Asian Academy of Management Journal, Vol. 8, No. 2, 31–43, July 2003

PRODUCTIVITY MEASUREMENT OF MALAYSIAN GOVERNMENT HOSPITALS USING DATA ENVELOPMENT ANALYSIS

Razli Che Razak
Universiti Utara Malaysia

ABSTRACT

Traditionally, productivity is defined in terms of the efficiency of transforming inputs into outputs. However, researchers have always argued that the concept of productivity should not be limited to efficiency only, ignoring the phenomenon of effectiveness. This is particularly true in an organization that is not profit-oriented, such as non-governmental and governmental organizations, where efficiency may take a back seat as opposed to effectiveness. This paper takes the approach of measuring productivity by incorporating both efficiency and effectiveness, when measuring the productivity of public hospitals in Malaysia. However, given the different unit of measures as well as the differences in the nature of the data measuring efficiency and effectiveness, we needed a method that was able to combine both subjective as well as objective data. Thus, we found the Data Envelopment Analysis (DEA) most useful for a composite measure of productivity. The main findings show that productivity measures using both efficiency and effectiveness through the DEA is more meaningful than a measure with efficiency only. The effectiveness variable is found to have an impact on measuring productivity.

INTRODUCTION

In the era of global competition in a borderless world, productivity growth is the path for sustained economic growth and enhanced living standards. Traditionally, productivity has been defined as the efficiency of transforming input into output (Bitran & Chang, 1984; Stoner et al., 1995; Parkan, 1992). From an economist's perspective, productivity is technical efficiency, which is normally measured by the ratio of unit output per unit input. This measure of productivity ignores the effectiveness dimension of productivity. While this measure of productivity may have negligible impact when comparing performance of profit-oriented organizations, it may not be reflective of the performance of non-profit oriented organizations. Over the last few years, researchers have commented on the need to include the effectiveness dimension in the measurement of productivity but refrained from doing so due to the lack of means to combine the efficiency and effectiveness dimensions to form an overall productivity measure. It is the contention of this paper, that both of these dimensions can be combined through the Data Envelopment Analysis (DEA) technique to measure productivity. Hospitals were assessed by DEA using six inputs and three outputs. We argue that effectiveness as measured by the quality of health

care in terms of patient satisfaction forms one of the outputs of hospitals, which also competes for the limited resources. Since, efforts towards improving quality of healthcare do divert resources from other outputs; one can argue that it is an output of the hospital system. The focus of the study is on input orientation since policy makers control the inputs, while outputs are exogenous. Though the proposed measure of productivity does not come up with an absolute measure, it does allow comparisons across organizations. This proposed measure of productivity is demonstrated through a sample of Malaysian public hospitals.

BACKGROUND LITERATURE

Productivity Measurement

A good productivity measurement can provide accurate estimation towards overall efficiency. Traditionally, productivity is measured using the ratio of unit output per unit input. If more than one input has been utilized, productivity is known as Total Factor Productivity. The concept of Total Factor Productivity is defined as the ratio of unit output per unit input of labour and capital (Taylor & Davis, 1977; Mali, 1978).

According to Sherman (1984), and McLaughlin and Coffey (1990), the concept and measurement of organizational productivity in the manufacturing sector are well studied as compared to that in the service sector. Productivity measurement of organization in the service sector is inherently more difficult given the intangible, perishable and heterogeneous nature of the output and the simultaneous consumption and production of the output. Gronroos (1990), argued that measurement of service productivity needs a more holistic approach to include customers' orientation, and further stressed that quality and productivity cannot be treated as different entities in service. Vuorinen et al. (1998) defined service productivity as the ability of service organizations to utilize their inputs to produce quality services as expected by customers.

Other researchers have also suggested that service productivity especially that of public sectors should incorporate the effectiveness dimension. Belgrave (1995), mentioned that input cost minimization do not normally feature effectiveness in measuring productivity. Effectiveness or service quality is important to public services provider and customer groups under their jurisdictions. Failure to integrate quality factor in service evaluation will reduce employees' motivation to change for the improvement of public sector efficiency. Public sector productivity measurement must combine both technical efficiency and effectiveness criteria i.e. outcome measurement and not merely measuring output to input ratio (Harker, 1995). Bouckaert (1992), argued that efficiency is a relationship between outputs to inputs; it

must be complemented with effectiveness. The effectiveness of the public sector is measured by the degree to which the intended purposes of the services are being met.

Productivity Measurement in the Healthcare Industry

The healthcare industry is one of the main industries in Malaysia. The trend of increasing the budget allocation to the Ministry of Health can be seen from a RM2.49 billion allocation (5.47% of the total budget) in 1992 to a RM3.79 billion (6.31%) in 1997. The growing cost of healthcare in Malaysia is heavily discussed in the mass media and the needs of third parties like healthcare insurance companies to cover part of the expenses. According to McConnel (1992), productivity is needed to overcome the rising cost. Deane (1987) defined hospital productivity as a ratio of output to input. She defined output as quantity and quality of output produced by hospital and input as total resources, which are directly or indirectly invested. Serway, Strum and Huang (1987) stated that the history of productivity measurement of hospitals only focused on the efficiency of inpatient operations. Adjustment has been made by considering outpatient operations at the end of the 1960s when outpatient services increased rapidly. They also suggested a composite productivity measure, which involved many sets of productivity indicators, be used, such as staff fulltime equivalent (FTE) per adjusted occupied bed, total operational expenses per net total income, productive FTE expenses per net income from patients and productive FTE expenses per number of adjusted patient days. Sear (1991) has suggested three ratios be employed in the measurement of hospital productivity; staff FTE to number of beds, total working hours per adjusted patient days and salary to adjusted patient days. In his other study, Sear (1992) noticed that all these ratios only measure operational efficiency as individual indicators and not globally like the DEA.

Data Envelopment Analysis Technique

DEA, as first operationalised by Charnes, Cooper and Rhodes (CCR) (1978) based on the ideas of Farrell, is one of the most successful methods in Operations Research. DEA is a non-parametric method used to estimate a hospital's relative efficiency (Sherman, 1984; Groskopf & Valdmanis, 1987; Borden, 1988; Morey, Fine & Loree, 1990; Zuckerman, Hadley & Iezzoni, 1996; Ozcan & McCue, 1996). To measure the productivity of Malaysian hospitals, we applied DEA since this method provided us with a relative and global measurement. Most researchers only focused on the efficiency aspect of productivity in their studies but we used efficiency, effectiveness and a multiple approach measurement to measure government hospital productivity. The effectiveness of a Malaysian hospital is obtained through the hospital outcomes indicator i.e. quality of output, which is measured by the patient satisfaction index (PSI). Patient satisfaction is a psychosocial dimension of healthcare monitored in Quality Assurance Programs by the Malaysian Ministry of Health (Ministry of Health, 1990).

METHODOLOGY

Questionnaire

Two types of questionnaires were used to measure the variables involved in this study namely efficiency-related variables and effectiveness-related variables. The former includes input and output variables. There are six major inputs and two major outputs of Malaysian government hospitals. Two direct hospital outputs used in this study are the number of patients discharged and inpatient days. On the input side, six variables representing resource consumption are defined as the number of doctors, the number of nurses and assistant nurses, the number of other medical staff, the number of administration and clerical staff, the number of inpatient beds and total expenses. The first four inputs are labour-related and the last two are capital-related. Input and output variables were selected among those that had been used extensively in the literature (Grosskopf & Valdmanis, 1987; Bruning & Register, 1989; White & Ozcan, 1996; Kooreman, 1994; Ferrier & Valdmanis, 1996; Grosskopf, Margaritis & Valdmanis, 1997; Parking & Hollingsworth, 1997; Matarodona & Junoy, 1997; Chan, 1998; Gerdtham et al., 1998), and from interviews with local medical experts.

The second questionnaire was developed to measure the effectiveness–related variable, namely, PSI. Forty-eight items were used to measure patient satisfaction, covering ten dimensions of service. Another two items were needed to capture overall perceptions of respondents towards the services and treatments offered by the hospitals. These items were measured on a 5-point Likert-like scale of 1 (very satisfied) to 5 (very dissatisfied). The questionnaire items were derived from focus group interviews, and extensive literature reviews based on studies by Reidenbach and Sandifer-Smallwood (1990), Bowers et al. (1994), Hall (1995), Hall and Press (1996), Dansky and Brannon (1996), Lam (1997), Oswald et al. (1998) and principles of healthcare quality services by Donabedian (1980). Validity and reliability test were conducted to check the usability of this questionnaire in the Malaysian environment. The validity test was evaluated by the correlation between the composite score of PSI with the two items measuring overall satisfaction. The results showed that both items were highly correlated and significant at 1% level with the composite score of PSI ($r = 0.666$ and $r = 0.646$). The reasonably high values of correlation showed that the 48 items used to measure patient satisfaction has face and convergence validity. The 48 items were also factor analysed into the following eight dimensions: attention to patients and visitors, service time, information relief and service ability, clinical and record service, confidentiality and payment information, physical appearance, facilities and equipment, and food. The Cronbach-alpha coefficients of reliability measures of the eight dimensions of service quality are 0.9330, 0.8900, 0.8762, 0.8103, 0.7805, 0.7364, 0.7242 and 0.7689. Nunnally (1978) deems alpha values of 0.70 or more to be acceptable. The validity and reliability tests, show our composite scale PSI, to be a reliable and valid measure of the construct of patient satisfaction.

We computed composite score index of patient satisfaction for each hospital using the 48 items.

Data Collection

Data was collected from two sources. Firstly, data measuring the input and output variables of hospital operations was obtained from the director of every government hospital in Peninsular Malaysia. There are 77 government hospitals, categorized as state hospitals, district hospitals with specialists and district hospitals without specialists. Seventy-seven sets of questionnaires were distributed by post to all the hospitals in Peninsular Malaysia after obtaining prior permission from the Deputy Director General of the Ministry of Health. Out of the 63 returned questionnaires only 57 (74%) were useable for analysis due to missing values. Table 1 presents the mean and standard deviation of input and output data of Malaysian government hospitals.

TABLE 1
DESCRIPTIVE STATISTICS OF INPUT AND OUTPUT VARIABLES

	Type of hospital		
	State hospital (N = 7)	District with specialist (N = 9)	District without specialist (N = 41)
Input			
Number of doctors	188	49	6
	(76)	(30)	(3)
Number of nurses and assistant nurses	649	263	63
	(198)	(106)	(25)
Number of other medical staff	500	264	74
	(238)	(143)	(38)
Number of administration and clerical staff	119	36	21
	(75)	(18)	(14)
Number of in-patient beds	815	348	103
	(271)	(152)	(38)
Total expenses (RM millions)	59.02	21.04	5.97
	(22.31)	(11.10)	(2.94)
Output			
Number of patients discharged	42968	21451	6049
	(12859)	(7691)	(2374)
Number of in-patient days	190807	73320	16373
	(60529)	(34295)	(8262)

* Numbers in parenthesis are standard deviation.

Secondly, the data regarding PSI was collected from the patients who had received treatment from the respective hospitals. Two methods were used, mail surveys and personal interviews. A set of questionnaire with a self-addressed envelope was posted to patients based on the latest list of sixty patient names and addresses that were supplied by the hospitals. To increase the response rate, we also conducted personal

interviews for the respective hospital by choosing the respondents through convenience sampling. Eight hundred and twenty five surveys were returned, of which 701 were usable. The test of Mann-Whitney U ($Z = –1.505$; $p > 0.05$) on the PSI for each hospital between postal and interview surveys showed that there were no significant differences on the PSI. We conclude that the responses obtained using both the postal method and interviews are not significantly different, and therefore were analysed as one sample. Table 2 depicts the demographic profiles of the respondents.

TABLE 2
PROFILE OF RESPONDENTS (N = 701)

	Demographics	Frequency	Percentage
1	Sex		
	Male	288	41.3
	Female	410	58.7
2	Race		
	Malay	580	83.2
	Chinese	70	10.1
	Indian	35	5.0
	Others	12	1.7
3	Age (years)		
	Under 21	46	6.9
	21 to 30	215	32.4
	31 to 40	157	23.7
	41 to 50	115	17.3
	Above 50	130	19.6
4	Marital Status		
	Single	158	22.7
	Married	511	73.3
	Divorce	28	4.0
5	Working Sector		
	Government	203	29.3
	Private	125	18.1
	Semi Government	17	2.5
	Self Employed	91	13.0
	Others	256	37.1
6	Current Monthly Income (RM)		
	< 1000	304	44.1
	1000 – < 2000	146	21.2
	2000 – < 3000	25	3.6
	3000 – < 4000	3	0.4
	4000 – < 5000	1	0.1
	> 5000	3	0.4
	No Income	207	30.0
7	Education Level (highest level achieved)	10	1.4
	Post Graduate Degree	36	5.2
	Degree	180	26.0
	Diploma	466	67.3
	Others		

ANALYSIS, RESULTS AND DISCUSSION

DEA can operate in the environment of constant return to scale or variable return to scale. The two basic DEA models were applied; Charnes, Cooper and Rhodes (CCR) and Banker, Charnes and Cooper (BCC) (Banker et al., 1984). The extended model used in this study is as shown.

Objective:

Maximize Productivity $(\theta_p) = \sum_{r=1}^{s} (v_r y_{ro} + v_{psi} PSI_o)$

Subject to

$$\sum_{r=1}^{s} (v_r y_{rj} + v_{psi} PSI_j) - \sum_{i=1}^{m} u_i x_{ij} \leq 1, j = 1, 2, \ldots n$$

$$\sum_{i=1}^{m} u_i x_{ij} = 1$$

$u_1, u_2, \ldots, u_i \geq 0$

$v_{1,} v_{2,} \ldots, v_r$ & $v_{psi} \geq 0$

v_r = weight of r th output

u_i = weight of i th input

y_{rj} = amount of r th output for hospital j

x_{ij} = amount of i th input for hospital j

v_{psi} = weight of PSI

PSI_j = Patient Satisfaction Index (PSI) for hospital j

Table 3 shows the distribution of the relative productivity of Malaysian hospitals upon utilization of both CCR and BCC models for the extended objective function.

TABLE 3
PRODUCTIVITY DISTRIBUTION (θ_P) SCORES

Score	CCR Model (θp ccr)	BCC Model (θp bcc)
0.600 – 0.699	2	1
0.700 – 0.799	7	4
0.800 – 0.899	13	9
0.900 – 0.999	9	9
1.000	26	34
Mean	0.9206	0.9466
Standard deviation	0.1003	0.0843

Results show that the average productivity of Malaysian hospitals is 0.9206 (CCR) and 0.9466 (BCC). The percentage of productive hospitals is 45.6% and 59.7%,

respectively. Hospitals need to lower their inputs by 7.94% (CCR model) and 5.34% (BCC model) respectively. Whether hospitals in Malaysia operate on constant return to scale or variable return to scale can be tested using Banker's asymptotic test and a non-parametric Kolmogorov-Smirnov test. The two semi-parametric procedures applied by Banker and Slaughter (1997) and Kolmogorov-Smirnov produced the results tabulated in Table 4.

TABLE 4
RETURN TO SCALE TEST

Productivity distribution	Statistical test	Test value	Result
1. Assumption: Exponential distribution $T_{EX} \sim F_{(2N,2N)}$	$T_{EX} = \frac{\sum_{p=1}^{57} (\theta_p ccr - 1)}{\sum_{p=1}^{57} (\theta_p bcc - 1)}$	$T_{EX} = \frac{-4.52}{-3.05} = 1.482^*$	Reject CRS
2. Assumption: Half-normal distribution $T_{HN} \sim F_{(N,N)}$	$T_{HN} = \frac{\sum_{p=1}^{57} (\theta_p ccr - 1)^2}{\sum_{p=1}^{57} (\theta_p bcc - 1)^2}$	$T_{HN} = \frac{0.92}{0.56} = 1.642^*$	Reject CRS
3. No assumption	$D_N = \text{Max}\lvert F_{n1}(X) - F_{n2}(X)\rvert$	$D_N = 0.158$	Fail to reject CRS

*Indicates significance at 5% level

Different tests produced different results. Under Banker's asymptotic test, we found evidence to reject the null hypothesis of constant return to scale at 5% significance level when the productivity distributions were assumed as exponential and half normal. But under a non-parametric test where no assumption for productivity distribution is made, the null hypothesis of constant return to scale cannot be rejected. According to Banker (1993), if the different tests provide different results, the findings should be based upon those without prior assumption on the distribution. We can therefore assume that hospitals in Malaysia operate on a constant return to scale.

We further tested whether there is a significant difference in productivities of the different types of hospital. For this, we used the non-parametric Kruskal-Wallis H test, given that DEA is a non-parametric procedure and productivity measures obtained is ordinal in nature. The results show no evidence ($\chi^2_{,2} = 0.093$, $p > 0.05$) to suggest that productivities of different types of hospitals are significantly different.

Does the inclusion of the effectiveness dimension impacts ranking of hospitals? This impact was ascertained by comparing the efficiency and overall productivity

measures. A cross tabulation of the productivity scores and efficiency scores is given in Table 5.

TABLE 5
DEACCR VS. PROD CCR CROSS TABULATION

		Productivity score					Total
		1.00	0.9–0.999	0.8–0.899	0.7–0.799	0.6–0.699	
Efficiency score	1.00	19					19
	0.9–0.999	3	7				10
	0.8–0.899	1		8			9
	0.7–0.799	2	1	4	3		10
	0.6–0.699	1	1		2	2	6
	0.5–0.599				2		2
	0.4–0.499			1			1
Total		26	9	13	7	2	57

Clearly, we see that of the 57 hospitals, 7 (12.3%) were able to achieve highest ranking by virtue of enhanced service quality index. This gives some indication that the inclusion of quality of healthcare index can moderate low efficiency measures. Since there are many expected values in Table 5 (less than 5), we considered the inefficient and unproductive hospitals as zero and efficient and productive hospitals as one. The classification is shown in Table 6 below.

TABLE 6
DEACCR VS. PROD CCR CROSS TABULATION (AFTER COMBINATION)

		Productivity score		**Total**
		1 = Productive	0 = Unproductive	
Efficiency score	1 = Efficient	19	0	**19**
	0 = Inefficient	7	31	**38**
Total		**26**	**31**	**57**

Based on Table 6, the results of the Chi-Square test is $\chi^2_{,1} = 33.981$ and $p < 0.0001$ shows that there is some degree of relationship between efficiency scores and productivity scores. Further, the results of the McNemar test indicate that a significant ($\chi^2_{,1} = 26.036$ and $p < 0.0001$) number of hospitals changed ranks when the effectiveness criteria is included in the productivity measurement. This clearly justifies the need to include the effectiveness measure in any productivity measurement, particularly for non-profit oriented organizations.

CONCLUSION

The study has shown that the DEA has great potential to measure public service productivity. The main advantage of the DEA in this study is its ability to combine

both efficiency and effectiveness into one composite measure of productivity. Our study has shown that measuring productivity without including an effectiveness measure can be misleading. The findings also demonstrate that the average productivity of Malaysian hospitals is 92.6% and that there is no significant difference in productivity among hospitals of different sizes. The size does not influence the productivity, as size would have been accounted for in the efficiency ratio, by means of the inputs. This study can be extended by comparing DEA productivity measures with other methods such as ratio analysis and stochastic frontier analysis in Malaysian public sector.

REFERENCES

Banker, R. D., Charnes, A. & Cooper, W. W. (1984). Some model for estimating technical and scale inefficiencies in data envelopment analysis. *Management Science*, 30 (9): 1078–1092.

Banker, R. D. (1993). Maximum likelihood, consistency and data envelopment analysis: a statistical foundation. *Management Science*, 39: 1265–1273.

Banker, R. D. & Slaughter, S. A. (1997). A field study of scale economies in software maintenance. *Management Science*, 43: 1265–1273.

Belgrave, J. (1995). Providing a world-class customer service. *Australian Journal of Public Administration,* 54 (3): 310–316.

Bitran, G. R. & Chang, L. (1984). Productivity measurement at the firm level. *Interfaces*, 14 (3): 29–40.

Bouckaert, G. (1992). Public productivity in retrospective. In Holzer, M. (ed.). *Public Productivity Handbook*. New York*:* Marcel Dekker, Inc.

Borden, J. P. (1988). An assessment of the impact of diagnosis-related group (drg) – based reimbursement on the technical efficiency of New Jersey hospitals using DEA. *Journal of Accounting & Public Policy*, 7: 77–96.

Chang, H. H. (1998). Determinants of hospital efficiency: the case of central government-owned hospital in Taiwan. *Omega*, 26 (2): 307–317.

Charnes, A., Cooper, W. W. & Rhodes, E. (1978). Measuring the efficiency of decision making units. *European Journal of Operations Research*, 2: 429–444.

Chirikos, T. N. & Sear, A. M. (1994). Technical efficiency and the competitive behavior of hospital. *Socio Econ. Planning*, 28 (4): 219–277.

Deane, L. M. (1987). Hospital productivity measurement in a changing environment. *Hospital Material Management*, 8 (3): 59–65.

Donabedian, A. (1980). *Explorations in Quality Assessment and Monitoring.* Vol. 1, *The Definition of Quality and Approaches to its Assessment.* National Health Administration Press.

Farrell, M. R. (1957). The measurement of productive efficiency. *Journal of Royal Statistics Society Research Association,* III: 253–290.

Ferrier, G. D. & Valdmanis, V. (1996). Rural hospital performance and its correlates. *Journal of Productivity Analysis*, 7: 65–80.

Giokas, D. I. (2001). Greek hospitals: how well their resources are used. *Omega*, 29: 73–83.

Gronroos, C. (1990). *Service Management and Marketing.* Lexington: MA.

Grosskopf, S. & Valdmanis, V. (1987). Measuring hospital performance: a non parametric approach. *Journal of Health Economics*, 6: 89–107.

Hall, M. F. & Press, I. (1996). Keys to patient satisfaction in the emergency department: results of a multiple facility study. *Hospital & Health Services Administration,* 41 (4): 515–532.

Harker, P. T. (1995). The service quality and productivity change. In Harker, P. T. (ed.). *The Service Productivity and Quality Challenge*. Dordrecht: Kluwer Academic Publishers.

Kooreman, P. (1994). Nursing home care in the Netherlands: a non-parametric efficiency analysis. *Journal of Health Economics*, 13: 301–316.

Mali, P. (1978). *Improving Total Productivity*. New York: John Wiley.

Matarrodona, E. G. & Puig-Junoy, J. (1997). *Market Structure and Hospital Efficiency: Evaluating Potential Effects of Deregulation in a National Health Service.* Working Paper, Department of Economics and Business at Universitat Pompeu Fabra, Trias Fargas 25–27, 08005 Barcelona, Spain.

McConnell, C. R. (1992). Is productivity coming into its own – Again? *Health Care Supervisor*, 10 (3): 75–85.

McLaughling, C. P. & Coffey, S. (1992). Measuring productivity in service. In Lovelock, C. H. (ed.). *Managing Services: Marketing, Operations and Human Resources,* 2nd edition. Englewood Cliffs, NJ: Prentice Hall.

Ministry of Health. (1990). *Quality Assurance Manual for Implementation of the National Indicator Approach for Health Programmes.* Kuala Lumpur: Health Division, Ministry of Health, September 1990.

Morey, R. C., Fine, D. J. & Loree, S. W. (1990). Comparing the allocative efficiencies of hospital. *Omega*, 18 (1): 71–83.

Nunnally, J. C. (1978). *Psychometric Theory.* New York: McGraw-Hill.

Oswald, S. L., Turner, D. E., Snipes, R. L. & Butler, D. (1998). Quality determinants and hospital satisfaction. *Marketing Health Services,* (Spring): 19–22.

Ozcan, Y. A. & McCue, M. J. (1996). Development of a financial performance index for hospitals: DEA approach. *Journal of the Operational Research Society*, 47 (1): 18–26.

Parkan, C. (1992). *Measuring the Effect of New Technology on Productivity.* Working Paper AR-92-01, Faculty of Business, City Polytechnic of Hong Kong.

Reidenbach, R. E. & Sandifer-Smallwood, B. S. (1990). Exploring perceptions of hospital operations by a modified SERVQUAL approach. *Journal of Health Care Marketing*, 10 (4): 47–55.

Sear, A. M. (1991). Comparison of efficiency and profitability of investor-owned multi hospital systems with not-for-profit hospitals. *Health Care Management Review*, 16 (2): 31–37.

_____. (1992). Operating characteristics and comparative performance of investor-owned multi-hospital systems. *Hospital and Health Services Administration*, 37 (3): 403–415.

Serway, G. D., Strum, D. W. & Haug, W. F. (1987). Alternative indicators for measuring hospital productivity. *Hospital and Health Services Administration*, 32 (3): 379–398.

Sherman, H. D. (1984). Improving the productivity of services businesses. *Sloan Management Review,* (Spring): 11–22.

Stoner, J. A. F., Freeman, R. E. & Gilbert, D. A. Jr. (1995). *Management,* 6th edition. Englewood Cliffs, NJ: Prentice Hall.

Taylor, B. W. & Davis, R. K. (1977). Corporate productivity – getting it all together. *Industrial Engineering*, 9 (3): 32–36.

Thanassoulis, E., Bonnssofiane, A. & Dyson, R. G. (1996). A comparison of DEA and ratio analysis as tools for performance assessment. *Omega*, 24 (3): 229–244.

Vuorinen, I., Jarvinen, R. & Laethinen, U. (1998). Content and measurement of productivity in the service sector: a conceptual analysis with an illustrative case from the insurance business. *International Journal of Service Industry Management*, 9 (4): 377–396.

Zuckerman, S., Hadley, J. & Iezzoni, L. (1994). Measuring hospital efficiency with frontier cost functions. *Journal of Health Economics*, 13: 255–280.