Strategy in practice: a quantitative approach to target setting

Fafaliou, Irene and Zervopoulos, Panagiotis

University of Piraeus, Open University of Cyprus

4 January 2014

STRATEGY IN PRACTICE: A QUANTITATIVE APPROACH TO TARGET SETTING

Irene Fafaliou
Department of Economics, University of Piraeus,
80 Karaoli & Dimitriou St, 185 34 Piraeus, Greece
Tel. : +30 2104142157
fafaliou@unipi.gr

Panagiotis D. Zervopoulos
Faculty of Economics and Management, Open University of Cyprus,
Latsia, 2252 Nicosia, Cyprus
Tel.: +30 2102912810
panagiotis.zervopoulos@ouc.ac.cy

ABSTRACT

An extended quality-driven efficiency-adjusted data envelopment analysis (QE-DEA) method is developed to measure the performance of service units. Performance is measured based on efficiency and users' satisfaction. The extended QE-DEA method identifies as benchmarks only units that are qualified both in efficiency and satisfaction and ensures that all of the units will be qualified in both dimensions of performance when their performance becomes maximal. If there are efficient units which fail to provide satisfactory services, an adjustment procedure is applied to their outputs before the assessment of the units' performance. Optimal output targets that lead every unit to maximal performance are defined by the extended QE-DEA. The presented expression relaxes the main assumption of the original QE-DEA method that is the fixed weights between original and adjusted outputs. The extended expression is applied to fifty public one-stop shops.

Keywords: Data envelopment analysis, Performance management, Efficiency, Satisfaction, Target setting, Trade-off

STRATEGY IN PRACTICE: A QUANTITATIVE APPROACH TO TARGET SETTING

1. INTRODUCTION

In this study, an extended quality-driven efficiency-adjusted data envelopment analysis (QE-DEA) expression is developed for target setting and is applied to fifty public one-stop shops. The objective of the extended expression is to identify outputs that lead the units under evaluation to achieve optimal performance, securing at the same time desirable levels of users' satisfaction with the services provided by every unit. The peculiarity that the applied method manages to deal with is the determination of the optimal balance between two inversely related variables: efficiency and users' satisfaction, which are incorporated in the analysis.

The extended QE-DEA method draws on DEA and algebraic analysis. DEA is a linear programming method put forth by Charnes et al. (1978). DEA measures the efficiency of operational units by forming a production frontier which consists of best-practice units. Input or/and output targets are then defined for the remaining units in order to be projected to the production frontier. Unlike stochastic methods, DEA requires an assumption for a production function as it is implicitly defined by the available empirical data.

Since the seminal paper of Charnes et al. (1978), DEA has been widely extended and applied to numerous areas (Emrouznejad et al., 2008). DEA has become a major technique for performance measurement and target setting. Lin (2011) and Amirteimoori and Mohaghegh Tabar (2010) extended DEA, facilitating target setting under the constraint of a fixed resource for the inputs of all of the units under evaluation. Knox Lovell and Pastor (1997) developed a modified DEA expression for performance measurement and target setting for the produced outputs of the units. The two scholars used a constant input in their program as the input information was incorporated in the outputs. Lim and Zhu (2013) modified three DEA expressions (i.e. radial, slacks-based and Nerlove-Luenberger) in order to attain user-determined targets for input and output variables.

The extended QE-DEA method identifies optimal outputs or inputs by setting a base target for users' satisfaction which applies to all sample units. In addition to the base target, the trade-off between the dimensions of performance is a constraint that should also be considered. The extended QE-DEA method relaxes a major assumption of the original method regarding the flexibility of weights when a modification is applied to outputs of partially qualified units (i.e. efficient units that do not meet the base target for users' satisfaction).

This study unfolds as follows. Section 2 analyzes the extended QE-DEA method. Section 3 presents an application of the extended method to fifty public one-stop shops, and Section 4 concludes.

2. FOUNDATIONS OF THE APPLIED TARGET-SETTING METHOD

The applied target-setting method is an extension of the QE-DEA method, put forth by Zervopoulos and Palaskas (2011). The scope of the latter method was the performance measurement and the operational restructuring of organizational units while the former method focuses on performance measurement and target setting. In other words, the QE-DEA algorithm is modified in order to accommodate an output-oriented analysis. In addition, the modified algorithm relaxes the assumption of fixed weights between original and adjusted variables, which was introduced by Zervopoulos and Palaskas (2011).

The extended QE-DEA method measures performance scores for every operational unit under evaluation and also target output levels which satisfy both efficiency and users' (e.g. customers' or citizens') satisfaction attainment. The QE-DEA method identifies benchmark units which are regarded as relatively efficient (i.e. efficiency score = 1.000) and also users report high levels of satisfaction from their provided services (i.e. satisfaction score ≥ 4, Table 1). Any unit that satisfies one of the two criteria cannot be a benchmark for the units that are disqualified in both criteria. Hence, the former unit cannot influence the procedure for determining target output levels for the latter units.

A novelty of the QE-DEA method is that partially qualified units are neither excluded from the analysis nor considered as fully disqualified. Instead, their input or output levels are adjusted appropriately (i.e. the inputs are increased when an input-oriented approach is selected, and the outputs are decreased in the case of the output orientation) to meet high users' satisfaction standards. The applied adjustment implies a trade-off between efficiency and users' satisfaction. In the context of target setting (e.g. output-oriented analysis), maximal output levels for a partially disqualified unit cannot be attained without deterioration of users' satisfaction (Gustafsson and Johnson, 2002; Kamakura et al., 2002; Lau, 2000; Zeithaml, 2000; Anderson et al., 1997) holding the amount and cost or resources, and technology used by every operational unit fixed. The QE-DEA algorithm does not require any assumption about the magnitude of trade-off between the two variables.

Users' satisfaction is measured on a five-point Likert scale, on which one represents 'very dissatisfied' and five stands for 'very satisfied'. The five-point scale is transformed into a percentage scale in order to be comparable with the efficiency scale which ranges from 0.0 to 1.0 (Table 1).

Table 1. Transformation of satisfaction scores

Five-point scale	Equivalent percentage scale
1.00 - 1.99	(0.2, 0.4)
2.00 - 2.99	[0.4, 0.6)
3.00 - 3.99	[0.6, 0.8)
4.00 - 5.00	[0.8, 1.0]

A unit is deemed qualified from a user's perspective when it scores at least four out of five or 80%.

Prior to the analysis of the extended QE-DEA algorithm, a list of symbols is provided.

Nomenclature	
φ	efficiency score ($\varphi \geq 1$)
x_{ij}	*i*th input of the *j*th unit
x_{io}	*i*th input of the *j*th reference unit
y_{rj}	*r*th output of the *j*th unit
y_{ro}	*r*th output of the *j*th reference unit
λ_j	non-negative scalar
p	performance score
s_j	users' satisfaction score of the *j*th unit
s_j	users' satisfaction score of the *j*th reference unit
$\overline{S}$	average users' satisfaction score of the units that are qualified in efficiency and users' satisfaction
$\left(\varphi^{-1}\right)'$	inverse adjusted efficiency score
φ_o^{-1}	inverse efficiency score lower bound
s_A	original users' satisfaction score
s_o	users' satisfaction score lower bound
s_A'	adjusted users' satisfaction score
v_i, u_r	non-negative multipliers
v^*	free in sign scalar

The first step for applying the target-setting method is to run an output-oriented variable returns to scale (VRS) DEA program (Banker et al. 1984).

$$\max \varphi$$

$$s.t. \quad \sum_{j=1}^{n} \lambda_j x_{ij} \leq x_{io} \qquad i = 1,...,m$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq \varphi y_{ro} \quad r = 1,...,t$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \geq 0 \tag{1}$$

The efficiency scores which are obtained from program (1) are evaluated together with the customers' or citizens' satisfaction scores. If the efficiency units also meet high users' satisfaction standards, then there is no need for adjustment of the production process. The performance scores of the units are obtained from program (2), which ensures the satisfaction of the two criteria for every unit that operates at optimal level.

$$\max p$$

$$s.t. \sum_{j=1}^{n} \lambda_j x_{ij} \leq x_{io} \quad i = 1,...,m$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq p y_{ro} \quad r = 1,...,t$$

$$\sum_{j=1}^{n} \lambda_j s_j \leq s_o$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \geq 0 \tag{2}$$

and

$$s_o = \begin{cases} s_o & \text{if } s_o \geq \bar{S} \\ \bar{S} & \text{otherwise} \end{cases}$$

If an efficient unit that does not meet the high users' satisfaction standards is present, then the outputs should be limited to ensure a high satisfaction score for this unit. The control over the outputs will have negative impact on the efficiency score of the unit. The new efficiency score is defined from formula (3) (Zervopoulos and Palaskas, 2011):

$$\left(\varphi^{-1}\right)' = \left(\varphi_o^{-1}\right)\left(\frac{[(s_A - s_o)^2(\varphi_o^{-1} - 1)^2](s_A^{'} - s_o)^2}{[(s_A - s_o)^2 + (\varphi_o^{-1} - 1)^2](s_A^{'} - s_o)^2 - (s_A - s_o)^2(\varphi_o^{-1} - 1)^2}\right)^{1/2} \tag{3}$$

where $\left(\varphi^{-1}\right)' < 1$.

Unlike the original QE-DEA model, its modified expression draws on the multiplier VRS DEA program to determine the adjusted output of the partially qualified units. To be more precise:

$$\min \sum_{i=1}^{m} v_i x_{io} + v^*$$

$$s.t. \sum_{r=1}^{t} u_r y_{ro} = 1$$

$$\sum_{r=1}^{t} u_r y_{rj} \leq \sum_{i=1}^{m} v_i x_{ij} + v^* \tag{4}$$

$v, u \geq 0$ and v^* is free in sign

and the modified expression is as follows:

$$\min \sum_{r=1}^{t} u_r y_{rc}$$

$$s.t.\ \sum_{r=1}^{t} u_r y_{rc} \leq 1$$

$$\left(\varphi^{-1}\right)_c' \sum_{r=1}^{t} u_r y_{rc} \leq \sum_{i=1}^{m} v_i x_{ic} + v^* \tag{5}$$

where $c \subset j$, $y_{rc}^{ad} \leq y_{rc}$, $y_{rc}^{ad} \geq \left(2 - \left(\varphi^{-1}\right)_c'\right) y_{rc}$, $v, u \geq 0$ and v^* is free in sign

The obtained outputs and weights are the adjusted outputs (y_{rc}^{ad}) and their assigned weights (u_r^{ad}).

The adjustment process secures that all of the efficient units will also provide high users' satisfaction level.

Subsequent to the adjustment process, the performance of the units under evaluation is measured by applying the following program:

$$\max p$$

$$s.t.\ \sum_{j=1}^{n} \lambda_j x_{ij} \leq x_{io} \qquad i = 1,\dots,m$$

$$\sum_{j=1}^{n} \lambda_j y_{rj}^t \geq p y_{ro}^t \quad r = 1,\dots,t;\ y_{rj}^t = y_{rj,j\neq c} + y_{rc}^{ad}$$

$$\sum_{j=1}^{n} \lambda_j s_j^t \leq s_o^t \qquad s_j^t = s_{j,j\neq c} + s_c$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \geq 0 \tag{6}$$

where $c \subset j$ and

$$s_o^t = \begin{cases} s_o & \text{if } s_o \geq \bar{S} \\ \bar{S} & \text{otherwise} \end{cases}$$

3. APPLICATION OF THE TARGET-SETTING METHOD

3.1 Presentation of the data

The applicability of the proposed target-setting method will be explicit through a numerical example. In the following example, we used data from the Greek Citizen Service Centers (CSCs) which are public one-stop shops appointed to the provision of administrative services to citizens (users). In particular, the sample consists of 50 CSCs. There are six input variables (i.e. employees, weekly working hours, PCs, fax machines, printers, and surface area) and two output variables (i.e. e-services and manual services provided to citizens). In addition, 764 citizens' satisfaction questionnaires were collected from all of the sample CSCs. The number of satisfaction questionnaires that were answered by citizens for every sample CSC ranges from 20 to 30. The design of the satisfaction survey drew on the SERVQUAL methodology developed by Parasuraman et al. (1988).

3.2 Numerical example

Prior to the application of the extended QE-DEA algorithm, the linear program (1) is used to classify the units and particularly to identify the units that are efficient but are not qualified in satisfaction (i.e. satisfaction score < 0.800). In Table 2, five out of fifty sample units (i.e. units 31, 32, 41, 49, and 50) are regarded as partially qualified as they are efficient but they fail to deliver satisfactory services to users.

Table 2. Units' classification

Units	Efficiency (φ^{-1})	Satisfaction	Classification	Units	Efficiency (φ^{-1})	Satisfaction	Classification
1	1.000	0.923	HE-HS	26	1.000	0.816	HE-HS
2	0.956	0.930	LE-HS	27	1.000	0.836	HE-HS
3	1.000	0.943	HE-HS	28	1.000	0.801	HE-HS
4	0.447	0.821	LE-HS	29	1.000	0.914	HE-HS
5	0.654	0.860	LE-HS	30	1.000	0.933	HE-HS
6	0.879	0.874	LE-HS	**31**	1.000	0.779	**HE-LS**
7	0.852	0.819	LE-HS	**32**	1.000	0.776	**HE-LS**
8	0.614	0.870	LE-HS	33	0.251	0.790	LE-LS
9	0.704	0.873	LE-HS	34	0.416	0.934	LE-HS
10	1.000	0.811	HE-HS	35	1.000	0.906	HE-HS
11	0.265	0.781	LE-LS	36	0.634	0.841	LE-HS
12	0.502	0.864	LE-HS	37	1.000	0.823	HE-HS
13	0.561	0.793	LE-LS	38	1.000	0.811	HE-HS
14	0.959	0.969	LE-HS	39	0.958	0.817	LE-HS
15	1.000	0.950	HE-HS	40	1.000	0.961	HE-HS
16	0.276	0.943	LE-HS	**41**	1.000	0.790	**HE-LS**
17	1.000	0.904	HE-HS	42	0.336	0.769	LE-LS
18	0.594	0.927	LE-HS	43	0.594	0.846	LE-HS
19	1.000	0.947	HE-HS	44	0.209	0.823	LE-HS
20	1.000	0.945	HE-HS	45	0.656	0.885	LE-HS
21	0.446	0.969	LE-HS	46	0.670	0.947	LE-HS

22	0.486	0.808	LE-HS	47	0.535	0.920	LE-HS
23	1.000	0.808	HE-HS	48	0.648	0.956	LE-HS
24	1.000	0.810	HE-HS	**49**	1.000	0.666	**HE-LS**
25	1.000	0.872	HE-HS	**50**	1.000	0.694	**HE-LS**

HE: high efficiency (efficiency score = 1.000); LE: low efficiency (efficiency score < 1.000); HS: high satisfaction (satisfaction score $\geq$0.800); LS: low satisfaction (satisfaction score < 0.800)

In this context, the outputs of the five partially qualified units should be adjusted to ensure that all of the benchmark units of the sample both are efficient and deliver satisfactory services to users. Drawing on formula (3), which is applied to every partially qualified unit, a satisfaction score is arbitrarily selected (e.g. s'_A = 0.800). This score should be at a minimum equal to the lower-satisfaction bound (i.e. 0.800, Table 1). The obtained efficiency score from formula (3) is not a relative measure but rather a stand-alone. In other words, the adjusted efficiency score of a unit does not take into account the movement of the remaining units towards the production frontier. This movement is probable, due to the modification of the outputs of the partially qualified unit. In addition, in formula (3), φ_o^{-1} and s_o are set equal to 0.200. According to Paradi et al. (2004), when efficiency scores lower than 0.200 are present, the dataset should be reviewed for faulty entries. The lower users' satisfaction bound is defined by the percentage transformation of the users' satisfaction scores which are measured in a five-point scale (Table 1).

The inverse relationship between efficiency and satisfaction is presented in the adjusted efficiency scores (Table 3). The adjusted efficiency scores are lower than the original efficiency scores after the increase of the level of satisfaction.

Table 3. Efficiency adjustment

Units	Original scores			Adjusted scores		
	Efficiency (φ^{-1})	Satisfaction	Classification	Efficiency (φ^{-1})	Satisfaction	Classification
31	1.000	0.779	HE-LS	0.953	0.800	LE-HS
32	1.000	0.776	HE-LS	0.946	0.800	LE-HS
41	1.000	0.790	HE-LS	0.978	0.800	LE-HS
49	1.000	0.666	HE-LS	0.743	0.800	LE-HS
50	1.000	0.694	HE-LS	0.789	0.800	LE-HS

The adjusted outputs of the five units are illustrated in Table 4. The adjusted outputs were defined by linear programs (4) and (5). The adjusted outputs are always lower than their original counterparts. The decrease in the output levels of the units that initially did not meet the criteria for both efficiency and high satisfaction is required in order to improve users' satisfaction while inputs and technology are fixed.

Table 4. Adjusted outputs

Units	Original outputs		Adjusted outputs	
	E-services	Services	E-services	Services
31	11764	9721	10285	8584
32	42216	322231	38229	283870
41	16901	62846	15427	55323
49	1699	1015	1493	921
50	3786	1348	3300	1211

The adjusted outputs replace the original outputs in the dataset, and then linear program (6) is applied. The scores displayed in columns two and seven of Table 5 represent the performance of the sample units. For defining performance, satisfaction was incorporated in the optimization together with input and output variables. Unlike the latter two variables, users' satisfaction is not fully controlled by the units. However, as was stated in the previous section, there is an underlying relationship between the activity of the units, which is expressed in terms of efficiency and users' satisfaction.

Columns 3-5 and 8-10 of Table 5 display the target levels for satisfaction and the two outputs which are optimal solutions for the optimization problem. All of the units which were partially qualified (i.e. units 31, 32, 41, 49, and 50) are regarded as benchmarks after the adjustment of their outputs according to the extended QE-DEA algorithm. These units, however, need to decrease their output levels compared to their original output levels.

The goal of the presented target-setting method is to define output targets which secure synchronous optimal operation and high users' satisfaction level. In many cases (e.g. units 5, 6, 16), the attainment of optimal (target) outputs is associated with the sacrifice of users' satisfaction, which never becomes unacceptable.

Table 5. Target-setting results

Units	Performance	Targets			Units	Performance	Targets		
		Satisfaction	E-services (Change)	Services (Change)			Satisfaction	E-services (Change)	Services (Change)
1	1.000	0.923	0.0%	0.0%	26	1.000	0.816	0.0%	0.0%
2	1.000	0.930	0.0%	0.0%	27	1.000	0.836	0.0%	0.0%
3	1.000	0.943	0.0%	0.0%	28	1.000	0.801	0.0%	0.0%
4	0.492	0.822	103.1%	103.1%	29	1.000	0.914	0.0%	0.0%
5	0.700	0.817	42.8%	301.4%	30	1.000	0.933	0.0%	0.0%
6	0.900	0.808	11.1%	55.6%	31	1.000	0.800	-12.6%	-11.7%
7	0.905	0.853	10.5%	57.3%	32	1.000	0.800	-9.4%	-11.9%
8	0.637	0.870	57.1%	287.2%	33	0.262	0.853	282.0%	282.0%
9	0.724	0.873	38.1%	155.7%	34	0.418	0.866	139.4%	594.6%
10	1.000	0.811	0.0%	0.0%	35	1.000	0.906	0.0%	0.0%
11	0.296	0.853	237.5%	237.5%	36	0.671	0.853	49.0%	282.8%
12	0.560	0.864	78.7%	88.7%	37	1.000	0.823	0.0%	0.0%
13	0.589	0.853	69.8%	3190.4%	38	1.000	0.811	0.0%	0.0%
14	1.000	0.969	0.0%	0.0%	39	0.977	0.853	2.4%	64.7%
15	1.000	0.950	0.0%	0.0%	40	1.000	0.961	0.0%	0.0%

16	0.276	0.844	262.3%	1111.7%	41	1.000	0.800	-8.7%	-12.0%
17	1.000	0.904	0.0%	0.0%	42	0.350	0.853	186.0%	186.0%
18	0.608	0.892	64.4%	64.4%	43	0.660	0.853	51.6%	86.2%
19	1.000	0.947	0.0%	0.0%	44	0.224	0.853	345.7%	345.7%
20	1.000	0.945	0.0%	0.0%	45	0.668	0.885	49.7%	199.0%
21	0.446	0.822	163.2%	124.2%	46	0.704	0.883	42.0%	42.0%
22	0.694	0.853	44.0%	3062.2%	47	0.536	0.920	86.5%	274.9%
23	1.000	0.808	0.0%	0.0%	48	0.648	0.910	54.4%	54.4%
24	1.000	0.810	0.0%	0.0%	49	1.000	0.800	-12.1%	-9.3%
25	1.000	0.872	0.0%	0.0%	50	1.000	0.800	-12.8%	-10.2%

4. CONCLUSIONS

The proposed target-setting method is an extension of the QE-DEA method. In particular, the algorithm of the QE-DEA method was modified appropriately to relax its major assumption regarding the fixed weights between the original and the adjusted variables and also to enable output-oriented analysis. The extended QE-DEA method applies twofold performance measurement, incorporating in the analysis both efficiency and users' satisfaction. The identified benchmark units always are efficient and deliver high-satisfaction services to users. In addition, unlike the original QE-DEA method, its extended expression ensures that all of the sample units will attain efficiency and high users' satisfaction when performance becomes maximal.

The managerial implications of the extended QE-DEA method were presented in the application to fifty public one-stop shops. However, the applicability of the method is not limited to public organizations.

REFERENCES

Amirteimoori, A. and Mohaghegh Tabar, M. (2010), Resource allocation and target setting in data envelopment analysis, *Expert Systems with Applications* 37: 3036-3039.

Anderson, E.W., Fornell, C. and Rust, R.T. (1997), Customer satisfaction, productivity, and profitability: differences between goods and services, *Marketing Science* 16 (2): 129-145.

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

Charnes, A., Cooper, W.W. and Rhodes, E. (1978), Measuring the efficiency of decision making units, *European Journal of Operational Research* 2 (6): 429-444.

Emrouznejad, A., Parker, B.R. and Tavares, G. (2008), Evaluation of research in efficiency and productivity: a survey and analysis of the first 30 years of scholarly literature in DEA, *Socio-Economic Planning Sciences* 42: 151-157.

Gustafsson, A. and Johnson, M.D. (2002), Measuring and managing the satisfaction-loyalty-performance links at Volvo, *Journal of Targeting, Measurement and Analysis for Marketing* 10 (3): 249-258.

Kamakura, W.A., Mittal, V., de Rosa, F. and Mazzon, J.A. (2002), Assessing the service-profit chain, *Marketing Science* 21 (3): 294-317.

Knox Lovell, C.A. and Pastor, J.T. (1997), Target setting: an application to a bank branch network, *European Journal of Operational Research* 98: 290-299.

Lau, R.S.M. (2000), Quality of work life and performance: an ad hoc investigation of two key elements in the service profit chain model, *International Journal of Service Industry Management* 11 (5): 422-437.

Lim, S. and Zhu, J. (2013), Incorporating performance measures with target levels in data envelopment analysis, *European Journal of Operational Research* 230: 634-642.

Lin, R. (2011), Allocating fixed costs or resources and setting targets via data envelopment analysis, *Applied Mathematics and Computation* 217: 6349-6358.

Paradi, J., Vela, S. and Yang, Z. (2004) Assessing bank and bank branch performance: modeling considerations and approaches, in Cooper, W.W, Seiford, L. and Zhu, J. (eds) (2004) *Handbook on Data Envelopment Analysis*, Kluwer Academic Publishers, London: 349-400.

Parasuraman, A., Zeithaml, V.A. and Berry, L. (1988), SERVQUAL: a multiple-item scale for measuring consumer perceptions of service quality, *Journal of Retailing* 64: 12-40.

Zeithaml, V.A. (2000), Service quality, profitability, and the economic worth of customers: what we know and what we need to learn, *Journal of the Academy of Marketing Science* 28 (1): 67-85.

Zervopoulos, P. and Palaskas, T. (2011), Applying quality-driven, efficiency-adjusted DEA (QE-DEA) in the pursuit of high-efficiency – high-quality service units: an input-oriented approach, *IMA Journal of Management Mathematics* 22: 401-417.