Technical Efficiency During Deregulation of the Urban Bus System in Sweden

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Abstract: This paper compares the levels of technical efficiency reached by bus transport companies during the period 1989-1996, taking into account the deregulation context in which they operate. The empirical evidence reveals that there are no substantial changes in the use of inputs after the bus transport market deregulation. The efficiency measures obtained in this study show that the gap between the most and the least efficient company varied very little during the observation period. These results could be explained by the presence of homogeneity between the companies with respect to the adoption of technology and utilisation of labour and capital.

Keywords: Technical Efficiency, deregulation, urban bus system, transport

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1. Introduction

The presence of the state in the Swedish urban transport service has been predominant for many decades. This is explained largely by the rapid development and consolidation of the welfare state, which is a specific characteristic of the Swedish economy. Therefore, the particular role of the state in transportation matters is to secure and provide all the country's citizens with urban transport service. With the aim to carry out this social goal, it was necessary, at least in the Swedish case, to largely subsidise the transportation system. The urban bus market was deregulated in 1989, one of the principal purposes being to reduce the costs of this service, in another words, to reduce the amount of the subsidies.

The objective of this paper is to estimate and compare the levels of technical efficiency reached by each bus transport company during the period 1989-1996, taking into account the deregulation context in which they operate. We estimate a technology frontier using a frontier production function approach. In this approach, developed by Forsund and Hjalmarsson (1979), a single production function represents the so-called frontier production function. The analysis is based on primary data collected by the author from the balance sheets of different urban bus companies.

There are few studies of urban bus deregulation in Sweden. Reduction in costs and subsidises as well as changes in the structure of the market are discussed in Alexandersson et. al. (1996). International economic literature concerning bus deregulation is varied and takes up many different topics, such as privatisation, cost minimising, cost-benefit analysis, etc. In Western Europe, the United Kingdom was the first country to privatize the urban transport market. With respect to deregulation in the United Kingdom a number of articles have been published (White, 1990; Savage,1993; Glaister, 1993). These studies show that competition has reduced costs and subsidies, as well as changes in welfare. Other empirical studies (Rus and Nombela, 1997; Thomson, 1992) analyse the deregulation effects in countries such as Spain and Chile. Gwilliam and Velde (1990) analyse current attitudes to deregulation in ten Western European countries.

This study is organised as follows: Section 2, provides a background to the urban transport sector and the deregulation process in Sweden. Section 3, describes the frontier production function approach. Section 4, describes the data utilised in this study. Section 5, discusses how technical efficiency can be measured using the chosen methodology and explains the changes in efficiency for the individual companies. Empirical results are also analysed in this section. Section 5, is the summary.

2. Bus deregulation in Sweden

For many years, the main characteristic of the Swedish public transport system was its clear dominance by publicly-owned enterprises. After several years of deregulation we observe a radical change in the market structure. On one hand, the participation of the state and local authorities has diminished year after year and, at the same time, private contractors have slowly increased their market shares. With the sale of the largest publicly-owned enterprise, the structure of ownership changed definitively in this sector. It is interesting to note that with this sale, for the first time foreign capital enters the Swedish transport bus market. However, state-owned and local companies still have 49 % of the market, while 33% belongs to foreign capital and 18% belongs to the Swedish private sector.

On a functional basis, the Swedish urban bus transport system is organised at two levels, namely at a county level that covers the country and at municipal level which covers the internal limits of a city. First, each county has a county public transport authority (CPTA). Second, there is a municipal public transport authority (MPTA) in middle sized and large cities. This study focuses on the MPTAs.

Before deregulation, with no exceptions, only publicly-owned enterprises had the right to obtain bus schedule licenses, thus excluding private bus companies. In other words, each local authority was at the same time regulator and operator. In general, the organisational form before and after deregulation has not changed. The largest and middle sized cities are covered by local transport networks. Each network is regulated by a local authority (MPTA) which has introduced, for the most part, the purchaser/provider organisation.

The 1989 transport act radically changed the urban bus transport market. Briefly, this law allowed private bus companies to obtain bus schedule licenses. Companies owned by local authorities would compete equally with the private sector. Thus, private bus companies began to operate in some cities by concessions won in competition with the local bus companies. These concessions were awarded by public bid. Thus, a great number of public bus companies disappeared and were replaced by private enterprises. It is important to add that two of the larger bus transport enterprises have taken over bus companies from the different local authorities (MPTA). A contract for public transport services normally regulates the following points: the geographic area to be served, vehicle kilometres, vehicle hours and number of buses, bus standard, passenger service and environmental requirements.

In Sweden, the urban bus transport system has and continues to be a strongly regulated activity. Actually, each local authority (MPTA) is still responsible for its own urban transportation system by setting the route structure of the network, the fare level and structure the level of capacity and quality of the service. A substantial difference is that now the local authorities are able to contract private bus companies. These bus companies act as entrepreneurs, i. e. they are paid by the local authorities.

In spite of the fact that operating costs for all local authorities are still on average higher than commercial revenues, the balance of the experience with deregulation of the public transport system to date has been positive. This conclusion seems paradoxical, but the explanation lies in the fact that costs of operation during the period after deregulation are notably reduced. Specifically, two positive results are worth mentioning: i) the competition has reduced costs for all local and county authorities, which signifies that the provided subsidies for the local and county authority have been reduced greatly, and ii) the production volume expressed in vehicle kilometres, vehicle hours and number of buses has been maintained almost without alteration, which is interpreted as an achievement of the deregulation.

3. The frontier production function

A frontier production function consists of those parts of the firms` production functions that express the maximum product obtainable for a given combination of inputs (Forsund and Hjalmarsson, 1987; Aigner and Chu, 1968). The pioneer in this field was Farrell (1957) who constructed an envelope isoquant for an industry. Farrell introduced a measure of productive efficiency which takes into account all the inputs, and yet avoids index number problems.

A frontier is distinguished according to the specification and the estimation methods used. In terms of specification, we have a parametric frontier functions which assume a particular functional form for the production or cost functions. An alternative approach is the non-parametric frontier, which requires no ad-hoc specifications of the functional forms. The specifications may or may not be based on an explicit statistical model of the relationship between the observed output and the frontier.

Classification of the frontier production functions is subject to whether observations in the output-input space are allowed to be above the frontier or not. If all observations lie on or below the frontier, the function is called deterministic, but stochastic if observations are above the frontier(Forsund and Hjalmarsson, 1987).

An empirical framework within which the frontier production function is specified, i.e. a deterministic parametric frontier without an explicit efficiency distribution, is presented by Aigner and Chu (1968). The restriction imposed here is that the observations in the production space lie on or below the frontier. This approach was further developed by Försund and Hjalmarsson (1979).

Since the original article by Aigner and Chu (1968), the methodological development in frontier production function estimation has gone from the deterministic programming approach to the stochastic composed error type of frontier, where statistical inference can be applied; for surveys, see Forsund et al (1980) and Schmidt (1985-86). However, the

”statistical” stochastic approach implies that the frontier has generated all data; see Schmidt (1985-86). This is, however, not consistent with the best-practice technology frontier framework. Against this background, we have chosen the deterministic approach. The deterministic parametric frontier approach, which was introduced by Aigner and Chu (1968) using an explicit Cobb-Douglas function, does however, have limitations when applied to the study of scale properties and technical progress. Forsund and Hjalmarsson (1979) generalized this approach, overcoming these limitations. Moreover, they proposed measures of technical change for a homothetic frontier production function, allowing neutrally variable to scale.

In this study we apply a deterministic frontier approach. The analysis of technical change is done by introducing trends in all parameters of the frontier function. The specification of technical change in the frontier production function takes the following homothetic form:

(1) $G(x,t) = g(v,t) \cdot u$

Where x = rate of output, v = vector of inputs, G (x,t) is a monotonically increasing function and g (v,t) is homogeneous of degree one in v, and a specific form of the efficiency distribution u. Calculation of the technical change measure is done by assuming that the parameters of the function in (1) are time functions. Changes in the returns to scale properties are accounted for by the scale parameters of the transformation function.

We have chosen the same functional specification as Forsund and Hjalmarsson (1979) i.e. the so called Zellner-Revankar specification of the transformation function together with a Cobb-Douglas kernel function:

(2) $Y^{\alpha-\gamma_4 t} e^{(\beta-\gamma_5 t)\cdot x} = Ae^{\gamma_3 t} \prod_{i=1}^{2} v_i^{a_i-\gamma_i t} \cdot u$

The changes in the constant term A, and the kernel elasticities for the inputs, and the scale parameters α and β, allow us to study the characteristics of technical change.

Considering the case of deterministic frontier without explicit efficiency distribution for u, the computation of the frontier function becomes very simple by minimising the sum of deviations from the frontier, with respect to input utilization. Logarithmic transformation reduces the estimation to a simple linear programming problem. The objective function to be minimised is:

$$(3) \qquad \sum_{t=1}^{T} \sum_{j=1}^{N} (\ln A + \gamma_3 t + (a_1 - \gamma_1 t)\cdot \ln v_1^j(t) + (a_2 - \gamma_2 t) \cdot \ln v_2^j(t) - (\alpha - \gamma_4 t)\cdot \ln x^j(t) - (\beta - \gamma_5 t)\cdot x^j(t))$$

where T is the number of periods and N the numbers of observations.

Due to the restriction that the observations are to be on, or below the frontier, we can rewrite (3) as:

$$(4) \qquad \ln A + \gamma_3 t + (a_1 - \gamma_1 t)\cdot \ln v_1^j(t) + (a_2 - \gamma_2 t)\cdot \ln v_2^j(t) - (\alpha - \gamma_4 t)\cdot \ln x^j(t) - (\beta - \gamma_5 t)\cdot x^j(t) \geq 0$$

The homogeneity constraint is expressed as:

(5) $$\sum_i a_{i,t} = \sum_{i=1}^{2} (a_i - \gamma_i \cdot t) = 1 \qquad t = 1,......., T$$

This implies that:

(6) $$\sum_{i=1}^{2} \gamma_i = 0$$

4. The data

In this study we have used primary data from the balance sheets of the different urban transport bus companies. The data used in this study covers the period 1989-1996. We include only companies with at least 25 workers and covering the city transport service. With these characteristics there were before deregulation 44 bus companies in Swedish urban transport. In 1996 the number had been reduced to 22 companies. This major reduction of the number of bus companies is a direct consequence of the urban transport market deregulation. The reason for this lies in the fact that the two largest bus companies have monopolized this market through awarded contracts and acquisition of municipal bus transport enterprises. These two bus companies are not included in the data set due to the fact that they operate in the entire country. Consequently, these companies are not comparable to the rest of the data set. It is worth mentioning that most of the bus transport companies which comprise the data set are owned by the state. We may add that two of the largest bus companies are owned by the Stockholm and Gothenburg municipalities. Only three companies are privately owned.

It should be noted that the number of observations are not the same during the period. This is because some bus transport companies have not had information available for the first year of the observed period. Therefore, the data panel comprises 16 observations for the first three years and 22 for the last five years of the period of study.

The output of a bus transport company is commonly defined as vehicle kilometres. Unfortunately, this measure was not possible to obtain for all the companies studied. Therefore, we chose the operating revenues as a measure of output. The current values are deflated with the official index for the transport sector (base year 1980) used in the National Account.

The data on labour input includes both blue-collar and white-collar workers. Labour input is measured in the total number of hours worked. Capital input is measured in the total number of seats. Operating costs input do not include the value of the wages. The current values of this input are also deflated by a price index for the transport sector used in the National Accounts. Summary statistics of the variables are given in Table 1.

Insert Table 1

In this study, we will use the following notations: L is labour (hours), K denotes capital (number of seats), M denotes operating costs (SEK), Y denotes operating revenues (SEK), K/Y, L/Y and M/Y are input coefficients for capital, labour and operating costs, respectively.

In order to describe the bus transport companies performance with respect to inputs and outputs, we show the input coefficients for capital, labour and operating costs in Table 2. This structural description gives us a good picture of the sector as a whole. It is interesting to note that the input coefficients recorded a very light variation during the period of study. This result is particularly due to unalterable market demand, as well as relatively stable price behavior.

Insert Table 2

5. Bus transport companies at the efficiency frontier

Our point of departure is to estimate a homothetic production function with a variable scale elasticity. The introduction of trends in all parameters of the frontier production function allows us to analyze the characteristics of technical changes and the efficiency of the individual bus companies. Estimation of the frontier production function is specified in the following way for three inputs:

(7) $Y^{\alpha-\gamma_5 t} e^{(\beta-\gamma_6 t)\cdot x} = Ae^{\gamma_4 t} K^{a_1-\gamma_1 t} L^{a_2-\gamma_2 t} M^{a_3-\gamma_3 t}$

Where: $Y =$ output

$K =$ capital

$L =$ labour

$M =$ operating costs

$A =$ constant term

$a_1, a_2, a_3 =$ elasticities for the inputs K, L and M, respectively

$\alpha, \beta =$ scale function parameters

$\gamma_1, \gamma_2, \gamma_3 =$ trends for the input elasticities

$\gamma_4 =$ trend for constant term A

$\gamma_5, \gamma_6 =$ trends for the scale function parameters

$t =$ time period: $t = 1$ in 1989, $t = 8$ in 1996

Considering the fact that extreme observations constitute the frontier, errors in data may be a problem. Even if the data have been carefully checked we performed sensitivity tests. This was done by excluding one observation on the frontier from the first run and then reestimating a new frontier without the observation in question. In this way, we can investigate the efficiency effects of the most extreme observations. The separately performed runs have been denoted as Case 1 and Case 2. The first case relates to the entire data set. While in Case 2 we have excluded the largest bus company namely, Stockholm Local Transport. This company operates in the capital of the country and represents, in our sample, more than 50% of the bus market.

Table 3 summarises the main estimates of the frontier production function. For Case 1, the kernel elasticities for capital, labour and operating costs input are 0.26, 0.22 and 0.52, respectively, in 1989. The trends are fairly strong. The capital and labour input elasticities decrease to 0.16, 0.18, respectively, while it increases to 0.66 for the operating costs. Another interpretation is that the marginal productivity of capital and labour increases, while operating costs decrease. From a technical change point of view, these results show that the bus transport sector experienced a capital and labour saving bias in technical change.

In Table 3 we can also see that the estimated trend in the scale elasticity function and β are zero in the two cases. This implies that the optimal scale does not change and the elasticity of scale function is the same for all the years.

As we can see in Table 3, comparison of Case 1 and 2 shows that the differences in the estimated parameters are very small. Therefore, the exclusion of the largest company does not have any influence on the results. This signifies that the estimations of measures of technical efficiency do not differ in the two cases (see Appendices 1 and 2).

Insert Table 3

Technical efficiency

The concept of efficiency, from a technical-economic point of view, is commonly utilised to denote how successfully a set of inputs is transformed into a set of outputs. It is worth emphasizing that this concept is relative, implying that the performance of an economic unit must be compared with some standard. In this work, the frontier production function (Equation 7) is our standard or reference point.

In relation to measures of efficiency, a mention of Farrell`s work (1957) is inevitable. Farrell defines technical efficiency as the distance between an observed input coefficient and the most efficient location on the efficiency frontier for the same factor proportions. A generalisation of the Farrell measures of efficiency was proposed by Forsund and Hjalmarsson (1979), extending thereby the analysis to the case of non-homogeneous and non-homothetic production functions, but retaining the initial assumption that a single production function represents the entire frontier production function. Similarly to Farrell`s measures, the distance between an observed unit and a reference point along a factor ray is used to measure efficiency.

In this study, technical efficiency is assessed in two different ways: the input saving measure E_1 and the output increasing measure E_2. The first is obtained by comparing an observed point of input requirements and output with the input requirements on the frontier production function corresponding to the observed output. The second is obtained by comparing an observed point of input requirements and output with the output that would be obtained on the frontier with the same amounts of inputs.

Insert Figures 1 and 2

The measures of technical efficiency were estimated for the bus transport companies sample. The results obtained are presented in Figures 1 and 2 for the years 1989, 1993 and 1996. These are calculated according to Case 1, i.e. for the whole data set. In the figures, the bus transport companies are organized in increasing order of efficiency values. Each rectangle in the diagrams represents an individual bus transport company, and these are labelled by a number. In this way, we can observe whether the observations change position during a given period.

Figure 1 illustrates the input saving measure E_1 for the selected years. This measure shows the relative reduction in the amount of inputs needed to produce the observed output using frontier technology compared with the observed use of inputs. We found that at the beginning of the period, observation (17) is least efficient. This bus company has a very small share of the total output and has an efficiency value E_1 of 0.63. This means that if it was efficient, it could have produced the same output with only about 63 per cent of the inputs actually used. On the other hand, the most efficient observations are (10) and (11). These bus companies are of medium size and have an efficiency measure equal to 1.

It is interesting to note that with respect to the position of the small and large companies in the efficiency distributions, there is no clear relationship between size and technical efficiency. For instance, in 1989 the largest bus company as well as the smallest one were not on the production frontier, while two medium size bus company were. In 1993, the third largest company was fully efficient (E_1 = 1), while the end of the period a small company was the only fully efficient unit observed.

We note that during the period the observations change position, but not dramatically. Another feature is that the variation in efficiency between observations during the period of study is very small. We can also add that the arithmetic average of E_1 is approximately equal to 0,80 during most years. The results indicate that the variation in efficiency for the different bus companies is very small.

Another measure of technical efficiency is the output increasing measure E_2, which shows the ratio between observed and potential output, the latter obtained by employing the observed amount of inputs using the frontier technology. In Figure 2 we present the output increasing measure. We can see that the range of variations is very similar to what we found for the previous measure E_1. As earlier noted, the most inefficient observation was in 1989 unit (17) then only produced 64 per cent of what could have been produced by using the frontier technology. The most efficient units were also in this case units (10) and (11).

The shape of the distributions, with respect to E_2, also changed during the period and these are fairly similar to the development of E_1 and the most efficient and most inefficient observations coincide for both measures. It should be noted that during the entire period the observations (16) and (17) are the least efficient. At the beginning of the period observation (11) is the most efficient, while unit (6) is fully efficient in 1993 and unit (22) in 1996.

The similarly in ranking according to E_1 and E_2 is also clearly demonstrated in Figures. 1 and 2. Comparison of the results reveals that the performance of the larger companies, (1) and (20), vary slightly during the selected years, moreover, none of these observations were ever on the frontier. It is worth noticing that the data base shows that the input coefficients of labour and operating costs decreased strongly for these observations, while the capital input increases for observation (1) and decreases for observation (20). This development explains the increase of the productivity of these companies. At the same time, the input coefficients for labour and operating costs decrease lightly for most other companies and were approximately constant for capital input.

6. Conclusions

In this paper we have presented a method to evaluate the technical efficiency of a sample of bus transport companies in a period of deregulation. Considering that the traditional statistical test possibilities are missing with the method used in this work, we have carried out a sensitivity analysis. The sensitivity analysis shows that the larger company did not distort the results obtained (see Table 3).

In general terms, the results of this study show that there are no substantial changes in the use of inputs after the bus transport market deregulation. The frontier production function analysis allows us to conclude that technical advance is characterised as capital and labour saving. An inspection of the input coefficients and cost shares for average companies and for companies on the frontier easily explain these results. At the same time during the analysed period, the average output grows. This increase in productivity is mainly due to rationalising in the use of inputs and can be attributed to the deregulation of the market.

The efficiency measures obtained in this study show that the gap between the most and the least efficient company varied very little during the observation period. We found that these results could be explained by the presence of homogeneity between the companies with respect to the adoption of technology and utilisation of labour and capital.

References

Aigner, D.J. and Chu, S.F.,(1968) ”On Estimating the Industry Production Function”. American Economic Review, 13, pp. 568-98.

Alexandersson, G., Fölster, S. and Hultén, S., (1996), ”Den Lokala Busstrafiken: en Lyckad Avreglering?. Ekonomisk Debatt, vol. 24, pp. 109-117.

De Rus, G. and Nombela, G., (1997), ”Privatisation of Urban Bus Services in Spain”. Journal of Transport Economics and Policy, 31, pp. 115-129.

Farrell, M.J., (1957), ”The Measurement of Productive Efficiency”. Journal of Royal Statistical Society, 120, pp. 449-60.

Försund, F. and Hjalmarsson, L., (1979), ”Frontier Production Functions and Technical Progress: A Study of General Milk Processing in Swedish Dairy Plants”, Econometrica, 47, pp. 883-900.

Försund, F. and Hjalmarsson, L., (1987), Analyses of Industrial Structure: A Putty-clay Approach, Almqvist & Wicksell, Stockholm.

Försund, F., Lovell, C. and Schmidt, P., (1980), ”A Survey of Frontier Production Funtions and their Relationschip to Efficiency Measurement”, Journal of Econometrics, 13, pp. 5-25.

Glaister, S., (1993), ”Bus Deregulation in the United Kingdom”. In Carbajo, J., ed., Regulatory Reform in Transport. Some Recent Experiences. World Bank.

Gwilliam, K. and van de Velde, D. M., (1990), ”The Potential for Regulatory Change in Europe Bus Markets”. Journal of Transport Economics and Policy, 24, pp. 333-350.

Savage, I., (1993), ”Deregulation and Privatization of Britain´s Local Bus Industry”. Journal of Regulatory Economics, 5, pp.143-158.

Schmidt, P., (1985-86), ”Frontier Production Functions”, Econometric Review, 4, pp 289-328.

Thomson, I., (1992), ”Urban Bus Deregulation in Chile”. Journal of Transport Economics and Policy, 26, pp. 319-326.

White, P., (1990), ”Bus Deregulation: A Welfare Balance Sheet”. Journal of Transport Economics and Policy, 24, pp. 311-332

Appendix 1. E_1 Measure of Technical Efficiency for Selected Years. Comparison of Case 1 and Case 2.

	1989		1993		1996	
Obs.	Case 1	Case 2	Case 1	Case 2	Case 1	Case 2
1			0,9659		0,9063	
2	0,7696	0,7691	0,7787	0,7782	0,7852	0,7862
3	0,8030	0,8034	0,6925	0,6929	0,8303	0,8320
4	0,7402	0,7388	0,7788	0,7784	0,6830	0,6833
5	0,8447	0,8451	0,8510	0,8525	0,8694	0,8719
6	0,9945	0,9926	1,0000	1,0000	0,9023	0,9035
7	0,8651	0,8631	0,8200	0,8193	0,7968	0,7969
8	0,6811	0,6807	0,7668	0,7675	0,8173	0,8184
9	0,8293	0,8275	0,8356	0,8352	0,7812	0,7812
10	1,0000	1,0000	0,8797	0,8801	0,7668	0,7679
11	1,0000	1,0000	0,9103	0,9102	0,8967	0,8949
12	0,6432	0,6426	0,7397	0,7400	0,7189	0,7199
13	0,7228	0,7220	0,7765	0,7764	0,6511	0,6514
14	0,8236	0,8230	0,7263	0,7268	0,8224	0,8238
15	0,7405	0,7395	0,8798	0,8799	0,7239	0,7244
16	0,6689	0,6685	0,6621	0,6624	0,6793	0,6806
17	0,6268	0,6257	0,6874	0,6870	0,6212	0,6223
18			0,8114	0,8105	0,8346	0,8347
19			0,7629	0,7635	0,8284	0,8295
20			0,6960	0,6978	0,8899	0,8931
21			0,7403	0,7396	0,7819	0,7825
22			0,8172	0,8163	1,0000	1,0000

Case 1 = Full data set

Case 2 = Largest bus company excluded.

Appendix 2. **E_2 Measure of Technical Efficiency for Selected Years. Comparison of Case 1 and Case 2.**

	1989		1993		1996	
Obs.	Case 1	Case 2	Case 1	Case 2	Case 1	Case 2
1			0,9671		0,9096	
2	0,7769	0,7766	0,7858	0,7855	0,7921	0,7933
3	0,8095	0,8099	0,7017	0,7024	0,8359	0,8377
4	0,7483	0,7472	0,7859	0,7857	0,6925	0,6931
5	0,8498	0,8504	0,8560	0,8576	0,8738	0,8763
6	0,9947	0,9929	1,0000	1,0000	0,9056	0,9069
7	0,8697	0,8678	0,8259	0,8254	0,8034	0,8037
8	0,6907	0,6905	0,7742	0,7751	0,8233	0,8245
9	0,8349	0,8333	0,8410	0,8408	0,7883	0,7884
10	1,0000	1,0000	0,8838	0,8843	0,7743	0,7755
11	1,0000	1,0000	0,9134	0,9134	0,9002	0,8986
12	0,6536	0,6533	0,7478	0,7483	0,7275	0,7288
13	0,7314	0,7308	0,7836	0,7838	0,6613	0,6619
14	0,8295	0,8290	0,7348	0,7355	0,8283	0,8298
15	0,7486	0,7478	0,8839	0,8841	0,7325	0,7332
16	0,6788	0,6786	0,6720	0,6727	0,6889	0,6905
17	0,6375	0,6367	0,6968	0,6967	0,6320	0,6334
18			0,8176	0,8169	0,8401	0,8404
19			0,7704	0,7712	0,8341	0,8353
20			0,7052	0,7072	0,8937	0,8968
21			0,7484	0,7480	0,7889	0,7896
22			0,8232	0,8225	1,0000	1,0000

Case 1 = Full data set

Case 2 = Largest bus company excluded.

Table 1: Description of the data

Variable	Mean	St. Dev.	Min	Max
Y (1000 SEK)	91208	177892	5047	985826
K (number of seats)	8965	17390	750	103725
L (hours)	697118	1391762	42390	8394790
M (1000 SEK)	46543	88726	2289	481923

Table 2: Input Coefficients (Capital, Labour and Operating Costs) 1989-1996

Year	K/Y	L/Y	M/Y
1989	0.08	7.69	0.56
1990	0.09	8.28	0.53
1991	0.08	8.23	0.53
1992	0.12	8.00	0.55
1993	0.10	7.58	0.51
1994	0.11	7.11	0.50
1994	0.10	6.94	0.48
1996	0.11	6.96	0.49

Table 3: Estimates of the Frontier Production Function.
(t = 1 in 1989, t = 8 in 1996)

	Case 1		Case 2	
	1989	1996	1989	1996
LnA	1.07068	1.07068	1.06897	1.06897
$\gamma_4 \cdot t$	0.00000	0.00000	0.00000	0.00000
$(a_1 - \gamma_1 \cdot t)$	0.25597	0.15763	0.25138	0.15330
γ_1	0.01405	0.01405	0.01401	0.01401
$(a_2 - \gamma_2 \cdot t)$	0.22234	0.18442	0.23618	0.18677
γ_2	0.00542	0.00542	0.00549	0.00549
$(a_3 - \gamma_3 \cdot t)$	0.52170	0.65800	0.52341	0.65993
γ_3	-0.01947	-0.01947	-0.01950	-0.01950
α	1.03759	1.03759	1.03872	1.03872
$(\alpha - \gamma_5 \cdot t)$	1.03759	1.03759	1.03872	1.03872
$\gamma_5 \cdot t$	0.00000	0.00000	0.00000	0.00000
β	0.00000	0.00000	0.00000	0.00000
$(\beta - \gamma_6 \cdot t)$	0.00000	0.00000	0.00000	0.00000
$\gamma_6 \cdot t$	0.00000	0.00000	0.00000	0.00000

Case 1 = Full data set

Case 2 = Largest bus company excluded

Figure 1: E_1 Measure of Technical Efficiency for Selected Years.

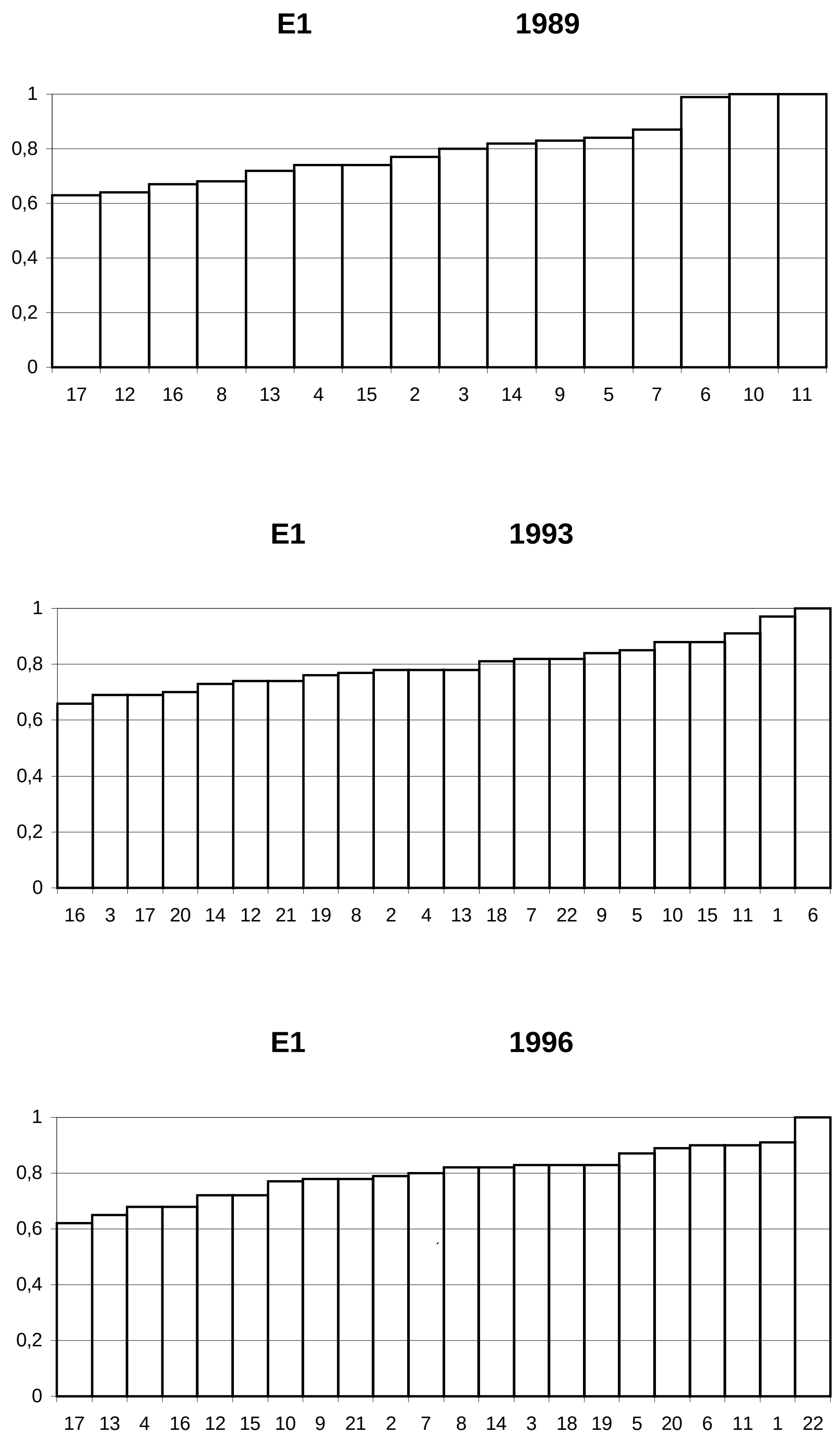

Figure 2: E_2 Measure of Technical Efficiency for Selected Years.