THE TECHNICAL EFFICIENCY OF SECONDARY SCHOOLS IN THE PARDUBICE REGION

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Abstract: *This contribution deals with capacity of secondary schools in the context of technical efficiency. The Czech education suffers from insufficient use of secondary but also primary school capacities. The aim of this paper is to evaluate technical efficiency of vocational secondary schools in the Pardubice region with the focus on their capacities, and that in relation to the actual number of pupils for the school year of 2016/2017. Data Envelopment Analysis (DEA) was used to meet this goal. Two inputs were selected – the number of classes and the expenditure on teacher salaries, and one output – actual number of pupils. The results of this analysis show that five vocational secondary schools from the 20 examined vocational secondary schools use effectively their capacities. The optimal utilization of capacities calculated as quotient of actual number of pupils and optimal number of pupils expresses the fact that the examined schools use their capacities on average only at 60 % - only three schools use their capacities above 80 %. This situation is caused by a long-term decline in birth rates when the number of secondary school pupils is decreasing.*

Keywords: *data envelopment analysis, secondary schools, capacity, technical efficiency, number of pupils.*

JEL Classification: *I210, H750.*

Introduction

Education is widely recognized as one of the key drivers of economic and social development. Attainment of education is necessary for individuals to prepare for their professional careers, but it also has a positive impact on the society [2]. Public expenditure is crucial to assure the access to education for all citizens. Therefore, providing a quality education is one of the most important public services. However, it is also necessary to spend public resources efficiently from economic point of view.

In recent times, the Czech Republic faces the problem of the lack of pupils of secondary schools in terms of school capacity. There is an excess supply (capacity of schools) over demand (number of pupils). This situation reduces the efficient use of public resources. Also because of the current way of financing secondary schools (according to the number of pupils), schools often do not receive enough funding for their activities.

The relevant literature distinguishes between two types of efficiency [7],[8],[16]: efficiency in resource allocation, that is, the capacity of decision-making units (DMUs) to adequately select input amounts in light of their relative prices, and technical efficiency, which is DMUs' capacity to maximize output given a certain level of inputs. This paper is concerned with the latter. Charnes et al. [6] defined technical efficiency as an ability of production units to maximize output at given level of inputs; or to minimize inputs by reaching the required level of outputs.

Technical efficiency is an object of DEA – Data Envelopment Analysis. The use of the DEA method while evaluating technical efficiency of schools is numerous and individual cases show that the DEA method can be used to evaluate both internal and external issues at all levels of schools or education systems. Tóth [19] determined the relationship between the efficiency of European higher education systems and the degree of state support as well as the

family's socio-economic background. Bradley, Johnes and Millington [5] evaluated the technical efficiency of all secondary schools in England, and Alexander, et al., [1] conducted a two-stage (DEA and regression) analysis of the efficiency of New Zealand secondary schools. Hussain et al. [10] also used the DEA model and the Malmquist index to evaluate efficiency and productivity of public schools in Pakistan for the period of years 1993 – 2012. Vrabková [20] evaluated technical efficiency of all 55 basic schools of the city of Ostrava with the focus on their capacities. We build on her paper and find this efficiency for secondary schools established by the Pardubice Region.

The aim of our paper is to evaluate technical efficiency of vocational secondary schools in the Pardubice region with the focus on their capacities and that in relation to the actual number of pupils for the school year of 2016/2017. Then, based on the results, formulate recommendations for improving chosen indicators. We chose vocational secondary schools for analysis because there is a perspicuous problem of low number of pupils. In the whole Czech Republic there is a drop in demand for vocational secondary schools, while the demand for grammar schools is rising.

1 Statement of a problem

Capacity utilization of secondary schools is determined by the number of applicants for specific fields, by the regional placement of schools, the image of schools or their results. However, the most important factor is the demographic trend, when the decreasing birth rate reduces the number of secondary school students.

In the Czech Republic, there has been a significant decline in birth rates since the 1990s [11]. Of course, this development is reflected in primary and secondary education. As a result of the decreasing number of pupils, the network of basic and secondary schools in the whole Czech Republic was optimized. Moreover, after 1989 there were many new educational facilities. The creation of new entities has not been regulated and their number has increased significantly. It was necessary to reduce unused capacities. The first efforts of the government to optimize the network of secondary schools occurred in 1995-2000, when several secondary schools were merged and new legal entities were created. Optimization efforts continued until the year 2003. The largest wave of merging came in 2011, when utilization of capacities of secondary schools was only about 60 %. This wave of merging covered almost all regions [14].

But this merging has met with disagreement among citizens. Berka adds that *"there is a reluctance of the representatives of regional self-government to reduce the system of secondary education, because it is necessary to confront the resistance of the stakeholders, which results in the outflow of voter's favour due to the media's response."* [3] Despite protests, the Pardubice Region (but also other regions) managed to merge some of the little-used secondary schools (e. g. Střední odborná škola and Střední odborné učiliště Pardubice created Střední škola potravinářství and služeb Pardubice, or Střední škola zahradnická Litomyšl and Střední odborná škola technická created Střední škola zahradnická and technická Litomyšl). At present, the Council of the Hradec Králové Region has approved the merger of 21 secondary schools in the region. The number of schools should be reduced to 10 schools. Most of them are vocational schools [3]. The merging is also considered in the Vysočina Region, or in Prague Region.

2 Methods

This study covers 20 vocational secondary schools in the Pardubice region. We used all these schools with the exclusion of vocational secondary schools that are part of higher vocational schools. We also excluded grammar schools because of different characteristics

compared to vocational secondary schools. Vocational secondary schools have significantly higher costs due to the need for more expensive equipment for practical training, or a higher number of teachers divided into practical and theoretical learning. The inclusion of grammar schools would then distort the results of the analysis. The data about schools was obtained from the internal materials of the Statutory City of Pardubice.

To estimate efficiency scores, we used data envelopment analysis (DEA). This is a non-parametric technique that considers each school as a decision-making unit (DMU) using inputs to produce outputs with the aim to compute efficiency scores. In a DEA model, technical efficiency is defined as the relative ability of each DMU (school) in producing outputs, and the term relative means that each organization is compared with any other homogeneous unit. The choice of a set of weights that combine several outputs and several inputs is the core of DEA analysis [6].

There are two different specifications of a DEA model: input-oriented and output-oriented. In the input-oriented model, DMUs minimize inputs while maintaining the same level of outputs. Conversely, in output-oriented models, DMUs are maximizing their level of outputs while keeping inputs constant. Basically, the difference is the ability that a DMU has to control input or output quantity. If it can control input, then an input-oriented version is preferable. In this paper, input-oriented model is employed [18]. Appearance of the efficient frontier depends on the nature of returns to scale. Returns to scale can be constant or variable. It should be taken into consideration that the integration of resources is not always the same in the education process. If they would be utilized at the same level, then we should calculate with constant Return to Scale (CRS), accordingly, variable return to scale (VRS) is preferable. The assumption of VRS provides a more realistic expression of economic reality and factual relations, events and activities [17]. The input-oriented VRS indices of DEA can be obtained by solving the following linear programming equations [12]:

$$\begin{aligned} &\text{maximize} && z = \sum_{i=1}^{r} u_i y_{iq} + \mu \\ &\text{subject to} && \sum_{i=1}^{r} u_i y_{ik} + \mu \leq \sum_{j=1}^{m} v_j x_{jk}, \quad k = 1,2,\dots,n \\ & && \sum_{j=1}^{m} v_j x_{jq} = 1 \\ & && u_i \geq 0, \quad i = 1,2,\dots,m, \\ & && v_j \geq 0, \quad j = 1,2,\dots,r, \\ & && \mu \ free \end{aligned} \tag{1}$$

where q represents the unit being evaluated, y_{iq} are the outputs of the unit q, x_{jq} are the inputs of the unit q, u_i and v_j are the weights of the individual inputs and outputs. The unit is effective (i.e lying at the efficiency boundary) when its efficiency z is equal to 1 (or 100 %). The inefficient unit has an efficiency rate of less than 1.

3 Problem solving

The following inputs and output criteria were chosen for the DEA analysis: number of classes, expenditure on teacher salaries as inputs, actual number of pupils as the output (see Table 2). Taking into consideration the entire sample of researched schools we can describe them as follows. Table 1 depicts the minimum, maximum, mean and standard deviation of each researched input and output.

Tab. 1: Statistical characteristics of inputs and outputs of the DEA model

Name	Mean	Maximum	Minimum	Standard deviation
Number of classes	16	37	6	7.8
Expenditure on teacher salaries (per pupil)	34 755	41 606	29 832	3 094
Actual number of pupils	374	968	146	198.8

Source: own processing

In our analysis we used input-based measures of efficiency. The choice of the specific DEA model depends on which of the given characteristics can be influenced and which cannot. Due to the fact that the actual number of pupils can hardly be influenced, the input-oriented model was chosen. The results of the efficiency DEA analysis are presented in Table 2. School with a coefficient of technical efficiency equal 1 is effective, a coefficient lower than 1 indicates that school is not effective.

Tab. 2: Order of vocational secondary schools according to their VRS efficiency (from the best to the worst)

School	**Number of classes**	**Expenditure on teacher salaries in CZK (per pupil)**	**Actual number of pupils**	**Efficiency VRS**	**Ranking**	**Optimal utilization of capacities (in %)**
SPŠCH Pardubice	37	30 916	968	1.00000	1	88.00
SPŠ potravinářství and služeb Pardubice	15	29 832	394	1.00000	1	65.67
SOU zemědělské Chvaletice	6	36 720	146	1.00000	1	52.14
SOU Svitavy	11	32 147	243	1.00000	1	41.05
SŠ obchodu, řemesel and služeb Žamberk	8	36 327	203	1.00000	1	37.59
ISŠ Moravská Třebová	15	29 932	316	0.99725	2	65.83
OA and SOŠ cestovního ruchu Choceň	21	30 136	500	0.99655	3	75.76
SOŠ and SOU Polička	12	36 807	302	0.96980	4	40.00
Průmyslová střední škola Letohrad	14	35 029	355	0.96891	5	51.45
SOU opravárenské Králíky	8	36 378	155	0.96596	6	48.44
SPŠ stavební Pardubice	9	37 512	218	0.95155	7	37.59
SPŠ Chrudim	18	33 797	449	0.94994	8	48.18
SŠ automobilní Ústí nad Orlicí	17	35 621	417	0.93364	9	62.24
SŠ zahradnická and technická Litomyšl	34	33 476	790	0.91349	10	84.85
ISŠ technická Vysoké Mýto	17	32 976	359	0.90465	11	65.27
SOU plynárenské Pardubice	13	38 200	300	0.88883	12	85.91
SOŠ and SOU technické Třemošnice	10	38 497	197	0.88609	13	65.67
Střední škola automobilní Holice	22	33 931	509	0.88561	14	70.80
SOŠ and SOU Lanškroun	18	35 259	296	0.84608	15	49.33
SŠ uměleckoprůmyslová Ústí nad Orlicí	17	41 606	371	0.83232	16	55.37

Source: own processing

DEA analysis identified five effective schools (SPŠCH Pardubice, SPŠ potravinářství and služeb Pardubice, SOU zemědělské Chvaletice, SOU Svitavy, SŠ obchodu, řemesel and služeb Žamberk). The last column of the table contains optimal utilization of capacities. We used data from the Ministry of education youth and sports [15] about the administrative capacity of the school to calculate the optimal utilization of capacities. The administrative capacity of the school expresses the optimal (maximal possible) number of pupils of these

schools in compliance with all legislative regulations. For evaluation of optimal utilization of capacities, it is desirable that actual capacities are equal or as near as possible to the optimal (determined) number of pupils of a school. The optimal utilization of capacities (OUC) can be calculated as quotient of actual (resp. real) number of pupils (A_{np}) and optimal number of pupils (O_{np}) that is the set capacity of a school, according to formula [20]:

$$OUC = \left(\frac{A_{np}}{O_{np}}\right) * 100 \tag{2}$$

You can see that the best capacity utilization reached SPŠCH Pardubice (88 %) - effective school. However, this indicator cannot be used as a parameter for DEA analysis because the funding of secondary schools takes into account the actual number of pupils. However, the low capacity of schools is definitely inefficient in terms of non-use of technical equipment.

SOU Svitavy and SŠ obchodu, řemesel and služeb Žamberk have low capacity utilization and yet they are considered effective. This is due to a lower number of classes and lower expenditure on teacher salaries (lower inputs). On the other side there is SŠ uměleckoprůmyslová Ústí nad Orlicí (the least effective). This school has the highest expenditure on teacher salaries.

One of the main benefits of the DEA analysis is that it allows for comparing the individual units and that the number of inputs and outputs can be altered in order for the less efficient units to reach the position of the most efficient unit in the researched sample. Table 3 shows the target values for all schools which did not reach 100 % efficiency.

Tab. 3: Improvements for the schools

School	Number of classes	Expenditure on teacher salaries in CZK (per pupil)	Actual number of pupils
SPŠCH Pardubice	37 to 37	30 916 to 30 916	968 to 968
SPŠ potravinářství a služeb Pardubice	15 to 15	29 832 to 29 832	394 to 394
SOU zemědělské Chvaletice	6 to 6	36 720 to 36 720	146 to 146
SOU Svitavy	11 to 11	32 147 to 32 147	243 to 243
SŠ obchodu, řemesel a služeb Žamberk	8 to 8	36 327 to 36 327	203 to 203
ISŠ Moravská Třebová	15 to 15	29 932 to 29 850	316 to 393
OA a SOŠ cestovního ruchu Choceň	21 to 19	30 136 to 30 032	500 to 500
SOŠ a SOU Polička	12 to 12	36 807 to 32 960	302 to 302
Průmyslová střední škola Letohrad	14 to 13	35 029 to 31 158	355 to 355
SOU opravárenské Králíky	8 to 8	36 378 to 35 140	155 to 180
SPŠ stavební Pardubice	9 to 8	37 512 to 35 695	218 to 218
SPŠ Chrudim	18 to 17	33 797 to 29 936	449 to 449
SŠ automobilní Ústí nad Orlicí	17 to 16	35 621 to 29 875	417 to 417
SŠ zahradnická a technická Litomyšl	34 to 30	33 476 to 30 580	790 to 790
ISŠ technická Vysoké Mýto	17 to 15	32 976 to 29 832	359 to 394
SOU plynárenské Pardubice	13 to 12	38 200 to 33 028	300 to 300
SOŠ a SOU technické Třemošnice	10 to 9	38 497 to 34 112	197 to 201
Střední škola automobilní Holice	22 to 19	33 931 to 30 049	509 to 509
SOŠ a SOU Lanškroun	18 to 15	35 259 to 29 832	296 to 394
SŠ uměleckoprůmyslová Ústí nad Orlicí	17 to 14	41 606 to 30 614	371 to 371

Source: own processing

4 Discussion

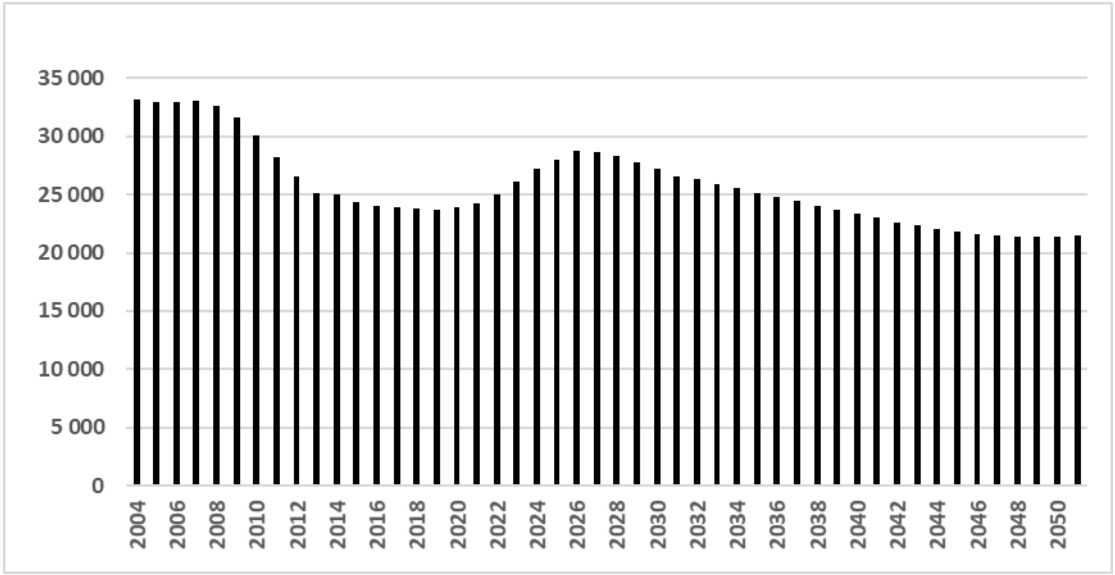
The results of the DEA analysis found that five examined secondary schools are technically efficient. Others are considered ineffective. The level of efficiency in other schools varies between 83.2 % and the above-mentioned 100 %. Analysis shows that the inefficiency of schools is due to an insufficient number of pupils. This finding was also confirmed by comparing the administrative capacity of the school with the actual number of pupils. Optimal utilization of capacities is only around 60 % on average for all the schools studied. Solution illustrated in table 3, it can be considered in two planes. The first option is to reduce the number of classes (input), the second option is to increase the number of students (output). The last option is to implement these options at the same time. In all these cases, the number of pupils per class will increase.

However, when choosing input-oriented model, the question arises as to the extent to which schools can influence inputs. School legislation reduces this possibility by stipulating the conditions for schools (e.g. the minimum and maximum allowed number of pupils in the class, or teacher salary scales).

The problem of insufficient number of pupils exists not only in secondary schools, but also in basic schools. Vrabková [20] evaluated technical efficiency of all 55 basic schools of the city of Ostrava with the focus on their capacities. She found that the utilization of disposable capacities of basic schools was in the school year of 2015/2016 rather inefficient. Only three basic schools were using their capacities in an efficient way.

In connection with the proposed merging of secondary schools, it is perhaps necessary to point out that in the near future there is a slight increase in the number of people in the years 15-19 (the age group for secondary schools). At the beginning of the 2030s, however, this age group should fall again (see Figure 1).

Fig. 1: Age composition of the population in the Pardubice Region until 2051: 15-19 years old



Source: own processing according to [9]

Nowadays, it is not necessary, nor appropriate to reduce the number of secondary schools. The question is whether the demographic development after the 2030s will evoke a real problem and the situation of secondary school capacities will become a strong motive for optimizing the network of secondary schools.

Conclusion

The aim of this paper was to evaluate technical efficiency of 20 vocational secondary schools in the Pardubice region with the focus on their capacities. We found that five examined secondary schools are technically efficient. However, insufficient number of pupils in these schools appears to be a serious problem. Optimal utilization of capacities reaches less than two-thirds. The improvement of capacities of secondary schools can be considered in two ways [20]. The first one is rationalization of capacities by merging of schools or by cancellation of a school (but this way is not popular with the public). As part of the optimization efforts, it is also necessary to take into account the location of the school. It is less problematic to merge in regional or former district towns. In smaller towns, secondary school performs not only educational, but also cultural and social functions (in these towns, however, the number of pupils is often insufficient). The other one is rationalization of capacities by administrative reduction of capacities of secondary schools (reduction of number of pupils in a class). Demographic development shows that in the next ten years we can expect a modest increase in the number of secondary school students. Capacity utilization should therefore be improved. However, then there should be a further decline in the number of secondary school students. Schools will therefore have to adapt to demographic trend again.

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