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Analysis of the Educational System - An Econometric and Managerial Perspective

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Abstract. *Studying education from an econometric perspective provides an understanding of how economic and social factors influence educational process. From this perspective, it is possible to understand how different groups of people are affected by the educational system and find solutions to create a more equitable environment. Regarding this research area, the specialized literature is very vast. However, few schools recognize the interdependence and contributions that school infrastructure (buildings and furniture) can make to the improvement of academic activities in the school. This paperwork thus aims to study the public educational field in Romania from a managerial, as well as a spatial econometric perspective, in order to provide possible solutions for the improvement of the quality of the educational act in schools. The research hypothesis of this work is that certain infrastructure factors, such as the number of teaching staff, classrooms, IT equipment, gymnasiums, school laboratories, school workshops, and sports fields, have an impact on the number of graduates in each county of Romania. Conducting a spatial econometric analysis, the results validate the research hypothesis. The number of graduates from a county is influenced by the number of teaching staff, the number of IT equipment, school laboratories or sports fields existing in the respective county. Thus, Romania should allocate more financial resources to education, especially to motivate teachers, but also to transform the teaching career into an attractive one for passionate and well-prepared young people.*

Keywords: Education, Educational Science, Schools Infrastructure, School Management, Econometric Spatial Model.

Introduction

Education is essential for the development of a society. Studying education provides a deep understanding of how people learn and grow and provides opportunities to improve educational processes. It can be an opportunity to analyze more deeply how the educational system works and can be improved. This can help to identify effective teaching and learning methods, as well as to find solutions to educational problems. Education also provides an understanding of how social, political and economic factors influence educational processes. Thus, it is easier to understand how different groups of people are affected by the educational system and can provide ways to create a more equitable education system. Studying education can help to find new and innovative approaches to teaching and learning and can provide insights into the development of educational policies and curricula. Furthermore, studying education can help to understand the role of technology in education and how it can be used to improve educational outcomes.

The field of education is a branch of science which deals with the study and development of learning and growth processes, as well as the methods and techniques by which these can be achieved. It focuses on understanding and improving the processes by which children, youth and adults learn. It also includes topics such as the psychology of learning, educational methodology, theory and practice of adult education, theory and practice of informal and special education. It can be studied from several perspectives, including the perspectives of politics, sociology, psychology,

[1] *This paper was co-financed by The Bucharest University of Economic Studies during the PhD program*

the social sciences, and educational science. Each of these disciplines provides a unique perspective on how education can be understood, implemented, and evaluated. Additionally, the field of education can be studied from the philosophical, historical, scientific and technological perspectives.

This paperwork thus aims to study the public educational field in Romania from a managerial, as well as a spatial econometric perspective, in order to provide possible solutions for the improvement of the quality of the educational act in schools. Studying education from a managerial point of view provides an understanding of how educational organizations can be managed efficiently and effectively. This perspective can help to understand how decision-makers within educational organizations can influence educational processes. Furthermore, studying education from a managerial point of view can help to understand how technology can be used to improve educational outcomes, as well as to understand how effective educational policies and programs can be created and implemented. It can also provide an understanding of how educational organizations can be managed to ensure a quality educational experience for students, teachers and administrators. Additionally, it may offer an insight into how educational organizations can be managed to ensure that resources are used efficiently and effectively.

Studying education from an econometric perspective provides an understanding of how economic and social factors influence educational processes, such as financial, material and human resources are allocated and used within the educational system. This can help to identify ways to make savings and use resources efficiently and effectively.

The research hypothesis of this work consists in the influence on the number of graduates in each county of Romania of certain infrastructure factors, such as: number of teaching staff, classrooms, IT equipment, gymnasiums, school laboratories, school workshops, sports fields. The study aims to verify if a county that has human and material resources in the educational field succeeds to contribute economically through a larger number of graduates in that county, graduates who become a very useful potential of human capital for development. The work is structured into the following parts: a brief review of the existing literature, the presentation of the econometric methodology and the part of results and discussions.

Literature review

Regarding the educational system, the specialized literature is very vast. Numerous scientific studies have tried to identify the main factors that influence student performance. Making a brief review of some studies, some recent, some less recent, but of particular importance, this section of the present work aims to present the reader with a starting point for a better understanding of the analysis carried out.

Faith E. Crampton, in his study „Spending on school infrastructure: does money matter" (2009), presented an emerging line of quantitative research that aims to determine if investment in school infrastructure affected student achievement. The theoretical framework posited that investment in human, social, and physical capital enhanced student achievement. Another study conducted in 2011 in Latin America came to the same conclusion. The upkeep of school infrastructure can lead to improved academic performance in educational institutions (Murillo & Roman, 2011). The school requires a factory model system that receives major inputs in the form of students and infrastructure on a continuous basis in order to produce the required output. Academic performance of students/pupils cannot be effective in an educational institution where buildings and furniture are in a dysfunctional state of use. The availability of educational or didactic resources, as well as the quality of infrastructure, should be the primary concerns of schools (Jamil, et al., 2018).

However, few schools recognize the interdependence and contributions that school infrastructure (buildings and furniture) maintenance can make to the improvement of academic activities in the school (Taiwo, 2000).

Another important study that worth mentioning is „Teachers' perceptions of their school managers' skills and their own self-efficacy levels" conducted by Sakiz et al. (2019). This study looked into the connections between teachers' degrees of self-efficacy and how well they thought their school managers were doing. The current survey involved 651 teachers who work in Turkey as a whole. All of the teachers completed two surveys, and descriptive and inferential statistics were used to examine the quantitative data that followed. The results showed that teachers' evaluations of their school supervisors' abilities and perceived teacher self-efficacy were significantly positively correlated. The results emphasize the necessity for developing comprehensive strategies to enhance the effectiveness, efficiency, and management of human resources in education.

All of these studies are important, but things have changed during the COVID-19 pandemic. The global education system was impacted by the coronavirus. Universities, colleges, and schools were closed to prevent the coronavirus from spreading. Parents, instructors, and kids all experienced challenges when schools were closed. Therefore, distance learning was the principal way to keep the educational system going. However, distant learning was difficult in developing nations due to a lack of computer and internet infrastructure. Therefore, nations developed an educational technology plan that includes free internet educational resources, online learning tools, and broadcast instruction. Institutions of higher learning developed curricula and post-coronavirus teaching-learning methodologies while they were closed. When schools reopened, the educational institutions created plans to make up for lost learning and welcomed back pupils with more technological resources than ever (Tadesse & Muluye, 2020).

Methodology

Spatial econometric models are statistical methods designed to analyze spatial data and quantify the impact of geographic location on economic outcomes. These models seek to answer questions like how does the economic activity of one region affect the nearby regions? How does population density influence economic growth in a city or region? Spatial econometric models are capable of capturing the relationships between economic activity and geography, including different types of location-based effects such as spillovers and externalities. They provide powerful insights into the dynamics of regional economies and help policymakers understand the importance of considering factors like location when formulating economic policies. At the heart of these models is a concept known as spatial autocorrelation: the idea that factors that are spatially close (in physical distance) tend to be correlated. Spatial autocorrelation can be measured using different metrics, such as Moran's I or Geary's C, and these metrics can provide crucial information about the strength of spatial relationships. Spatial econometric models incorporate the effects of spatial autocorrelation into their predictions and allow researchers to account for the impact of spatial proximity on economic outcomes such as poverty, migration, and income inequality. They are also used to forecast future economic growth in a region and provide policymakers a better understanding of how geography affects economic performance. Spatial econometric models are a powerful tool for economists and policymakers to better understand the complex dynamics at play within regional economies and make informed decisions about the best course of action. Although there are still many challenges associated with these models (e.g., data availability), their use is growing in

importance as more and more organizations recognize the need to consider the impact of geography and spatial relationships on economic outcomes.

Due to the spatial dependencies between observations, a simple regression model may not be suitable for an analysis as it violates the assumption of independence of errors. In recent years, the spatial model has been extended to panel data models which can consider dependencies created by errors or temporal lag of the time series. Kapoor et al. (2007), Baltagi et al. (2007) and Lee and Yu (2010) have proposed tests to select the most appropriate model for potential predictions (e.g. Hausmann test). A model developed by Baltagi and Li (2004) is widely used in empirical studies. This model was created in a study on cigarette demand in 46 American states from 1963 to 1992.

There are three types of spatial interactions to consider. The first model, SAR, looks at how the dependent variable in unit i affects the dependent variable in unit j (j being different from i). This dependence is calculated with the help of a spatial weight matrix WYt that displays the spatial associations between the observations of endogenous variables. The model follows the equation $Yt = \rho WYt + Xt\beta + Ut$, where ρ stands for the spatial autoregressive parameter and Ut represents a vector of errors. The second model, SEM, measures the effect of interactions between the error terms. This is calculated using a spatial weight matrix Wμt which shows that units could act similarly due to an unobserved trait. This model follows the equation $Yt = Xt\beta + Ut$, where λ is the spatial autoregressive parameter and Vt is a vector of errors.

A model that encompasses both effects, called SAC, would look like (Elhorst, J.P., 2017): $Yt = \rho WYt + Xt\beta + ut$, $ut = \lambda ut + \varepsilon t$. The parameters ρ and λ measure the strength of these spatial dependencies. For panel data, the model includes fixed or random effects and takes the following form (Elhorst, J.P., 2017): $Yt=\rho WYt+Xt\beta+\mu+ut$, $ut = \lambda ut + \varepsilon t$. μ: vector for fixed or random effects. In order to test which of these dependencies should be included in the regression model, the following tests are necessary:

a. LM test for spatial lag

H0: No spatial lag dependency of the dependent variable (The classic regression model is the right one)

H1: There is a spatial lag dependency of the dependent variable (The spatial regression model is the right one)

b. LM test for spatial errors

H0: No spatial error dependency

H1: There is a spatial error dependency

After the results of the tests have been obtained, the most suitable model to explain the relationship between the endogenous and the exogenous variables is chosen, with the interpretation of the coefficients that resulted.

The accessibility to these models has increased as various software have been developed through which the necessary tests can be performed. Thus, in this study, Geoda (software dedicated to spatial econometrics) and the specific packages from STATA are used. This is an ideal environment for analysis due to the already existing tools and infrastructure in panel data analysis. These available packages offer comprehensive and important tools in estimating econometric models by integrating both the spatial components between observations and those arising from errors. In addition, both models with fixed or random effects are implemented. With the help of the Geoda software, the spatial weight matrix is created and then introduced into STATA to create the spatial models.

Results and discussions

With the help of the created maps, it can be easily observed that the large economic and university centers of Romania (Bucharest, Iasi, Cluj, Timisoara, Constanta) are the ones that record the highest values for the number of graduates, for classrooms, IT equipment or the number of teachers. Also, in the analyzed period, there are no counties that registered significant changes. In figures 1, 2 and 3, the maps for 2012 and 2020 are similar.

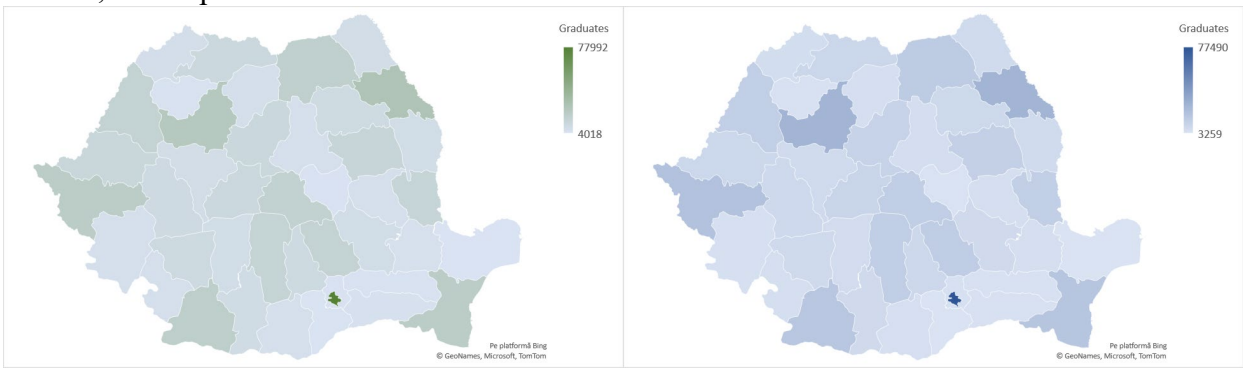


Figure 1. Number of graduates in 2012 (left) and in 2021 (right)

Source: Authors' own contribution using Excel.

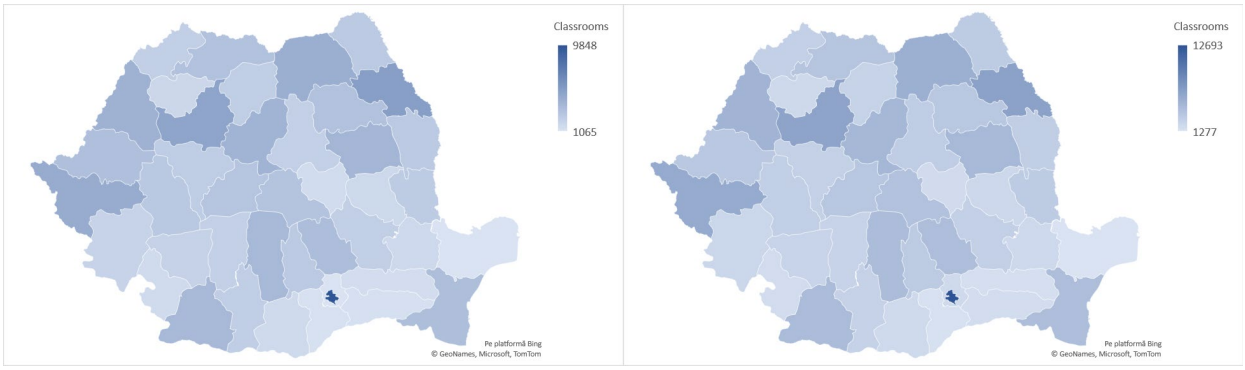


Figure 2. Number of classrooms in 2012 (left) and in 2021 (right)

Source: Authors' own contribution using Excel.

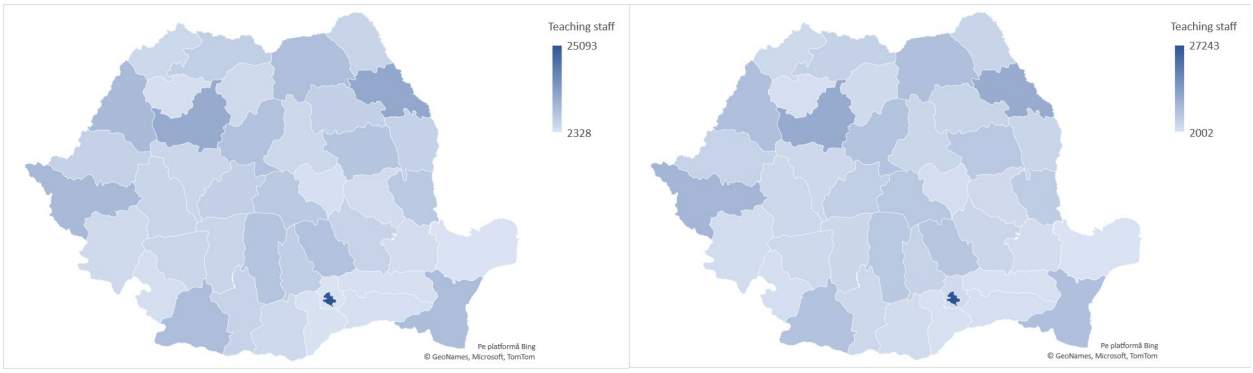


Figure 3. Number of teaching staff in 2012 (left) and in 2021 (right)

Source: Authors' own contribution using Excel.

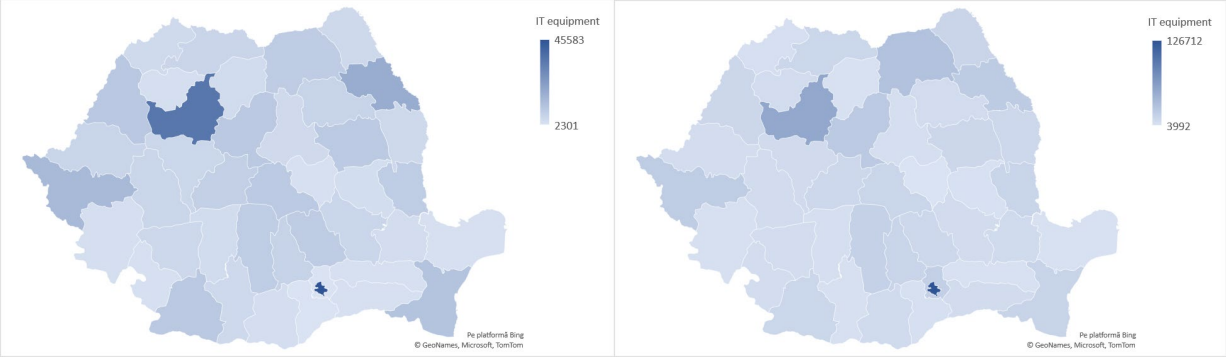


Figure 4. Number of IT equipment in 2012 (left) and in 2021 (right)

Source: Authors' own contribution using Excel.

Regarding the evolution of these variables over time (2021 compared to 2012), only the IT equipment present in schools and universities, as well as the number of available classrooms, have registered increases in all the counties of the country (see Appendix 1). For IT infrastructure, the highest additional values were recorded in Cluj (+19812), Ilfov (+17951), Suceava (+23240) and Bucharest (+81129). The smallest increases were registered in Olt (+959) and Satu Mare (+1753). Looking at the number of teaching staff, only 9 counties out of the 42 total registered an increase in this regard. The largest increase was in the City of Bucharest (+2150), and the smallest in Mures County (+6). Although there is a real deficit in terms of teaching staff, counties such as Olt (-791) or Dambovita (-721) recorded decreases. This is one of the main problems facing the education system. Studies show that human resources are important. However, the counties of Romania have recorded lower and lower values in the last 10 years. This leads to a poor quality of the educational act by employing unqualified personnel, especially in the case of subjects such as information technology, informatics or physics. The dependent variable, the number of graduates, registered decreases in each of the Romanian counties. The biggest decrease was recorded in Arad County (-4267), and the biggest increase in Cluj County (+3542). This only confirms the fact that a developed county, which emphasizes the endowments of educational units, offering a quality didactic act, attracts a larger number of students, respectively produces a larger number of graduates.

In order to see how material and human resources influence the number of graduates, an econometric analysis was conducted. Spatial model specifications with panel data were estimated to account for the presence of spatial dependencies.

In the first stage of the analysis, the stationarity of the data was checked. With a p-value less than 0.05, the null hypothesis was accepted, showing that the panel is stationary, both for the dependent variable and the independent variables.

Following spatial dependence tests (Pesaran test), the null hypothesis was rejected. The spatial errors are not independent, which means that a spatial model is required. Also, in the simple model, the coefficients of the independent variables number of classes, number of school workshops, sports fields and IT equipment are not statistically significant (p-value greater than 0.05). Regarding the normal distribution of errors, the null hypothesis cannot be rejected for a 90% probability of guaranteeing the results.

In terms of spatial dependence, an attempt was made to estimate the fitted model using Stata's xsmle package. Beginning with the SDM model, it was determined whether it could be reduced to SAR or SEM. In addition, an inverse squared distance matrix was employed. The tests revealed that the model can transform into either SAR or SEM, with the results indicating that the

alternative hypothesis canbe accepted with a 95% certainty of the results for both tests used. The following step was to develop a model with autoregressive errors (SAC). Thus, the SAC model is better than SDM, SAR or SEM and the results can be seen in Table 1 below:

Table 1. Spatial econometric model: SAC

Parameters	SAC
School laboratories	2.508756***
Teaching staff	1.425639***
Sports field	-15.9257***
IT equipment	-0.0318114***
Spatial Parameters	
Lambda	5,69e+07***
Rho	-5,53e+07***
Variance	
Sigma2_e	531345.4***

Source: Authors' own contribution using STATA

[1] ***Statistically significant at the 5% level.

The obtained results indicate that the number of graduates and the number of laboratories in schools or the number of teaching staff are correlated in the same sense, which is not at all surprising. Unexpected is the fact that the number of graduates is inversely correlated with the number of sports fields or IT equipment. It can be said that human resources are more important than any other material resource present in educational institutions. An increase in the number of teaching staff will lead to an increase in the number of graduates from that county. Thus, students, in particular, would no longer have to go to another county to study. The reality shows that there are localities where a teacher, although he does not have the necessary qualification, teaches several subjects in a high school to cover the shortage of teaching staff. In these cases, students with financial possibilities choose to attend higher pre-university courses in a locality or county where the educational act is one of quality. The same applies to the available school laboratories. The explanation is not valid for the number of sports fields or IT technology. This could be explained by the fact that they represent large investments, which could lead to a lack of funds for classrooms or human resources. It may also be the case that the territorial distribution for these two variables is relatively uniform in relation to the population.

The spatial coefficient rho, which is associated with the variable's spatial lag, is negative and significant for the model. This negative value is the residual spatial dependence after accounting for the positive spatial dependence reflected in the lambda parameter. As a result, we can say that what happens in one county has a significant impact on activity in neighboring counties, but there are cases where the dependence is inverse. As a result, an increase in the number

of graduates in one county can lead to a decrease in another. This is understandable given that there are counties that are magnets for education. We can talk about a migratory movement of the population. In particular, students enrolled in a higher education cycle, be it secondary or tertiary, opt for the counties where the educational infrastructure is developed, remaining that in the analyzed county, the number of the school population, respectively of the graduates, will decrease. Changes in the values of the independent variables in a county have a direct effect on the number of graduates from that county, and an indirect effect on the number of graduates from another county. The indirect influence augments the direct influence, increasing the overall effect. The results of the tests confirm the existence of all of these effects, with the direct being positive and the indirect being negative. The overall effect is diminished. Results are presented in Table 2.

Table 2. Spatial effects

Efect	Coeficient	P-value
LR_Direct		
School laboratories	2.9536	0.001
Teaching staff	1.651776	0.000
Sports field	-18.16792	0.000
IT equipment	-0.0372409	0.000
LR_Indirect		
School laboratories	-0.5617773	0.004
Teaching staff	-0.3150519	0.000
Sports field	3.498804	0.004
IT equipment	0.0071893	0.005
LR_Total		
School laboratories	2.391823	0.001
Teaching staff	1.336724	0.000
Sports field	-14.66912	0.000
IT equipment	-0.0300516	0.000

Source: Authors' own contribution using STATA

Conclusion

There are numerous perspectives from which the study and analysis of an educational system can be carried out. However, one of the fundamental elements of which the system is composed is the infrastructure at its disposal. Here we can include the human resource, the factor and determinant of this activity, the degree of technology, digitalization, workshops and classrooms for students and many others. All of these are organized and led by the manager of each educational institution and have an essential role in the didactic activity carried out every day of the course. The present paper did nothing but analyze the infrastructure of the educational system in Romania, but from a new perspective, that of spatial econometrics. Following the existing effects between the 41 counties and the Municipality of Bucharest, influential relationships were identified between the number of graduates and different social or technological factors related to the school infrastructure. The statistical and econometric analysis validated the starting research hypothesis: the number of graduates from a county is influenced by the number of teaching staff, the number of IT equipment, school laboratories or sports fields existing in the respective county.

Thus, the result of its research is of interest for the authorities that deal with the creation of local and national public policies in the field of education. Romania should allocate more financial

resources to education, especially to motivate teachers, but also to transform the teaching career into an attractive one for passionate and well-prepared young people. Thus, each county could become an attractive educational center, this then contributing to a healthy and long-term economic development.

Of course, this research has several limitations that must be remembered. First of all, the perspective on education was made only from a quantitative point of view, without including qualitative factors, such as: the degree of qualification of teaching staff, the quality of the educational act, the digital skills of students and teachers or the proportion of funds attracted by to the school from external sources. One of the causes is the lack of data. In the absence of these data, the analysis within the proposed study does not provide a complete picture of the educational system in Romania. Secondly, this analysis focuses only on the number of graduates as the dependent variable. A future analysis could consider a separate analysis for pre-university and university education, considering the number of graduates, but also the graduation average, professional status after graduation or pass rate of the national baccalaureate exam according to existing data. The educational system offers multiple research perspectives, both in terms of the quality of the educational act, as well as the subject of interest, the pupil/student or the teaching staff.

However, the present research brings an important perspective to the specialized literature in that it offers a managerial, but also an econometric and spatial perspective. Thus, different from a classic panel data model, this spatial model also captures the interaction between counties. As we well know, within the educational system, sometimes, there can be a process of migration of the population to the great educational centers of the country, especially in the case of university centers. Thus, the work contributes to the development of research in this field.

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Appendix

Appendix 1

County	Graduates	Classrooms	School laboratories	Gymansiums	School workshops	Teaching staff	Sports field	IT equipment
Alba	-1113	308	-28	5	-15	-452	19	4610
Arad	-4267	224	-80	-9	-8	-273	28	2332
Argeș	-1476	643	55	-3	-34	-566	0	9910
Bacău County	-1363	818	-11	-9	-49	-449	36	3960
Bihor	-2759	934	-26	18	-19	-511	52	3634
Bistrița-Năsăud	-1576	208	-3	-18	-27	-238	8	1042
Botoșani County	-1000	530	-14	-11	-8	-150	16	10361
Brașov	-3017	898	-48	14	-8	455	9	5474
Brăila County	-759	403	-47	-4	-6	-248	17	6926
Buzău	-1013	472	-14	-18	-26	-580	7	3744
Caraș-Severin	-1875	230	-82	-14	-18	-649	14	2817
Călărași	-1290	513	-4	2	0	-197	19	6897

County	Graduates	Classrooms	School laboratories	Gymansiums	School workshops	Teaching staff	Sports field	IT equipment
Cluj	3542	1391	297	16	-86	659	20	19812
Constanța	-2235	917	7	-16	-27	-140	0	4865
Covasna	-874	376	-16	0	3	-55	1	960
Dâmbovița County	-2183	591	-43	-2	-61	-721	6	8684
Dolj	-1766	776	64	-12	13	-368	23	4389
Galați	-1298	643	-10	8	-37	-453	43	7094
Giurgiu	-1053	249	-3	-1	0	-69	28	4570
Gorj	-3248	356	3	-5	-26	-607	26	3726
Harghita	-889	813	-34	4	-13	246	-4	2632
Hunedoara	-2213	183	-82	-12	-10	-667	8	3683
Ialomița	-849	226	19	-4	1	-443	7	2416
Iași	-225	1212	433	25	-94	-42	-7	5214
Ilfov County	0	953	-6	17	4	1035	44	17951
Maramureș	-2628	593	44	-3	-13	-281	3	7990
Mehedinți	-1517	258	-28	3	-3	-302	10	5659
Mureș	-1285	744	-38	1	-31	6	-1	14981

County	Graduates	Classrooms	School laboratories	Gymansiums	School workshops	Teaching staff	Sports field	IT equipment
Neamț	-1711	373	-53	-6	-17	-685	18	2842
Olt	-1806	266	-87	-12	-23	-791	8	959
Prahova	-1791	847	65	10	-53	-528	34	4341
Satu Mare	-1431	516	5	-12	-30	-310	8	1753
Sălaj	-1016	313	-20	-1	-7	-313	-1	6198
Sibiu	-1523	643	-9	-2	-11	155	-1	5167
Suceava	-2822	1119	-57	4	-13	12	28	23240
Teleorman County	-1701	364	-68	7	8	-633	8	7348
Timiș	-343	1313	154	2	-28	1039	38	8445
Tulcea County	-709	189	-4	-6	-11	-326	4	2238
Vaslui	-1130	370	7	-9	-9	-654	19	8031
Vâlcea	-2172	341	-20	-15	-41	-480	5	2895
Vrancea	-1304	428	33	-2	-16	104	15	1931
Bucharest	-502	2845	222	1	-82	2150	57	81129

DOI: 10.2478/picbe-2023-0190, pp. 2172-2183, ISSN 2558-9652
Proceedings of the 17th International Conference on Business Excellence 2023