Demonopolization of urban transport in Poland has been lasting for almost two decades, whereas 17 years have passed since first Public Transport Authorities (PTAs) were established in 1992. At the same time Polish towns have independently looked for ways of efficient public transport organisation, reaching out for many methods inspired by solutions used worldwide but at the same time taking into account domestic restrictions.

It has resulted in a wide variety of experiences – starting with Elbląg, which divided and privatised the public bus operator and now all services are tendered by a PTA, and finishing with Zielona Góra, where the operator continues to function as a budget entity (a public sector entity without separate legal personality that covers its costs directly from the city budget) and manages the transport system on his own within a ‘German’ model. There are numerous other solutions in between – among others private-public companies in Tczew (with a private partner as a majority stock holder) and in Kalisz (with a public partner as a majority stock holder), competition between private and public operators in Gdynia, or separating a part of the market for free competition while preserving the dominant role of a public operator in Warsaw. The discussed cases were in detail presented in the paper at the European Transport Conference (Wolański, 2007).

Such a wide variety creates possibilities of comparing efficiency of particular urban transport organisation systems implemented in similar realities, which was the subject of the author’s doctoral dissertation entitled “Economic efficiency of urban transport demonopolization in Poland”. This paper presents a part of econometric modelling results, created for the needs of that thesis with the help of Stochastic Frontier Analysis – the state-of-the-art method of efficiency measurement.
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**RESEARCH METHOD**

Efficiency measurement model used in this paper has been based on an analysis of the cost of purchase or production of a buskilometre in different towns, which is consistent with previous research done in Poland among others by R. Tomanek (2002). The most important innovation is taking into account the fact that differentiation of the cost may result from many other factors, than an organisational model, such as vehicle type, its size, age and equipment.

The cost-based approach is reasonable in as much as in the case of a vast majority of Polish towns it is the public side that decides about qualitative aspects of the carriage offer, preparing at least a time-table outline, putting forward specified quality requirements and finally shaping the price policy. Therefore a public body usually ‘buys buskilometres’ and makes its own decisions concerning their use. The quality of this use, i.e. adapting the offer to market needs, does not directly result from the operator’s ownership issues.

A disadvantage of such an attitude is impossibility to take into account the cities where local governments settle accounts with operators on net basis (the operator gets a farebox and a fixed subsidy) but the number of implementations of such a solution in Poland is very small indeed, thus we may assume that it would not lead to statistically significant results.

With this kind of approach, it is a good solution within the scope of modelling to use Stochastic Frontier Analysis. It is based on the assumption that the cost function may be defined by an equation (Greene, 2007, E33-1-3):

\[ y_i = \beta' x_i + v_i + u_i \]

where in this case:

- \( y \) denotes the cost of buskilometre for given services;
- \( \beta' x \) – parameters of a given transport service (such as bus length, age, etc.), multiplied by their estimated influence on costs (negative or positive);
- \( v \) – random variable with normal distribution, showing different kinds of objective cost deviations, not providing for inefficiency but resulting from factors not included in the model;
- \( u \) – inefficiency, a random variable with half-normal distribution, thus accepting only non-negative values.

The first element denotes deterministic part of the cost, which together with \( v \) create so-called cost frontier, i.e. a kind of idealised minimum cost; after deducting this cost each observation is characterised by non-negative inefficiency \( u \) (Greene, 2007, E33-1-3).

The variable \( u \) in this paper is defined as ‘absolute inefficiency’ in contrast to ‘relative inefficiency’ denoted by (Coelli, 1996, 9):

\[ \frac{u_i}{\beta' x_i} \]

Therefore \( u \) itself illustrates the value of inefficiency expressed in currency (PLN – polish zloty). On the other hand ‘relative inefficiency’ is a no dimension value showing inefficiency
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in relation to the deterministic element of cost frontier. And thus relative inefficiency amounting to 24% means that – excluding the random element \( v \) – the real remuneration paid to the operator equals 124% of deterministic element of cost frontier, while equalling 50% means that the remuneration equals 150% of this element.

W. Greene (2007, E33-4) underlines that as a rule, especially in the case of classic Cobb-Douglas’s production function, particular explanatory variables \( (x_i) \) may denote logarithms of particular inputs.

The choice of parameters of vector \( \beta \) is achieved by using the method of maximum likelihood.

An essential advantage of SFA is taking into account that not each variation from the forecasted value means inefficiency, which is secured by random variable \( v \). Whereas using SFA one should remember that defined coefficients \( \beta \) do not mean average dependence, for the deterministic element of the equation is closer to the “ideal” than to a “typical case”, as in the case of linear regression.

In order to carry out research, first a set of potential variables explaining the price of a bus kilometre or being able to differentiate the effectiveness of concluded contracts, such as the vehicle’s age or size, the period of the contract, mean speed on given routes etc., have been set.

Then the necessary data allowing to create a data base for a model have been collected. Some of them were taken from a statistical journal published in Polish on a six-month basis “Urban communication in numbers” (2007) by Polish Chamber of Urban Transport (IGKM) – they were available only in the case of carriers operating without the Polish Transport Authorities. The remaining data should be collected within the questionnaire, conducted in the first half of 2008, directed to all PTAs, that are IGKM members as well as to some other smaller transport authorities.

The data base record was a single value of dependent variable, i.e. a gross price expressed in PLN per kilometre, paid to the operator by the Public Transport Authority (adjusted by the municipal company’s profit or loss), or a mean cost of performing a service in a municipal company acting in a model without PTA (‘German’ model). This value might refer to the whole network or even to a single service. Therefore it was necessary to weigh the data implicitly using the number of services the given rate concerned. Under the term service we in principle understand one bus in motion, although in some cases it is possible for one vehicle to perform two services obtained in different bids, e.g. on day and night lines. However, these are very rare phenomena.

In this way a data base including facts on 281 transport services rates, within which transport services were provided for 12 PTAs by 4002 buses, was created. It was connected with secondary data for 18 towns operating without the PTA. These operators together run 1546 buses on average working day basis. The difference of scale was unavoidable and resulted from the specificity of demonopolization in Poland.
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On account of diversity of dependent variables, in the case of towns where transport services are performed directly by public companies and towns where transport authorities exist, an assumption of creating two models has been adopted:

- the first model, a general one, concerning all towns independently of whether transport authorities were established there or not;
- the second model, related only and solely to contracts concluded within tenders by operators and transport authorities (independently of its organisational form – this criterion should be treated as functional), where a set of potential dependent variables may be somewhat bigger.

In practice these models turned out to be much more similar than had been expected; nevertheless their diversity was maintained in order to obtain more precise results.

RESEARCH RESULTS

The created models

A number of attempts allowed creating three statistically significant models, out of which one concerned the whole of researched services and two referred only to transportation tasks granted in the course of a tender.

Trials with both linear and logarithmic dependence were simultaneously conducted for some variables, while the chosen ones guaranteed higher reliability. Whereas in none of the models logically correct and statistically significant dependencies were obtained between cost, and among others:

- the size of an order granted to a given operator – in this case in a parallel linear regression model even an inverse proportionality was observed; the reason for this may have been the fact that setting the cost frontier was obstructed by existence of groups of big and inefficient public operators; it needs stressing that a similar proportionality was already observed by Miller (1970);
- the amount of average wage in a given region – probably it was more diverse than drivers’ wages due to a different inhabitants’ professional structure and also on account of a general practice of drivers commuting from suburban areas, where wage expectations are lower and more even nationwide.

It was also necessary to resign from the assumed weights in the form of a number of services and substituting it by a logarithm of the same value.

The obtained models are presented in the following tables.
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Table 1. Stochastic buskilometre cost frontier – all services.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard error</th>
<th>Critical significance level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>3.750</td>
<td>0.536</td>
<td>≤0.01</td>
</tr>
<tr>
<td>Average length of a bus [m]</td>
<td>0.130</td>
<td>0.016</td>
<td>≤0.01</td>
</tr>
<tr>
<td>Average log of bus age [years]</td>
<td>-1.038</td>
<td>0.302</td>
<td>≤0.01</td>
</tr>
<tr>
<td>Annual bus mileage [kkm/year]</td>
<td>-0.007</td>
<td>0.002</td>
<td>≤0.01</td>
</tr>
<tr>
<td>Share of low floor buses [%]</td>
<td>0.641</td>
<td>0.153</td>
<td>≤0.01</td>
</tr>
<tr>
<td>Average speed (incl. stops) [km/h]</td>
<td>-0.027</td>
<td>0.015</td>
<td>≤0.05</td>
</tr>
</tbody>
</table>

Table 2. Stochastic buskilometre cost frontier – tendered services (model A).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard error</th>
<th>Critical significance level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>3.296</td>
<td>0.594</td>
<td>≤0.01</td>
</tr>
<tr>
<td>Average length of a bus [m]</td>
<td>0.128</td>
<td>0.022</td>
<td>≤0.01</td>
</tr>
<tr>
<td>Average log of bus age [years]</td>
<td>-0.807</td>
<td>0.440</td>
<td>≤0.10</td>
</tr>
<tr>
<td>Annual bus mileage [kkm/year]</td>
<td>-0.006</td>
<td>0.003</td>
<td>≤0.05</td>
</tr>
<tr>
<td>Share of low floor buses [%]</td>
<td>0.561</td>
<td>0.189</td>
<td>≤0.01</td>
</tr>
<tr>
<td>Average speed (incl. stops) [km/h]</td>
<td>-0.041</td>
<td>0.028</td>
<td>≤0.15</td>
</tr>
</tbody>
</table>

Table 3. Stochastic buskilometre cost frontier – tendered services (model B).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard error</th>
<th>Critical significance level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>2.491</td>
<td>0.583</td>
<td>≤0.01</td>
</tr>
<tr>
<td>Average length of a bus [m]</td>
<td>0.138</td>
<td>0.023</td>
<td>≤0.01</td>
</tr>
<tr>
<td>Average log of bus age [years]</td>
<td>-0.726</td>
<td>0.327</td>
<td>≤0.05</td>
</tr>
<tr>
<td>Annual bus mileage [kkm/year]</td>
<td>-0.007</td>
<td>0.002</td>
<td>≤0.01</td>
</tr>
<tr>
<td>Share of low floor buses [%]</td>
<td>0.479</td>
<td>0.172</td>
<td>≤0.05</td>
</tr>
<tr>
<td>Share of buses equipped in AC and CCTV [%] (if only AC / only CCTV, than 0.5 of the value)</td>
<td>0.499</td>
<td>0.348</td>
<td>≤0.20 (0.151)</td>
</tr>
</tbody>
</table>
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An analysis of efficiency of organisational models

Graph 1. Relative inefficiency according to organizational scheme, operator ownership & award type

The created models allow drawing a number of important conclusions. Primarily, comparing relative efficiency depending on organizational scheme, operator ownership and award type (comp. graph 1) indicates a much higher efficiency of private and public operators who received orders in the course of tendering rather than of the remaining public companies. If a public operator gets an order in the course of tendering, with the existence of PTA, the cost is 12% lower in relation to direct award (an average cost equalling 129% of cost frontier instead of 146% of cost frontier).

If a private operator wins the tender, the cost is on average by another 2% lower. In the case of private operators who received contracts under the direct award procedure, attention should be drawn to a small number of services and the fact that these orders were awarded in mid-90ties, when the Public Procurement Act was not in force yet; nevertheless those contracts were preceded by negotiations. Hence the private operators’ efficiency should be considered jointly, on assumption that in both cases they were chosen in the course of competition.
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It is surprising that public companies operating without PTAs are much more efficient than those operating within PTAs’ direct awards despite a part of competences and costs being taken over by these entities. Therefore it means that the dominant way of transport organization in Poland is the least efficient, which results from “artificial” establishment of PTAs, which anyway are forced to outsource services of a particular operator and have limited influence of them. Obviously, this is an ascertainment of the dominant state of the facts. In theory and in some practical cases it is possible to establish healthy relations between contracting authority and operator, as between normal customer and seller. Then the possibility of the external quality control is an essential advantage.

Graph 2. Absolute inefficiency according to organizational scheme, operator ownership & award type

The situation looks somewhat different if absolute efficiency expressed in Polish zlotys (comp. graph 2, 1 PLN ≈ 4.4 EUR) is considered. In this case the difference between efficiency of private and public operators receiving contracts in the course of tenders becomes more pronounced. This discrepancy may result from a number of possibilities:

- private operators provide services with a lower cost frontier, thus of lower quality (e.g. older bus fleet) or on more advantageous principles (e.g. longer-term contracts or higher yearly mileage);
- after all public operators provide twice more services won in the course of tendering than private operators, which results from a certain number of tenders in which private operators find it difficult to satisfy the criteria (e.g. the requirement of owning a bus
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fleet at the moment of tendering); this causes “overvaluing” the cost frontier in case of specific contracts for public operators;

It is also important, that some municipal operators provide services both on the basis of direct awards and tenders – in this case higher incomes from direct awards may allow them to offer lower prices in tenders, which creates an illusory efficiency of this form of placing orders. This has been proven by an analysis of single operators.

It is also worth paying attention to the fact that the shown buskilometre cost of public operators does not illustrate the entire costs incurred by local authorities, including costs of lost opportunities to which the author had no access. For example, private operators purchase or lease land on their own, while municipal operators may use land contributed to the company by a town.

Graph 3. Relative inefficiency in subsequent cities

Some interesting information is also provided by comparing efficiency of private and public operators within the range of individual towns (comp. graph 3). It clearly shows diversity of absolute inefficiency between separate towns as well as local differences between private and public operators.

And thus only in one town (M) private operators turned out to be more expensive than public ones; however then they owned only 0.5% of the market share in this town and serviced a very specific market segment. At present their share has significantly increased since they clearly won biddings with a public operator.

However there are towns, e.g. a large town B (over 1500 services), where private operators run more then 20% of the network, reaching inefficiency of 27% compared to municipal operator’s relative inefficiency equalling 60%. It means an over 20% saving possible to achieve in the case of putting up tasks accomplished by this public company for tendering.
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Graph 4. Distribution of relative inefficiency – private vs. public

Graph 4 also well conveys the diversity of operators’ efficiency. It shows that if in the case of private operators over 75% of tasks reach inefficiency not exceeding 30%, in the case of public companies almost 70% of operators exceed this value. Nevertheless, there is a group of communal operators who maintain very high efficiency, the more so that in some cases they have a wider scope of tasks (there is no separate PTA).

**Tendering efficiency analysis**

A level of efficiency also depends on specific solutions within the Competitive Tendering (CT) tactics used in a given town. Thanks to using appropriate methods, it is possible to increase efficiency of this process significantly, usually simultaneously ensuring high quality services and protecting against the risk of private monopoly or oligopoly.
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Graph 5. Relative inefficiency according to the number of services within a contract

Analysing efficiency depending on the number of services within a contract (comp. graph 5), we may come to a conclusion that contracts for a large number of transport tasks, over 60, are the least efficient. It is due to the fact that such contracts are relatively difficult to execute and usually just one offer is submitted, which induces reflection whether such a tender is actually based on competition principles. Out of over 800 services covered by such large orders, more than 700 fell to municipal operators. The aforementioned doubts are deepened by the carried out analysis indicating that some contracting authorities use clauses seriously limiting competition; the already mentioned requirement to own suitable buses at the moment of submitting a tender is the most popular among them.

In turn, high efficiency is characteristic of orders within the range of 20-60 tasks allowing competition between many operators, also those who do not have bus garages in a given town. Highly efficient are also contracts up to 5 busses which can be easily accepted even by small companies (however such contracts are relatively few).
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An other factor differentiating CT efficiency is the period for which the contracts are concluded (comp. graph 6). In case of a used bus fleet, contracts for relatively short periods, however definitely exceeding 1 year, are a good solution. In case of a new bus fleet, longer periods are preferred, though a period exceeding 8 years causes higher risk, therefore lower efficiency.

It can be caused also by the fact that in Poland indexation of operators’ remuneration by inflation prevails, which does not take into consideration either high dynamics of fuel or wage costs or even declining, due to congestion, speed in towns. Introducing more advanced indexation methods will certainly bring about a further increase of efficiency of longer-term contracts, even those over 8 years.

The other cause is, that the longest contracts are more often pro forma tenders, aiming to award the services to a communal operator, similarly as in the case of the biggest orders over.
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**Graph 7. Relative inefficiency according to the number of tender contracts in the city**

The number of contracts concluded by one transport authority (comp. graph 7) is yet another factor influencing efficiency demonopolization of urban transport systems. This variable has a very interesting distribution as there is a large group of PTAs which have up to 10 (usually fewer than 5-6) contracts concluded under the tender procedure and 2 PTAs which concluded a significantly greater number of contracts, reaching some 100. It is the second group of authorities that actually reach higher efficiency on account of high dynamics of the market making it attractive for many private operators.

**CONCLUSIONS**

The prepared econometric models show that tendering of public transport results in a considerable improvement of efficiency. It forces public firms to achieve efficiency level similar to that of private operators, although following the results of particular tendering cases indicates that it is not always possible. Sometimes tenders are won by municipal operators on account of terms restricting competition, while sometimes the firms getting a part of their orders under the direct award procedure are able to tender remaining services at prices lower than average, which will soon be forbidden by The European Parliament and the Council of Europe Regulation (EC) No. 1370/2007 of 23rd October 2007.

Also an analysis at the level of separate towns points to lower costs incurred by private than by public operators.

However, a positive difference between efficiency of public operators acting for PTA under the direct award procedure and in a classic municipal monopoly comes as a surprise, especially if additional costs of PTA’s functioning are taken into consideration. It is the public operators’ receiving orders without competitive procedures from PTAs that is the least effective organisational form. This result came as a considerable surprise in comparison with
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the results of earlier research and general beliefs that establishing such entities in itself is considered pro-efficient. It is also a contradiction of trends recently prevailing in Poland.

It also needs stressing that there is a significant differentiation of efficiency between individual public operators, regardless of organisational structures in which they operate. There is a group of highly efficient companies as well as a group of much less efficient ones. This may be explained by inside organisational solutions, which are not included within the scope of this research.

The observed differentiation causes that the decision concerning demonopolization of urban transport is not obvious – it should be made on the basis of a current audit concerning urban operator’s costs related to valuation of potential of actual introducing competition in a given town. This should prevent stopping demonopolization at the moment of setting up PTA and generating additional cost, but before introducing CT and achieving the expected benefits.

Also designing a tendering system we should look for solutions conductive to constant competition between operators; these solutions include dividing network into small bundles up to 60 services, concluding long-term contracts, though not longer than 8 years (and up to 3 years on used rolling stock). Also a creation of a dynamic market is essential. This dynamics can be achieved with a smaller number of contracts, even if every year 1-2 tenders are organised for 20 services.

With such a structure of tendering systems – still rather rare in Poland – a greater diversity of efficiency between private and public operators should take place. However, a possibility of gradual cease or privatisation of a municipal operator who will be unable to satisfy market requirements should be taken into consideration.

It also needs emphasizing that the analyses made in the doctoral dissertation – not included in this work on account of its volume – showed that available fragmentary data suggest a rather positive than negative influence of demonopolization on the number of passengers carried, which authorises to use cost as an efficiency indicator.

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