Application of the non-parametric DEA method to analyse the efficiency of selected services provided by municipalities, example of primary schools

Marek Jetmar[1] *and Jan Kubát*[2]

Abstract:

Efficiency is often understood as the relationship between inputs (costs) that should be spent economically and outputs of the public organization's activities. Different comparative methods based on an institutional comparison of the cost per unit of production of specific public goods, or even a territorial comparison are used in order to measure the efficiency. The aim of our research is to find out whether the Data envelopment analysis (DEA) can be applied for monitoring the efficiency of the provision of public services at the level of municipalities in the Czech Republic.

DEA is a non-parametric method for the estimation of the production frontier (or, more precisely, the best-practice frontier). It measures technical efficiency of a decision making unit relatively to other units in the sample. The units that form the frontier are classified as efficient while the units not on the frontier are considered as inefficient. Inefficient units are further assigned efficiency score measuring their shortcomings. Efficiency of public institutions is examined either as a whole or by focusing only on the specific service they provide. We have gone the second way, i.e. we are exploring the efficiency of individual services provided by municipalities.

We examined the provision of services in the fields of education, library, public security, transport etc. What is concerning financial inputs, we identified the relevant costs at the level of items and sections of budget structure, used in the Czech Republic. We worked with current, ie. operating expenses only. We used in parts factual, non-financial inputs and outputs.

The population size of municipalities and their distance to development centers defined by the Regional Development Strategy of the Czech Republic 2021-2027 (regional metropoles, centers with more than 10,000 inhabitants and so-called third-type municipalities (ORP)) became the sorting criteria. This made it possible to calculate efficiencies not only in the context of a whole set of municipalities, but also for groups of similar municipalities (homogenous group). Formally, we have set of sixteen municipality categories, taking into account their population size, spatial distance to the higher-ranked settlements, as well as the degree of delegation of powers.

We analyse efficiency of primary schools established by Czech municipalities during the years 2016-2018. In total, there are more than 2 560 primary schools in the 2018. For the efficiency analysis, we consider the following variables: Total expenditures (wages of teaching staff were not included as they are provided uniformly according to the wage tables and financed through transfer from the budget chapter of the Ministry of Education, Youth and Sports), Number of pupils and Number of school classes. Our aim was to verify the efficiency of this method for assessing the efficiency of particularly local public services.

Our research shows that efficiency of municipal schools increases not only with the size of the seat (examined in the context of the whole data set), but also the average efficiency within the size categories studied increases with the increase of the population.

One of the outcomes is the creation of algorithms that can calculate the efficiency of the municipality in the context of the given parameters (selection of a group of municipalities according to population size, type, spatial location, classification in administrative districts, etc.).

Keywords: communities and municipalities; efficiency; DEA; primary schools

Points for Practitioners:

[1] deputy head of Department of Economics and Management, AMBIS University, Prague, Czechia
[2] AMBIS University, Prague, Czechia

The reason of our research was to developed model which would be possible to calculate the efficiencies of a particular municipality both within the context of the whole dataset and within the created homogenous group of municipalities of a similar nature. Our research team uses data about inputs and outputs for the area of primary education, local public libraries, road maintenance, municipal police service, providing services of municipal authorities. For the same time periods, we have expenditures of municipalities by type and sector breakdown (system MONITOR of the Ministry of Finance of the Czech Republic).

The developed DEA model represents a core of software application created in cooperation with AMBIS university and the Czech Technical University Transport Faculty. Through a software application created in cooperation with AMBIS university and the Czech Technical University Transport Faculty, it is possible to subsequently compare the observed efficiencies not only with similar municipalities, but also with municipalities and towns in the chosen administrative district of the municipality with extended scope, the district of the county, or any other municipality. In addition to the achieved efficiency ranking, it is possible to find out the relationship to the mean value, the distance from the upper and lower decile, etc. It is a tool that the Ministry of the Interior of the Czech Republic and representatives of municipalities can use to compare the efficiency of municipalities.

1. Introduction

The high share of the public sector in GDP and its allocation decisions are examined from the point of view of the efficiency of activities, the efficiency of public administration management activities in the public sector. However, even in the public sector, achieving efficiencies in spending the financial resources of the budget system is a major challenge. The tendency towards inefficiencies in the public sector is a major manifestation of its failures as well as government failures and failures in public administration, both at the state and local government level. Efficiency is understood as a situation in which the maximum amount of goods and the maximum benefit can be obtained from the available social resources. The economy is at the limit of utility (Musgrave and Musgrave, 1976; Samuelson and Nordhaus, 1992; Stiglitz, 2000 and other authors).

Efficiency in a narrower sense is often understood as the relationship between inputs (costs) that should be spent economically, there should be no waste of resources, material and human (economy), and outputs from the activities of an institution, an organisation in the public sector, i.e. what is the efficiency of activity results, what is the benefit of the client (user, customer), when the result is Jetmar and Toth, 2019). Efficiency is therefore understood as the efficiency of the resources invested and the benefits gained by them on output.

The issue of efficiency of public, especially territorial, administration is an object of interest of the Ministry of Interior in the Czech Republic. Following the implementation of the territorial reform of the public administration at the beginning of the millennium, the attention of the Ministry of Interior focused on supporting processes towards the modernisation of the public administration. It is about increasing the efficiency of public spending at all levels of government, efficiency, enhancing transparency of decision-making and accountability to citizens. Particularly in recent years, the focus has been on implementing systemic approaches to quality management.

Strategic framework for the development of public administration, conceptual document of the Ministry of Interior for the years 2014-2020, adopted by the resolution of the Government of the Czech Republic No. 680/2014 and the Implementation Plans including annexes (MV CR, 2014; MV CR, 2016), through the specific objective 3.2, advocated the application of sustainable systemic approaches to quality management. The focus is also on the activities of local authorities, in addition to the institutions of government. The services provided by the territorial public administration do not only fulfil the legally defined characteristics - the local authority tries to reflect the requirements of the stakeholders, which typically include clients of the office, local citizens and entrepreneurs, employees of the office, representatives and many others (MV CR, 2016).

2. Applying Non-parametric Methods to Analyse and Compare the Efficiency of Municipalities

2.1. Background to the Investigation

Researchers have been discussing for a long time the possibilities and limits of using the Data Envelope Analysis method (DEA) to evaluate the performance of the public sector and the efficiency of the provision of public services, respectively. Analysing the efficiency of municipalities and their comparability is an important tool of public policies and activities of public authorities (ministries, counties, municipalities). The application of the non-parametric DEA method is a way to transfer knowledge of economic theory into practice and to help improve decision-making and governance in the public sphere.

Data envelope analysis is used to evaluate the technical efficiency of production units, which should have several inputs and several outputs. The method was applied first in the corporate sphere in order to optimise the activities of homogeneous production units and branches (Decision Making Unit - DMU). In the case of examining efficiencies in public administration, in the Czech context we can understand as a unit a municipality or possibly a type of municipality - ORP (a municipality with an extended scope), their organisational units or contributory organisations providing a specific service.

The unit for which there are proportions of outputs and inputs for which the technical efficiency rate is greater than or equal to that of all other units is considered efficient. The units with the greatest efficiency value are so-called efficient and determine an boundary of efficiency. It defines the line of production possibilities. Units that move below this threshold are considered inefficient. Subsequent optimisation aims to improve the efficiency of units below this threshold, i.e. by increasing output or removing part of resources. Efficiency scores for individual DMUs are used for relative efficiency comparison. This is a percentage-based conversion of the efficiency achieved, i.e. efficient units are at 100%, whereas the closer the value is to 0, the more inefficient the unit is.

Thus, in our context of examining municipalities, the value of 100% indicates an "efficient" municipality, of which, given the nature of the constructed limit on production possibilities, there can and does be more. In basic DEA models, efficient units are assigned a unit measure of efficiency. Given the fact that there may be a number of units that are efficient, it is advisable to examine the relationships between them as well, super-efficiency is monitored (Andersen and Petersen, 1993). In DEA super-efficiency models, the original efficient units receive a super-efficiency rate higher than one (for input-oriented models) or lower than one (for output-oriented models). All super-efficiency models are based on the weight of the original efficient unit being placed at zero when calculating the super-efficiency rate (the valued unit is thus essentially removed from the set of units), resulting in a change to the original efficiency boundary. The super-efficiency model then measures the distance between the inputs and outputs of the rated unit from the new efficient boundary.

As part of our investigation, carried out during the implementation of the project Application of non-parametric methods (DEA, FDH) to analyse and to compare the efficiency of municipalities, TAČR No. TL01000463, we examined the efficiency of basic services, the provision of which should be the responsibility of all municipalities. This is the area of primary education and pre-school education, waste management, safety, operation of municipal infrastructure, etc. The limit to the application of this method is the availability of data relating to outputs and non-financial inputs. The method assumes the use of several inputs and outputs, which ideally should not be in a functional relationship or strongly correlated with each other.

When examining the efficiency of municipalities, we follow three steps by default. We calculate the efficiency of a particular municipality in the context of the whole set of municipalities that provide a given public service (primary school, operation of the municipal library, activities of the municipal/municipal police, etc. However, this is a very heterogeneous group of units internally, so we subsequently assess efficiencies in the context of similar municipalities. For this purpose, a methodology for the segmentation of municipalities has been developed, taking into account the population size of the municipality, its role in the public administration system (delegation of powers by the State), the relationship of the municipality to development centres, or its position vis-à-vis the poles of agglomerations or metropolitan areas. For specific efficiency calculations, this methodology is then adjusted in part to take into account the availability of data and the number of observations.

The software application subsequently created makes it possible to monitor the efficiency of the municipality even in the context of the territorial units monitored by the state, i.e. the administrative districts of the ORP and the regions. Average efficiencies for individual groups of municipalities have also been calculated for communication of results, allowing generalization of findings and interpretation of achieved relationships between categories of municipalities.

2.2 Theory and Literature

The most frequently cited authors in the field of data envelope analysis, i.e. the DEA method, are Charnes, Cooper and Rhodes (1978), Banker, Charnes and Cooper (1984) and Charnes et al. (1994), who created the original models. These were subsequently modified and further developed in the context of the examined phenomena (taking into account variable returns of scale, etc.).

An inner circle of researchers is involved in examining municipalities and more municipalities, respectively. The efficiency of public institutions is examined either as a whole or by focusing only on the specific service they provide. Geys and Moesen (2009a) analyse the efficiency of Flemish municipalities. The efficiency of Flemish

communities is analysed on a sample of 304 (out of 308) municipalities based on data from 2000 using three methods - DEA (CRS i VRS — constant returns to scale, variable returns to scale), non-parametric FDH (Free Disposal Hull) method and SFA (Stochastic parameter econometric method, Frontier Approach). In their analyses, input is the total current expenditure recorded in municipal budgets. The outputs then reflect the important competences of Flemish communities, which include the areas of social affairs and basic education, the provision of water supply and sewage and the operation of other technical infrastructure, the management of local roads, waste management, environmental care, the operation of infrastructure for leisure and sports activities. The authors state that non-parametric methods quantify relative efficiency rather than absolute efficiency.

Kalb, Geys and Heninemann (2012) and Geys, Like Geys and Moesen (2009 a) and Geys and Moesen (2009 b), Heinemann and Kalb (2013) focus, through the DEA and FDH method, on examining the so-called global efficiency of municipalities and not on the efficiency of municipalities in providing a service (waste management, drinking water supply, etc. Drew, Kortt and Dollery (2015a) and Drew, Kortt and Dollery (2015b) argue that the DEA's potential is its important contribution to public policy formulation. They further state that DEA can also be used to identify determinants of municipal potency. Drew, Kortt and Dollery (2015a) recommend two-step research where efficiency scores are first quantified and then entered into regression analysis. Da Cruz and Marques (2014) quote that inputs to the DEA efficiency of municipalities can be the same across countries, but outputs must vary due to the roles of self-government in each country. The variables that represent inputs are number of employees, labour costs, material and other expenses, credit costs. They list the number of businesses in municipality, the number of households, the population and the length of local roads as outputs. They formulate four DEA models that differ in input-output specifications, further elaborating them in the context of variable and constant returns of scale.

Afonso and Venâncio (2019) analyse the spending efficiency of 278 Portuguese municipalities in 2011 and 2016 through a two-step analysis - DEA at VRS and regression analysis. They consider the total expenditure of the municipality per capita as inputs. Outputs are the population over 65, the number of nursery and primary school buildings as a percentage of the number of children of the relevant school age, the number of children enrolled in kindergartens and primary schools as a percentage of the number of children of the relevant school age, the number of museums, botanical gardens of zoos and aquariums per capita, the supply of water per capita and the collection of municipal waste per capita and construction permits issued. Conversely, See (2015) and Gomézová et al. (2017) analyse the efficiency of the water management service only.

In the case of a number of foreign studies, it appears that as the size of the municipality or administrative unit increases, the efficiency of the provision of services increases, thus promoting economies of scale. This was partly demonstrated in our investigation, particularly in the provision of primary education services. Efficiency gains are observable when examining the efficiency of community groups over the whole population. At the same time, small municipalities also show an average lower efficiency within homogeneous groups. The positional aspect, i.e. the proximity of the municipality to larger development centres, is reflected differently in the different services examined.

3. Methodology

3.1 The Model Parameters

We use contemporary design of the DEA method, presented by Milan Hladík (Hladík, 2019). It is a DEA model with super-efficiency, variable returns from a range that measures the distance from the efficiency boundary (data envelope) not by Eucleid, like classic DEA models but by Chebysheva's distance and is thus, according to the author, more robust.

The linearized Hladík's model without super-efficiency looks like this:

$$Max \rightarrow e$$
$$y_0{}^T u - v_0 \geq 1 + e$$
$$x_0{}^T v \leq 1 - e$$
$$y\,u - x\,v\ -1\,v_0 \leq 0$$
$$u, v \geq 0$$

Where, y_0 and x_0 are vectors of the outputs and inputs of the examined unit, e is the efficiency of the examined unit, y a x are then matrices of outputs and inputs of all units, v_0 is an additional variable that can take any (even negative) value.

Hladík's model (linearized) and with super-efficiency, for an illustrative case for Unit A will look like:

$$Max \rightarrow e$$

Under Conditions

$$\begin{gathered}
-e - \emptyset + \partial + 2\,u_1 + 4\,u_2 \geq 0(\mathrm{A}) \\
-e - 5\,\mathrm{v}_1 - 8\,\mathrm{v}_2 \geq -2(\mathrm{A}) \\
1\,u_1 + 2\,u_2 \leq 6\,\mathrm{v}_1 + 7\,\mathrm{v}_2 - \emptyset + \partial(B) \\
2\,u_1 + 3\,u_2 \leq 6\,\mathrm{v}_1 + 6\,\mathrm{v}_2 - \emptyset + \partial(C) \\
2\,u_1 + 1\,u_2 \leq 2\,\mathrm{v}_1 + 3\,\mathrm{v}_2 - \emptyset + \partial(D) \\
2\,u_1 + 4\,u_2 \leq 3\,\mathrm{v}_1 + 2\,\mathrm{v}_2 - \emptyset + \partial(E) \\
3\,u_1 + 3\,u_2 \leq 3\,\mathrm{v}_1 + 3\,\mathrm{v}_2 - \emptyset + \partial(F) \\
3\,u_1 + 2\,u_2 \leq 1\,\mathrm{v}_1 + 5\,\mathrm{v}_2 - \emptyset + \partial(G) \\
4\,u_1 + 2\,u_2 \leq 7\,\mathrm{v}_1 + 6\,\mathrm{v}_2 - \emptyset + \partial(H) \\
u_1 \geq 0, u_2 \geq 0, v_1 \geq 0, v_2 \geq 0, \emptyset \geq 0, \partial \geq 0
\end{gathered}$$

Where e is efficiency, $\emptyset$ and ∂ are auxiliary variables on the basis of which the optimal weights of inputs (v') and outputs (u') are calculated as follows:

$$v' = v\,e$$
$$u' = u(2 - e)$$

The super-efficiency model enables efficient units to be compared with each other (in the input-oriented model, all efficient units have efficiency =1). The principle of DEA models with super-efficiency is that the weight of the initially efficient unit is laid down to zero, thus removing the unit from the comparison file. This will also change the original efficiency threshold. These efficient units are then retroactively added for the scales already calculated. Thus, the super-efficiency model measures the distance between the inputs and outputs of a given efficient unit from the new boundary of efficiency, which is calculated on a set excluding that compared unit. And since this unit was originally efficient, excluding it from the envelope (line or boundary of efficiency) means that it will have an efficiency of ≥1.

3.3 Examples of Model Application, Efficiency of Primary Schools

We calculate the efficiency of a particular municipality both in the context of the whole dataset and within the created group of municipalities of a similar nature. It is also possible, through a software application, to compare the efficiencies found with similar municipalities, possibly also municipalities in the administrative district of the extended municipality, or even the county. In addition to the achieved efficiency ranking, we also observe the relationship to the mean value, the distance from the upper and lower decile, etc. Average efficiencies have also been calculated for this purpose, allowing discussion of efficiencies to be held between community groups.

The current expenditure of all Czech municipalities on the operation of primary schools was 23.8 billion CZK in 2019, which was 3.7% of current expenditure in total. Municipalities without primary schools and schools without current expenditures were excluded from the analysis.

For the efficiency of the municipalities in the field of primary education, there is only one input - the current expenditure on primary schools in total. It is the sum of sections 3113, 3117, 3118, 3119 (Czech budgetary system), data were received from the Monitor application. This sum represents all current expenditures related to the operation of the primary school, which are paid from the municipality's budget. Wages of teaching staff were not included as they are provided uniformly according to the wage tables and financed through transfer from the budget chapter of the Ministry of Education, Youth and Sports.

Due to the fact that the primary school data relates to the school year and not to the calendar year, the current expenditure has to be recalculated to the school year. Thus, the current expenditure of school year T is calculated as 1/3 of the current expenditure of calendar year T + 2/3 of the current expenditure of calendar year T+1.

Outputs for measuring the efficiency of municipalities in primary schools are two:

- Total number of pupils (in school year);
- Total number of classes in the school year.

Data are collected and provided by the Ministry of Education, Youth and Sports. The data comes from the school registers on 30 September of the given school year. There available were data on primary schools for school

years 2016, 2017 and 2018. In database is not possible to distinguish the pupils from the certain municipality (it means citizens) and from the surrounding municipalities, that have no own school. For the purposes of calculating efficiencies of providing services, we aggregate data for all primary schools on the territory of municipality. This is due to the impossibility of differentiating the expenditure for each school in the municipality's budget.

Standard groups developed also for comparison efficiency of other municipal services are used for the splitting municipalities providing the school services. Municipalities over 50,000 inhabitants being merged into one group, as well as small communities under 500 inhabitants being merged into groups by commute. Thus, the original groups 101 and 201 are merged into the 101 group and the original groups 102 and 202 into 102. The reason is obvious - a small number of observations.

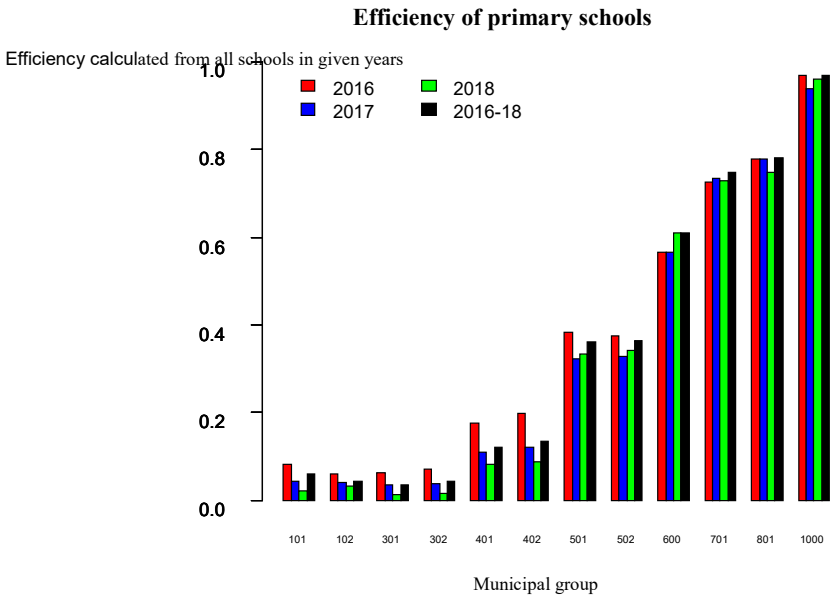
Tab. 1: Groups of municipalites for calculating the efficiency of primary schools

Municipal group for calculation	Residents from	Residents to	Distance to 15 minutes to ORP/aglomeration	Number of municipalities	Number of municipalities with school(s)
101	0	499	Yes	1 707	126
102	0	499	No	1 717	143
301	500	999	Yes	855	547
302	500	999	No	524	344
401	1 000	1 999	Yes	499	458
402	1 000	1 999	No	256	240
501	2 000	4 999	Yes	259	257
502	2 000	4 999	No	168	166
600	5 000	9 999	without distinction	142	142
701	10 000	19 999	without distinction	69	69
801	20 000	49 999	without distinction	44	44
1000	50 000	and more	without distinction	18	18

Ref: JETMAR, M. A DALŠÍ, (2021). Metodika uplatnění neparametrických metod (DEA, FDH) k analýze a ke komparaci efektivnosti obcí. AMBIS, vysoká škola a.s. a ČVUT v Praze Fakulta dopravní

Figure no.1 shows the results calculation of the efficiencies of municipalities in primary schools in each year and on average available school years (2016 to 2018) within homogenous groups of municipalities. To make sense of this comparison between groups of municipalities, efficiency is calculated on the whole set of municipalities at once. Clearly, efficiencies increase with the size of the municipality.

Fig. 1: Efficiency of primary schools in school years 2016-2018 and average 2016-2018, full data set



Ref: JETMAR, M. A DALŠÍ, (2021). Metodika uplatnění neparametrických metod (DEA, FDH) k analýze a ke komparaci efektivnosti obcí. AMBIS, vysoká škola a.s. a ČVUT v Praze Fakulta dopravní

Table No. 2 shows efficiency results not only for individual groups in the context of the whole data set, but also separately for (within) individual groups of municipalities.

Tab. 2: Efficiencies of municipal primary schools in groups of municipalities in school years

		Efficiency calculated on the entire file				Efficiency calculated within groups			
Municipal group for calculation	**Number of municipalities with school(s)**	**2016**	**2017**	**2018**	**2016-18**	**2016**	**2017**	**2018**	**2016-18**
101	127	8.1%	4.2%	2.1%	5.9%	11.0%	8.3%	8.0%	9.9%
102	145	6.0%	4.0%	3.1%	4.4%	14.2%	10.1%	7.2%	11.1%
301	552	6.2%	3.4%	1.3%	3.6%	28.9%	21.3%	22.4%	23.5%
302	348	7.2%	3.7%	1.6%	4.2%	42.4%	29.8%	20.7%	18.3%
401	458	17.5%	11.0%	8.1%	12.2%	32.8%	28.7%	24.0%	29.9%
402	243	19.9%	12.2%	8.6%	13.5%	43.1%	36.4%	33.8%	35.7%
501	257	38.3%	32.4%	33.3%	36.2%	57.9%	52.9%	53.9%	55.3%
502	166	37.4%	32.8%	34.3%	36.4%	72.6%	70.8%	66.7%	72.0%
600	142	56.5%	56.7%	61.0%	61.1%	75.7%	72.9%	70.9%	74.1%
701	69	72.8%	73.6%	72.8%	74.8%	79.6%	84.4%	86.9%	87.6%
801	44	78.0%	77.8%	74.8%	78.1%	85.7%	85.0%	82.9%	84.4%
1000	18	97.1%	94.0%	96.3%	97.0%	100.3%	96.9%	99.6%	99.8%
Total	**2 569**	**21.4%**	**17.2%**	**15.9%**	**18.7%**	**42.2%**	**36.5%**	**34.0%**	**36.1%**

Ref: JETMAR, M. A DALŠÍ, (2021). Metodika uplatnění neparametrických metod (DEA, FDH) k analýze a ke komparaci efektivnosti obcí. AMBIS, vysoká škola a.s. a ČVUT v Praze Fakulta dopravní

The analysis shows an average increase in efficiency between categories as the population of the municipality grows. However, schools in the highest size category of municipalities are on average more efficient. The average lower efficiency of school facilities in the background of agglomerations or with good accessibility to ORP is also a significant finding compared to municipalities with greater distance to development centres.

The results achieved can be interpreted as promoting economies of scale with the size of the municipality and therefore the school. At the same time, it should be borne in mind that the functional dependence of small municipalities on larger centres is also reflected in the preference of a part of their population to use public services where they stay during the day. This effect may also be supported by the lack of capacity of schools in municipalities experiencing severe suburbanisation.

4. Conclusions

Many foreign researchers are exploring options for applying a method of analysing data envelope analyses to assess the efficiency of local government services and more widely the public sector. We also aimed to assess the limits and appropriateness of using the DEA when examining the efficiency of municipalities.

The high number of observations consisting in the high number of municipalities in the Czech Republic makes it possible to examine the efficiency of basic public services provided by municipalities not only within the whole population but in smaller homogeneous groups. As a first step, the efficiency across the whole set of municipalities providing the relevant services was examined. In the second step, there was an examination of efficiencies in smaller more homogeneous groups reflecting the size of the municipality/city and its position in the settlement structure, as this view better reflects the Czech Republic's settlement reality and the impossibility of changing it in the medium and probably not even in the long term. I.e. when seeking to strengthen the efficiency of local and regional authorities, it is necessary to compare with the corresponding unit and not with larger centres where different effects (savings of scale, etc.) are displayed. This allows not only to interpret the differences between different types of municipalities, but also to have a subsequent debate on ways to improve the efficiency of different categories of municipalities.

The developed model makes it possible to calculate the efficiencies of a particular municipality both within the context of the whole dataset and within the created group of municipalities of a similar nature. Through a software application created in cooperation with AMBIS university and the Czech Technical University

Transport Faculty, it is possible to subsequently compare the observed efficiencies not only with similar municipalities, but also with municipalities and towns in the chosen administrative district of the municipality with extended scope, the district of the county, or any other municipality. In addition to the achieved efficiency ranking, it is possible to find out the relationship to the mean value, the distance from the upper and lower decile, etc.

In number of studies have appeared, that as the size of the municipality or administrative unit increases, the efficiency of the provision of services increases too. This effect was demonstrated in our investigation too (economies of scale and lower unit costs). At the same time, small municipalities also show an average lower efficiency within homogeneous groups. I.e. the majority of the examined services demonstrated efficiencies as the population size of the residence increased. Conversely, the positional aspect towards the centres, which formed another important parameter, was reflected in the examination of the efficiency of primary schools, with other services not playing a more significant role.

It can be inferred from the investigation carried out by us that it is possible to use the method of data envelope analyses for the purposes of examining efficiency, but its application is influenced by the availability and quality of data collected by public authorities. i.e. The DEA is not appropriate to use when there is only data for one input or output, the data are strongly correlated with each other, the data are not collected for the whole set of service providers, or they are collected haphazardly or with a long periodicity.

References:

Andersen P. and N.C. Petersen.1993. A procedure for ranking efficient units in data envelopment analysis. Management Science 39(10):1261–1264.

Banker, R.D., A. Charnes and W.W Cooper. 1984. Some models for estimating technical and scale efficiencies in data envelopment analysis. Management Science 30:1078–1092.

Charnes, A., W.W. Cooper, A.Y.Lewin and L.M. Seiford. 1994. *Data envelopment analysis: theory, methodology, and applications.* Norwell: Kluwer Academic Publishers.

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

Da Cruz, N. F., and R. C. Marques 2014. Revisiting the Determinants of Local Government Performance. Omega, Elsevier 44:91–103.

Drew, J., M. Kortt and B. Dollery. 2015a. What Determines Efficiency in Local Government? A DEA Analysis of NSW Local Government. Economic Papers A Journal of Applied Economics and Policy 34 (4):234-256.

Drew, J., M. Kortt and B. Dollery. 2015b. No Aladdin's Cave in New South Wales? Local Government Amalgamation, Scale Economies and Data Envelopment Specification. Administration & Society 49(10):1450-1470.

Geys, B., F. Heinemann and A. Kalb. 2013. Local Government Efficiency in German Municipalities. Spatial Research and Planning 71(4):283-293.

Geys, B., and W. Moesen. 2009a. Measuring Local Government Technical (In)Efficiency: An Application and Comparison of FDH, DEA, and Econometric Approaches. Public Performance & Management Review, vol.32, no. 4:499-513.

Geys, B., and W. Moesen. 2009b. Exploring sources of local government technical inefficiency: Evidence from Flemish municipalities. Public Finance and Management, vol. 9, no1:1-29.

Hladík, Milan. 2019. Universal efficiency scores in data envelopment analysis based on a robust approach. Expert Systems with Applications 122:242-252.

Jablonský, Josef and Milan Dlouhý. 2016. *Modely hodnocení efektivnosti a alokace zdrojů*. Praha: Professional Publishing.

Jetmar, Marek and others. 2021. *Metodika uplatnění neparametrických metod (DEA, FDH) k analýze a ke komparaci efektivnosti obcí.* Prague: AMBIS, vysoká škola a.s. a ČVUT v Praze Fakulta dopravní.

Kalb, A., Geys, B., and F. Heinemann. 2012. Value for Money? German Local Government Efficiency in a Comparative Perspective. Applied Economics 44(2):201-218.

Musgrave, Richard A. and Peggy B. Musgrave. 1976. *Public Finance in Theory and Practice.* New York: McGraw-Hill.

MV ČR, (2014). Usnesení vlády České republiky č. 680/2014, ke Strategickému rámci rozvoje veřejné správy České republiky pro období 2014 – 2020, https://www.mvcr.cz/clanek/strategicky-ramec-rozvoje.aspx (accessed May 2021).

MV ČR, (2016). Usnesení vlády České republiky č. 1088/2016, k aktualizaci Strategického rámce rozvoje veřejné správy ČR pro období 2014-2020 a Implementačních plánů včetně příloh, https://www.mvcr.cz/clanek/strategicky-ramec-rozvoje.aspx (accessed May 2021).

Peková, Jitka, Marek Jetmar and Petr Toth. 2019. *Veřejný sektor, teorie a praxe v ČR.* Praha: Wolters Kluwer.

Samuelson, Paul A. and Willim D. Nordahaus. 1992. *Economics.* New York: McGraw-Hill.
Stiglitz, Joseph E. 2000. *Economics of the public sector* (3rd ed.). New York: W.W. Norton & Company