

# Using DEA to Assess the Seven Schools in the Oregon University System (OUS)

Kiatiphong Lertsathitphong

David Loewi

EMGT 537/637 Productivity Analysis

August 09, 2004

Instructor: Dr. Tim Anderson

# Agenda

- Purposes of study
- Model building
- Results and Analysis
- Recommendations
- Brief explanation of Malmquist Productivity Index (MPI)

# Purpose of the project

- To help setting educational policies in the state and at individual institutions

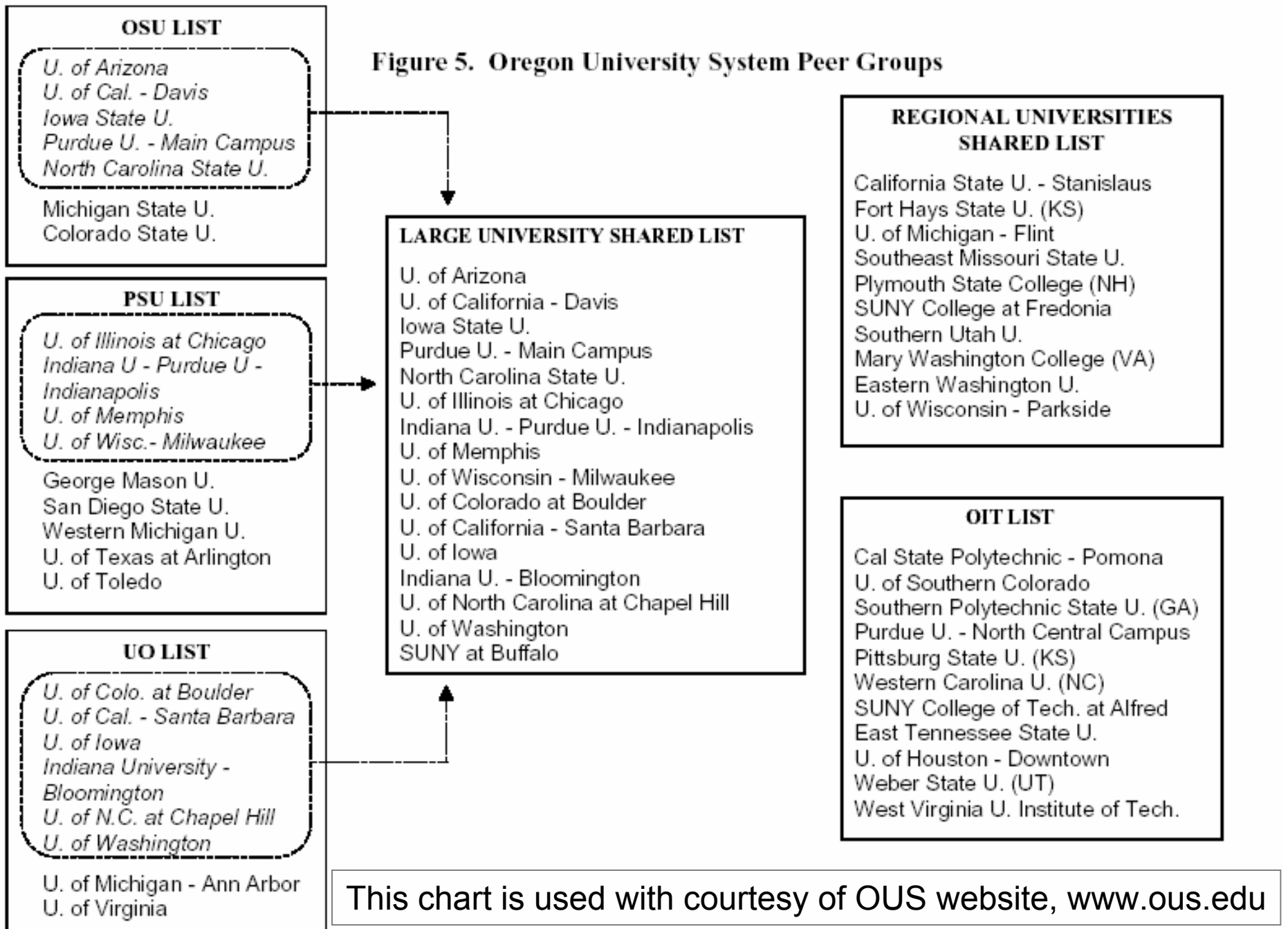
## Recipients of this analysis might include:

- Oregon agencies, legislators, administrators
- The schools themselves
- Students thinking about these schools
- DEA researchers

# DMUs in Oregon University System (OUS)

- OSU—Oregon State University
- PSU—Portland State University
- UO—University of Oregon
  
- EOU—Eastern Oregon University
- SOU—Southern State University
- WOU—Western Oregon University
  
- OIT—Oregon Institute of Technology

**Figure 5. Oregon University System Peer Groups**



# Three main factors used to build models

- Select right combinations of inputs and outputs
  - How well do these inputs & outputs reflect the success of the schools being analyzed (KSFs ?)
  - Relationship between the particular inputs and the outputs...
  - ...multi-level model used by Knox Lovell in CCLS too hard for us to implement
- Select input or output orientation
- Select constant or variable return to scale

# The data for Malmquist

- Inputs

- Undergrad enrollment
- **Graduate enrollment**
- Faculty Compensation

- Outputs

- First-time Freshmen Persistence
- First-time Freshmen Completion
- Research and Development (R&D)

**Where is the completion rate of graduate students?**

All data are used by courtesy of OUS website, [www.ous.edu](http://www.ous.edu)

# The data for Envelopment Model

- Inputs

- Undergrad enrollment
- 2002-03 budget (all funds)
- Faculty Compensation (indexed against comparison schools)

**We wish we could obtain all data about fund for more years.**

- Outputs

- First-time freshmen persistence (%)
- First-time freshmen completion (%)

All data are used by courtesy of OUS website, [www.ous.edu](http://www.ous.edu)



# Full data for Malmquist models

	Institution	Undergrad enrollment	Grad enrollment	Faculty Compensation
Period 1 (1999)	EOU	3,393	1,042	90.90
	OIT	3,549	5	99.30
	OSU	14,933	4,684	92.20
	PSU	20,313	13,903	86.10
	SOU	6,393	1,850	93.10
	UO	16,033	5,922	90.40
	WOU	4,718	1,635	91.40

First-time Freshmen Persistence	First-time Freshmen Completion	Research and Development (R&D)
68.60	31.90	1819.887
66.20	42.90	2191.145
81.10	59.80	105285.278
70.10	34.50	23986.279
73.10	36.30	2574.978
82.80	61.80	56402.991
73.30	51.60	6343.666

Period 2 (2000)	EOU	3,754	1,279	87.20
	OIT	3,699	12	99.50
	OSU	15,820	4,969	94.50
	PSU	21,594	14,089	85.90
	SOU	6,141	1,724	94.80
	UO	16,650	5,718	91.00
	WOU	4,808	1,663	87.20

68.40	42.50	2148.766
77.20	37.00	2605.111
82.50	62.10	113292.514
72.00	39.50	26446.984
74.10	42.10	3193.740
83.70	61.10	59380.847
75.40	55.60	7739.545

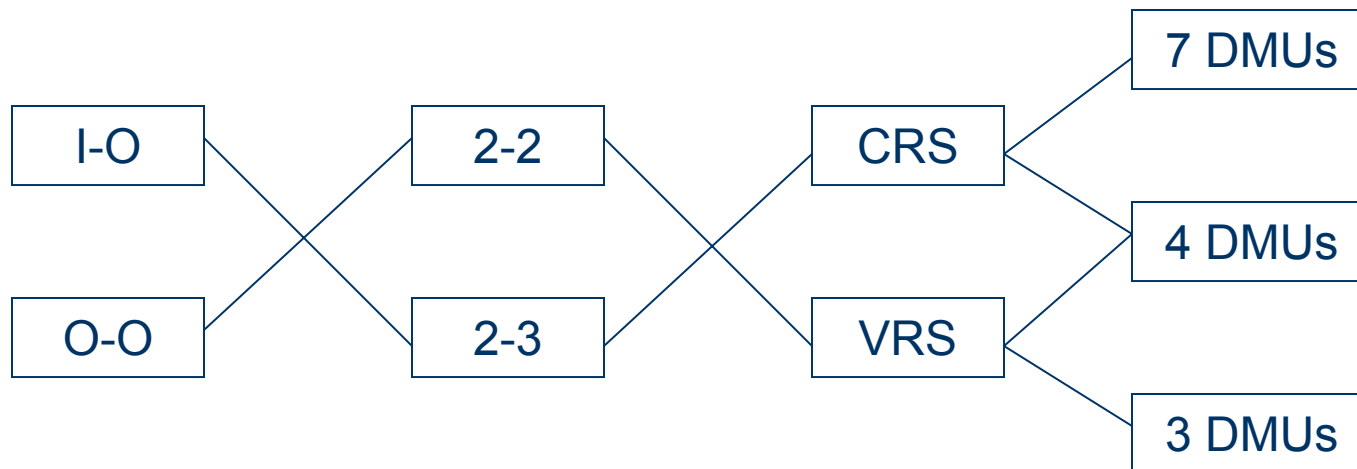
Period 3 (2001)	EOU	4,000	1,026	82.80
	OIT	4,102	9	96.30
	OSU	16,830	4,502	90.60
	PSU	22,350	14,126	84.80
	SOU	6,187	1,526	90.60
	UO	17,641	5,782	88.00
	WOU	5,027	1,954	94.60

68.00	46.30	3300.862
73.70	40.80	1942.613
82.50	63.40	123241.451
71.30	37.00	25935.791
74.10	41.50	4016.037
85.20	61.90	67357.664
79.10	50.40	8569.768

Period 4 (2002)	EOU	4,248	1,084	84.00
	OIT	4,071	4	96.80
	OSU	17,424	4,692	90.90
	PSU	23,334	13,471	85.20
	SOU	6,301	1,447	91.90
	UO	18,412	5,811	90.30
	WOU	5,030	1,672	96.40

67.50	36.90	2606.068
76.50	46.70	2438.790
83.80	63.30	134395.750
71.10	39.30	28467.832
74.90	41.40	3776.519
84.90	61.70	68206.681
75.80	43.80	8420.761

# How many possible models are there in this case?



$$2 \times 2 \times 2 \times 3 = 24 \text{ models}$$

# Efficiency Changes Over Time

- Change in Technical Efficiency (P or “catch-up”
  - How do you compare to the frontier?
- Change in Technical Possibilities (E or “ $\Phi$ ”)
  - How has the frontier changed?
- Simply comparing  $\theta^t$  and  $\theta^{t+1}$  for a DMU can't separate these two sources of change
  - Notice how we use the superscript to refer to time period.

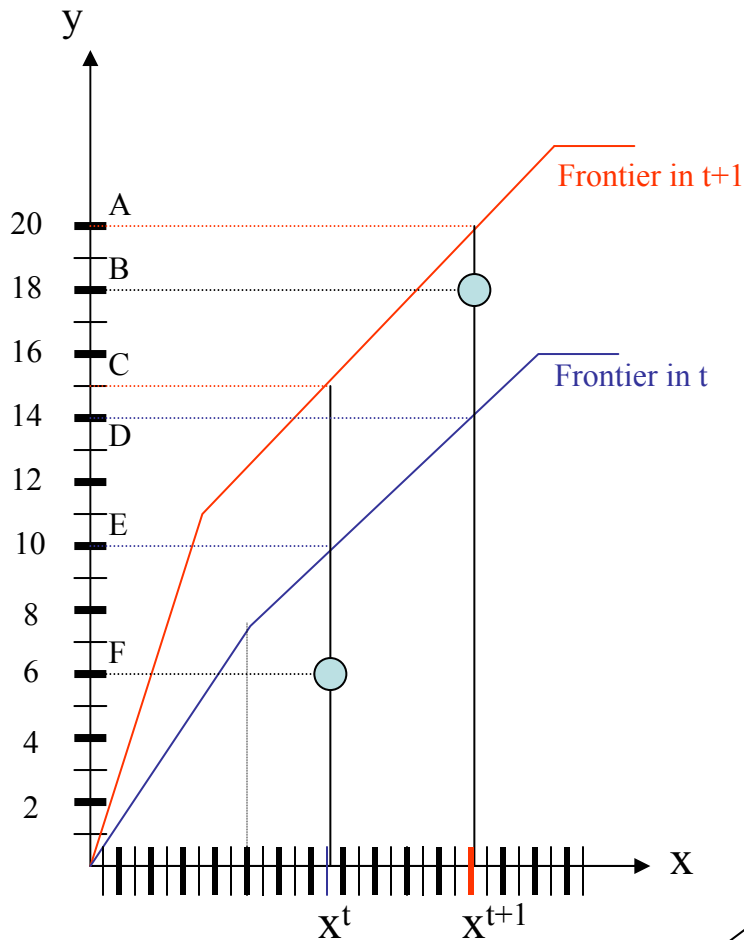
# Malmquist Productivity Index (M)

- $P \equiv$  Measure of technical progress
  - Are we closer to the new frontier than we were to the old frontier?
- $E \equiv$  Measure of relative technical efficiency between two periods
  - Our efficiency change relative to our peers in the same period
- $M \equiv P * E$

Malmquist slides used by courtesy of Dr. Anderson

# Example

- What is the level of output in year t of the DMU being studied?



In year t+1? \_\_\_\_\_

$$\phi^t = \underline{\hspace{2cm}}$$

$$\phi^{t+1} = \underline{\hspace{2cm}}$$

$$E = \frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)} = \frac{OB / OA}{OF / OE}$$

$$E = \frac{OB / OA}{OF / OE} = \frac{18 / 20}{6 / 10} = \frac{180}{120} = 1.5$$

**New Notation**  
 $D_o^t(x^{t+1}, y^{t+1})$   
 Distance measure for the DMU at t+1 measured with respect to the frontier (or technology available) at time t.

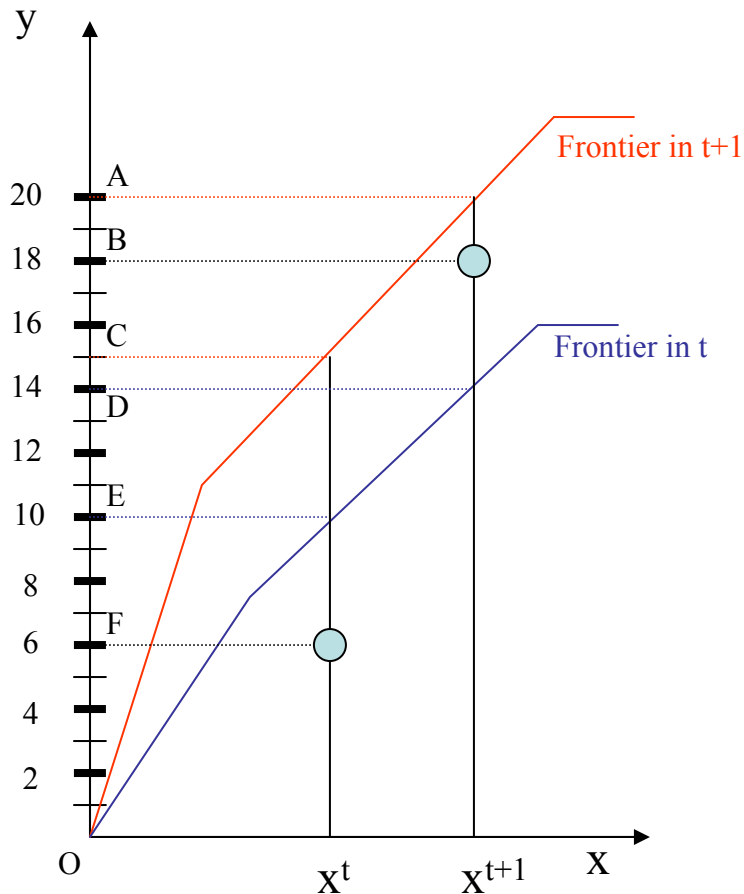
E measures the change in technical efficiency and this indicates a 50% increase from t to t+1 for this DMU.

Now measure technical progress  
 On the basis of the one DMU at  
 two different times, we have two  
 estimates of the change in the  
 frontier over time.

Take the geometric mean of the  
 two.

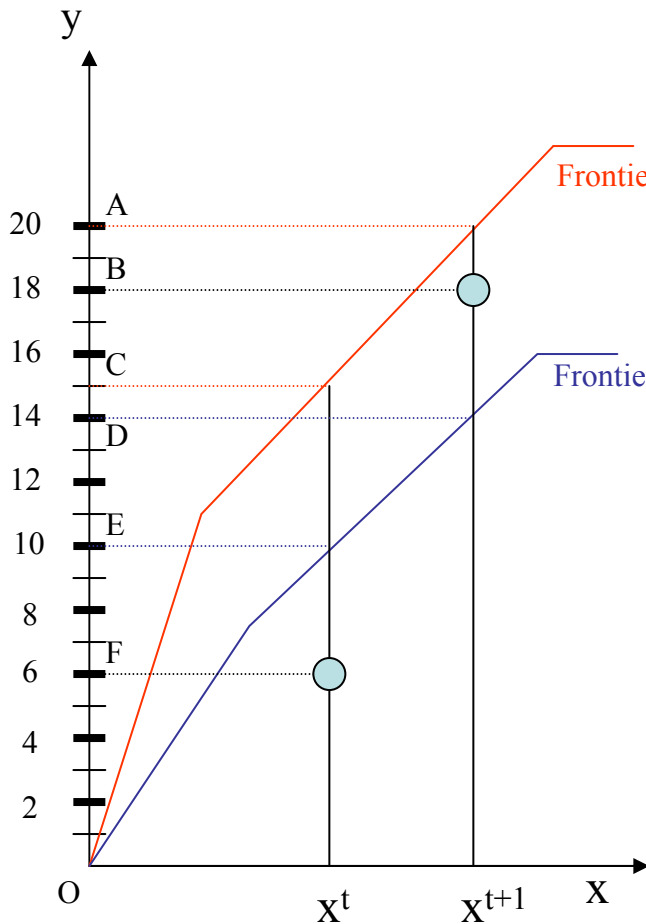
$$P = \sqrt{\frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^{t+1}, y^{t+1})} \cdot \frac{D_o^t(x^t, y^t)}{D_o^{t+1}(x^t, y^t)}} = \sqrt{\frac{OB/OD}{OB/OA} \cdot \frac{OF/OE}{OF/OC}}$$

$$P = \sqrt{\frac{OB/OD}{OB/OA} \cdot \frac{OF/OE}{OF/OC}} = \sqrt{\frac{OA}{OD} \cdot \frac{OC}{OE}} = \sqrt{\frac{20}{14} \cdot \frac{15}{10}} = \sqrt{\frac{15}{7}} \approx 1.46$$



# Malmquist Productivity Index

## Index



Ratio of past and present performance relative to frontier (technology) of time  $t+1$

Ratio of past and present performance relative to frontier (technology) of time  $t$

$$M_o^{t+1}(x^{t+1}, y^{t+1}, x^t, y^t) = \sqrt{\frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)} \cdot \frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^t, y^t)}}$$

$$M = \sqrt{\frac{OB / OD}{OF / OE} \cdot \frac{OB / OA}{OF / OC}} = \sqrt{\frac{18 / 14}{6 / 10} \cdot \frac{18 / 20}{6 / 15}} \approx 2.196$$

Also, note  $M = P * E = 1.46 * 1.5 = 2.19$

# Results: Malmquist I-O, 2-2, CRS, 7DMUs

## Inputs

Undergrad enrollment  
Faculty Compensation

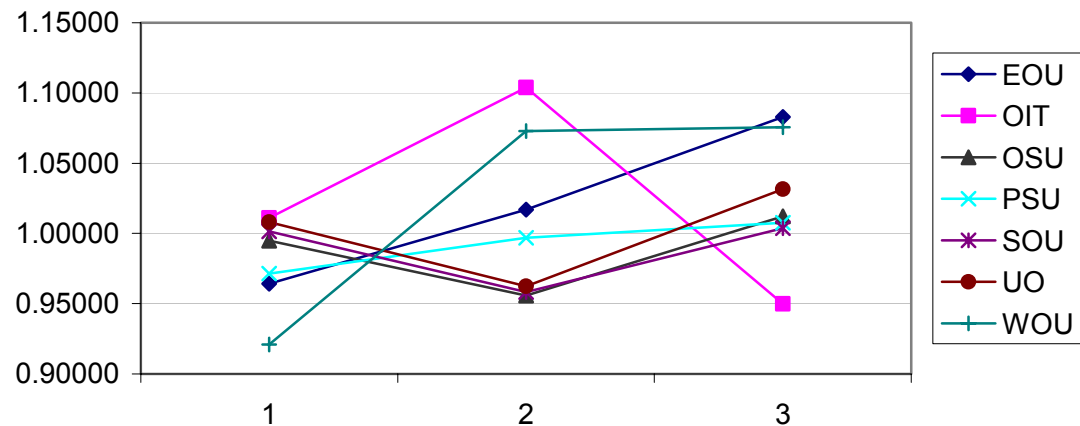
## Outputs

First-time Freshmen Persistence  
First-time Freshmen Completion

DMU No.	DMUs	Period 1- Period 2			Period 2- Period 3			Period 3- Period 4		
		<i>Input-Oriented</i>	<i>Efficiency Change</i>	<i>Frontier Shift</i>	<i>Input-Oriented</i>	<i>Efficiency Change</i>	<i>Frontier Shift</i>	<i>Input-Oriented</i>	<i>Efficiency Change</i>	<i>Frontier Shift</i>
		<i>CRS</i>			<i>CRS</i>			<i>CRS</i>		
		<i>Malmquist Index</i>			<i>Malmquist Index</i>			<i>Malmquist Index</i>		
1	EOU	0.96404	1.00000	0.96404	1.01685	1.00000	1.01685	1.08301	1.00000	1.08301
2	OIT	1.01093	1.00000	1.01093	1.10377	1.00000	1.10377	0.94974	1.00000	0.94974
3	OSU	0.99480	0.99029	1.00456	0.95563	0.98476	0.97042	1.01212	1.00000	1.01212
4	PSU	0.97135	0.97543	0.99581	0.99689	1.04935	0.95001	1.00754	0.97842	1.02976
5	SOU	1.00138	1.06770	0.93789	0.95830	0.93468	1.02527	1.00381	0.96794	1.03706
6	UO	1.00804	1.00000	1.00804	0.96239	1.00000	0.96239	1.03156	1.00000	1.03156
7	WOU	0.92098	1.00000	0.92098	1.07300	1.00000	1.07300	1.07550	1.02096	1.05342

DMU No.	DMUs	<i>Input-Oriented</i>	<i>Input-Oriented</i>	<i>Input-Oriented</i>
		<i>CRS</i>	<i>CRS</i>	<i>CRS</i>
		<i>Malmquist Index</i>	<i>Malmquist Index</i>	<i>Malmquist Index</i>
1	EOU	0.96404	1.01685	1.08301
2	OIT	1.01093	1.10377	0.94974
3	OSU	0.99480	0.95563	1.01212
4	PSU	0.97135	0.99689	1.00754
5	SOU	1.00138	0.95830	1.00381
6	UO	1.00804	0.96239	1.03156
7	WOU	0.92098	1.07300	1.07550

Malmquist for 7 DMUs from year 1999-2002





# Results: Malmquist I-O, 2-2, CRS, 3DMUs

## Inputs

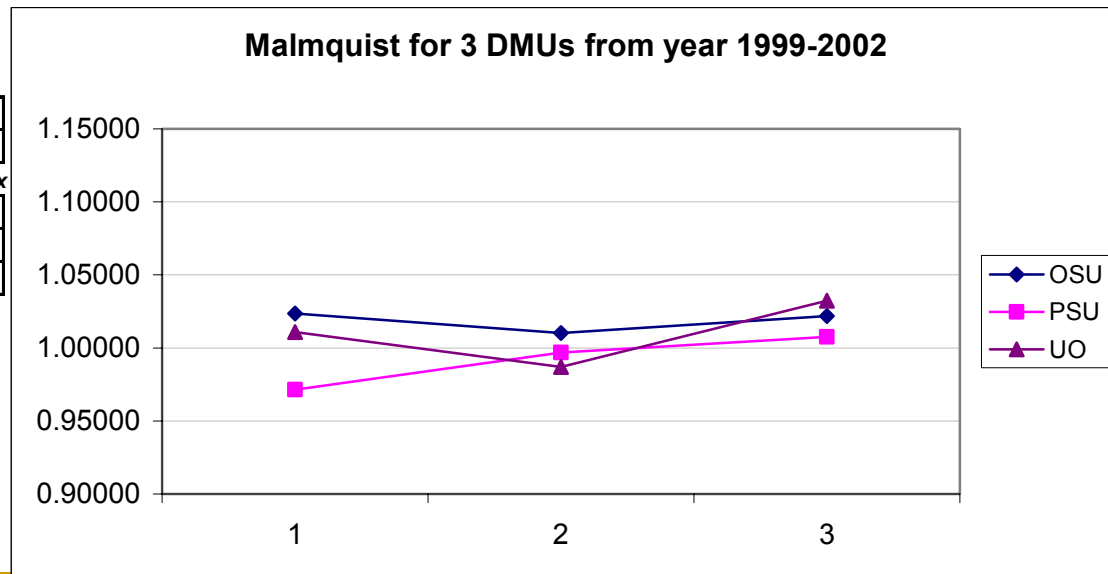
Undergrad enrollment  
Faculty Compensation

## Outputs

First-time Freshmen Persistence  
First-time Freshmen Completion

DMU No.	DMUs	Period 1- Period 2			Period 2- Period 3			Period 3- Period 4		
		<i>Input-Oriented</i>	<i>Efficiency Change</i>	<i>Frontier Shift</i>	<i>Input-Oriented</i>	<i>Efficiency Change</i>	<i>Frontier Shift</i>	<i>Input-Oriented</i>	<i>Efficiency Change</i>	<i>Frontier Shift</i>
		<i>CRS</i>			<i>CRS</i>			<i>CRS</i>		
1	OSU	1.02348	1.00000	1.02348	1.01032	1.00000	1.01032	1.02185	1.00000	1.02185
2	PSU	0.97135	0.97543	0.99581	0.99689	1.04935	0.95001	1.00754	0.97842	1.02976
3	UO	1.01081	1.00000	1.01081	0.98704	1.00000	0.98704	1.03244	1.00000	1.03244

DMU No.	DMUs	<i>Input-Oriented</i>	<i>Input-Oriented</i>	<i>Input-Oriented</i>
		<i>CRS</i>	<i>CRS</i>	<i>CRS</i>
		<i>Malmquist Index</i>	<i>Malmquist Index</i>	<i>Malmquist Index</i>
1	OSU	1.02348	1.01032	1.02185
2	PSU	0.97135	0.99689	1.00754
3	UO	1.01081	0.98704	1.03244



# Results: Malmquist I-O, 2-2, CRS, 4DMUs

## Inputs

Undergrad enrollment  
Faculty Compensation

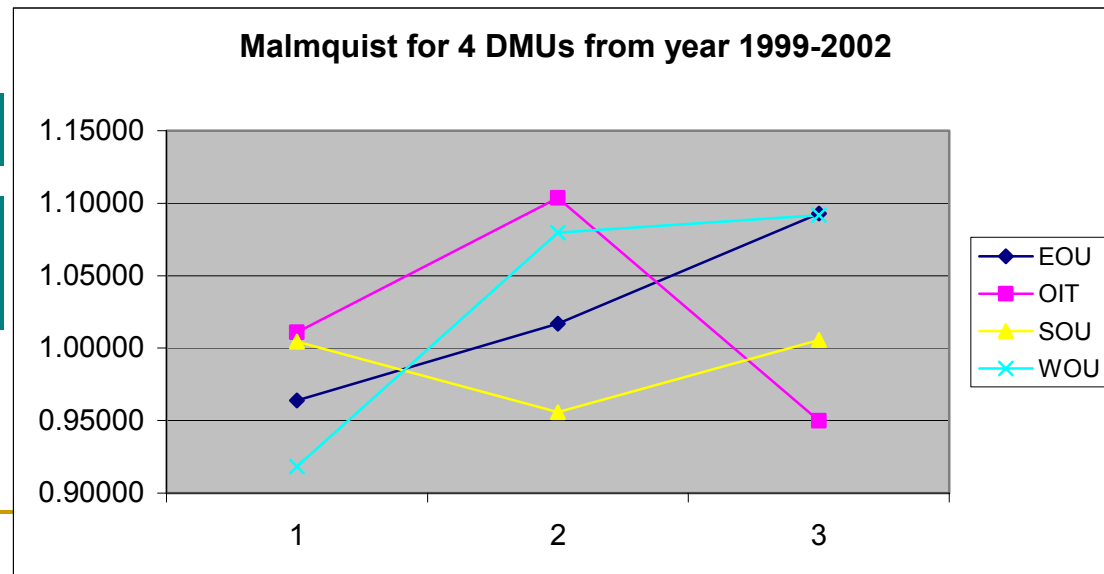
## Outputs

First-time Freshmen Persistence  
First-time Freshmen Completion

DMU No.	DMUs	Period 1- Period 2			Period 2- Period 3			Period 3- Period 4		
		Input-Oriented CRS Malmquist Index	Efficiency Change	Frontier Shift	Input-Oriented CRS Malmquist Index	Efficiency Change	Frontier Shift	Input-Oriented CRS Malmquist Index	Efficiency Change	Frontier Shift
1	EOU	0.96404	1.00000	0.96404	1.01685	1.00000	1.01685	1.09300	1.00000	1.09300
2	OIT	1.01093	1.00000	1.01093	1.10377	1.00000	1.10377	0.94974	1.00000	0.94974
3	SOU	1.00452	1.08307	0.92748	0.95570	0.92417	1.03412	1.00550	0.97815	1.02797
4	WOU	0.91827	1.00000	0.91827	1.07968	1.00000	1.07968	1.09176	1.01861	1.07182

DMU No.	DMUs	Input-Oriented CRS Malmquist Index	Input-Oriented CRS Malmquist Index	Input-Oriented CRS Malmquist Index
1	EOU	0.96404	1.01685	1.09300
2	OIT	1.01093	1.10377	0.94974
3	SOU	1.00452	0.95570	1.00550
4	WOU	0.91827	1.07968	1.09176

Malmquist for 4 DMUs from year 1999-2002



## Efficiency report

### Inputs

Undergrad enrollment  
Faculty Compensation  
2002-03 all fund

### Outputs

First-time Freshmen Persistence  
First-time Freshmen Completion

Input-Oriented CRS							
DMU No.	DMU Name	Efficiency	Σλ	RTS	Benchmarks		
1	EOU	1.00000	1.000	Constant	1.000	EOU	
2	OIT	1.00000	1.000	Constant	1.000	OIT	
3	OSU	1.00000	1.000	Constant	1.000	OSU	
4	PSU	0.95470	0.925	Increasing	0.391	EOU	0.533 OSU
5	SOU	0.99501	1.079	Decreasing	0.955	EOU	0.068 OSU 0.056 UO
6	UO	1.00000	1.000	Constant	1.000	UO	
7	WOU	0.97947	1.064	Decreasing	0.651	EOU	0.379 OIT 0.034 UO

## Target report

Input-Oriented  
CRS Model Target

		Efficient Input Target		
DMU No.	DMU Name	Undergrad enrollment	Faculty Compensation	2002-03 all fund
1	EOU	4248.00000	84.00000	22238.85800
2	OIT	4071.00000	96.80000	12961.38200
3	OSU	17424.00000	90.90000	265059.22300
4	PSU	10955.41905	81.34079	150079.82256
5	SOU	6269.56062	91.44146	56995.52587
6	UO	18412.00000	90.30000	317565.15000
7	WOU	4926.72138	94.42066	30042.23713

Efficient Output Target	
First-time Freshmen Persistence	First-time Freshmen Completion
67.50000	36.90000
76.50000	46.70000
83.80000	63.30000
71.10000	48.19674
74.90000	42.98773
84.90000	61.70000
75.80000	43.80000

## Data

Institution	Undergrad enrollment	Faculty Compensation	2002-03 all fund
EOU	4,248	84.00	22,239
OIT	4,071	96.80	12,961
OSU	17,424	90.90	265,059
PSU	23,334	85.20	157,200
SOU	6,301	91.90	57,281
UO	18,412	90.30	317,565
WOU	5,030	96.40	54,910

First-time Freshmen Persistence	First-time Freshmen Completion
67.50	36.90
76.50	46.70
83.80	63.30
71.10	39.30
74.90	41.40
84.90	61.70
75.80	43.80

## Slack report

Input-Oriented  
CRS Model Slacks

		Input Slacks		
DMU No.	DMU Name	Undergrad enrollment	Faculty Compensation	2002-03 all fund
1	EOU	0.00000	0.00000	0.00000
2	OIT	0.00000	0.00000	0.00000
3	OSU	0.00000	0.00000	0.00000
4	PSU	11321.64742	0.00000	0.00000
5	SOU	0.00000	0.00000	0.00000
6	UO	0.00000	0.00000	0.00000
7	WOU	0.00000	0.00000	23740.45787

Output Slacks	
First-time Freshmen Persistence	First-time Freshmen Completion
0.00000	0.00000
0.00000	0.00000
0.00000	0.00000
0.00000	8.89674
0.00000	1.58773
0.00000	0.00000
0.00000	0.00000

# Results:

# Envelopment I-O, 3-2, CRS, 7DMUs

## Efficiency report

# Results:

# Envelopment

# I-O, 3-2, VRS,

# 7DMUs

**Inputs**  
Undergrad enrollment  
Faculty Compensation  
2002-03 all fund

**Outputs**  
First-time Freshmen Persistence  
First-time Freshmen Completion

<i>Input-Oriented VRS</i>			<b>Benchmarks</b>			
<i>DMU No.</i>	<i>DMU Name</i>	<i>Efficiency</i>				
1	EOU	1.00000	1.000	EOU		
2	OIT	1.00000	1.000	OIT		
3	OSU	1.00000	1.000	OSU		
4	PSU	1.00000	1.000	PSU		
5	SOU	0.99961	0.310	EOU	0.528	OIT
6	UO	1.00000	1.000	UO		
7	WOU	0.98251	0.133	EOU	0.808	OIT
					0.059	UO

## Target report

Input-Oriented  
VRS Model Target

		<i>Efficient Input Target</i>		
<i>DMU No.</i>	<i>DMU Name</i>	<i>Undergrad enrollment</i>	<i>Faculty Compensation</i>	<i>2002-03 all fund</i>
1	EOU	4248.00000	84.00000	22238.85800
2	OIT	4071.00000	96.80000	12961.38200
3	OSU	17424.00000	90.90000	265059.22300
4	PSU	23334.00000	85.20000	157200.34700
5	SOU	6298.52770	91.86394	57258.86077
6	UO	18412.00000	90.30000	317565.15000
7	WOU	4942.04272	94.71430	32195.91993

<i>Efficient Output Target</i>	
<i>First-time Freshmen Persistence</i>	<i>First-time Freshmen Completion</i>
67.50000	36.90000
76.50000	46.70000
83.80000	63.30000
71.10000	39.30000
74.90000	46.32473
84.90000	61.70000
75.80000	46.28369

## Data

Institution	Undergrad enrollment	Faculty Compensation	2002-03 all fund
EOU	4,248	84.00	22,239
OIT	4,071	96.80	12,961
OSU	17,424	90.90	265,059
PSU	23,334	85.20	157,200
SOU	6,301	91.90	57,281
UO	18,412	90.30	317,565
WOU	5,030	96.40	54,910

First-time Freshmen Persistence	First-time Freshmen Completion
67.50	36.90
76.50	46.70
83.80	63.30
71.10	39.30
74.90	41.40
84.90	61.70
75.80	43.80

## Slack report

Input-Oriented  
VRS Model Slacks

		<i>Input Slacks</i>		
<i>DMU No.</i>	<i>DMU Name</i>	<i>Undergrad enrollment</i>	<i>Faculty Compensation</i>	<i>2002-03 all fund</i>
1	EOU	0.00000	0.00000	0.00000
2	OIT	0.00000	0.00000	0.00000
3	OSU	0.00000	0.00000	0.00000
4	PSU	0.00000	0.00000	0.00000
5	SOU	0.00000	0.00000	0.00000
6	UO	0.00000	0.00000	0.00000
7	WOU	0.00000	0.00000	21754.03087

<i>Output Slacks</i>	
<i>First-time Freshmen Persistence</i>	<i>First-time Freshmen Completion</i>
0.00000	0.00000
0.00000	0.00000
0.00000	0.00000
0.00000	0.00000
0.00000	4.92473
0.00000	0.00000
0.00000	2.48369

Table shows the availability of data from OUS website

		87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03
1.1	Total Unduplicated Headcount: Undergraduate & Graduate Enrollment												Y	Y	Y	Y	Y	
1.2	New Undergraduate Enrollment								Y	Y	Y	Y	Y	Y	Y	Y	Y	
2.1	First-time Freshmen Persistence		Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
2.2	First-time Freshmen Completion							Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
2.3	Recent Graduate Satisfaction								Y	Y	Y	Y	Y	Y	Y			
2.4	Faculty Compensation													Y	Y	Y	Y	
2.5	Research and Development (R&D)					Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
2.6	Philanthropy					Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y		
3.1	Total Degree Production	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y		
3.2	Oregon Shortage Area Degree Production							Y	Y	Y	Y	Y	Y	Y	Y	Y		
3.3	Recent Graduate Success								Y	Y	Y	Y	Y	Y	Y			
3.4	Internships																	
4.1	Research and Development (R&D)					Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
4.2	Philanthropy																	

Table shows the availability of data from OUS website

		87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03
1.1	Total Unduplicated Headcount: Undergraduate & Graduate Enrollment											Y	Y	Y	Y	Y	Y	
1.2	New Undergraduate Enrollment								Y	Y	Y	Y	Y	Y	Y	Y	Y	
2.1	First-time Freshmen Persistence		Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
2.2	First-time Freshmen Completion							Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
2.3	Recent Graduate Satisfaction								Y	Y	Y	Y	Y	Y	Y			
2.4	Faculty Compensation													Y	Y	Y	Y	
2.5	Research and Development (R&D)					Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
2.6	Philanthropy					Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y		
3.1	Total Degree Production	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y		
3.2	Oregon Shortage Area Degree Production							Y	Y	Y	Y	Y	Y	Y	Y	Y		
3.3	Recent Graduate Success								Y	Y	Y	Y	Y	Y	Y			
3.4	Internships																	
4.1	Research and Development (R&D)					Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
4.2	Philanthropy																	

# Recommendations

- Where possible, expand and standardize the data set.
- Bring DEA into the mix of methods used by the state
- Attempt to collect (really) comparable data on the schools best suited to a comparison study
- Garbage in, garbage out

# Recommendation 2-Software

Microsoft Excel - data set & I-O results\_PSU-DSU-UO\_Reduced2

Type a question for help

100%

	A	B	C	D	E	F	G	H	I	J	K	L
2	Undergrad enrollment		First-time Freshmen Persistence		Period1	Period2						
3	Faculty Compensation		First-time Freshmen Completion									
4												
5	<i>Input-Oriented</i>											
6	CRS											
7	<i>DMU No.</i>	<i>DMUs in Period1</i>	<i>Malmquist Index</i>	<i>Efficiency Change</i>	<i>Frontier Shift</i>							
8	1	DSU	1.02348	1.00000	1.02348							
9	2	PSU	0.97136	0.97543	0.99681							
10	3	UO	1.01081	1.00000	1.01081							
11												
12												

Ready NUM

**Questions ??**