: 255-269.

- (2010). Data Envelopment Analysis with classification and regression tree - A case of banking efficiency. ***Expert Systems,* 27(4)**: 231-246.

- (2009). A combined neural network and DEA for measuring efficiency of large scale datasets. ***Computers and Industrial Engineering,* 56(1)**: 249-254.

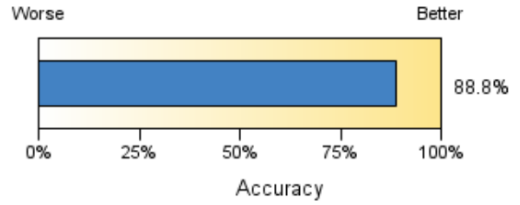
AI / ML / DEA / FT1000 Case study



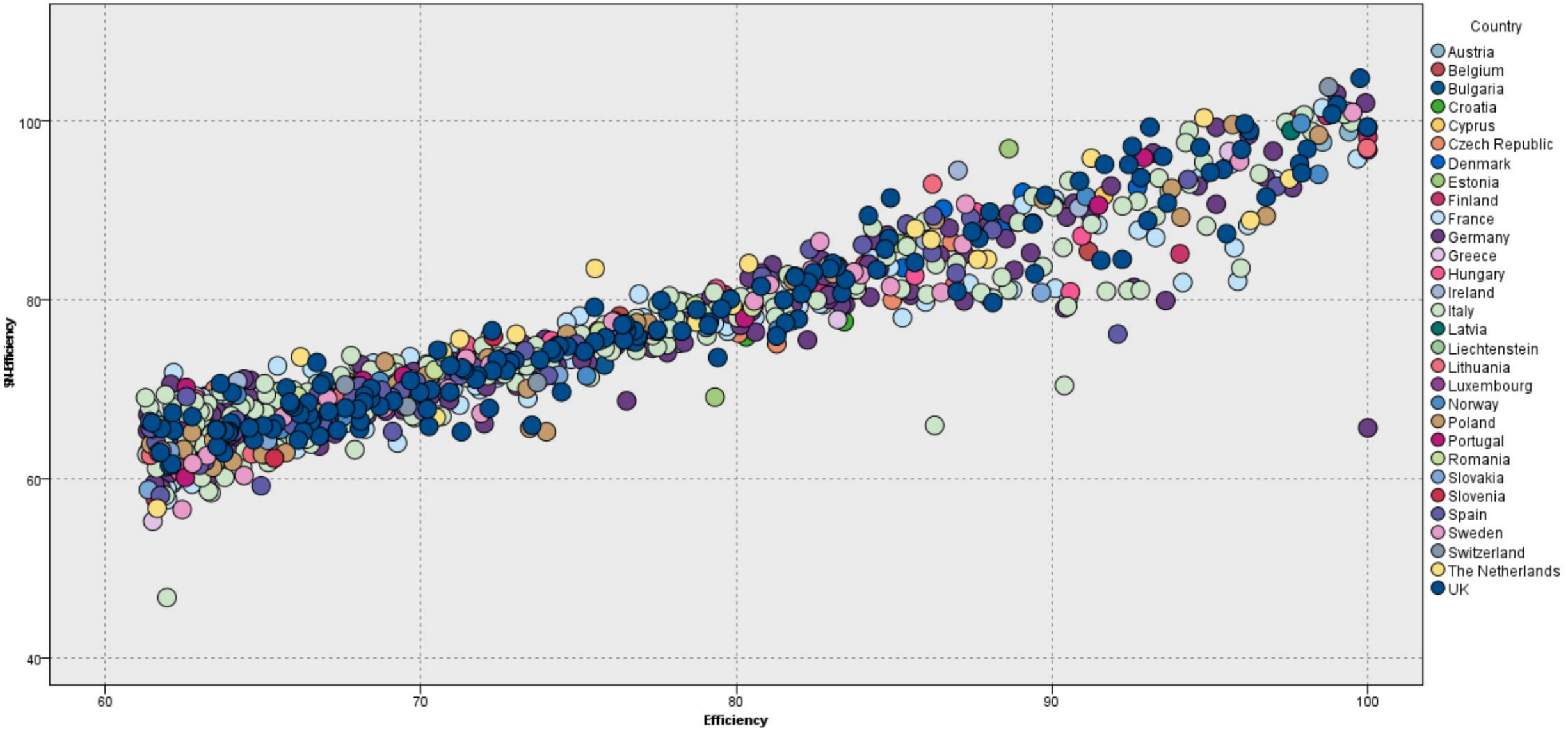


Model Summary

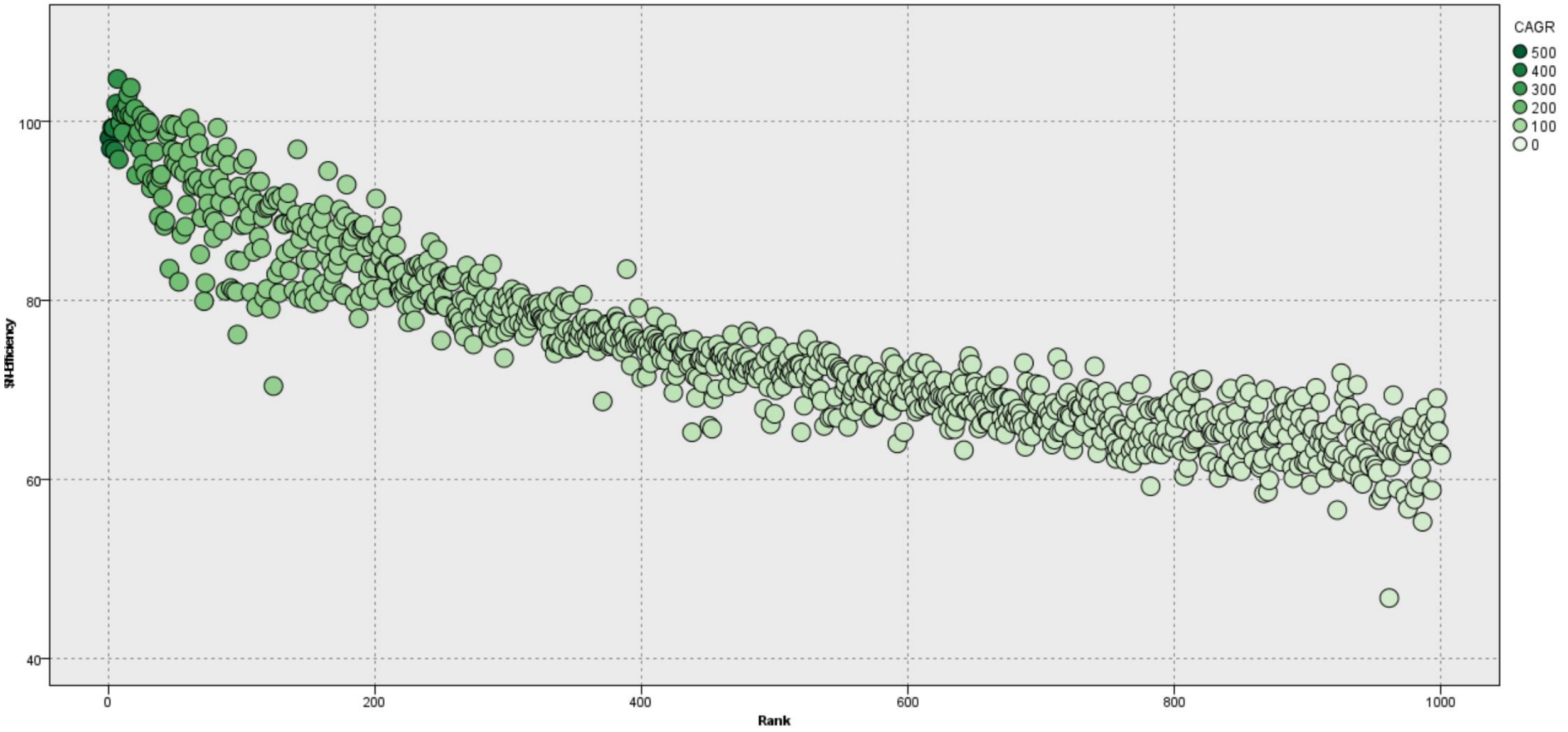
Target	Efficiency
Model	Multilayer Perceptron
Stopping Rule Used	Error cannot be further decreased
Hidden Layer 1 Neurons	5



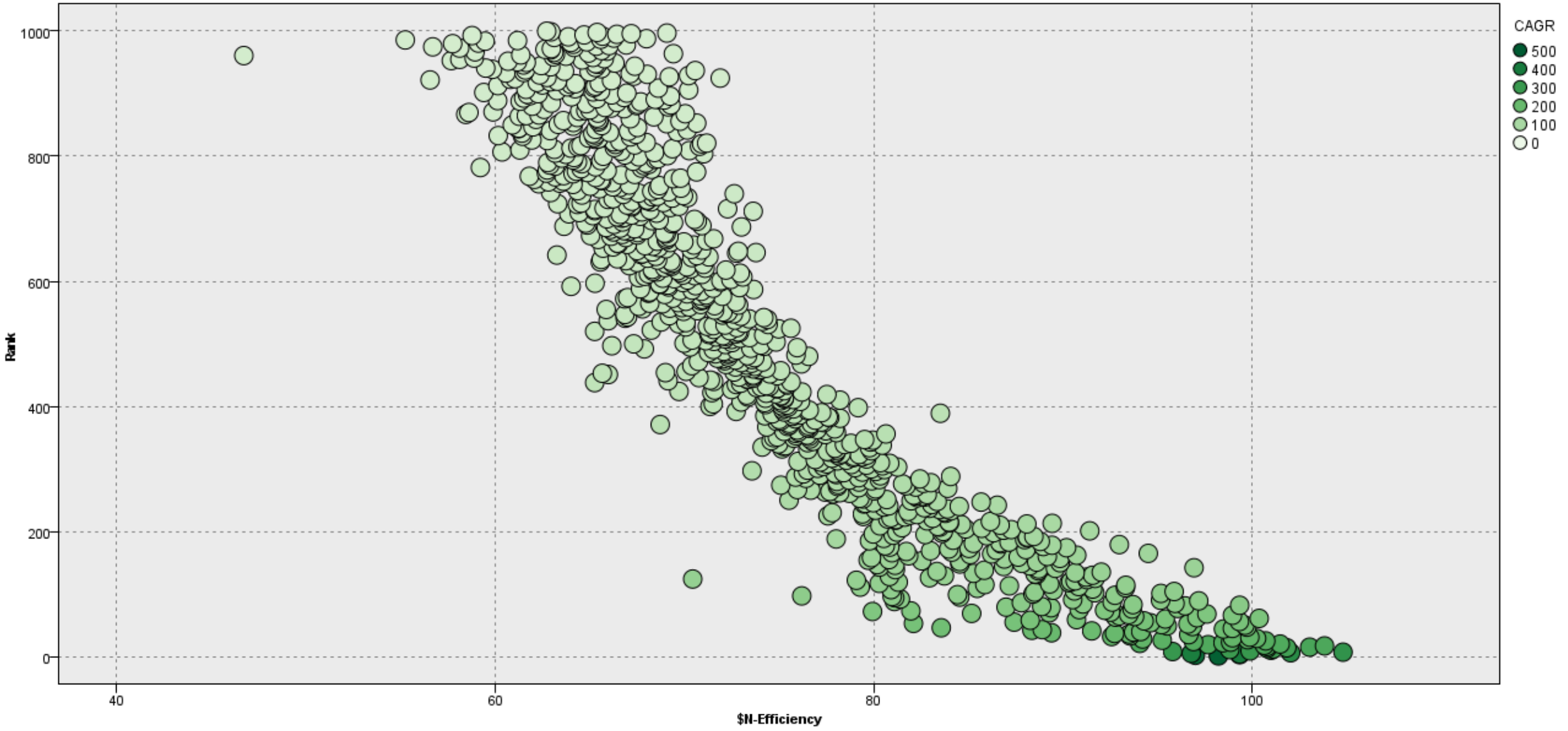
AI / ML / DEA / FT1000 Case study



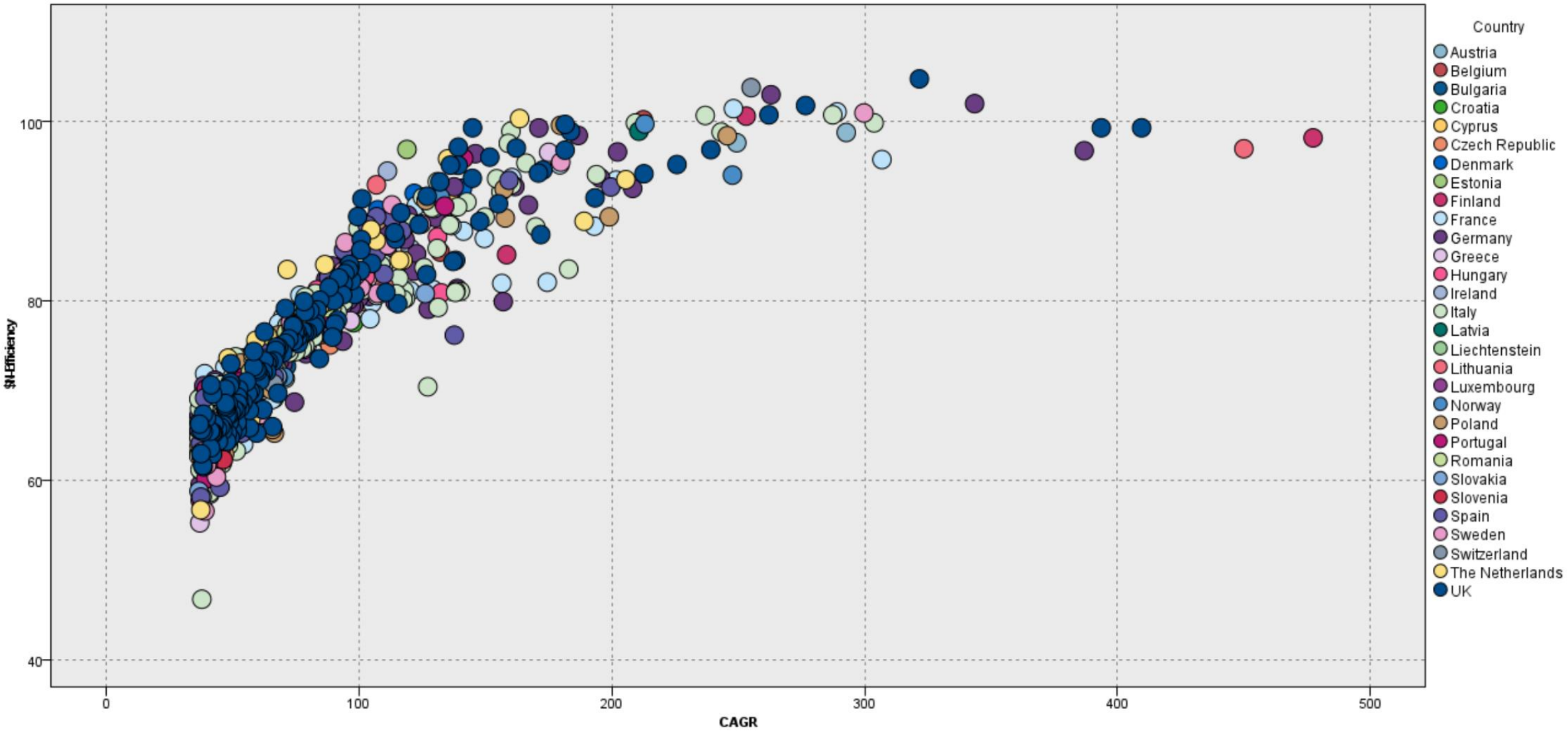
AI / ML / DEA / FT1000 Case study



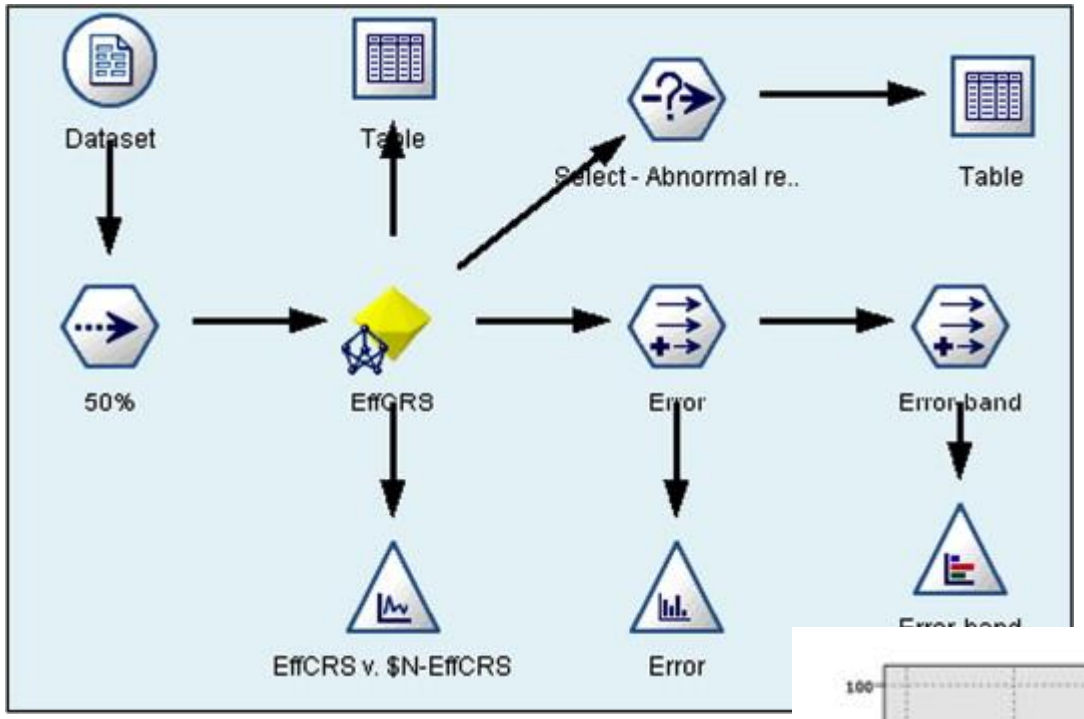
AI / ML / DEA / FT1000 Case study

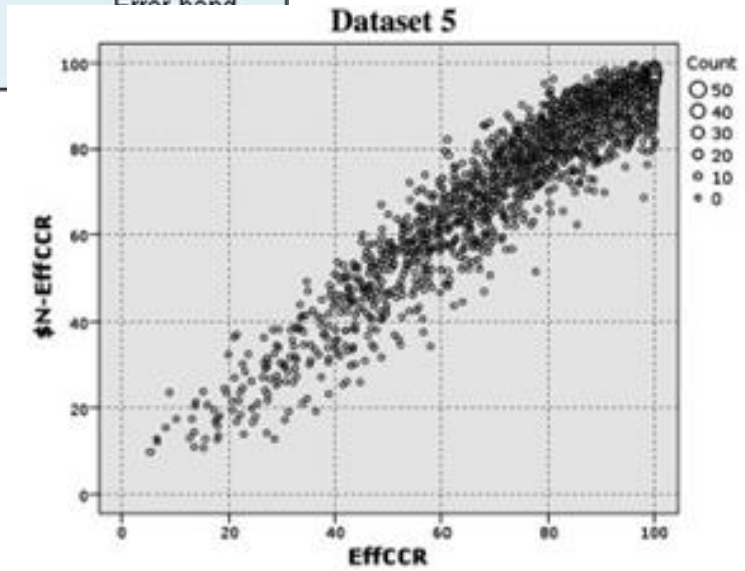


AI / ML / DEA / FT1000 Case study



AI / ML / DEA / Banking Case study





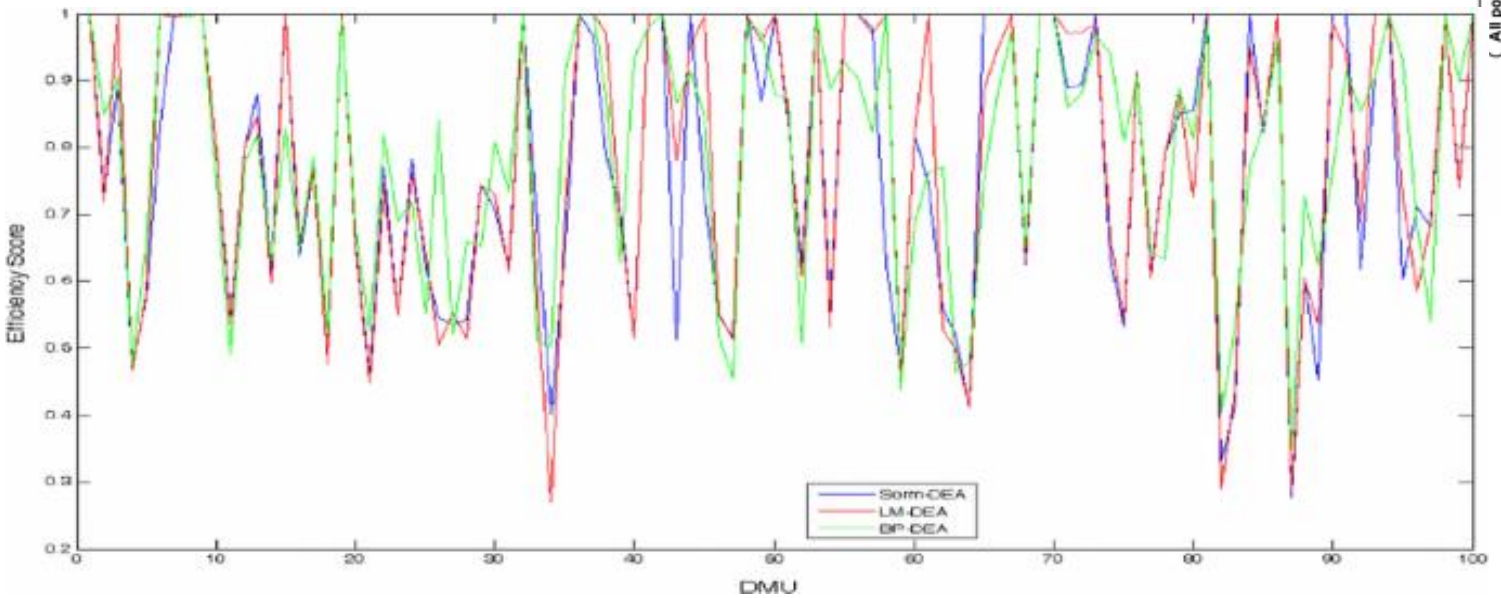
Back-propagation DEA algorithm

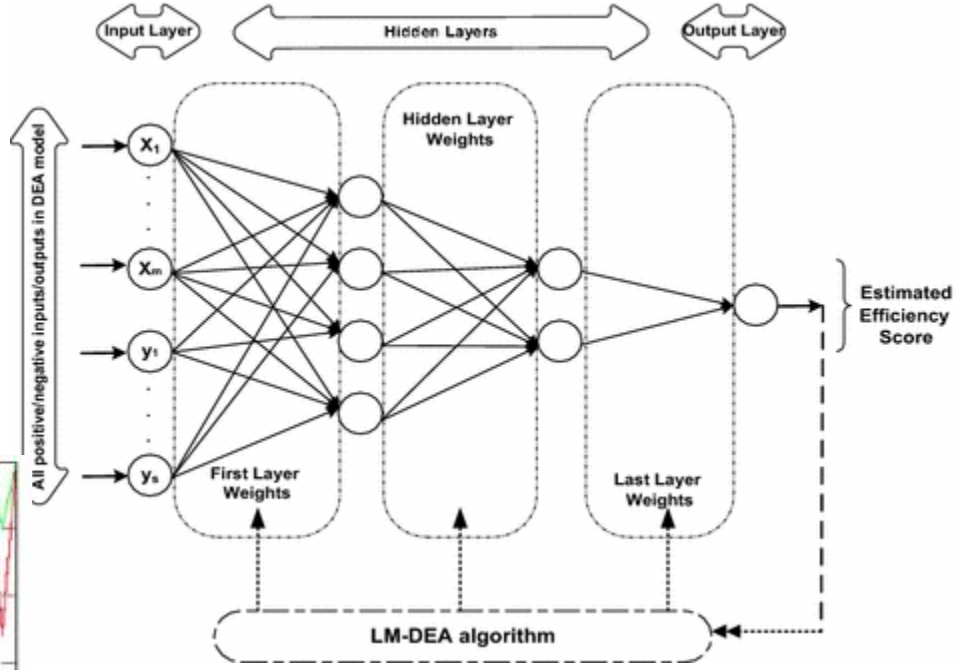
1) Initialize all weights // usually to small random numbers //
2) While terminating condition is not satisfied {
3) For each training sample of DMUs in samples
{
4) For each hidden layer neuron j
{
// note that for resource variables $x_1 \ldots x_n$ and
// outcome variables $y_1 \ldots y_n$ the $O_k = I_k$, θ_k is bias //
5) $I_j = \sum_i w_{ij} O_j + \theta_j$
6) $O_j = 1/(1+e^{-I_j})^{-1}$;
}
7) $Err_j = DEAeff_j (1 - DEAeff_j) (ESTeff_j - DEAeff_j)$
// $DEAeff_j$ is the efficiency as obtain from DEA
// $ESTeff_j$ is the efficiency as estimated by neural network
8) For each unit j in the hidden layers
9) $Err_j = O_j(1 - O_j) \sum_k Err_k w_{jk}$;
10) For each weight w_{ij} in network
{
11) $\Delta w_{ij} = (l)\ Err_j \times O_j$;
12) $w_{ij} = w_{ij} + \Delta w_{ij}$;
}
13) For each bias θ_j in network
{
14) $\Delta \theta_j = (l)\ Err_j$
15) $\theta_j = \theta_j + \Delta \theta_j$;
}
16) }
17) }

AI / ML / DEA / Banking Case study

LM-DEA algorithm

0. Initialize the weights and parameters μ *and* $0 < \beta < 1$. (we suggest $\mu = 0.01,\ \beta = 0.1$)
1. while *terminating condition is not satisfied*
2. For *each training sample of DMUs is samples*
3. *compute MSE*
4. *solve* $F(W) = E^T E$.
5. *solve* $\Delta W = [J^T J + \mu I]^{-1} J^T E$
6. while $(F(W + \Delta W) \geq F(W))$
7. $\mu = \frac{\mu}{\beta}$
8. $\Delta W = [J^T J + \mu I]^{-1} J^T E$
9. $W = W + \Delta W$
10. endwhile
11. $\mu = \mu\beta$
12. endfor
13. endwhile





Levenberg–Marquardt (LM) algorithm as faster back propagation (FBP)

AI / ML / DEA / Banking Case study

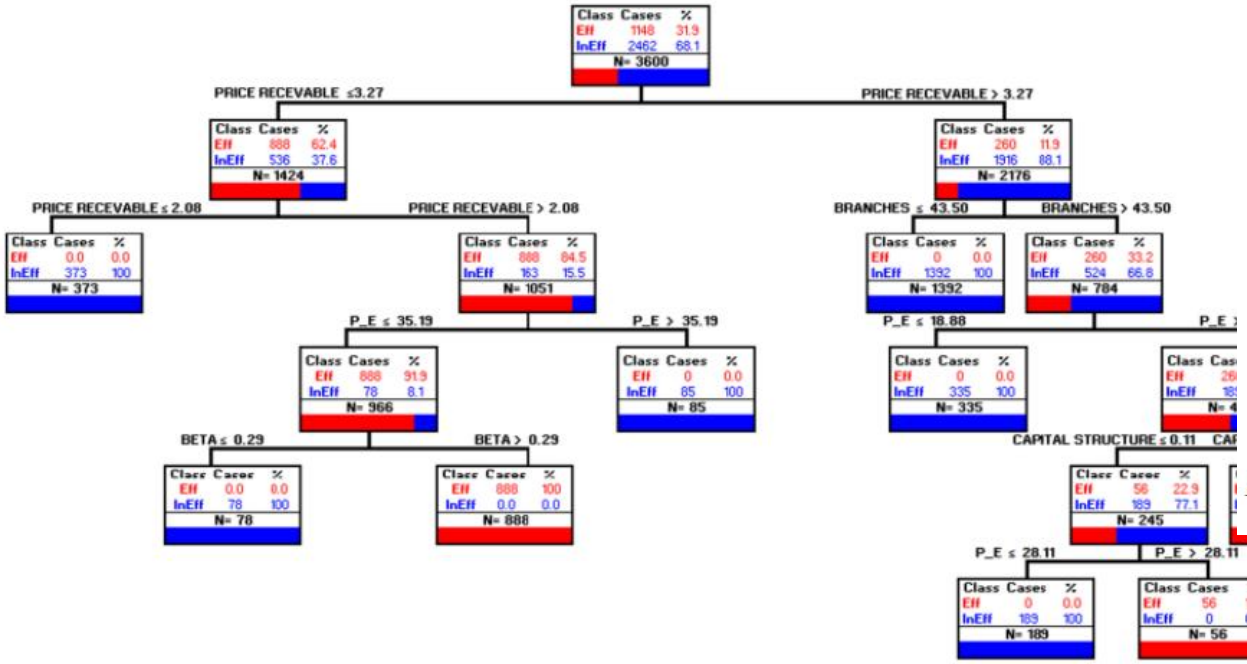
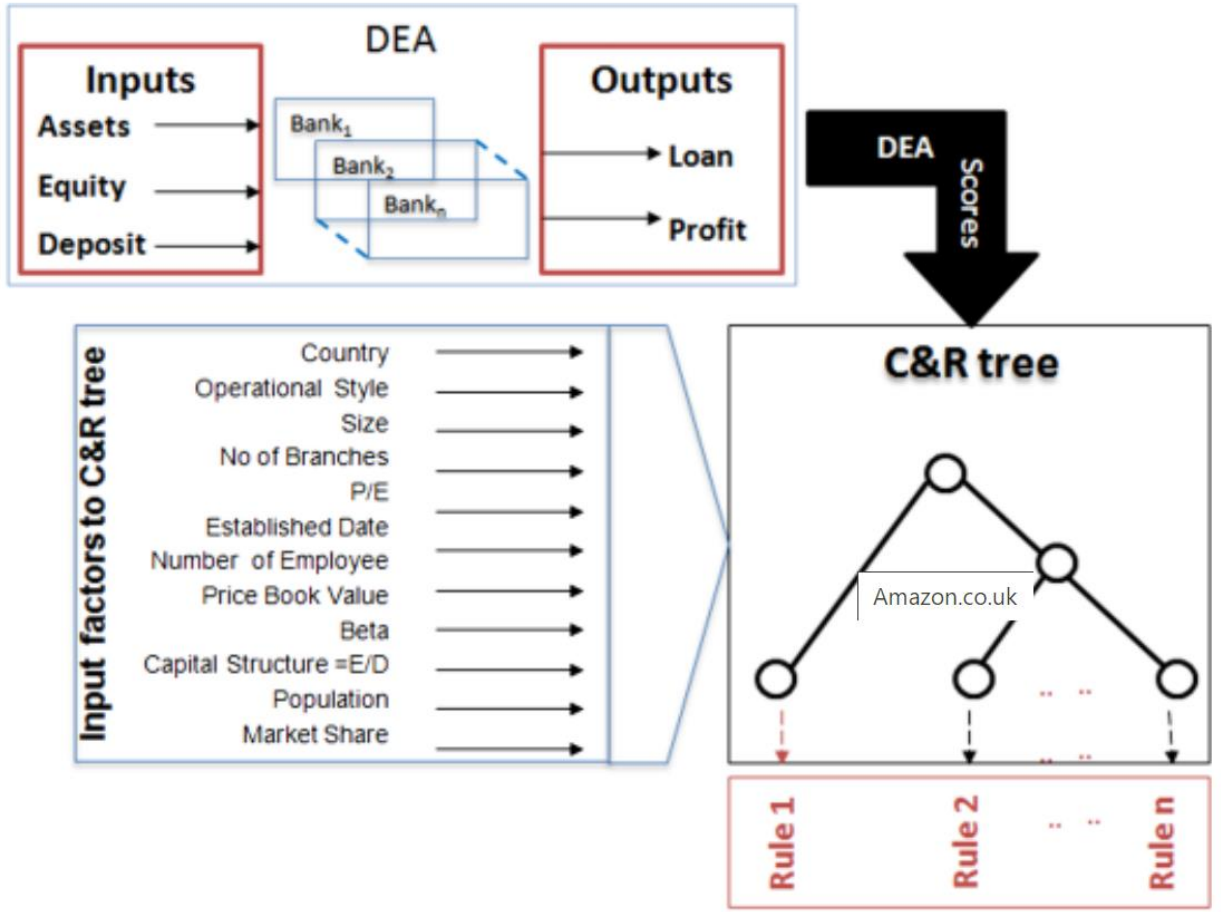
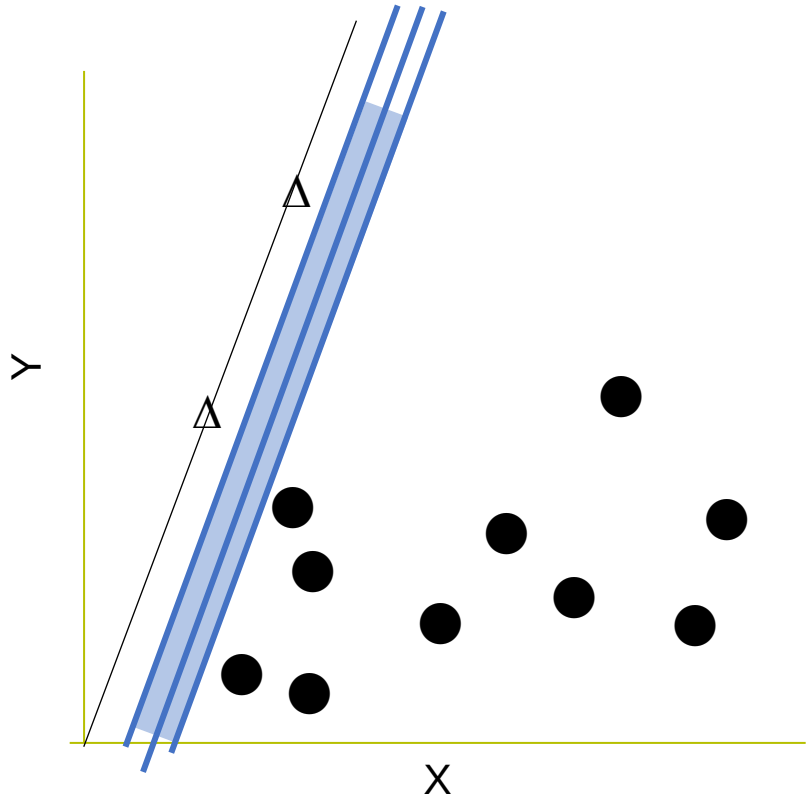


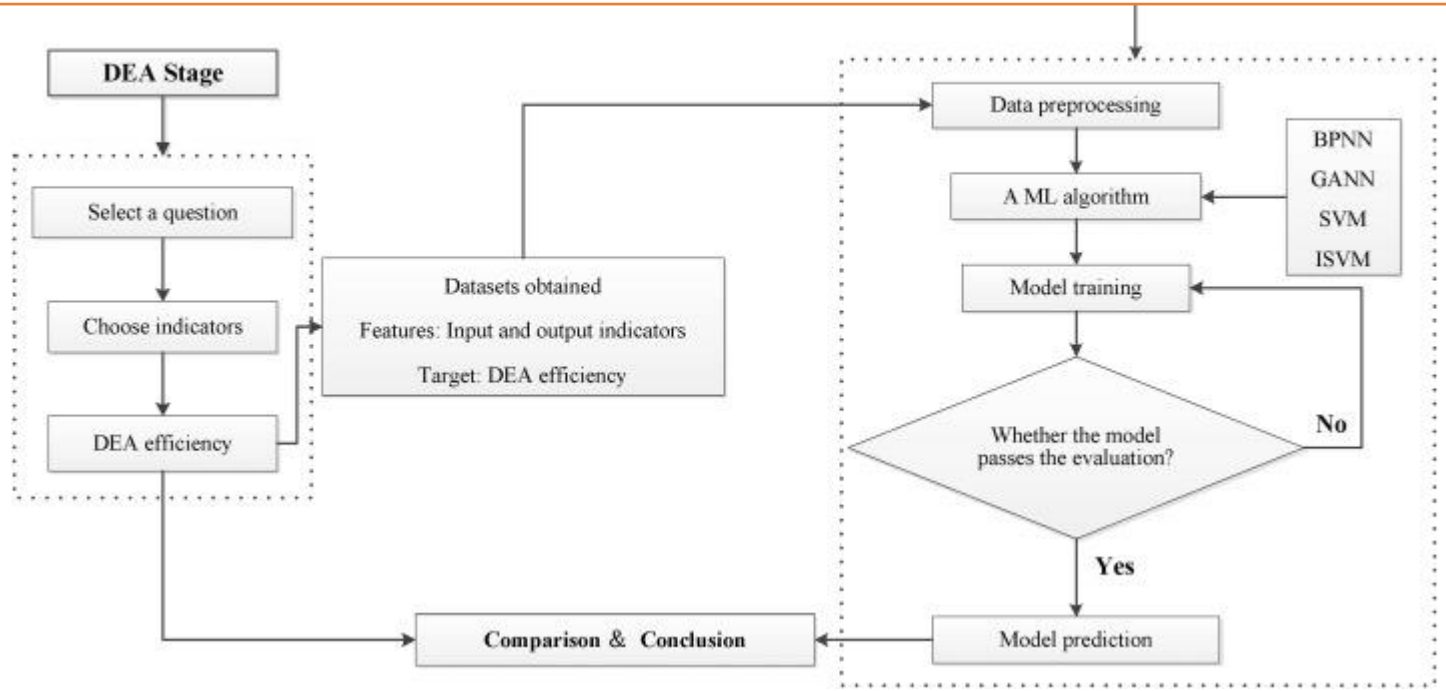
Figure 8: *C&R tree for GCC commercial banks.*

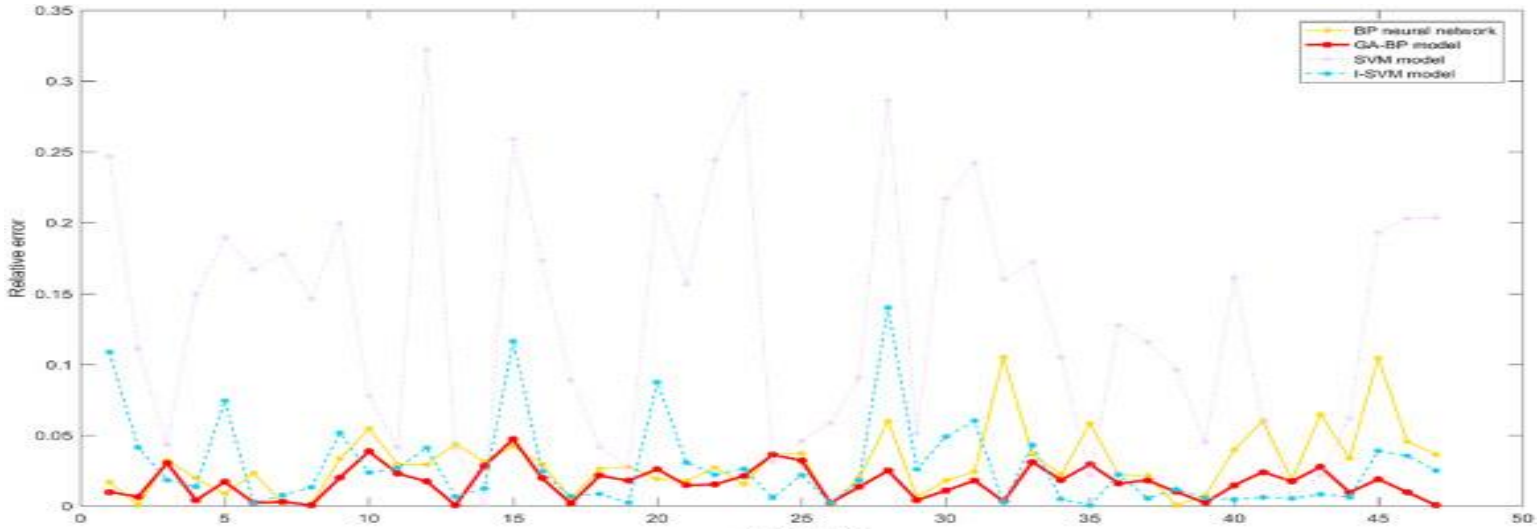


DEA/C&R methodology for assessing GCC commercial banks.

AI / ML / DEA / SVM/ Banking Case study



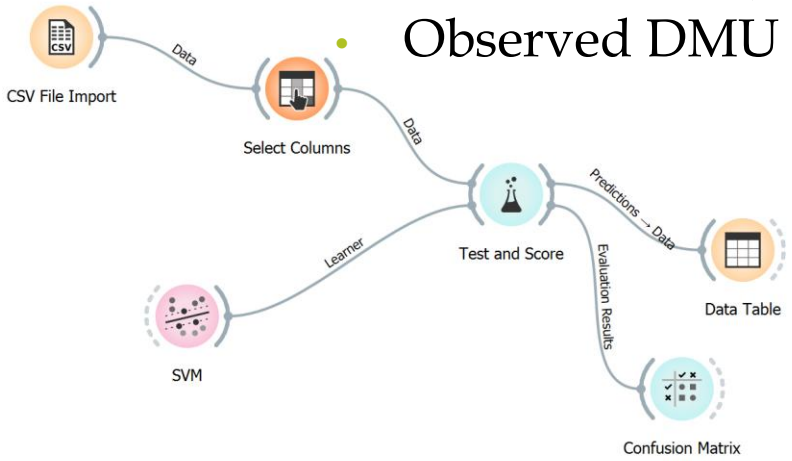




AI / ML / DEA / SVM classification

Predict: Efficient (Yes, No)

- Observed DMU (Efficient, No)

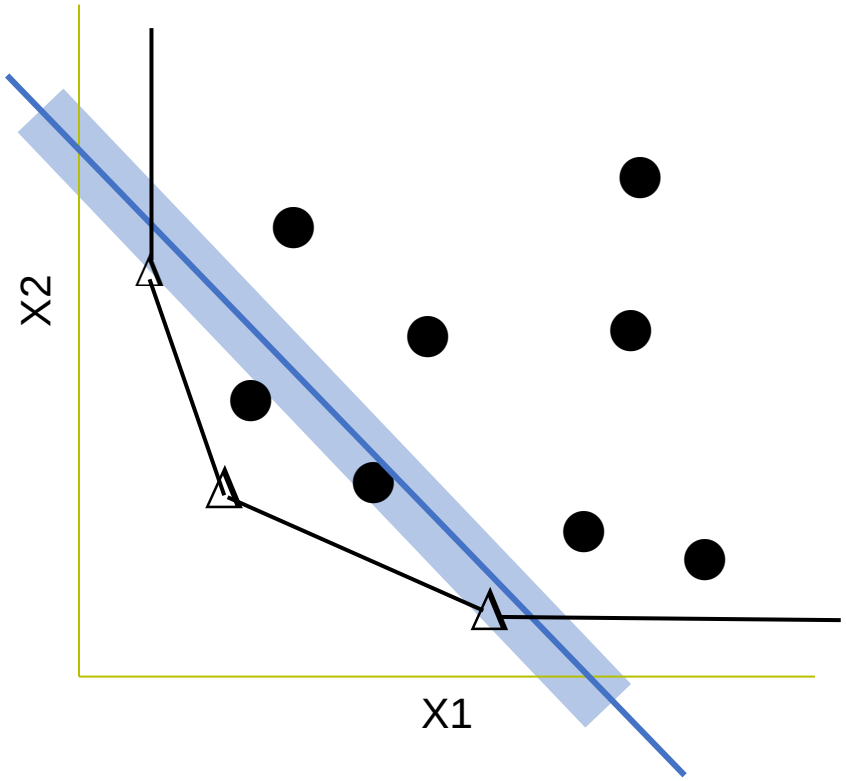


$$\text{minimize } L(\mathbf{w}) = \|\mathbf{w}\|^2 / 2$$

subject to:

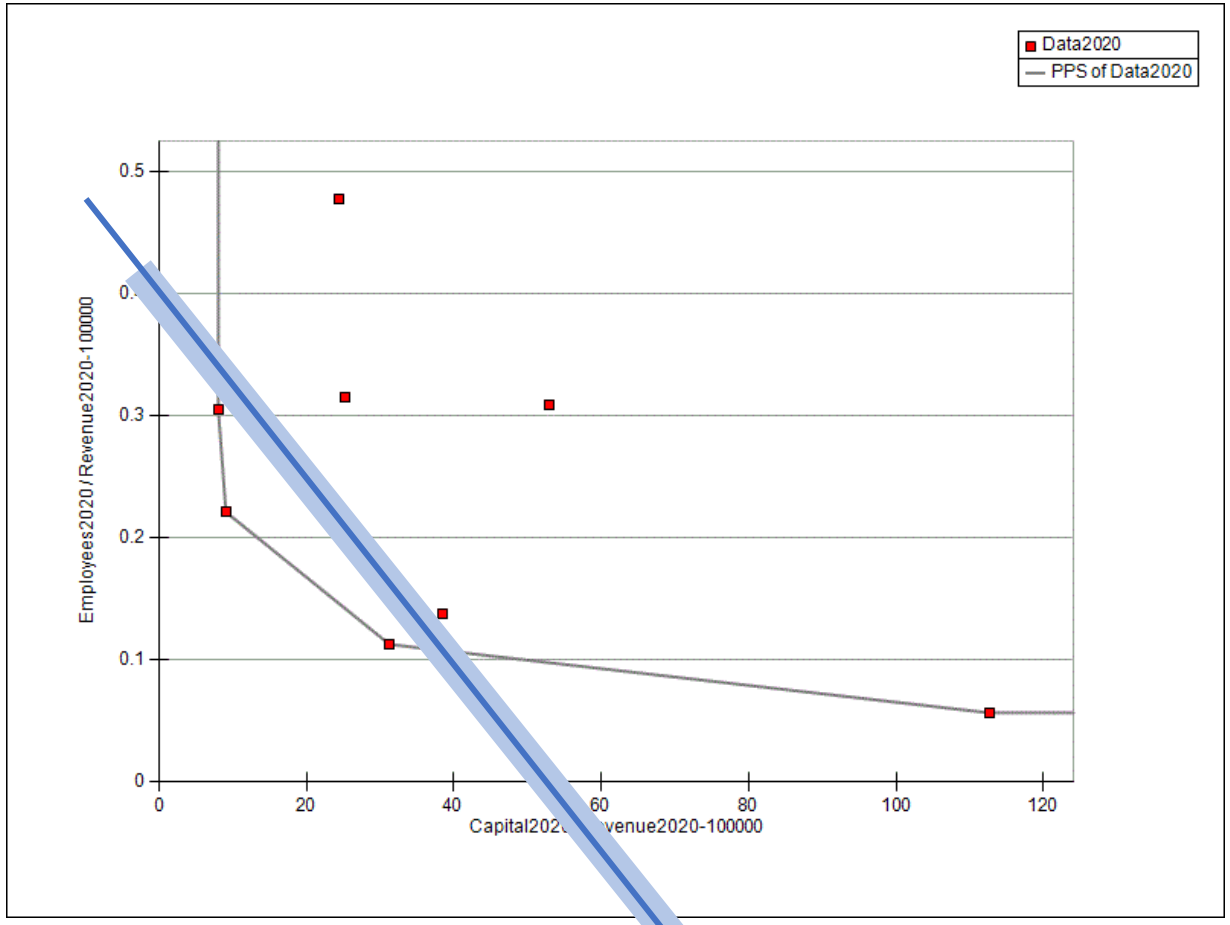
$w_1 x_{i1} + w_2 x_{i2} + b \geq +1$ for $i \in$ **eff**

$w_1 x_{i1} + w_2 x_{i2} + b \leq -1$ for $i \in$ **n-eff**



AI / ML / DEA / SVM classification

"Support vectors" are those points that lie on the boundaries of the margin:



Non-separable case: there is no line separating errorlessly the two groups
Here, SVM **minimize** $L(\mathbf{w},C)$:

$$L(\mathbf{w},C) = \|\mathbf{w}\|^2/2 + C\sum_i \xi_i$$

maximize the margin — **minimize** the training errors

$L(\boldsymbol{w},C)$ = Complexity + Errors

subject to:

$w_1 x_{i1} + w_2 x_{i2} + b \geq +1 - \xi_i$ for $i \in \Delta$

$w_1 x_{i1} + w_2 x_{i2} + b \leq -1 + \xi_i$ for $j \in$ ●

$\xi_{I,j} \geq 0$

Conclusion

In conclusion, **AI-driven DEA** is a game-changer for businesses seeking to unlock their full potential.
By harnessing the power of artificial intelligence, organizations can **measure and predict performance** with unprecedented **accuracy and efficiency**.

osts Acdmy Travel Grant MSCBA Aston Conf Books Software ClimateChange Jrnals Jobs My BgData Biblio-Sources » Other

Search

International Conference on Data Envelopment Analysis

CENTRE FOR BUSINESS ANALYTICS IN PRACTICE
UNIVERSITY OF SURREY

DEA 45

SURREY BUSINESS SCHOOL
UNIVERSITY OF SURREY

September 4-6, 2023, University of Surrey, Guildford, UK

Call for Papers

Dear Colleagues,

We have the great pleasure of inviting you to participate in the **DEA45: International Conference on Data Envelopment Analysis** that will take place on **September 4-6, 2023** and will be hosted by Centre for Business Analytics in Practice at Surrey Business School, University of Surrey Guildford, UK.

UNIVERSITY OF SURREY

DEA 45

CLICK HERE to submit your paper (title & abstract).

https://dataenvelopment.com/dea45/

https://www.sharjah.ac.ae/en/Media/Conferences/ICBAP/Pages/default.aspx

Travel | Grant | MSCBA | Aston | Conf | Books | Software | ClimateChange | Jrnals | Jobs | My | BgData | Biblio-Sources

DATE:
JAN. 8-11 2024

PLACE:
UNIVERSITY OF SHARJAH

Register →

https://www.sharjah.ac.ae/en/Media/Conferences/ICBAP/

Call for papers: IMA Journal of Management Mathematics – Special Issue: “Leveraging Business Analytics and AI in Consumer Behaviour Analysis”

By admin

Call for papers

Guest Editors

Ali Emrouznejad, Professor and Chair in Business Analytics, Director, Centre for Business Analytics in Practice, Surrey Business School, Guildford, UK

Panagiotis (Panos) Zervopoulos, Associate Professor, College of Business Administration, University of Sharjah, Sharjah, UAE

John Rice, *Professor and Director of the DBA Program*, College of Business Administration, University of Sharjah, Sharjah, UAE

Call for papers: Socio-Economic Planning Sciences – Special Issue: “Analytical Models and AI for Sustainable Development: Enhancing Decision-Making”

By a_emrouz

Call for papers

Guest Editors

Ali Emrouznejad, Professor and Chair in Business Analytics, Director, Centre for Business Analytics in Practice, Surrey Business School, Guildford, UK

Dima Rachid Jamali, Professor and Dean of the College of Business Administration at the University of Sharjah, Sharjah, UAE

Panagiotis (Panos) Zervopoulos, Associate Professor, College of Business Administration, University of Sharjah, Sharjah, UAE

Call for papers: Environmental Science and Policy; Special issue on “DEA-based index systems for addressing the United Nations’ SDGs”

Guest editors:

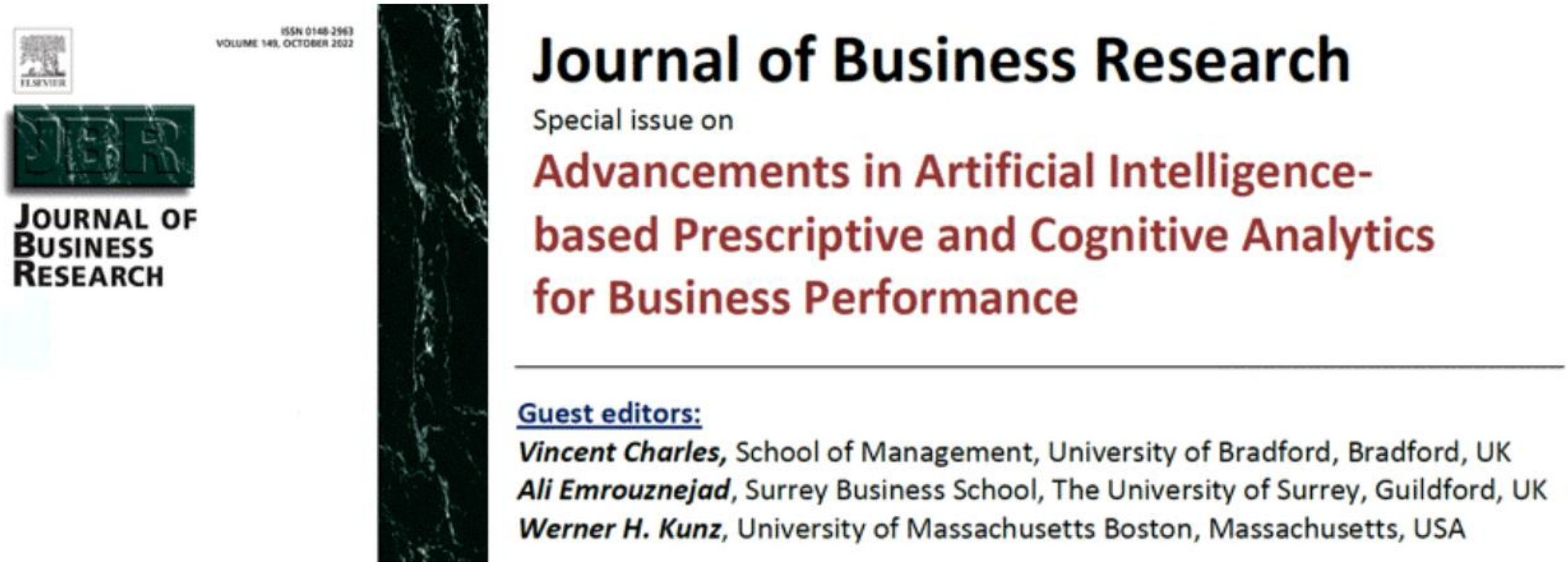
Vincent Charles,
School of Management, University of Bradford, Bradford, UK,

Ali Emrouznejad,
Centre for Business Analytics in Practice, Surrey Business School,
The University of Surrey, Guildford, UK

Guest editors:

Vincent Charles, School of Management, University of Bradford, Bradford, UK,
Ali Emrouznejad, Surrey Business School, The University of Surrey, Guildford, UK
Werner H. Kunz, University of Massachusetts Boston, Massachusetts, USA

Call for papers



Annals of Operations Research Special Issue: Transparent and Responsible Artificial Intelligence: Implications for Operations Research

Guest Editors

Ali Emrouznejad, Surrey Business School, University of Surrey, UK
Soumyadeb Chowdhury, TBS Business School, Toulouse, France

?

Ali Emrouznejad

Professor and Chair in Business Analytics

Director, Centre for Business Analytics in Practice

Surrey Business School, University of Surrey

UK