Journal of Applied Economics, Vol. VIII, No. 1 (May 2005), 171-190

EVALUATING TARGET ACHIEVEMENTS IN THE PUBLIC SECTOR: AN APPLICATION OF A RARE NON-PARAMETRIC DEA AND MALMQUIST INDICES

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Submitted June 2003; accepted February 2004

This paper provides an assessment of the extent to which targets set by a public authority are achieved by its operational units. A rare DEA framework and its subsequent Malmquist indices are applied on data comprising 19 units over a four year period of 1996 to 1999. The mean efficiency scores by which targets are achieved across the sample years are moderate, in the range 0.81 to 0.93. Average productivity progress across the sample years has been 26 percent. The results illustrate the usefulness of DEA even when there are no inputs and the decomposable Malmquist index for productivity is an asset in exploring causes of productivity growth.

JEL classification codes: L92, C61
Key words: target achievement, traffic safety, data envelopment analysis, Malmquist indices

I. Introduction

Traffic safety has been a long time policy objective in most modern countries and it is generally believed that compulsory vehicle inspections are

* Thanks are due to Harald Minken and Rune Elvik both at the Norwegian Institute of Transport Economics for useful comments on an earlier version of this paper. I would also like to thank the Norwegian Public Roads Administration for funding this study. I am also indebted to two anonymous referees. Errors in this paper are of course mine and none should be attributed to the above named persons. Correspondence should be addressed to The Norwegian University of Science and Technology, N- 7491 Trondheim, Norway or The Norwegian Public Roads Administration, PO box 8142 Dep., N-0033 Oslo Norway. Email: James.odeck@vegvesen.no.

a necessary means for combating motor vehicle accidents. The underlying rationale is that if vehicles and/or vehicle drivers meet certain standards and/or certain degree of compliance with regulation accidents due to technical failure or violation of regulation will be reduced. In fact compulsory motor vehicle inspections are conducted in most countries of the world, often by public agencies. Traditionally, the tasks of these agencies have been directed toward passenger vehicles. In recent years, however, more attention is being paid to heavy vehicles mainly due to two reasons. The first is that the proportion of heavy vehicles in road traffic is increasing and hence the percentage of heavy vehicles involved in motor vehicle accidents is also increasing. The second is that the percentage of heavy vehicles involved in motor accidents is still small but the rate of serious injuries and fatalities once they are involved in accidents is high. Thus, increasing amount of resources is now being used by agencies in heavy vehicle inspection services to enhance traffic safety. In fact studies have shown that increased heavy vehicle inspections are economically beneficial to the society at large as it generates benefits greater than costs (Elvik, 1999).

One way of increasing the performance in heavy vehicle inspection services, which the Norwegian Public Roads administration (NPRA) has adopted since 1996, is to set targets that should be met by the regional operational units involved in actual inspection services. The targets comprise the number of different vehicles to be controlled categorised by the type of control to be performed. Further, these targets are structured and designed to promote the NPRAs objective of enhancing traffic safety.

A problem faced by the management of a public agency such as the NPRA, however, is how to gauge the extent to which the targets set are met. A second problem is how to evaluate the productivity by which the targets are being met from one year to the other so as to gain insight on productivity improvement or regress in services offered to the public.

This study has two related objectives. The first objective is to evaluate the operating efficiency by which the operational units are able to meet or surpass the targets set for them by NPRA. We accomplish this by, first a simple descriptive analysis and then by applying a now well known linear programming technique termed Data Envelopment Analysis (DEA) coined by Charnes et al. (1978) for application in the public sector and non-profit organisations where prices may be non-existent. The motivation for applying DEA, like in many other previous studies, is that it is a powerful tool that can easily aggregate performance indicators into one single performance indicator.

The second objective is to investigate the productivity by which the operational units meet their objectives. The question addressed is the extent to which operational units' progress in meeting their targets as compared to others facing the same conditions. We accomplish this by using the Malmquist productivity index approach that originated from Malmquist (1953) within a consumer context. Since the NPRA is part of the public sector where economic behaviour is uncertain and there is no information on the prices of services produced, Malmquist index based on DEA approach is well suited for our case.

This paper is by no means the first to investigate target achievements by means of DEA. A recent study on target assessments and which is appreciated includes that of Lovell and Pastor (1997) where bank branch networks are investigated. As far as we know, however, our study is the first study to evaluate target achievements within the transport sector and in particular with respect to road safety using DEA approach. Further, we contend that this is the first study to investigate productivity growth in *target achievements* in the transport sector, specifically using Malmquist indices. We note further that Odeck (2000) conducted a study on the productivity growth in the Norwegian vehicle inspectorate with data from 1989-91, but did not consider the target achievement problem.

The remainder of this paper is organised into sections as follows. Section II gives a brief summary of the target setting procedures, describes the performance targets and provides a descriptive analysis of the ability of the RRA's to meet their targets. Section III introduces DEA approach used for measuring target performance and its subsequent extensions to Malmquist indices. In section IV, the empirical results are presented and discussed. The final section contains concluding remarks and future extensions.

II. Target Setting Procedures and Data

As a means of enhancing road traffic safety at the national level, The Norwegian Public Road Administration (NPRA) which is the national public roads authority in charge of traffic safety, sets performance targets to be met by its regional operational units known as the Regional Road Agencies (RRA).

The process of target setting proceeds by way of an instruction from the General Director of the NPRA to the managers of the RRAs. The target indicators are standardised and are the same for all the RRAs. The NPRA uses regional data, past experience, total resources accorded to the RRAs and other regional specific characteristics such as traffic volume etc as a basis for discussion. After 1996, the year when target setting was introduced, the NPRA has had a norm that for each target the RRAs should at least meet their previous year's performance volumes for each indicator. At the end of each quarter, the RRA's are informed on how well they perform through meetings between the director general of NPRA and the managers of RRA's. The data for our study correspond to the annual periods of 1996 through 1999. Thus we evaluate the annual achievements starting from 1996 and ending in 1999.

There are three indicators that are used for target setting within heavy vehicle inspections to enhance traffic safety and with which we are here concerned. These are:

1. Number of heavy vehicles controlled with respect to condition for use along road sites and in companies.

2. Technical controls of heavy vehicles both in halls and along road sites.

3. Seat belt controls along road sites for all vehicles including passenger vehicles.

Thus ultimately, the task of the operational units of traffic safety is to perform inspections on heavy vehicles with the addition of safety or seat belts controls also on passenger vehicles.

Our data set comprises 19 units covering all the autonomous regions in Norway. The success indicators cover the target values of all the three indicators described above. We have converted each target value and achieved value to a single success indicator defined as percent of target value actually achieved. These are essentially pure numbers independent of the units in which the underlying indicators are measured and ranges from zero (an achievement of zero) to plus infinity where 100 imply exact achievements of targets. Thus an indicator above 100 implies that a target is surpassed.

A descriptive analysis of the target achievement by the operational units may be obtained by exploring Table 1, where the results of target achievements of the 3 indicators for all the 19 operational units of the NPRA are presented.

Table 1. Target Achievements

	1996			1997			1998			1999		
	(A)	(B)	(C)	(A)	(B)	(C)	(A)	(B)	(C)	(A)	(B)	(C)
Mean	1.01	0.98	1.09	1.01	1.03	0.92	1.29	1.02	0.97	1.00	1.02	1.05
Min	0.88	0.73	0.75	0.69	0.63	0.53	0.86	0.63	0.52	0.56	0.59	0.69
Max	1.13	1.27	1.56	1.24	1.49	1.23	1.96	1.72	1.31	1.48	1.59	1.67
Std. dev.	0.07	0.12	0.21	0.14	0.18	0.17	0.35	0.24	0.21	0.18	0.18	0.21
Freq. dist.:												
< 70	0	0	0	1	1	3	0	2	3	1	1	1
71-80	0	2	1	1	1	1	0	0	2	0	0	1
81-90	1	2	2	1	1	6	1	1	1	1	1	0
91-100	6	8	3	5	5	4	1	7	4	10	7	7
101-110	9	5	5	6	5	3	6	6	4	3	8	4
111-120	3	1	3	4	3	1	3	1	3	3	1	3
121-130	0	1	1	1	2	1	0	0	1	0	0	1
131-140	0	0	2	0	0	0	2	0	1	0	0	1
141-150	0	0	1	0	1	0	1	1	0	1	0	0
> 150	0	0	1	0	0	0	5	1	0	0	1	1

Notes: (A): Usage controls; (B): Technical controls; (C): Safety belt controls.

The impression one gets from the mean of the data, with exception of usage control in 1998, is that the majority of the operational units are proficient at meeting their targets. Taking target by target, the mean achievement of usage, technical and safety belt controls are in the range 1.01 to 1.29, 0.98 to 1.03, and 0.92 to 1.05 respectively. For the safety belt controls in particular, a tremendous fluctuation is observed with 13 units exceeding targets in 1996, only 5 in 1997, 9 in 1998 and 10 in 1999.

On target-by-target basis, the mean operational unit at worst comes within 14% percent of meeting the target. The standard deviation is observed to first increase in the two first years and then to decrease or stabilize in the final year. A explanation for increasing standard errors is difficult to give, however, the fact that the standard errors are decreasing in the final year may imply that targets, after their implementations have become tighter eventually forcing units to be homogenous. Considering now the distribution of achievements, it is observed that there is a concentration of units lying in the range 91-110% of target achievement. There are few units below 91 and above 111% although the variation is dependent on the target being considered. We also reckon that some unit failed to meet their targets while others managed to surpass their targets by a very large margin, a case that is persistent throughout the years of observation. Since a high proportion of units exceed their targets especially in the first year, this may suggest the targets were too soft to start with.

The observations above however, depict mixed results. Some targets exhibit larger variations than others as can be seen from the frequency distribution. No general conclusion on the performance of the individual units can thus be reached by the piecemeal approach above as performance varies by target being considered. There is therefore a need for a model-based approach that offers an aggregated measure of performance. Second, such a measure should also be able to measure the productivity by which targets are achieved from one year to another. We develop such a model in the next section.

One precaution is however, in order before proceeding. We are here interested in measuring the efficiency and productivity by which targets set by the NPRA are met assuming that these targets are set right and accurately reflects the features of each operational unit's environment. The NPRA could not supply us with the data used to set targets (i.e. inputs are non-available) due to confidentiality purposes. This is precisely what makes us use a rare formulation of DEA, as the subsequent section will show. However, the NPRA ensured us of the following which are essential for the analysis that we carry out in the succeeding sections: (1) no inspection units were allotted with increased resources in the period that we study and, (2) no units were given softer targets i.e. the NPRA did not soften any targets in year *t + 1* for any under achievements in year *t*. As explained by The NPRA, (2) is currently maintained for the simple reason that the whole target setting process will be evaluated in the year 2002. Combining (1) and (2) together, the target-resource ratio of any of the units has been non-decreasing in the sample year of study.

III. A DEA and Malmquist Based Analysis of Performance and Productivity Growth

The question that we pose is: are there any potential for efficiency improvements and productivity improvements in targets achievement by the NPRAs operational units and, if so, what are the magnitudes? To this end we subject the data to a DEA analysis.

We thus assume that the operational unit managers attempt to maximise the services that they provide. Further, we assume that the services they provide consist of the indicators discussed in the preceding section. The denominators of these indicators are assumed fixed and given by the NPRA. This assumption of course ignores the possibility that the managers may sandbag so as to minimise the possibility of receiving higher targets the following year. This possibility is relevant but we ignore it as the NPRA could not supply us with the relevant data. However, it offers future research possibilities, which we hope to turn to in another study on the target setting procedures themselves.

The DEA formulation that we use in this study corresponds to the well-known Banker et al. (1984) BCC formulation, but without inputs. For a thorough treatment of DEA models without inputs or without outputs see a recent paper by Lovell and Pastor (1999).

Let the vector of success indicators for the operational unit *j* be represented by $y^j = (y^{1j}, ..., y^{3j}),\ j = 1,..,19$. Each element of y^i is the ratio of an achieved value to target value so that it is units-free. The assumption that the managers of the operational units maximise their success indicators leads to the following linear programming problem,

$$\underset{\phi,\lambda}{Max}\ \phi \tag{1}$$

subject to

$$\phi y^{ij} \leq \sum_k \lambda_k y^{ik} - s^{+ik}, \quad i = 1,...,3 \tag{2}$$

$$\sum_k \lambda_k = 1 \tag{3}$$

$$\lambda_k, s^{+ik} \geq 0 \qquad k = 1,..., j,...,19 \tag{4}$$

where the optimal value of ϕ denotes the performances indicator, *i* indexes the success indicators, *k* indexes the operational units and $\lambda = (\lambda_1,\ldots, \lambda_k,\ldots, \lambda_{19})$ is a vector of intensity variables and s^{+ik} is the output slack variable.

Note that in standard DEA model constraint (3) would imply variable return to scale. Since there are no inputs, it makes the specification equal to a specification with a constant input (Lovell and Pastor, 1999). The objective of this problem is to maximize the radial expansion of the vector of success indicators for the operational units being evaluated. The constraints, i.e. equations (2) and (3), limit this expansion to a convex combination of success indicators of other operational units in the sample. Thus the managers of the operational units are here assumed to select a mix of success indicators that varies from one unit to another reflecting variation in location of the unit, size and traffic volumes. The Maximization problem then determines the proportion by which the success indicators can be feasibly expanded in each operational unit. A performance indicator for operational unit *j* is provided by the maximization above as the optimal value of ϕ. Best practice performance is identified in a unit that have output slacks $s^{+ik} = 0$ and optimal $\phi^* = 1$. This is because it is not possible to expand all success indicators equiproportionaly without exceeding best practice observed in the sample. Units with optimal $\phi^* > 1$ perform less than best practice ones. Thus an efficiency measure (E) for a unit being evaluated can be readily derived as the inverse of the optimum value ϕ^*. An operational unit obtaining a score E = 1 will be technically efficient while those with a score E < 1 will be technically inefficient.

Productivity and technical change between periods can be measured in several ways. In this study we apply the Malmquist index. This index was first presented in consumer theory by Malmquist (1953) and later for productivity analysis by many e.g. Caves et al. (1982). The Malmquist index has several advantages, which makes it suitable for our purpose. No assumption regarding the economic behaviour of production units, e.g. cost minimisation or revenue maximisation, needs to be made. Since the economic behaviour of the operational production units of the NPRA is uncertain and there in no price information on services produced, as often is the case for many public sector bodies, the choice of Malmquist index is well justified.

The productivity growth[1] in target achievement for an individual operational unit can be measured by the Malmquist index as improved efficiency relative to the benchmark frontier. Thus Malmquist index for productivity growth can easily be expressed in DEA efficiency measures. The Malmquist output based productivity index expressed in DEA output measure for observation *k* between time periods *t* and *t+1*, based on the technology at time *t* is,

$$M_{t,k} = \frac{E_{t,k(t+1)}}{E_{t,k(t)}} \tag{5}$$

i.e., the ratio between the output increasing efficiency measure for unit *k* observed at time *t+1* and *t* respectively, and measured against the technology at time *t*. If M > 1 the productivity growth is said to have been positive. Note that the base year can be any year. The Malmquist index above can be divided into two components. The first component is known as the "catching up index" and it shows the relative change in efficiency between the periods. The second component is known as "frontier productivity index" and it shows the relative distance between the frontiers i.e. measures the change of frontiers between two periods. It is therefore sometimes referred to as the technical change effect (see Färe et al., 1989; Berg et al., 1991; and Bjurek and Hjalmarsson, 1995). The decomposed Malmquist index is defined as,

[1] In order to preserve terminology compatible with the traditional definition of Malmquist productivity index, we use productivity growth to mean the same thing as change in target achievement or target achievement index.

$$M_{t,k} = \frac{E_{t+1,k(t+1)}}{E_{t,k(t)}} \frac{E_{t,k(t+1)}}{E_{t+1,k(t+1)}} = MC_{t,k} \times MF_{t,k} \tag{6}$$

where $MC_{t,k}$ is the catching up effect and $MF_{t,k}$ is the change of the frontier between time period's *t* and *t+1* for unit k. It follows from (6) that for a fully efficient unit both years, MC = 1. In that case the index is a pure frontier distance measure.

Unfortunately, like many indexes, Malmquist index is dependent on the chosen reference technology. This may create a problem in the sense that the circularity property of the indexes is not obeyed. To elaborate, assume that we were evaluating the productivity growth between year *t* and *t+1* but with year *t+2* as the base technology. In relation to equation (6), we now have three technology periods *t, t+1* and *t+2*. However, we see that if equation (6) was to be applied directly, the frontier technology that we are measuring against does not appear on the right hand side of the expression for frontier index. Hence the *Frisch circular relation* is not obeyed and equation (6) is not applicable (Frisch, 1932). The Malmquist index expressed can however be adjusted to obey the circularity property. For a formal treatment and applications see Berg et al. (1991), Bjurek and Hjalmarsson (1995) and Odeck (2000). Since our data set comprise a short period of time where the interest is to gain insight on productivity growth from when the target setting system was introduced, we will base our analysis on a fixed reference technology with 1996 as the base year. The decomposed Malmquist index for unit *k* with fixed technology (*f*) and obeying the circularity property identical to equation (6) is defined as (see Berg et al., 1991, and Bjurek and Hjalmarsson, 1995),

$$M_{f,k} = \frac{E_{t+1,k(t+1)}}{E_{t,k(t)}} \frac{\dfrac{E_{f,k(t+1)}}{E_{t+1,k(t+1)}}}{\dfrac{E_{f,k(t)}}{E_{t,k(t)}}} = MC_{f,k} \times MF_{f,k} \tag{7}$$

where $E_{f,k(t)}$ and $E_{f,k(t+1)}$ denotes the output increasing efficiency given the fixed reference technology *f* at time *t* and *t+1* respectively. When calculating the productivity change for an entire period, Bjurek and Hjalmarsson (1995) have proposed to use a fixed based index for period $t = 1,\ldots,T$, as,

$$M_{f,k} = \prod_{t=1}^{T} \frac{E_{t+1,k(t+1)}}{E_{t,k(t)}} \frac{\dfrac{E_{f,k(t+1)}}{E_{t+1,k(t+1)}}}{\dfrac{E_{f,k(t)}}{E_{t,k(t)}}} = MC \times MF \tag{8}$$

There are however, some drawbacks with the base period index used here (see for instance Althin, 2001). If the base period is altered, the measurement of productivity change will most likely be different as a direct result effect of the base period alteration. The second drawback pertains to reference with a fixed technology far a way in time. Here, the comparison with a technology far away and has less or nothing in common with the current technology being evaluated, may appear useless and strange. For this study, however, these problems may be considered less relevant for the following two reasons. Firstly, we are interested in investigating the change that occurred as a result of the introduction of the targeting setting process. Base period index will thus give an indication on how successful the regime introduced has been relative to the old one. Secondly, the periods we consider are relatively short to expect tremendous short and not far away in time i.e. data are from 1996 to 1999.

IV. Empirical Results

The data set at our disposal comprises target achievement indicators described in section II. In Table 2 we present the summary results of the DEA efficiency scores for each observation year as well as their frequency distributions.

The mean efficiency declines from 0.93 in 1996 to 0.81 in 1999. The same tendency is also observed for the least efficient unit, which declines from 0.82 to 0.62 in 1996 and 1999 respectively. We however, observe the reverse with respect to the spread around the mean which rises from 0.06 in 1996 to 0.14 in 1998 and then falls to 0.11 in the last year of observation. Looking at the frequency distributions, it is observed that the number of units in the interval 91-100 percent of efficiency is stable at 14 units in 1996 and 1997 then falls to only 4 units in 1999. Further, the total number of units below efficiency score of 0.81 rises from zero in 1996 to 12 in 1998, and then falls slightly to 10 in 1999.

Table 2. Summary Results and Frequency Distribution of DEA Efficiency Scores

	1996	1997	1998	1999
Mean	0.93	0.92	0.81	0.81
Min	0.82	0.65	0.57	0.62
Max	1.00	1.00	1.00	1.00
Std. Dev.	0.06	0.10	0.14	0.11
Freq. distribution (%):				
< 70	0	1	3	2
71-80	0	1	9	8
81-90	5	3	1	5
91-100	14	14	6	4

A likely explanation to the observed falling trend in efficiency scores is that in the first year when target setting procedure was introduced, many units resorted to full utilisation of their potentials to achieve targets set for them by the NPRA. Later, since there has not been any increase in resources allotted to the operational units in the sample period of study, more and more units had less unexploited resources which could be used to achieve the targets.

It should however, be borne in mind that the efficient units for each year merely mean that these units performed best in the sample. It does not mean or imply that they performed exceptionally well, or that they managed to meet or surpass all or even most of their targets. Thus the efficiency scores here only give an indication on how competitive the units are in achieving their targets as compared to each other at every point in time.

It is of interest to investigate whether units maintain their relative positions on the frontier from one year to the other. Some useful insight may be gained by examining the overall distribution that is shown in Table 3.

There are fluctuations among individual units with respect to efficiency scores from one year to the other. In terms of the number of frontier units maintaining their relative positions, only 5 units appear on the frontier more than one time and only 1 is on the frontier more than twice (unit no.19) when

Table 3. Overall Distribution of Efficiency Scores

Units	1996	1997	1998	1999	Relative change in effic. score (1996/99)	Number of times on the frontier
k1	0.93	0.87	0.79	0.62	-0.33	0
k2	0.98	1.00	0.70	0.88	-0.10	1
k3	0.93	1.00	1.00	0.73	-0.21	2
k4	0.82	1.00	0.87	0.77	-0.07	1
k5	0.92	0.95	0.99	0.72	-0.22	0
k6	0.91	0.98	0.94	0.67	-0.26	0
k7	1.00	0.89	0.72	0.82	-0.18	1
k8	0.86	0.92	0.74	0.77	-0.11	0
k9	0.92	0.99	0.73	0.77	-0.17	0
k10	1.00	1.00	0.57	0.77	-0.22	2
k11	0.86	0.91	1.00	0.75	-0.13	1
k12	1.00	0.89	0.71	1.00	0.00	2
k13	0.91	0.96	0.72	0.75	-0.18	0
k14	0.99	1.00	0.70	0.82	-0.18	1
k15	0.91	0.91	0.73	0.80	-0.12	0
k16	0.92	0.97	0.73	0.82	-0.11	0
k17	0.87	0.71	1.00	1.00	0.15	2
k18	0.86	0.97	0.69	0.98	0.15	0
k19	1.00	0.65	1.00	1.00	0.00	3

all years of observation are considered. This fact demonstrates the rate of fluctuation in performance of operational units. The Spearman rank correlation (s) between the efficiency scores for the different years gave some insignificant results. The significant results were between the year of 1996 and 1998 at 0.50, 1996 and 1999 at 0.60, and 1998 and 1999 at 0.59. In general we may conclude that there is variability in the ability of operational units to meet their targets as efficiency scores range from 0.57 (least efficient) to 1.00 (best practice unit) across all years of observation. Further, the mean efficiency scores have fallen in the period of observation indicating that units are experiencing difficulties in meeting their targets over time. Nonetheless, these results should be of considerable interest to the managers of the NPRA who want may know the magnitudes of potentials for improvement in target achievements among its operational units. This information may be useful when setting targets.

We now turn to evaluate the productivity growth in target achievement by subjecting the data to a Malmquist index analysis as outlined in the preceding section. In principle we could have used any year as the base year. However, with only 3 periods (1996-97, 97-98 and 98-99) on hand, we find it more interesting to explore the developments based on the first year of 1996 when targets setting was first introduced.

The values for the fixed base indexes for the individual units calculated using equation (8) are presented in Table 4. Values greater than one in the table indicates progress; values less than one reflect regress in target achievements.

For 17 operational units the catching-up index (MC) is a regress and only two units show an unchanged catching-up index. The frontier shift index (MF) is greater than 1 for all units suggesting that there has been a general technological improvement among all units. The frequency distribution at the bottom of the table summarizes these trends. These results show that some units did not benefit from technological improvement. For instance, unit k16 experiences advancement in technological capacity but records diminished efficiency improvement as measured by MC. The lagging performance in efficiency outweighs technological improvement such that the total productivity (M) fell across the sample year. A further example is unit k10 and k11 which simultaneously experiences positive technological advancement and negative efficiency change which (on net) yield constant total productivity. These examples clearly illustrate the advantages of the decomposable productivity measure: the operational units perform differently in terms of their ability to adapt to change.

The total productivity growth in target achievement for an average operational unit shown in Table 5 is respectable at about 26 percent (score of 1.26) for the whole period i.e. from 1996 to 1999. Here we have taken the

Table 4. The Fixed Base Malmquist Productivity Index, Base Year 1996

Operational units	Total productivity growth (M)	Catching-up index (MC)	Frontier shift index (MF)
k1	0.99	0.98	1.01
k2	1.05	0.98	1.07
k3	0.99	0.98	1.01
k4	1.02	0.99	1.02
k5	1.00	0.98	1.01
k6	1.00	0.99	1.01
k7	0.97	0.94	1.04
k8	1.02	0.99	1.04
k9	1.00	0.98	1.02
k10	1.00	0.99	1.01
k11	1.00	0.99	1.01
k12	1.03	1.00	1.03
k13	0.99	0.98	1.01
k14	1.00	0.99	1.01
k15	1.03	1.00	1.03
k16	0.97	0.93	1.04
k17	1.83	1.15	1.59
k18	1.33	1.15	1.16
k19	1.15	1.00	1.15
Frequency distribution:			
< 70	0	0	0
71-80	0	0	0
81-90	0	0	0
91-100	11	17	0
101-110	5	0	16
111-120	1	2	2
121-130	1	1	0

Table 5. Mean Productivity Indices for the Average Unit

Year	Total Productivity Growth (M_f)	Catching-up Index (MC_f)	Frontier Shift (MF_f)
1996/97	1.01	1.04	0.97
1997/98	1.19	0.98	1.21
1998/99	1.04	0.97	1.07
1996/99	1.26	0.99	1.26

output-weighted means of our measures across units for each pair of year. Looking at the developments on a period-by-period basis, productivity progress is found to be 1, 19 and 4 percent for the periods 1996-97, 1997-98 and 1998-99 respectively. The values for frontier shift index, which by definition measures the technological innovation, shows the same trend. The catching-up index which is the relative change in efficiency between the periods is however, decreasing throughout the years of observation and is in fact a regress after the period 1996/97. Thus a natural conclusion to draw here is that the observed productivity growth is mainly due to technological improvements among the operational units. A possible explanation for the observed productivity growth for the average unit is that the target setting process whereby the unit managers are collectively informed of their performances has inspired some form of competition and the end result is productivity growth in achieving targets. This improvement in productivity is manifested in technological improvement - most likely explained by the fact that units have found themselves forced to find new ways or methods of achieving targets. The slow progress in the last period (1998-99) probably suggests that target achievement based on last years performances without extra resources allotted to the operational units might, after four years, be just getting close to its point of saturation. This impression is strengthened by the observation in Table 2 that the number of units obtaining efficiency scores in the interval 91 to 100 percent in 1999 has falls to only 4 units.

There are however, some deductions that may be drawn to help explain the productivity results above. The NPRA informed us that there has not been any increase in resource allocation to its operational units since 1996. So when compulsory target achievement was introduced in 1996, the operational units most likely utilised their otherwise idle factor inputs thereby contributing to productivity progress. In the short-run, changes in the utilisation of factor inputs are mainly reflected in catching-up component (MC), while technological shift (MF) occur in somewhat longer time period. This is exactly what we observe in the productivity indices above: in the very short period we observe that there is an increase in the catching-up index (MC) while the technological shift is a regress. Later we observe the reverse with a formidable increase in technological shift. This suggests that units eventually found production enhancing techniques and an example here could be better use of the available manpower such as the right man at the right place. The technological progress on the average outweighs the regress in efficiency as measured by (MC) such that the overall productivity increases during the sample period.

V. Conclusions and Future Extensions

A rare application of DEA and Malmquist indices has been used in this paper to investigate target achievements of the operational units of the Norwegian Public Roads Administration (NPRA) charged with traffic safety services. The DEA framework applied corresponds to BCC model with a unique constant input, or equivalently, with no input. We have thus been able to provide an assessment of performance with limited data expressed only as percentage of target achievement. The data set stretches across four years starting from 1996.

From the data available we have been able to derive some useful insight on the efficiency and productivity by which targets set by the NPRA are met by the operational units. We have found the mean efficiency for the operational unit to lie the interval of 0.81-0.93 depending on the year of observation. There are however, some fluctuations among individual units with respect to efficiency scores from one year to the other. These observations, especially with respect to the ranking of units should be of interest to managers of the NPRA as they reveal best practice performers.

The second finding concerns the productivity by which the operational units are able to meet their targets from one year to the other. On the average, operational units have been productive in meeting their targets and the average productivity across the periods has been 26 percent. A likely explanation for the observed productivity progress is that, in the very short run operational units have been able to utilise efficiently their resources (factor inputs) and this is mainly manifested in the catching-up component of the Malmquist index. In the somewhat longer run, units have been able to maintain and improve the "state-of-the-art" technology. This study has also illustrated the advantages of the decomposable productivity measure: the operational units perform differently in terms of their ability to adapt to change. Factors such as area of operation in terms of large cities or not and coastal area or not, does not seem to impact on performance. We have here evaluated the efficiency and productivity in target achievements in the Norwegian traffic safety sector given the limited data available.

However, the results of this study should be interpreted with caution. The study's time span cover a period of 4 years, which rather too short a time for anyone to draw robust conclusions on the productivity growth of any sector. Nevertheless, the results presented here shed some useful light on how targets are achieved in the sector considered.

Nonetheless, much work remains to be done. One area is to obtain additional information on the specific characteristics of the operational units such as the operating environment in which the units seek to meet their targets. Such information would help explain the differences in target achievements between units. Another area is to investigate the target setting procedures themselves. The NPRA has not been able to supply us with extensive data used in their target setting process. If available, such data would help in exploring such things as scale efficiency as well as whether units are really output maximizers or input minimizers. Further, with such information, we would be able to carry out sensitivity tests as well as apply other competing methods to efficiency measurement. This indicates that there are still some future research directions in this field.

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