Productivity and Efficiency Analysis
Assignment 2
Due Date: Apr. 1, 2022, 5pm

Please solve the following questions and justify your answer by using Python. Show all your analysis result in your report. **Upload your "zip" file including MS Word report and Python code with file name: PEA_Assignment2_ID_Name.zip" to _NTU COOL_** by due. The late submission is not allowed.

Numerical Analysis (100%)

Data Envelopment Analysis (DEA): Solve this problem by the Python + Pulp (or Gurobi).

The assignment estimates the efficiency of US airlines in 2008. We have two inputs and two outputs as follows.

Inputs

Fuel (FU) is the number of gallons consumed annually, estimated by fuel expenses over the average jet fuel cost per gallon.

Employee (EP) is defined as the number of employees during the year, which includes flight shipping staff, pilots, flight attendants, and managers but not ground shipping drivers. Average prices are calculated by salaries and benefits expenses over number of employees.

Outputs

Passenger Output (PO) is the actual output of available seat-miles during the year. Available seat-miles is calculated as the number of seats including first class and economy on an airplane multiplied by the distance traveled measured in miles. The average price per passenger mile is calculated as the scheduled passenger revenue divided by passenger-miles.

Freight Output (FO) is the actual output of available freight-ton-miles during the year. Available freight-ton-miles is calculated as the number of available tons of freight and mail multiplied by the distance flown measured in miles. The average price is calculated as the scheduled freight and mail revenue divided by ton-miles.

   i.   (10%) Please define the **set, parameters, and decision variables** used in **input-oriented CRS and VRS formulations** of DEA.
   ii. (15%) Estimate **input-oriented** efficiency of each firm. Please show the results of **technical** efficiency (VRS model), **overall** efficiency (CRS model), **scale** efficiency. (Hint: Try to learn and use an optimization solver to solve the problem *__"iteratively"__*.)
   iii. (15%) Estimate **profit** efficiency, and **allocative** efficiency.
   iv. (15%) Estimate **cross efficiency** of each firm.
   v.   (15%) Estimate **super efficiency** of each firm.

    vi.   (10%) Estimate **slack-based measure (SBM)** of each firm.

    vii.   (20%) Based on efficiency analysis you provide above, what **managerial implication or insight** do you observe/get? How to drive productivity in practice?

For detailed description of dataset, please see the following reference.

Lee, C.-Y., A.L. Johnson, 2012, "Two-dimensional Efficiency Decomposition to Measure the Demand Effect in Productivity Analysis", European Journal of Operational Research, 216 (3), 584-593.

Note

1. Show all your work in detail. **<u>Innovative</u>** <u>idea is encouraged</u>.
2. If your answer refers to any external source, please "must" give an academic citation. Any "plagiarism" is not allowed.

Table Dataset for 13 US airlines companies in 2008

2008 U.S. Airlines		input				Output			
		Fuel		Employee		Passenger		Freight	
Company	No.	Gallons (10^6)	Price Per Gallons	Units	Price per unit	Passenger-miles (10^6)	Price per Passenger-miles	Ton-miles (10^6)	Price per Ton-miles
AirTran Airways	A	392	3.05	8259	57500.9	23756	0.13	870	0.56
Alaska Airlines	B	381	3.05	9628	78780.6	24183	0.14	1359	1.76
American Airlines	C	2673	3.05	70923	85219.2	163483	0.14	12449	0.43
American Eagle Airlines	D	282	3.05	9683	85219.2	10370	0.30	509	0.43
Continental	E	1608	3.05	40630	70145.2	99047	0.14	3726	0.47
Delta Air Lines	F	2074	3.05	47420	101265	128635	0.13	9214	0.48
ExpressJet airlines	G	75	3.05	7115	55874.1	11962	0.14	536	0.90
JetBlue Airways	I	458	3.05	10177	68193	32436	0.12	1462	0.60
Northwest Airlines	J	1722	3.05	29124	92775.7	83862	0.13	6337	0.46
SkyWest Airlines	K	400	3.05	8987	80571.3	14618	0.18	785	1.21
Southwest Airline	L	1217	3.05	34680	96309.1	99636	0.14	6597	1.05
United Airlines	M	2532	3.05	51536	83669.7	135480	0.13	10928	0.44
US Airways	O	1303	3.05	32683	68261.8	74106	0.13	4258	0.48