Juxtaposition of Efficiency & Quality in Healthcare: a DEA approach

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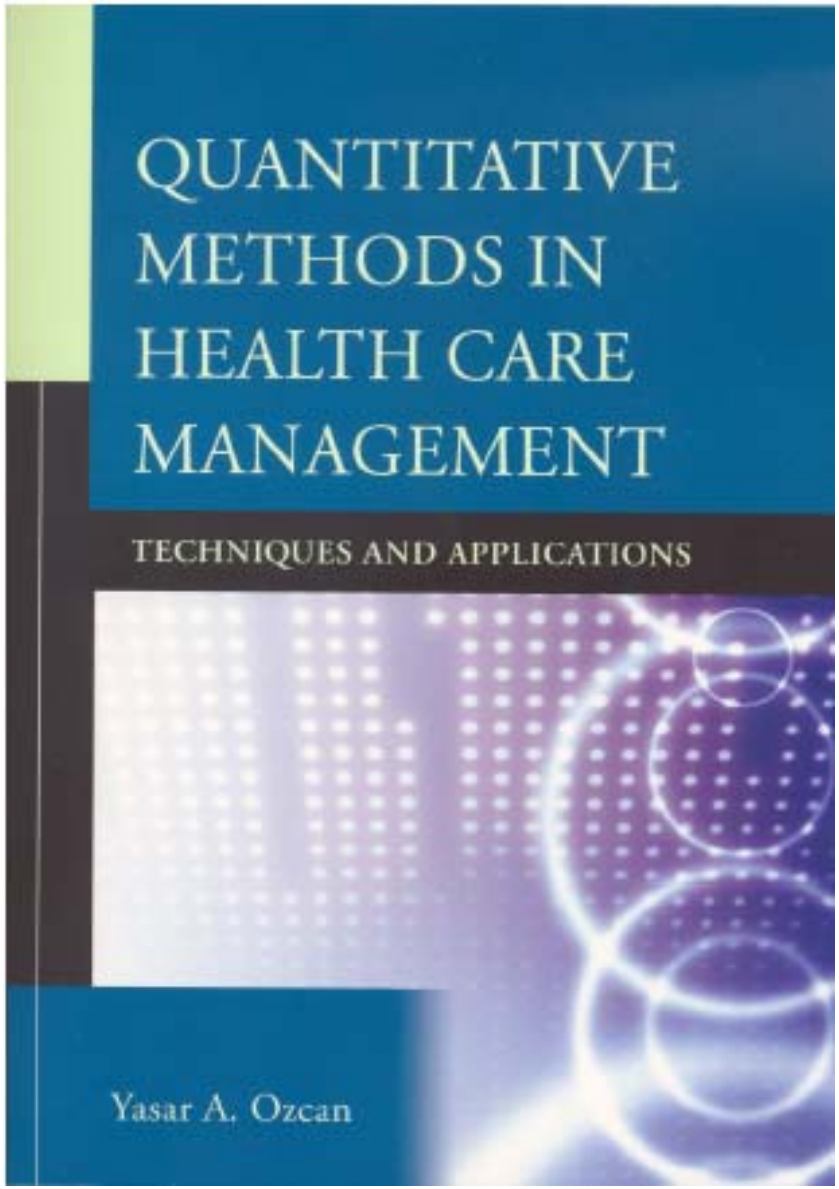
by
Yasar A. Ozcan, Ph.D.
Professor
Department of Health Administration
ozcan@vcu.edu



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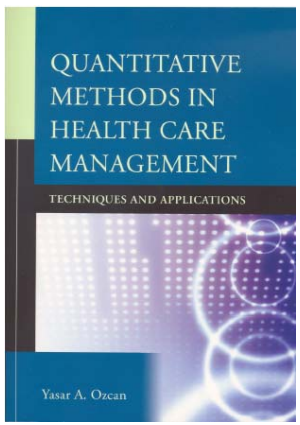

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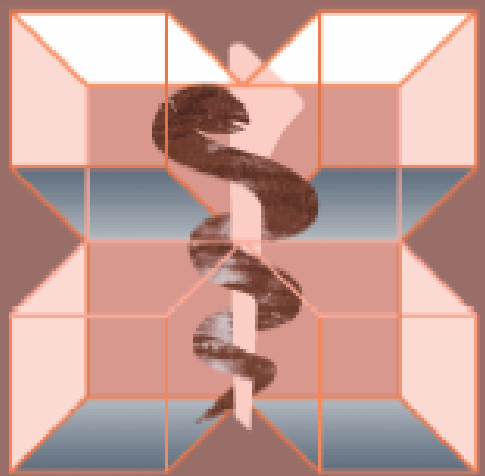

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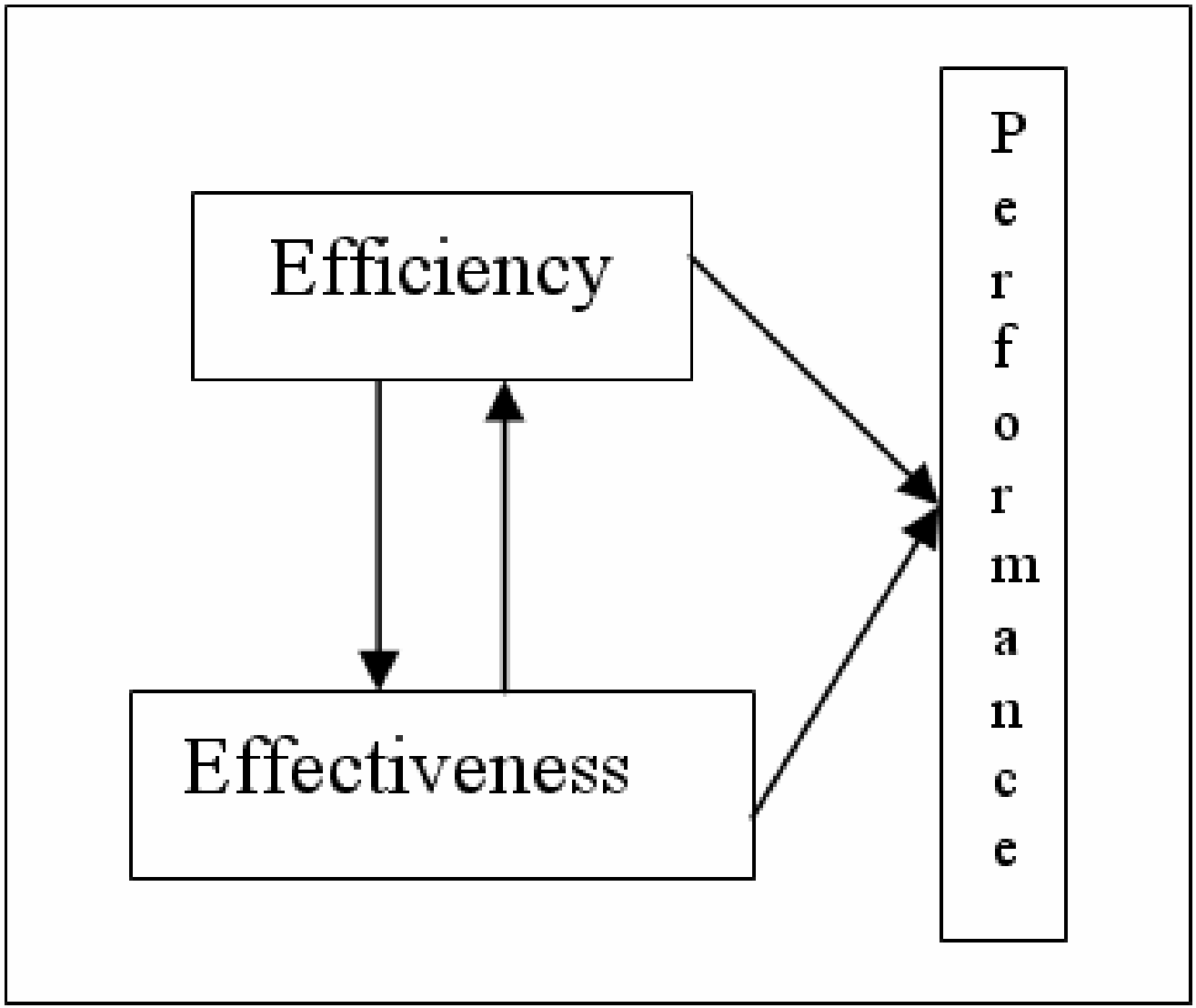
Components of Performance



Components of Performance

- **Efficiency:** (Productivity?)
  - Resources used in the attainment of outputs
- **Effectiveness:** (Quality?)
  - The attainment of pre-established goals in sense of outcomes or outputs

Performance Comparisons

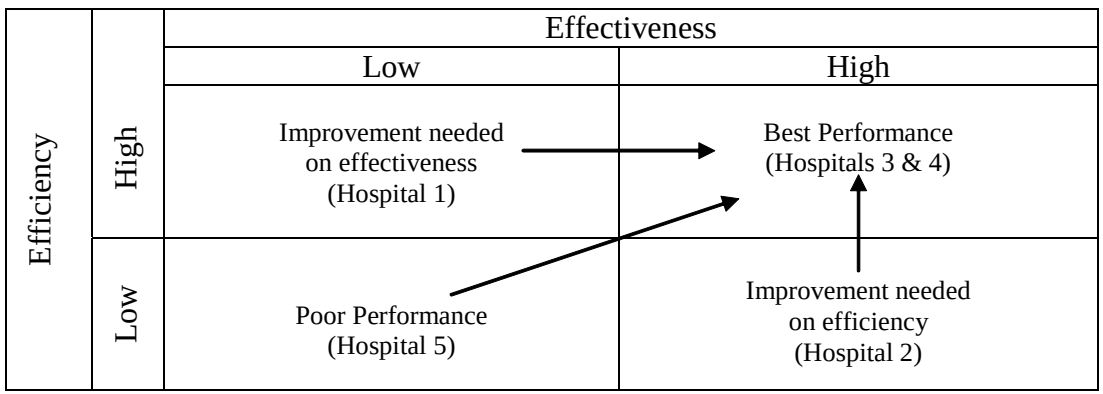
- Performance:
  - is relative
  - can be compared across different providers at one point in time or
  - can be compared by the same unit across multiple points in time

Performance Comparisons

Health Care Organization	Efficiency Time 1	Efficiency Time 2	Effectiveness Time 1	Effectiveness Time 2
Hospital 1	0.81	0.88	0.86	0.93
Hospital 2	1.00	0.84	0.84	0.91
Hospital 3	1.00	1.00	1.00	1.00
Hospital 4	0.78	0.94	0.86	0.96
Hospital 5	0.62	0.55	0.71	0.62

Health Care Organization	Efficiency Time 1	Efficiency Time 2	Effectiveness Time 1	Effectiveness Time 2
Hospital 1	0.81	0.88	0.86	0.93
Hospital 2	1.00	0.84	0.84	0.91
Hospital 3	**1.00**	**1.00**	**1.00**	**1.00**
Hospital 4	0.78	**0.94**	0.86	**0.96**
Hospital 5	0.62	0.55	0.71	0.62

Figure 1.2 Performance classification schema.



Comparisons

•In this example there is no question about the performance of Hospital 3, which held its efficiency and effectiveness score at the top on both periods. *Relative* to other hospitals, this particular hospital would be considered as ***benchmark*** health care organization.

•Conversely, the other hospitals relative to Hospital 3 had some performance issues. Hospital 4, although relatively inefficient and ineffective in Time 1, closed this gap and became high performer in Time 2.

•The situation for Hospital 1 is also promising, both efficiency and effectiveness improved in time, however, this hospital needs more improvement on its efficiency to become a high performer as Hospitals 3 & 4.

•Hospital 2 exhibits a mix performance from Time 1 to Time 2 whose efficiency went down while effectiveness reached its relative high standard.

•In the past, many health care managers argued this point to improve quality (effectiveness) something has to be given away from efficiency. Of course, performance of Hospital 4 argues against this point.

•Lastly, there is a poor performance by Hospital 5 in Time 1, and this poor performance amplified in Time 2.

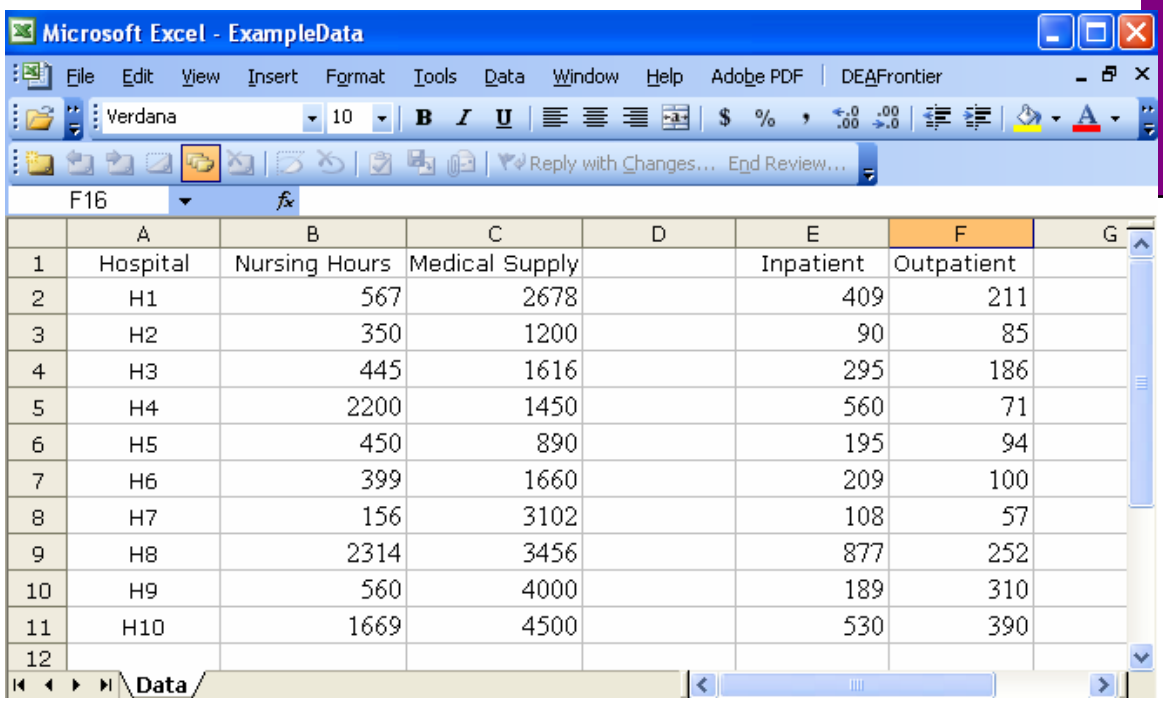
•Given these scenarios, one can classify the health care performance by these organizations into four groups based on their efficiency and effectiveness scores using Time 2 scores as shown in Table 1.2.

•Hospitals exhibiting less than high performance in either measure should plan to move upper-right quadrant of the performance classification schema.

EFFICIENCY COMPONENT
Hospital Inputs and Outputs

Hospitals j	Inputs		Outputs	
	Nursing Hours x_{1j}	Medical Supplies($) X_{2j}	Inpatient Admissions y_{1j}	Outpatient Visits Y_{2j}
1	567	2678	409	211
2	350	1200	90	85
3	445	1616	295	186
4	2200	1450	560	71
5	450	890	195	94
6	399	1660	209	100
7	156	3102	108	57
8	2314	3456	877	252
9	560	4000	189	310
10	1669	4500	530	390

Efficiency Report



	A	B	C	D	E	F	G
1	Hospital	Nursing Hours	Medical Supply		Inpatient	Outpatient	
2	H1	567	2678		409	211	
3	H2	350	1200		90	85	
4	H3	445	1616		295	186	
5	H4	2200	1450		560	71	
6	H5	450	890		195	94	
7	H6	399	1660		209	100	
8	H7	156	3102		108	57	
9	H8	2314	3456		877	252	
10	H9	560	4000		189	310	
11	H10	1669	4500		530	390	
12							

	Input-Oriented
	CRS
DMU Name	Efficiency
H1	1.00000
H2	0.61541
H3	1.00000
H4	1.00000
H5	1.00000
H6	0.75780
H7	0.96852
H8	1.00000
H9	1.00000
H10	0.75297

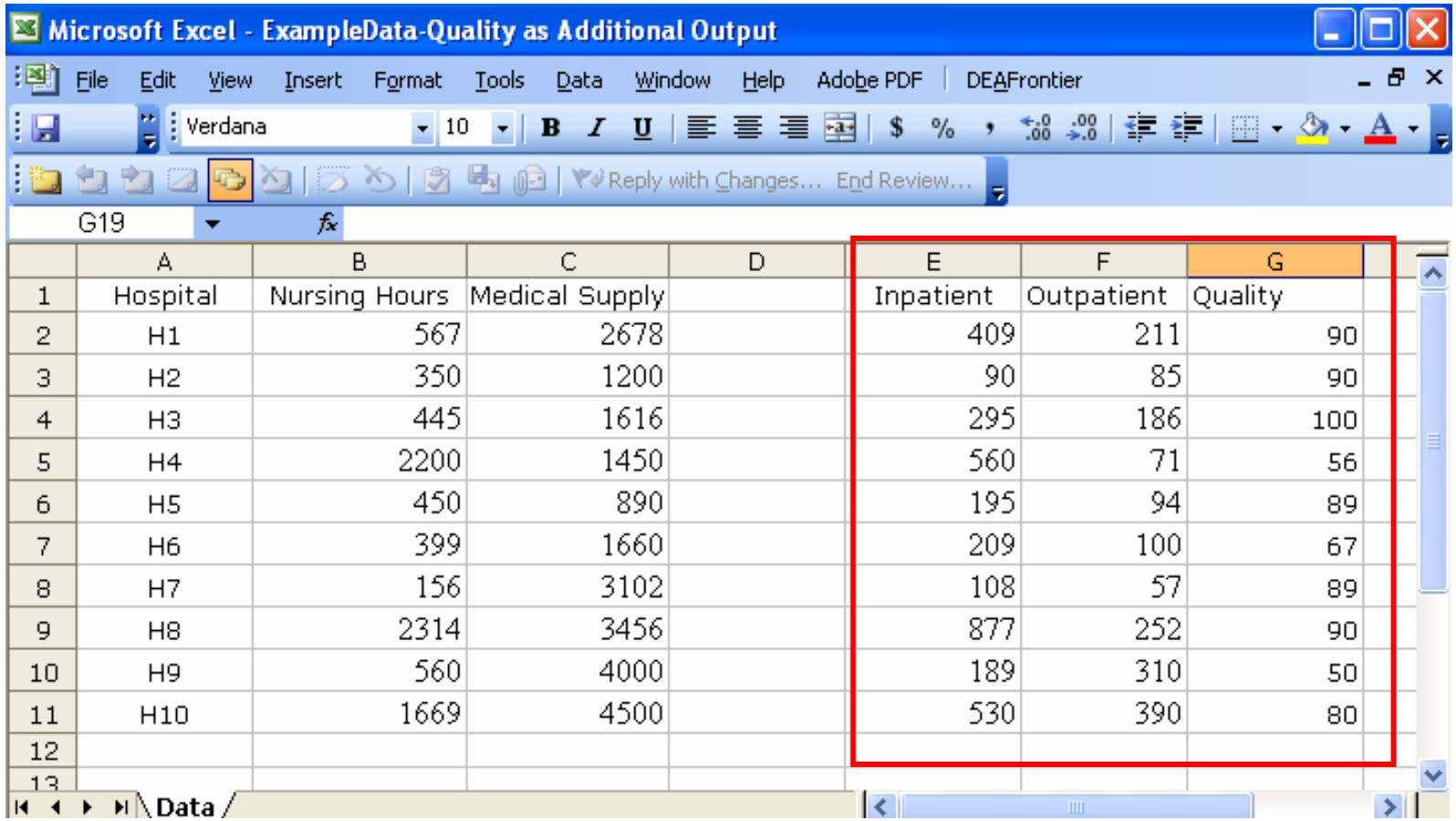
HOW SHOULD WE INCORPORATE QUALITY into DEA MODEL?

QUALITY & DEA MODEL

- As an additional output?
- As an independent output?
- Combine efficiency and quality some other way?

DEA & Quality

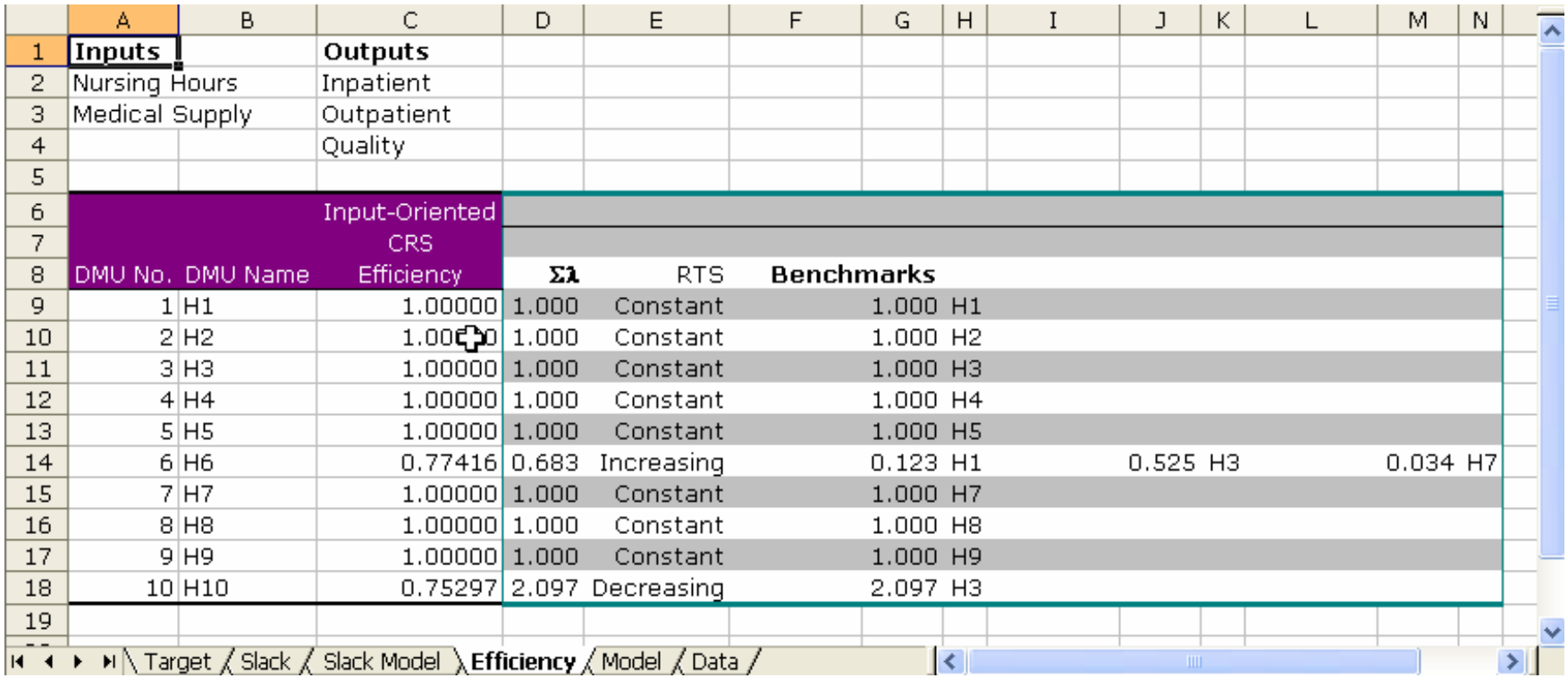
Quality as an Additional Output



	A	B	C	D	E	F	G
1	Hospital	Nursing Hours	Medical Supply		Inpatient	Outpatient	Quality
2	H1	567	2678		409	211	90
3	H2	350	1200		90	85	90
4	H3	445	1616		295	186	100
5	H4	2200	1450		560	71	56
6	H5	450	890		195	94	89
7	H6	399	1660		209	100	67
8	H7	156	3102		108	57	89
9	H8	2314	3456		877	252	90
10	H9	560	4000		189	310	50
11	H10	1669	4500		530	390	80
12							
13							

DEA & Quality

Quality as an Additional Output



	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	**Inputs**		**Outputs**											
2	Nursing Hours		Inpatient											
3	Medical Supply		Outpatient											
4			Quality											
5														
6			Input-Oriented											
7			CRS											
8	DMU No.	DMU Name	Efficiency	**Σλ**	RTS	**Benchmarks**								
9	1	H1	1.00000	1.000	Constant	1.000	H1							
10	2	H2	1.00000	1.000	Constant	1.000	H2							
11	3	H3	1.00000	1.000	Constant	1.000	H3							
12	4	H4	1.00000	1.000	Constant	1.000	H4							
13	5	H5	1.00000	1.000	Constant	1.000	H5							
14	6	H6	0.77416	0.683	Increasing	0.123	H1			0.525	H3		0.034	H7
15	7	H7	1.00000	1.000	Constant	1.000	H7							
16	8	H8	1.00000	1.000	Constant	1.000	H8							
17	9	H9	1.00000	1.000	Constant	1.000	H9							
18	10	H10	0.75297	2.097	Decreasing	2.097	H3							
19														

Target / Slack / Slack Model / **Efficiency** / Model / Data /

DEA & Quality

Quality as an Additional Output

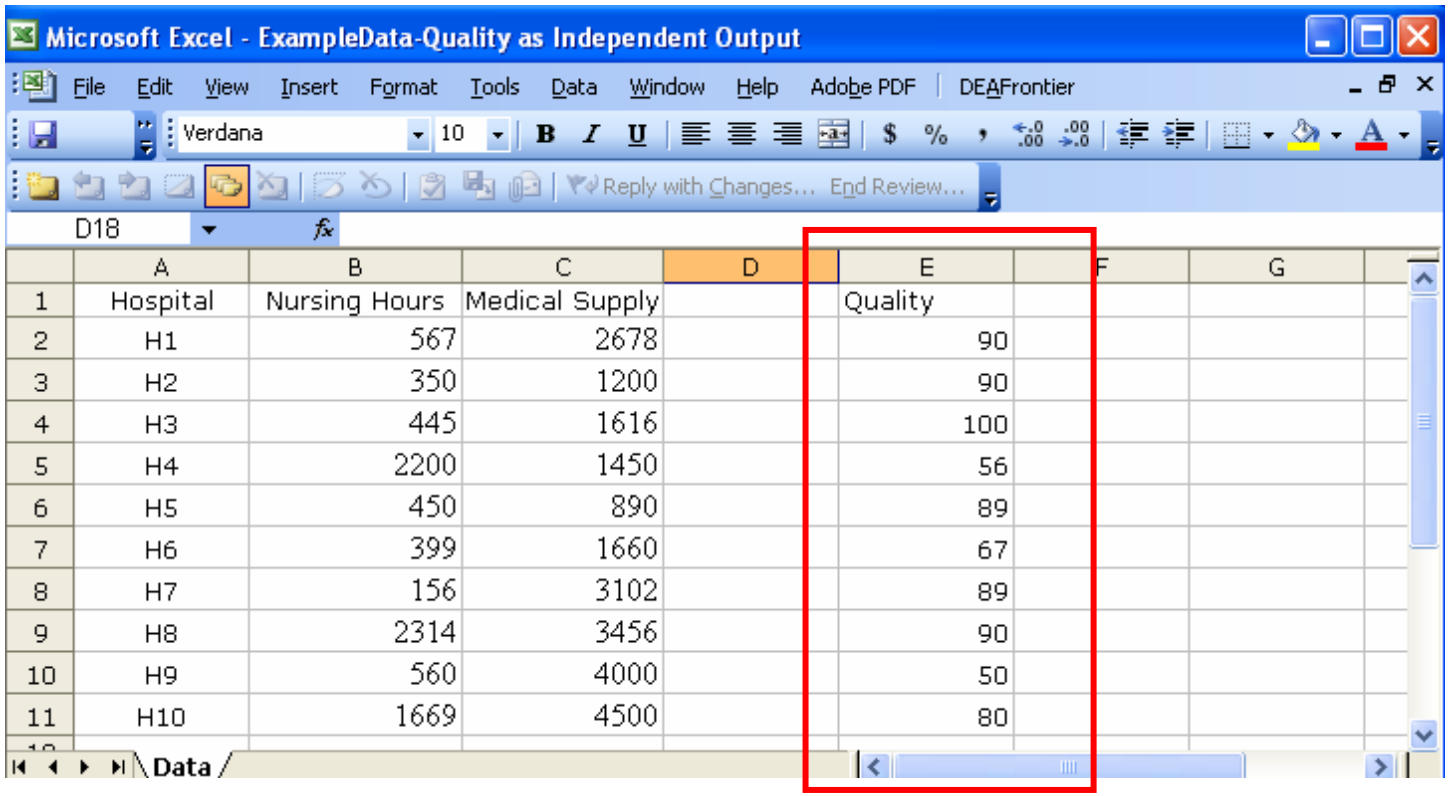
	Basic Model	Quality as additional output	
DMU Name	Input-Oriented CRS Efficiency	Input-Oriented CRS Efficiency	Raw Quality Score
H1	1.00000	1.00000	90
H2	0.61541	1.00000	90
H3	1.00000	1.00000	100
H4	1.00000	1.00000	56
H5	1.00000	1.00000	89
H6	0.75780	0.77416	67
H7	0.96852	1.00000	89
H8	1.00000	1.00000	90
H9	1.00000	1.00000	50
H10	0.75297	0.75297	80
Average	0.90947	0.95271	80

Quality as an Additional Output

- Closer examination of the last two columns of the previous Table, we observe that the two hospitals, H2 and H7, which are now among the best performers, they have raw quality scores of 90 and 89, respectively.
- Although this may be acceptable, assuming 90 is a good raw quality score, yet other hospitals such as H4 and H9 despite their perfect DEA scores, the raw quality scores, 50 and 56, are not near to acceptable levels.
- Thus, this illustration shows the weakness for inclusion of quality variable into benchmark model as an additional output.

DEA & Quality

Quality as Independent Output



	A	B	C	D	E	F	G
1	Hospital	Nursing Hours	Medical Supply		Quality		
2	H1	567	2678		90		
3	H2	350	1200		90		
4	H3	445	1616		100		
5	H4	2200	1450		56		
6	H5	450	890		89		
7	H6	399	1660		67		
8	H7	156	3102		89		
9	H8	2314	3456		90		
10	H9	560	4000		50		
11	H10	1669	4500		80		

DEA & Quality

Quality as Independent Output

	A	B	C	D	E	F	G	H	I	J	K
1	**Inputs**		**Outputs**								
2	Nursing Hours		Quality								
3	Medical Supply										
4											
5			Input-Oriented								
6			CRS								
7	DMU No.	DMU Name	Efficiency	Σλ	RTS	**Benchmarks**					
8	1	H1	0.56340	1.002	Decreasing	0.841	H2		0.161	H7	
9	2	H2	1.00000	1.000	Constant	1.000	H2				
10	3	H3	0.86100	1.111	Decreasing	1.081	H2		0.030	H7	
11	4	H4	0.38362	0.625	Increasing	0.625	H5				
12	5	H5	1.00000	1.000	Constant	1.000	H5				
13	6	H6	0.61644	0.742	Increasing	0.671	H2		0.070	H7	
14	7	H7	1.00000	1.000	Constant	1.000	H7				
15	8	H8	0.26074	1.013	Decreasing	1.013	H5				
16	9	H9	0.27245	0.558	Increasing	0.338	H2		0.221	H7	
17	10	H10	0.21111	0.894	Increasing	0.499	H2		0.395	H5	

Target / Slack / Slack Model / **Efficiency** / Model / Data

DEA & Quality

Quality as Independent Output

	Basic Model	Quality as independent Output	
DMU Name	Input-Oriented CRS Efficiency	Input-Oriented CRS Efficiency	Raw Quality Score
H1	1.00000	0.56340	90
H2	0.61541	1.00000	90
H3	1.00000	0.86100	100
H4	1.00000	0.38362	56
H5	1.00000	1.00000	89
H6	0.75780	0.61644	67
H7	0.96852	1.00000	89
H8	1.00000	0.26074	90
H9	1.00000	0.27245	50
H10	0.75297	0.21111	80
Average	0.90947	0.61688	80

Quality as an Independent Output

- While we can validate that hospital H5 is both efficient and effective in both DEA models, and it has near acceptable raw quality score, however, we cannot validate quality DEA score for hospitals H1, H3 and H8. These hospitals had good raw quality scores but the DEA model resulted poor performance on quality.

- This brings the dilemma on how to incorporate quality into DEA models. In these example we used only one quality variable. Other dimensions of the quality certainly would change the results of these evaluations.

- This is a fertile area of research in DEA health care, and many operational research and health services researchers will be examining this issue as more public data becomes available in quality of care. In the future, better models would be built and validated for health care managers' use.

DEA & Quality

Combining Efficiency & Quality

	Basic Model	
DMU Name	Input-Oriented CRS Efficiency	Raw Quality Score
H1	1.00000	90
H2	0.61541	90
H3	1.00000	100
H4	1.00000	56
H5	1.00000	89
H6	0.75780	67
H7	0.96852	89
H8	1.00000	90
H9	1.00000	50
H10	0.75297	80
Average	0.90947	80

DEA & Quality

Combining Efficiency & Quality

Efficiency	Effectiveness (Quality): Low <90	Effectiveness (Quality): High >=90
High = 1.0	Improvement Need on Quality **H4, H5, H9**	Best Performance H1, H3, H8
Low < 1.0	Poor Performance H6, H7, H10	**Improvement Need on Efficiency H2**

	Basic Model	
DMU Name	Input-Oriented CRS Efficiency	Raw Quality Score
H1	1.00000	90
H2	0.61541	90
H3	1.00000	100
H4	1.00000	56
H5	1.00000	89
H6	0.75780	67
H7	0.96852	89
H8	1.00000	90
H9	1.00000	50
H10	0.75297	80
Average	0.90947	80

NOW THE REAL EXAMPLE

An Application to American Hospitals with Electronic Medical Records (EMR)

Hospital EMR Use and Performance: A National Study*

Hospital EMR use is identified using the HIMSS data and is indicated by a hospital's reporting that the facility uses fully automated computerized patient records (HIMSS 2004).

*A.S. Kazley & Y.A. Ozcan

Efficiency Measure

- Hospital efficiency is measured using Data Envelopment Analysis (DEA). In this study, a CRS, input-oriented model is used.

- Inputs include: Beds, Service-mix, Labor, Non-Labor Expenses

- Outputs include: Case-mix adjusted admissions, outpatient visits

Quality Measure

Hospital quality is measured using data from the Hospital Quality Alliance for the purpose of public reporting on the Hospital Compare Website.

•The data include information about clinician adherence to clinical guidelines for patients with three conditions including pneumonia, acute myocardial infarction and congestive heart failure (HQA 2004).

•The data were coded to produce a total hospital quality score by providing a dichotomous measure of whether the hospital performed above (1) or below (0) the national average for each individual measure and then dividing this score by the number of measures the hospital reported.

•This resulted in the range of scores from 0 to 1 with one indicating perfect adherence to clinical guidelines in these measures.

Cut-off Point for this Study

- Once the hospital quality and efficiency scores were calculated, the scores were dichotomized to identify the top performers in quality and efficiency.

- High quality performers were identified as those with a score of at or above the national mean.

- High efficiency performers were identified as those with DEA scores at or above the 75th percentile nationally.

Hospital EMR Use and Performance: A National Study

Research Findings

		Quality		
		Low	High	Total
Efficiency	High	391	494	885
	Low	989	1017	2006
	Total	1380	1511	2891
	Chi-square(1d.f.)=6.456 p<.05			

Hospital EMR Use and Performance: A National Study

Hospitals with EMRs

Efficiency	Quality: Low	Quality: High	Total
High	50 (14.4%)	78 (22.4%)	128 (36.8%)
Low	85 (24.4%)	135 (38.8%)	220 (63.2%)
Total	135 (38.8%)	213 (61.2%)	348 (100.0%)

Bivariate Probit Results

Variable		Confidence Interval	
EFFICIENCY	COEF.	LOWER	UPPER
EMR	-0.089	-0.243	0.065
SIZE	0	0	0
FOR-PROFIT	0.004	-0.145	0.152
PUBLIC	-0.005	0.141	0.131
SYSTEM MEMBER	-0.101	-0.212	0.011
NON-TEACHING	-0.03	-0.231	0.171
CASE MIX	-1.23***	-1.487	-0.975
CONSTANT	2.26***	1.944	2.573
QUALITY			
EMR	.176*	0.025	0.326
SIZE	0	0	0
FOR-PROFIT	-.422***	-0.564	-0.281
PUBLIC	-.159*	-0.284	-0.032
SYSTEM MEMBER	0.087	-0.017	0.191
NON-TEACHING	.314**	0.11	0.519
CASE MIX	.712***	0.461	0.963
CONSTANT	-.836***	-1.138	-0.535
*p<.05 **p<.01 ***p<.001			

Conclusions

- EMR use does not necessarily influence hospital efficiency, but it does appear to have a relationship to quality.

- The correlation between hospital EMR use and quality is likely the result of decreased errors based on human mistakes, handwriting errors, and drug interactions.

- The standardized care that is the result of EMR use also likely leads to greater documentation and information about patients.

Conclusions

It is possible that hospital quality gains associated with EMR use occur at the cost of hospital efficiency. This could happen in two ways:

- First
  - EMR systems have many standardized fields to ensure that care is routine and clinicians are collecting and considering all pertinent information.
  - In some ways, this overload of information may be excessive and may slow down the processes of care, thus decreasing efficiency while also promoting quality through the better collection and documentation of patient information.
  - If this is the case, physicians may find they are taking more time collecting and entering patient information than before EMR implementation as they are being more thorough with information.
  - In addition, as they review an EMR for a patient they have not seen before, they may be reviewing more medical history than is customary with paper records since the standardized fields likely increased the clinician compliance to questions.

Conclusions

- Second
  - Physicians, nurses, and other clinicians may still be adjusting to the practice and equipment used for EMRs. It is likely that this period of adjustment may include hardware and software malfunctions, human errors, and the need for policy development to support the EMR practice.
  - If clinicians are taking computerized devices directly into the examination rooms to record information while providing care, this will require that they adjust to this practice. On the other hand, if they are first recording the information in the paper chart and then depending upon office support staff to transcribe the information to an EMR, efficiency would not increase.

Implications

- Because hospital quality is shown to be associated with EMR use, the practice should be further examined and promoted in health care organizations.
- Practitioners should seek ways to implement and use EMRs if they do not already.
- Policy makers and payer groups may wish to create incentives for EMR use due to the potential quality improvements. However, since not all hospitals have the financial resources to purchase and implement EMRs, programs to make the software and hardware available should be explored and developed.
- Practitioners and researchers should attempt to determine how EMR use can provide efficiency gains.
- Future research may wish to examine what system and implementation factors influence efficiency.
- Future research may also seek to determine if there is an optimal period of time between date of implementation and increased quality performance.