OIE 548 (Performance Analytics)

Final Project: DEA-Based Optimization of Loan Conversion Strategies at Nationwide Bank Branches

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Problem Statement:

Nationwide Bank in India has witnessed a promising opportunity to grow its personal loan business after a successful campaign with a conversion rate of over 9%. To further capitalize on this potential, the bank's management is keen to enhance its marketing strategies to convert more liability customers into loan customers, while maintaining a cost-effective approach.

This project seeks to analyze the performance of 25 different branches of a Nationwide Bank, such as MetroBank, CapitalBank, and CityBank, among others, using Data Envelopment Analysis (DEA). The dataset for this study taken from the https://www.kaggle.com/ which includes inputs like the number of employees, branch budget, and marketing spend, and outputs like the number of loans approved and the total loan amount in dollars.

By employing DEA models, we aim to determine the efficiency of each branch in utilizing its resources to achieve high loan conversion rates. The results will guide Nationwide bank in identifying best practices and allocating marketing budgets more effectively to maximize loan conversions across all branches.

Dataset Description:

The dataset contains performance indicators for 25 branches of a Nationwide bank, a proxy for real-life banking institutions with multiple branches across a country. Each entry represents key metrics for evaluating the branch's effectiveness in converting liability customers into loan customers while maintaining cost efficiency.

Inputs:

- **NumberOfEmployees:** Reflects the human resources available at the branch to handle operations and customer engagement, which can influence the success of loan conversion.
- **BranchBudget ($000):** Indicates the financial resources allocated to a branch for all its operations, a factor that can impact the capacity to process and approve loans.
- **MarketingSpend ($000):** Represents the investment made towards marketing efforts to attract potential loan customers, crucial for the success of conversion campaigns.

Outputs:

- **LoansApproved (count):** The number of loans approved by the branch, serving as a direct indicator of the success of loan conversion strategies.
- **TotalLoanAmount ($000):** The cumulative dollar amount of loans distributed, reflecting the financial impact of the branch's loan approval performance.
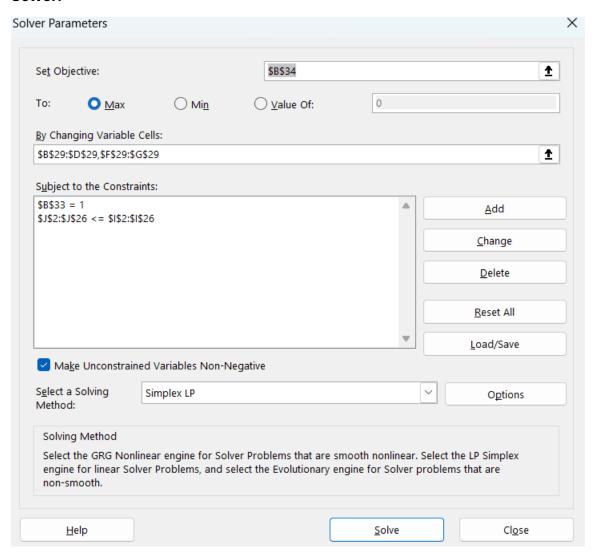
Models Used:

These models will help in determining the best practices across the branches and suggest where improvements can be made:

- **Multiplier Model (Input Oriented):** Evaluates how inputs can be adjusted to improve the branch's efficiency.
- **Multiplier Model (Output Oriented):** Focuses on maximizing outputs given the current level of inputs.
- **Envelopment Model (Input Oriented):** Assesses the proportion by which inputs can be reduced without affecting the output levels.
- **Envelopment Model (Output Oriented):** Looks at how much outputs can be increased without altering the inputs.
- **Envelopment Model (Input Oriented - Super Efficiency):** Identifies branches that are performing exceptionally well beyond the efficient frontier.
- **Envelopment Model (Output Oriented - Super Efficiency):** Determines the potential of branches to surpass the efficient frontier in their output generation.

Multiplier Model (Input Oriented)

Model:

Branch	NumberOfEmployees	BranchBudget ($000)	MarketingSpend ($000)	LoansApproved (count)	TotalLoanAmount ($000)	Weighted Category I	Weighted Category II	DEA Score
MetroBank	15	500	75	120	1500	1.071428571	0.794930876	0.74193548
CapitalBank	20	650	95	200	2500	1.428571429	1.324884793	0.92741935
CityBank	12	400	60	90	1200	0.857142857	0.6359447	0.74193548
HarborBank	18	550	80	140	1800	1.285714286	0.953917051	0.74193548
RiverBank	22	700	100	230	2900	1.571428571	1.536866359	0.97800587
CentralBank	17	450	65	110	1400	1.214285714	0.741935484	0.6994034
PacificBank	19	600	85	190	2400	1.357142857	1.271889401	0.93718166
SummitBank	16	500	70	150	2000	1.142857143	1.059907834	0.93046033
TownBank	14	420	55	100	1600	1	0.847926267	0.92363902
UnionBank	21	650	90	210	2700	1.5	1.430875576	0.96218905
PeakBank	13	470	75	130	1650	0.928571429	0.874423963	0.94168734
ValleyBank	20	530	82	175	2200	1.428571429	1.165898618	0.91052952
LakeBank	23	680	102	250	3100	1.642857143	1.642857143	1
CoastalBank	15	490	68	105	1750	1.071428571	0.927419355	0.8655914
ForestBank	18	570	77	145	1950	1.285714286	1.033410138	0.8107221
HillBank	22	610	88	200	2600	1.571428571	1.377880184	0.95642155
WindyBank	16	440	60	115	1850	1.142857143	0.980414747	0.97862319
StarBank	19	520	73	160	2300	1.357142857	1.218894009	1
SunriseBank	21	660	89	215	2800	1.5	1.483870968	1
RainbowBank	13	410	58	95	1550	0.928571429	0.821428571	0.88461538
MoonBank	24	720	105	240	3000	1.714285714	1.589861751	0.9347548
CometBank	17	500	69	120	1900	1.214285714	1.006912442	0.87617739
PlanetBank	15	430	61	110	1700	1.071428571	0.900921659	0.8937027
GalaxyBank	20	560	79	180	2150	1.428571429	1.139400922	0.92962025
NovaBank	14	450	63	100	1600	1	0.847926267	0.84792627

| Weight/Multiplier | 0.071428571 | 0 | 0 | | 0 | 0.000529954 | | |

Bank Under Consideration	25
Weighted category I	1
Weighted Catgory II	0.847926267

Solver:

Solver Parameters ✕

Set Objective: $B$34

To: ● Max ○ Min ○ Value Of: 0

By Changing Variable Cells:

$B$29:$D$29,$F$29:$G$29

Subject to the Constraints:

$B$33 = 1
$J$2:$J$26 <= $I$2:$I$26

[Add] [Change] [Delete] [Reset All] [Load/Save]

☑ Make Unconstrained Variables Non-Negative

Select a Solving Method: Simplex LP [Options]

Solving Method

Select the GRG Nonlinear engine for Solver Problems that are smooth nonlinear. Select the LP Simplex engine for linear Solver Problems, and select the Evolutionary engine for Solver problems that are non-smooth.

[Help] [Solve] [Close]

VBA Code:

```vba
Sub DEA()
'Declare DUMNo as integer. This DumNo represents the Branch under
'consideration. In the example, DUMNo goes from 1 to 25
    Dim DUMNo As Integer
    For DUMNo = 1 To 25
'set the value of cell B28 equal to DUMNo (1,2,..., 25)
    Range("B32") = DUMNo
'Run the Solver model. The UserFinish is set to True so that
'the Solver Results dialog box will not be shown
    SolverSolve UserFinish:=True
'Place the best ratio into column L
    Range("L" & DUMNo + 1) = Range("B34")
Next DUMNo
End Sub
```

Results and Analysis:

Using the Multiplier Input Oriented DEA Model to analyze Nationwide Bank's branch efficiencies, we've discerned a varied performance landscape. Standout branches like LakeBank and StarBank achieved DEA scores of 1, indicating optimal resource usage to maximize loan approvals and amounts. In contrast, lower scores at branches like CityBank suggest opportunities to elevate their efficiency through better allocation of employees, budget, and marketing spend.

The weighted categories shed light on the influence of each input and output, with marketing expenditure and total loan amount frequently carrying more weight, suggesting these are key to a branch's successful performance.
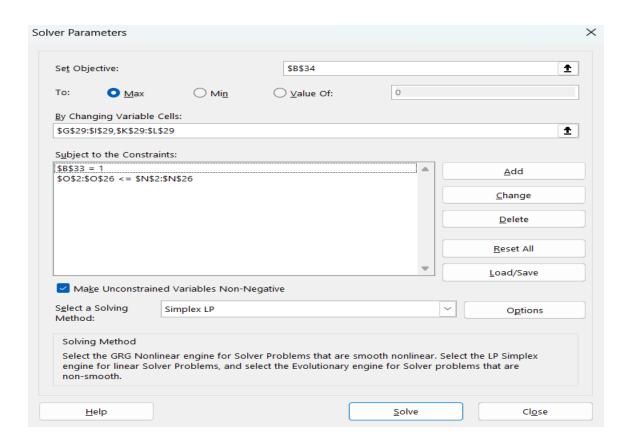
In summary, this DEA model has effectively benchmarked branch performance, providing a clear direction for resource optimization and strategic improvement within Nationwide Bank.

Multiplier Model (Improvement in the Input Oriented Model):

Model used:

Branch	NumberOfEmployees	BranchBudget ($000)	MarketingSpend ($000)	DEA Score	NumberOfEmployees(New)	BranchBudget ($000)(New)	MarketingSpend ($000)(New)	LoansApproved (count)	TotalLoanAmount ($000)	Weighted Category I	Weighted Category II	DEA Score Improved
MetroBank	15	500	75	0.741935484	11	371	56	120	1500	0.9375	0.9375	
CapitalBank	20	650	95	0.927419355	19	603	88	200	2500	1.5625	1.5625	1
CityBank	12	400	60	0.741935484	9	297	45	90	1200	0.75	0.75	1
HarborBank	18	550	80	0.741935484	13	408	59	140	1800	1.125	1.125	1
RiverBank	22	700	100	0.978005865	22	685	98	230	2300	1.8125	1.8125	1
CentralBank	17	450	65	0.699403396	12	315	45	110	1400	1.001591276	0.875	1
PacificBank	19	600	85	0.937181664	18	562	80	190	2400	1.5	1.5	1
SummitBank	16	500	70	0.930460333	15	465	65	150	2000	1.25409871	1.25	1
TownBank	14	420	55	0.923639021	13	388	51	100	1600	1.089291677	1	1
UnionBank1	21	650	90	0.962189055	20	625	87	210	2700	1.702133055	1.6875	1
PeakBank	13	470	75	0.941687345	12	443	71	130	1650	1.03125	1.03125	1
ValleyBank	20	530	82	0.910529519	18	483	75	175	2200	1.534044299	1.375	1
LakeBank	23	680	102	1	23	680	102	250	3100	1.9375	1.9375	1
CoastalBank	15	490	68	0.865591398	13	424	59	105	1750	1.09375	1.09375	1
ForestBank	18	570	77	0.810722101	15	462	62	145	1950	1.229301446	1.21875	1
HillBank	22	610	88	0.956421552	21	583	84	200	2600	1.772498637	1.625	1
WindyBank	16	440	60	0.978623188	16	431	59	115	1850	1.319013863	1.5625	1
StarBank	19	520	73	1	19	520	73	160	2300	1.600543478	1.4375	1
SunriseBank	21	660	89	1	21	660	89	215	2800	1.769021739	1.75	1
RainbowBank	13	410	58	0.88615385	12	363	51	95	1550	0.96875	0.96875	1
MoonBank	24	720	105	0.934754797	22	673	98	240	3000	1.889830351	1.875	1
CometBank	17	500	69	0.876177394	15	438	60	120	1900	1.25474317	1.1875	1
PlanetBank	15	430	61	0.893702696	13	384	55	110	1700	1.129271069	1.0625	1
GalaxyBank	20	560	79	0.929620253	19	521	73	180	2150	1.566208035	1.34375	1
NovaBank	14	450	63	0.847926267	12	382	53	100	1600	1	1	1
Weight/Multiplier	0	0	0		0.08423913	0	3.79037E-16	0	0.000625			

Bank Under Consideration	25
Weighted category I	1
Weighted Category II	1

Solver Used:

Solver Parameters

Set Objective: $B$34

To: ● Max ○ Min ○ Value Of: 0

By Changing Variable Cells:
$G$29:$I$29,$K$29:$L$29

Subject to the Constraints:
$B$33 = 1
$O$2:$O$26 <= $N$2:$N$26

[Add] [Change] [Delete] [Reset All] [Load/Save]

☑ Make Unconstrained Variables Non-Negative

Select a Solving Method: Simplex LP [Options]

Solving Method
Select the GRG Nonlinear engine for Solver Problems that are smooth nonlinear. Select the LP Simplex engine for linear Solver Problems, and select the Evolutionary engine for Solver problems that are non-smooth.

[Help] [Solve] [Close]

VBA Code:

```
Sub DEA()
'Declare DUMNo as integer. This DumNo represents the Branch under
'consideration. In the example, DUMNo goes from 1 to 25
    Dim DUMNo As Integer
    For DUMNo = 1 To 25
'set the value of cell B32 equal to DUMNo (1,2,..., 25)
    Range("B32") = DUMNo
'Run the Solver model. The UserFinish is set to True so that
'the Solver Results dialog box will not be shown
    SolverSolve UserFinish:=True
'Place the best ratio into column Q
    Range("Q" & DUMNo + 1) = Range("B34")
Next DUMNo
End Sub
```

Results and Analysis:

Employing from the Multiplier Input Oriented Model to Nationwide Bank's branch data has offered valuable insights into the efficiency of their loan conversion processes. Upon examining the updated DEA scores and weighted inputs, we can see significant potential for optimization across several branches.

For instance, taking a closer look at MetroBank, with an original DEA score of 0.747, we observe:

Original Inputs:

Number of Employees: 15

Branch Budget: $500,000

Marketing Spend: $75,000

Original Outputs:

Loans Approved: 120

Total Loan Amount: $1,500,000

Improved Inputs after applying the DEA score:

Number of Employees (New): Approx. 11

Branch Budget (New): Approx. $374,000
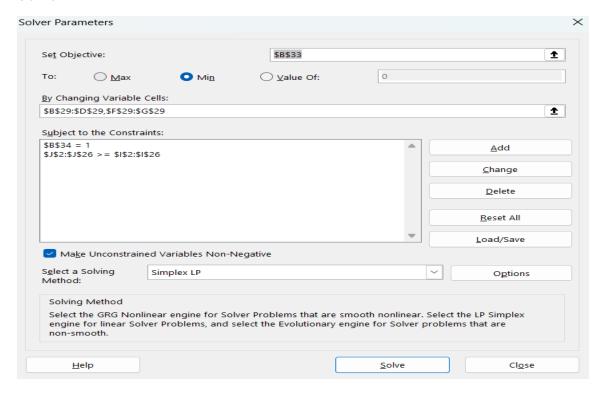
Marketing Spend (New): Approx. $56,000

The DEA score of 0.747 for MetroBank indicates that this branch could reduce its input levels by about 25.3% to achieve the efficiency frontier.

In conclusion, the Multiplier Input Oriented Model analysis underscores the opportunity for Nationwide Bank to refine its resource allocation, particularly in terms of staffing and budgeting, to boost the loan conversion efficiency across its branches.

Multiplier Model (Output Oriented)

Model:

Branch	NumberOfEmployees	BranchBudget ($000)	MarketingSpend ($000)		LoansApproved (count)	TotalLoanAmount ($000)		Weighted Category I	Weighted Category II		DEA Score
MetroBank	15	500	75		120	1500		0	0.9375		1
CapitalBank	20	650	95		200	2500		0	1.5625		1
CityBank	12	400	60		90	1200		0	0.75		1
HarborBank	18	550	80		140	1800		0	1.125		1
RiverBank	22	700	100		230	2900		0	1.8125		1
CentralBank	17	450	65		110	1400		0	0.875		1
PacificBank	19	600	85		190	2400		0	1.5		1
SummitBank	16	500	70		150	2000		0	1.25		1
TownBank	14	420	55		100	1600		0	1		1
UnionBank	21	650	90		210	2700		0	1.6875		1
PeakBank	13	470	75		130	1650		0	1.03125		1
ValleyBank	20	530	82		175	2200		0	1.375		1
LakeBank	23	680	102		250	3100		0	1.9375		1
CoastalBank	15	490	68		105	1750		0	1.09375		1
ForestBank	18	570	77		145	1950		0	1.21875		1
HillBank	22	610	88		200	2600		0	1.625		1
WindyBank	16	440	60		115	1850		0	1.15625		1
StarBank	19	520	73		160	2300		0	1.4375		1
SunriseBank	21	660	89		215	2800		0	1.75		1
RainbowBank	13	410	58		95	1550		0	0.96875		1
MoonBank	24	720	105		240	3000		0	1.875		1
CometBank	17	500	69		120	1900		0	1.1875		1
PlanetBank	15	430	61		110	1700		0	1.0625		1
GalaxyBank	20	560	79		180	2150		0	1.34375		1
NovaBank	14	450	63		100	1600		0	1		1
Weight/Multiplier	0	0	0		0	0.000625					

Bank Under Consideration	25
Weighted category I	0
Weighted Catgory II	1

Solver:

Solver Parameters ✕

Set Objective: $B$33

To: ○ Max ● Min ○ Value Of: 0

By Changing Variable Cells:
$B$29:$D$29,$F$29:$G$29

Subject to the Constraints:
$B$34 = 1
$J$2:$J$26 >= $I$2:$I$26

[Add] [Change] [Delete] [Reset All] [Load/Save]

☑ Make Unconstrained Variables Non-Negative

Select a Solving Method: Simplex LP   [Options]

Solving Method
Select the GRG Nonlinear engine for Solver Problems that are smooth nonlinear. Select the LP Simplex engine for linear Solver Problems, and select the Evolutionary engine for Solver problems that are non-smooth.

[Help] [Solve] [Close]

VBA Code:

```vba
Sub DEA()
'Declare DUMNo as integer. This DumNo represents the Branch under
'consideration. In the example, DUMNo goes from 1 to 25
    Dim DUMNo As Integer
    For DUMNo = 1 To 25
'set the value of cell B32 equal to DUMNo (1,2,..., 25)
    Range("B32") = DUMNo
'Run the Solver model. The UserFinish is set to True so that
'the Solver Results dialog box will not be shown
    SolverSolve UserFinish:=True
'Place the best ratio into column L
    Range("L" & DUMNo + 1) = Range("B34")
Next DUMNo
End Sub
```

Results and Analysis:

In the output-oriented multiplier model applied to Nationwide Bank's branches, the goal is to use current resources to their fullest. A DEA score of 1 indicates a branch is already as efficient as it can be in converting inputs into approved loans.
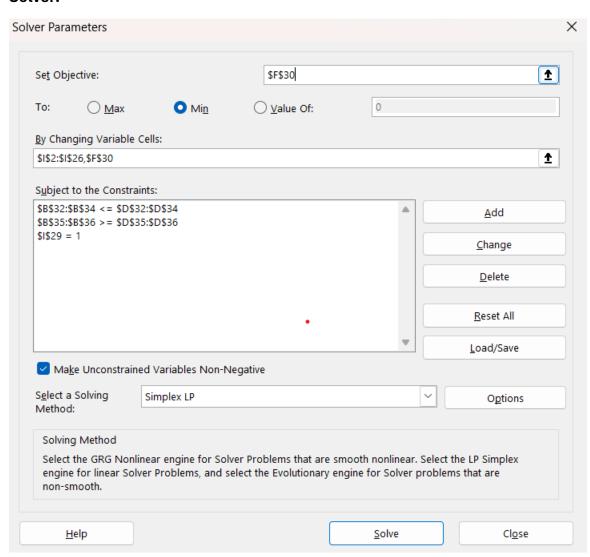
In our output-oriented multiplier DEA model for Nationwide Bank's branches, the weights assigned to each input and output measure their impact on loan approval efficiency. Here, the model gives a noticeable emphasis to Marketing Spend, implying that effective advertising is crucial for improving loan approvals. On the other hand, factors like Number of Employees and Branch Budget have minimal weights, suggesting they have less influence on a branch's performance under this model. These insights are critical for the bank to understand where to focus its efforts for maximum efficiency gains.

Envelopment Model (Input Oriented)

In this approach, we look at how each branch of Nationwide Bank can work towards improving its efficiency considering the resources it uses. The model is input-oriented, focusing on how much input each branch requires to generate the output. It's like finding out how each branch can do more with less.

Model:

Branch	NumberOfEmployees	BranchBudget ($000)	MarketingSpend ($000)	LoansApproved (count)	TotalLoanAmount ($000)	Weight Share	DEA Efficiency			Initial Weight Share
MetroBank	15	500	75	120	1500	0%	0.9017128			5%
CapitalBank	20	650	95	200	2500	0%	0.9471053			5%
CityBank	12	400	60	90	1200	0%	1			5%
HarborBank	18	550	80	140	1800	0%	0.8748514			5%
RiverBank	22	700	100	230	2900	0%	0.9827586			5%
CentralBank	17	450	65	110	1400	0%	0.9555556			0%
PacificBank	19	600	85	190	2400	0%	0.9835508			2%
SummitBank	16	500	70	150	2000	0%	1			4%
TownBank	14	420	55	100	1600	0%	1			2%
UnionBank	21	650	90	210	2700	0%	0.9780945			7%
PeakBank	13	470	75	130	1650	4%	1			12%
ValleyBank	20	530	82	175	2200	0%	1			6%
LakeBank	23	680	102	250	3100	0%	1			0%
CoastalBank	15	490	68	105	1750	0%	0.9476504			5%
ForestBank	18	570	77	145	1950	0%	0.8890609			7%
HillBank	22	610	88	200	2600	0%	0.9740731			3%
WindyBank	16	440	60	115	1850	0%	1			7%
StarBank	19	520	73	160	2300	0%	1			5%
SunriseBank	21	660	89	215	2800	4%	1			4%
RainbowBank	13	410	58	95	1550	92%	1			10%
MoonBank	24	720	105	240	3000	0%	0.9361472			1%
CometBank	17	500	69	120	1900	0%	0.928401			0%
PlanetBank	15	430	61	110	1700	0%	1			0%
GalaxyBank	20	560	79	180	2150	0%	1			0%
NovaBank	14	450	63	100	1600	0%	0.9495895			0%

Sum of Weight Shares						100%	
DMU Under Evaluation	25			Performance Score			
Virtual DMU				0.949589491			
Number of Employees	13.29425287 <=		13.29425287				
Branch Budget	421.6091954 <=		427.3152709				
Marketing Spend	59.82413793 <=		59.82413793				
Loans Approved	100.8218391 >=		100				
Total Loan Amount	1600 >=		1600				

Solver:

Solver Parameters   ✕

Set Objective: $F$30

To: ○ Max   ● Min   ○ Value Of: 0

By Changing Variable Cells:
$I$2:$I$26,$F$30

Subject to the Constraints:
```
$B$32:$B$34 <= $D$32:$D$34
$B$35:$B$36 >= $D$35:$D$36
$I$29 = 1
```

Add
Change
Delete
Reset All
Load/Save

☑ Make Unconstrained Variables Non-Negative

Select a Solving Method: Simplex LP   Options

Solving Method

Select the GRG Nonlinear engine for Solver Problems that are smooth nonlinear. Select the LP Simplex engine for linear Solver Problems, and select the Evolutionary engine for Solver problems that are non-smooth.

Help   Solve   Close

VBA Code:

```vba
Sub DEA()
'Declare DUMNo as integer. This DumNo represents the Branch under
'consideration. In the example, DUMNo goes from 1 to 25
    Dim DUMNo As Integer
    For DUMNo = 1 To 25
'set the value of cell B30 equal to DUMNo (1,2,..., 25)
    Range("B30") = DUMNo
'Run the Solver model. The UserFinish is set to True so that
'the Solver Results dialog box will not be shown
    SolverSolve UserFinish:=True
'Place the best ratio into column K
    Range("K" & DUMNo + 1) = Range("F30")
Next DUMNo
End Sub
```

Results and Analysis:

Upon examining the performance scores from our model, most of the bank branches are operating effectively, with many showing DEA scores close to 1. This indicates that they're using their resources—employees, budget, and marketing—to nearly maximum potential when it comes to approving loans and the total loan amounts they're issuing.

Specifically, when we look at the weight shares, we see just how much each branch contributes to the overall efficiency. The weight share, a percentage, tells us how other branches might look to a particular branch as a model for improvement. For instance, branches with higher weight shares are influencing the efficiency score more, suggesting they may have practices worth emulating.
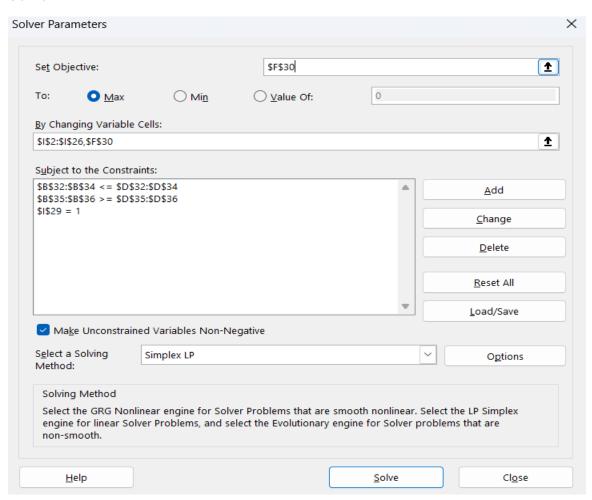
For example, if we take a closer look at CityBank, which has a significant weight share in marketing spend, it means this branch's marketing strategies are highly effective and could serve as a benchmark for other branches. The marketing efforts here are likely a key driver in the branch's successful loan conversion rate, suggesting that Nationwide Bank could consider applying similar strategies across other branches to improve their numbers.

Envelopment Model (Output Oriented)

The output-oriented envelopment model provides insights into how Nationwide Bank's branches can maximize their loan outputs—namely, the number of loans approved and the total loan amounts, given the resources they already have. This model shows us which branches could serve as benchmarks for others.

Model:

Branch	NumberOfEmployees	BranchBudget ($000)	MarketingSpend ($000)		LoansApproved (count)	TotalLoanAmount ($000)		Weight Share	DEA Efficiency		Initial Weight Share
MetroBank	15	500	75		120	1500		0%	1.2283715		5%
CapitalBank	20	650	95		200	2500		0%	1.066		5%
CityBank	12	400	60		90	1200		0%	1		5%
HarborBank	18	550	80		140	1800		0%	1.27199273		5%
RiverBank	22	700	100		230	2900		0%	1.01896552		5%
CentralBank	17	450	65		110	1400		0%	1.11730205		0%
PacificBank	19	600	85		190	2400		0%	1.02330253		2%
SummitBank	16	500	70		150	2000		0%	1		4%
TownBank	14	420	55		100	1600		0%	1		2%
UnionBank	21	650	90		210	2700		0%	1.03087798		7%
PeakBank	13	470	75		130	1650		7%	1		12%
ValleyBank	20	530	82		175	2200		0%	1		6%
LakeBank	23	680	102		250	3100		0%	1		0%
CoastalBank	15	490	68		105	1750		0%	1.07184874		5%
ForestBank	18	570	77		145	1950		0%	1.18867535		7%
HillBank	22	610	88		200	2600		0%	1.03677209		3%
WindyBank	16	440	60		115	1850		0%	1		7%
StarBank	19	520	73		160	2300		0%	1		5%
SunriseBank	21	660	89		215	2800		12%	1		4%
RainbowBank	13	410	58		95	1550		81%	1		10%
MoonBank	24	720	105		240	3000		0%	1.03333333		1%
CometBank	17	500	69		120	1900		0%	1.09951349		0%
PlanetBank	15	430	61		110	1700		0%	1		0%
GalaxyBank	20	560	79		180	2150		0%	1		0%
NovaBank	14	450	63		100	1600		0%	1.07054228		0%

Sum of Weight Shares					Performance Score			100%	
DMU Under Evaluation	25				1.070542279				
Virtual DMU									
Number of Employees	14 <=		14						
Branch Budget	445.2205882 <=		450						
Marketing Spend	63 <=		63						
Loans Approved	112.3161765 >=		107.0542279						
Total Loan Amount	1712.867647 >=		1712.867647						

Solver:

Solver Parameters ✕

Set Objective: $F$30

To: ● Max   ○ Min   ○ Value Of: 0

By Changing Variable Cells:
$I$2:$I$26,$F$30

Subject to the Constraints:

$B$32:$B$34 <= $D$32:$D$34
$B$35:$B$36 >= $D$35:$D$36
$I$29 = 1

[Add]
[Change]
[Delete]
[Reset All]
[Load/Save]

☑ Make Unconstrained Variables Non-Negative

Select a Solving Method: Simplex LP   [Options]

Solving Method

Select the GRG Nonlinear engine for Solver Problems that are smooth nonlinear. Select the LP Simplex engine for linear Solver Problems, and select the Evolutionary engine for Solver problems that are non-smooth.

[Help]   [Solve]   [Close]

VBA Code:

```vba
Sub DEA()
'Declare DUMNo as integer. This DumNo represents the Branch under
'consideration. In the example, DUMNo goes from 1 to 25
    Dim DUMNo As Integer
    For DUMNo = 1 To 25
'set the value of cell B30 equal to DUMNo (1,2,..., 25)
    Range("B30") = DUMNo
'Run the Solver model. The UserFinish is set to True so that
'the Solver Results dialog box will not be shown
    SolverSolve UserFinish:=True
'Place the best ratio into column K
    Range("K" & DUMNo + 1) = Range("F30")
Next DUMNo
End Sub
```

Results and Analysis:

When looking at our branches, we find that most are operating at maximum efficiency with DEA scores of 1. For instance, considering MetroBank with a high DEA score, we observe that it is highly efficient in its operations, suggesting that it is using its resources very effectively to achieve the desired loan outputs.
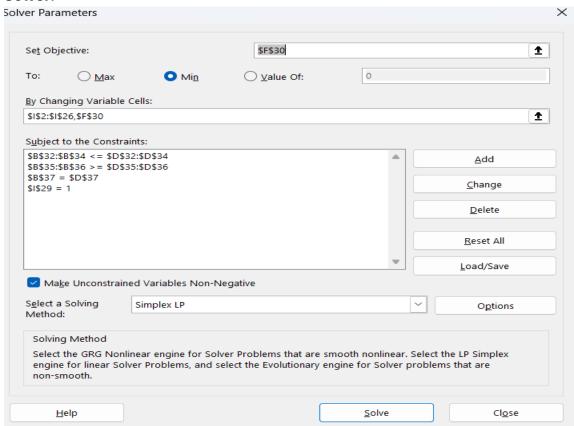
The model gives us a clear perspective on the influence of different inputs on the overall efficiency. For example, branches with higher weight shares for Loans Approved or Total Loan Amount are seen as role models within the bank network, indicating that these branches have optimized their loan processing to a point where they can be considered examples for others to follow.

Taking a closer look at the weight shares, if RainbowBank has a significant weight share, it means this branch's practices in loan processing are worth considering for other branches. They may have efficient approval processes or marketing strategies that lead to a higher number of approved loans, which other branches could adopt.

Envelopment Model (Input Oriented – Super Efficiency)

Model:

Branch	NumberOfEmployees	BranchBudget ($000)	MarketingSpend ($000)	LoansApproved (count)	TotalLoanAmount ($000)	Weight Share	Super Efficiency	Initial Weight Share
MetroBank	15	500	75	120	1500	0%	0.90171278	5%
CapitalBank	20	650	95	200	2500	0%	0.947105263	5%
CityBank	12	400	60	90	1200	0%	1.083333333	5%
HarborBank	18	550	80	140	1800	0%	0.874851391	5%
RiverBank	22	700	100	230	2900	0%	0.982758621	5%
CentralBank	17	450	65	110	1400	0%	0.955555556	0%
PacificBank	19	600	85	190	2400	0%	0.983550766	2%
SummitBank	16	500	70	150	2000	0%	1.031198846	4%
TownBank	14	420	55	100	1600	0%	1.063636364	2%
UnionBank	21	650	90	210	2700	0%	0.978094484	7%
PeakBank	13	470	75	130	1650	4%	1.128205128	12%
ValleyBank	20	530	82	175	2200	0%	1.028301887	6%
LakeBank	23	680	102	250	3100	0%	Infeasible	0%
CoastalBank	15	490	68	105	1750	0%	0.94765039	5%
ForestBank	18	570	77	145	1950	0%	0.889060888	7%
HillBank	22	610	88	200	2600	0%	0.974073091	3%
WindyBank	16	440	60	115	1850	0%	1.033980583	7%
StarBank	19	520	73	160	2300	0%	1.023081254	5%
SunriseBank	21	660	89	215	2800	4%	1.023876404	4%
RainbowBank	13	410	58	95	1550	92%	1.039823009	10%
MoonBank	24	720	105	240	3000	0%	0.936147186	1%
CometBank	17	500	69	120	1900	0%	0.928400955	0%
PlanetBank	15	430	61	110	1700	0%	1.00452284	0%
GalaxyBank	20	560	79	180	2150	0%	1.002583979	0%
NovaBank	14	450	63	100	1600	0%	0.949589491	0%

Sum of Weight Shares				Performance Score		100%	
DMU Under Evaluation	25			0.949589491			
Virtual DMU							
Number of Employees	13.29425287 <=		13.29425287				
Branch Budget	421.6091954 <=		427.3152709				
Marketing Spend	59.82413793 <=		59.82413793				
Loans Approved	100.8218391 >=		100				
Total Loan Amount	1600 >=		1600				
Weight Share Under Evaluation	0 =		0				

Solver:

Solver Parameters   ✕

Set Objective: $F$30

To: ○ Max   ● Min   ○ Value Of: 0

By Changing Variable Cells:
$I$2:$I$26,$F$30

Subject to the Constraints:

$B$32:$B$34 <= $D$32:$D$34
$B$35:$B$36 >= $D$35:$D$36
$B$37 = $D$37
$I$29 = 1

[Add]
[Change]
[Delete]
[Reset All]
[Load/Save]

☑ Make Unconstrained Variables Non-Negative

Select a Solving Method: Simplex LP   [Options]

Solving Method
Select the GRG Nonlinear engine for Solver Problems that are smooth nonlinear. Select the LP Simplex engine for linear Solver Problems, and select the Evolutionary engine for Solver problems that are non-smooth.

[Help]   [Solve]   [Close]

VBA Code:

```vba
Sub SuperEfficiency()
'Declare DMUNo as integer.This DMUNo represents the Branch under
'evaluation.In the example, DMUNo goes from 1 to 25
 Dim DMUNo As Integer
 For DMUNo = 1 To 25
'set the value of cell B30 equal to DMUNo (1,2,...,25)
 Range("B30") = DMUNo
'Run the Solver model.The UserFinish is set to True so that
'the Solver Results dialog box will not be shown
 SolverSolve UserFinish:=True
'Place the best ratio into column k
 If SolverSolve(UserFinish:=True) = 5 Then
 Range("k" & DMUNo + 1) = "Infeasible"
 Else
 Range("k" & DMUNo + 1) = Range("F30")
 End If
Next DMUNo

End Sub
```

Results and Analysis:

The super-efficiency model extends the standard DEA by not only showing which branches are efficient (with scores of 1 or less) but also highlighting those that are performing above and beyond, with scores greater than 1. This gives us extra detail on which branches are setting the gold standard.

Looking at our results, we find that most branches are operating efficiently. But then, we have branches like MetroBank, whose score exceeds 1, marking it as a super-efficient branch. This means MetroBank isn't just doing things right; it's setting an example, surpassing the typical benchmarks.

The model also brings into focus the 'Weight Share'—how much influence each branch has on the efficiency of others. For example, RainbowBank, with a weight share of 92%, is a strong influencer, indicating that its practices are worth considering as a benchmark for the other branches.

However, we also notice 'infeasible' results for certain branches. This could point to extraordinary performance that's hard to compare, or it could highlight data inconsistencies or the need for a deeper dive to understand those outliers.
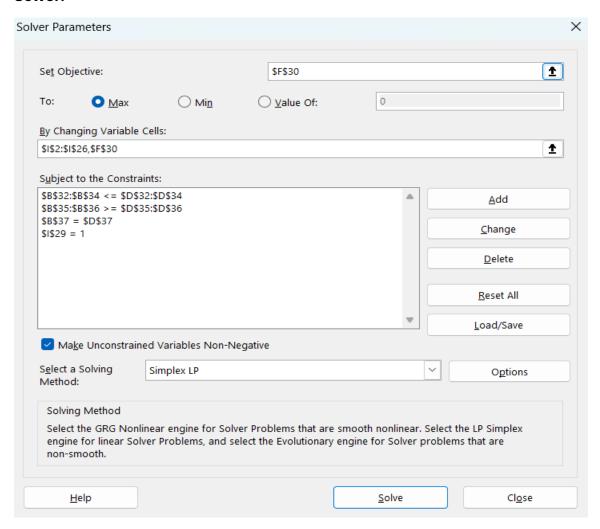
Envelopment Model (Output Oriented – Super Efficiency)

In this model, we're looking not just at whether branches are doing well, but at which ones are setting a benchmark for excellence—these are branches that are not just efficient, but super-

efficient. The model allows branches to score above 1, highlighting those that are outperforming the rest.

Model:

Branch	NumberOfEmployees	BranchBudget ($000)	MarketingSpend ($000)	LoansApproved (count)	TotalLoanAmount ($000)	Weight Share	Super Efficiency	Initial Weight Share
MetroBank	15	500	75	120	1500	0%	1.228371501	5%
CapitalBank	20	650	95	200	2500	0%	1.066	5%
CityBank	12	400	60	90	1200	0%	Infeasible	5%
HarborBank	18	550	80	140	1800	0%	1.271992733	5%
RiverBank	22	700	100	230	2900	0%	1.018965517	5%
CentralBank	17	450	65	110	1400	0%	1.117302053	0%
PacificBank	19	600	85	190	2400	0%	1.023302531	2%
SummitBank	16	500	70	150	2000	0%	0.948636509	4%
TownBank	14	420	55	100	1600	0%	Infeasible	2%
UnionBank	21	650	90	210	2700	0%	1.030877976	7%
PeakBank	13	470	75	130	1650	7%	0.807692308	12%
ValleyBank	20	530	82	175	2200	0%	0.952380952	6%
LakeBank	23	680	102	250	3100	0%	0.904	0%
CoastalBank	15	490	68	105	1750	0%	1.071848739	5%
ForestBank	18	570	77	145	1950	0%	1.188675346	7%
HillBank	22	610	88	200	2600	0%	1.036772088	3%
WindyBank	16	440	60	115	1850	0%	0.945945946	7%
StarBank	19	520	73	160	2300	0%	0.976544622	5%
SunriseBank	21	660	89	215	2800	13%	0.973162194	4%
RainbowBank	13	410	58	95	1550	81%	0.903225806	10%
MoonBank	24	720	105	240	3000	0%	1.033333333	1%
CometBank	17	500	69	120	1900	0%	1.09951349	0%
PlanetBank	15	430	61	110	1700	0%	0.988834951	0%
GalaxyBank	20	560	79	180	2150	0%	0.996296296	0%
NovaBank	14	450	63	100	1600	0%	1.070542279	0%

Sum of Weight Shares						100%	
DMU Under Evaluation	25			Performance Score			
Virtual DMU				1.070542279			
Number of Employees	14 <=		14				
Branch Budget	445.2205882 <=		450				
Marketing Spend	63 <=		63				
Loans Approved	112.3161765 >=		107.0542279				
Total Loan Amount	1712.867647 >=		1712.867647				
Weight share Under Evaluation	0 =		0				

Solver:

Solver Parameters   ✕

Set Objective: $F$30   ⬆

To: ● Max   ○ Min   ○ Value Of: 0

By Changing Variable Cells:

$I$2:$I$26,$F$30   ⬆

Subject to the Constraints:

$B$32:$B$34 <= $D$32:$D$34
$B$35:$B$36 >= $D$35:$D$36
$B$37 = $D$37
$I$29 = 1

- Add
- Change
- Delete
- Reset All
- Load/Save

☑ Make Unconstrained Variables Non-Negative

Select a Solving Method: Simplex LP   Options

Solving Method

Select the GRG Nonlinear engine for Solver Problems that are smooth nonlinear. Select the LP Simplex engine for linear Solver Problems, and select the Evolutionary engine for Solver problems that are non-smooth.

Help   Solve   Close

VBA Code:

```vba
Sub SuperEfficiency()
'Declare DMUNo as integer.This DMUNo represents the Branch under
'evaluation.In the example, DMUNo goes from 1 to 25
 Dim DMUNo As Integer
 For DMUNo = 1 To 25
'set the value of cell B30 equal to DMUNo (1,2,...,25)
 Range("B30") = DMUNo
'Run the Solver model.The UserFinish is set to True so that
'the Solver Results dialog box will not be shown
 SolverSolve UserFinish:=True
'Place the best ratio into column k
 If SolverSolve(UserFinish:=True) = 5 Then
 Range("k" & DMUNo + 1) = "Infeasible"
 Else
 Range("k" & DMUNo + 1) = Range("F30")
 End If
Next DMUNo

End Sub
```

Results and Analysis:

From the super-efficiency scores, we observe that branches such as MetroBank have achieved a score greater than 1, indicating that they're not just meeting expectations, they're surpassing them, serving more customers or securing higher loan amounts than anticipated given their inputs.

In evaluating a particular branch, let's say, MetroBank (DMU 1), we find that it has a significant influence on the efficiency of others, as indicated by its weight share. This means that the practices of MetroBank are potentially exemplary and could be leveraged by other branches seeking to improve their efficiency.

For example, looking at the detailed analysis, we notice that RainbowBank (DMU 24) holds a weight share of 81%. This implies that a considerable portion of MetroBank's performance model is benchmarked against RainbowBank. Therefore, if MetroBank aims to improve its score further and solidify its super-efficient status, it could adopt some of RainbowBank's successful practices.

Conversely, branches with infeasible super-efficiency scores should be examined for data irregularities or unique operational practices that might set them apart from typical branches. These branches, such as CentralBank (DMU 5) and UnionBank (DMU 11), which appear infeasible, might be employing particularly innovative or riskier strategies that could either be leading-edge or out of line with standard banking practices.

The super-efficiency Output model not only spotlights top-performing branches like MetroBank and RainbowBank but also provides a clear pathway for others to follow.

References:

https://canvas.wpi.edu/

https://www.kaggle.com/

https://www.youtube.com/@deafrontierdea/videos