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The AHPSort II to evaluate the High-level instruction performances

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Abstract

This paper proposes a model for ranking Italian high schools based on several performance outputs. To analyze the performance of Italian public High Schools we consider the students' school performance and their academic achievements; also the school characteristics may influence the performance evaluation of high schools, although the importance of these aspects is certainly less than the results achieved by students. Data are from Eduscopio and ScuolaInChiaro portals and refers to the 2019/20 school year. We analyze a sample of 263 high schools (HS) in all Italian Regions. For each school we consider nine outputs related to students' school and academic performance, and school characteristics. We assess the performance of high schools using a multi-criteria approach. Our analysis involves a high number of schools, so we apply the AHPSort II method which in addition to defining the ranking of schools also defines their classification. Our results show that scientific lyceums are all in the first class regardless of the geographic area.
Keywords: school ranking; academic performance; students' achievements; AHPSort II.
2020 AMS subject classifications: 90 Operations research, mathematical programming. [1]

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1 Introduction

This paper focuses on the evaluation of Italian high schools' performance. In Italy, Eduscopio (Giovanni Agnelli Foundation) and ScuolaInChiaro (Ministry of Education) represent important sources of information for such an evaluation; they provide annually, for each school, data on students' school careers, their academic achievements and school characteristics. In particular, Eduscopio provides students' and their families with a ranking of high school in the area of residence based on university performance of school leavers; ScuolaInChiaro makes available to the community all the information relating to Italian schools of all levels, in an organic and structured form.
This paper aims to provide the ranking of Italian high schools, taking into account the school and academic careers of students as well as the characteristics of the school. The multi-criteria approach may be a useful tool to assess the performance of high schools. By considering the above datasets, [Mancini and Marcarelli, 2019] derived the ranking among the typologies of schools; more recently, [Mancini and Marcarelli, 2022] provide a ranking among the school types both at a national level and within each geographic area. Furthermore, applying the AHP method and comparing the results with those obtained by a further MCDM method, PROMETHEE, they found significant differences between HS according to criteria related to school and academic performance both within and between geographic areas. Many studies have dealt with the application of multi-criteria methods in the field of education [Giannoulis and Ishizaka, 2010, Goztepe, 2020, Mancini and Marcarelli, 2022, Stamenkovic et al., 2016].
By taking into account some performance indicators used by Eduscopio and ScuolaInChiaro and according to the approach proposed by [Mancini and Marcarelli, 2022, 2019], this study analyzes nine performance outputs for a sample of 263 Italian high schools. However, unlike [Mancini and Marcarelli, 2022, 2019] in which the schools were grouped into 6 different types of schools and 3 geographic areas, we provide the ranking among all the schools. Due to the characteristics of the problem (e.g., independence among the elements, the high number of alternatives) and the output required, among multi-criteria methods proposed in the literature, this paper focuses on the Analytic Hierarchy Process Sort II (AHPSort II) method. The available data allows us to avoid some disadvantages of the AHP. There is no inconsistency in the judgment matrices because entries of matrices are ratios between performance indices. Furthermore, the AHPSort II allows to analyze a sorting decision problem through a feasible interaction with the decision makers precisely because it foresees a limited number of interactions. The goal of this paper is to obtain a ranking of high schools in Italy (we consider 251 schools in our study) by sorting them into ordered classes.
Finally, in order to verify the impact (role) of the geographical and/or the school

typology factors on the performance of a school, we compare our results with those obtained by [Mancini and Marcarelli, 2022, 2019].

The paper is organized as follows: Section 2 reports a literature overview on the topic; Section 3 defines the methodology; Section 4 reports the case study and the main results; Sections 5 and 6 provide a discussion and some concluding remarks, respectively.

2 Literature overview

The literature on school ranking is vast. Past studies have mainly focused on the school quality and its student achievements [Eide and Showalter, 1998], some other on school's contribution to student academic performance [Jamelske, 2009, Kelly and Downey, 2010] or on the question of "school accountability" affecting the school choice [Burgess et al., 2013, Hart and Figlio, 2015, Nunes et al., 2018]. Many factors may influence students' achievements, such as their socioeconomic status, family background, geographical area of residence and the type of school attended [Agasisti and Murtinu, 2012, Lauer, 2003] as far as school and class size, students' features and school management and resources [Giambona and Porcu, 2018, Masci et al., 2018]. As regards the impact of secondary school on academic performance, recently, Aina et al. [2011] and Aina et al. [2021] have demonstrated that differences in university students' achievements across high schools cannot be limited to the first-year and have to consider the geographic differences. In recent study, several authors used multi-criteria methods for analysed school ranking and their performance. Bana e Costa and Oliveira [2012] use the Measuring Attractiveness by a Categorical Based Evaluation Technique (MACBETH) which allows a multi-criteria evaluation of the different scientific areas within high schools in order to offer an accurate evaluation for each range of activities proposed by the school. Blasco-Blasco et al. [2021] analyze the performance of high schools with a particular focus on student achievement indicators. The authors analyze the student support policies of the schools with the use of Technique for Others Preference by Similarity to Ideal Solution (TOPSIS). Yendra et al. [2018] also use TOPSIS integrated with AHP for the analysis of the quality of the training offer of the high school and higher level. Recently, Mancini and Marcarelli [2019] analyzed the performance of Italian high schools, and derived a ranking among different typologies of schools based on the students' academic achievements, their school performance and the school characteristics. Then, Mancini and Marcarelli [2022] made an in-deep analysis taking into account the geographic areas. Using AHP and Promethee methods they derive a ranking among the school typologies both at a national level and within each geographic area.

3 Methodology

AHPSort II is a Multi-Criteria Decision Analysis (MCDA) method for solving sorting problems. This method allows you to use several criteria and a very large number of alternatives [Ishizaka et al., 2012]. Furthermore, it is a method that provides for a limited interaction with the decision maker [Fattoruso et al., 2022]. The procedure can be repeated or easily automated. The AHPSort II method is described below. We consider a set of alternatives A=(a_1, ..., a_i) evaluated respect a set of criteria G=(g_1, ..., g_j); therefore, $g_j(a_i)$ represents the evaluation of alternative a_i on criterion g_j. Moreover, we consider a set of classes C=(C_1, ..., C_o); the construction of the classes requires the definition by the Decision Maker (DM) of the limiting profiles lp_{ij} or of the central profiles cp_{ij} for each considered g_j criterion [Ishizaka et al., 2020]. The lp_{ij} are defined by the DM when he is able to clearly separate the classes from each other, therefore they represent thresholds that separate the classes from each other; alternatively, when this is not possible, the DM opts to define the cp_{ij} which represent the centroids of each class for all the considered criteria. The AHPSort II allows you to analyze a large number of alternatives by using representative profiles rp_{sj} = (rp_{1j}, ..., rp_{sj}). The rp are points homogeneously distributed in the observed data for each g_j criterion. Once all the elements that constitute the decision problem have been defined, AHPSort II foresees the evaluation of local priorities: w_j for g_j; p_{sj} for rp_{sj}; and, p_{oj} alternatively for lp_{ij} or cp_{ij}. The local priorities are determined using Pairwise Comparison Matrices (PCMs) with the eigenvalue method [Ishizaka et al., 2020]. The determination of the local priority of the alternatives p_{ij} is instead defined through the following linear interpolation formula:

$$p_{ij} = p_{sj} + \frac{p_{s+1j} - p_{sj}}{rp_{s+1j} - rp_{sj}} \cdot (g_j(a_i) - rp_{sj}). \tag{1}$$

The global priority of the alternative a_i is defined as follow:

$$p_i = \sum_{j=1}^{J} p_{ij} \cdot w_j. \tag{2}$$

while the global priority p_k of lp_{ij} or cp_{ij} is defined as:

$$p_k = \sum_{j=1}^{J} p_{oj} \cdot w_j \tag{3}$$

The sorting of a_i to a C class takes place considering the final global priority; therefore, considering the proximity of p_i to p_k.

4 Case study

4.1 Data

Our case study concerns the evaluation of the performance of schools in Italy. In particular, our reference sample is composed of 56 scientific lyceums (SL), 38 classical high schools (CL), 39 linguistic high schools (LL), 26 high schools of human sciences (HSL), 43 commercial technical high schools (CTHS), 49 High School Technological Technician (TTHS). Figure 1 shows the percentage of schools considered in this study divided by typology.

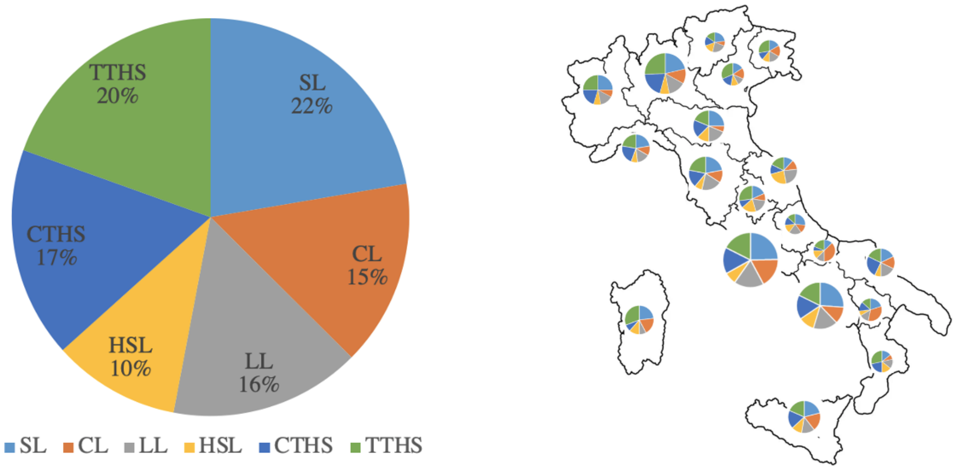

Figure 1: Typologies of high schools in Italy

Each school is evaluated against criteria that determine the performance of the school among these are: Maturity score (g_1) defined as the weighted average score between the high school graduation score of enrolled students e non-enrolled students; INVALSI test score (g_2) defined as the average of each student's math, reading and foreign language test scores; Percentage of graduates in good standing (without failures) (g_3); Students enrolled in the academic year (g_4). In addition to the school performance criteria, schools are evaluated for the academic performance of their students; this type of criteria include: the percentage of students who pass the first year (g_5); percentage of academic credits achieved at the end of the first year (g_6); average exam score (g_7). Finally, the evaluation of schools also takes into account criteria that consider the characteristics of each school, including the average number of students per class (g_8) and the percentage of teachers employed part-time (g_9). The data was collected by the Eduscopio and ScuolaInChiaro portals for the 2019-2020 academic year.

4.2 Results

In our paper we consider a set of alternatives $A = (a_1, \ldots, a_{251})$ evaluated respect the criteria set $G = (g_1, \ldots, g_9)$; the evaluation table of $g_j(a_i)$ is reported in Appendix A.

The decision-makers involved in the construction of our study are school managers of the different typology of schools considered which from here on we will generically call DMs.

We report in Table 1 the weights w_j of criteria defined with the eigenvalue method.

	g_1	g_2	g_3	g_4	g_5	g_6	g_7	g_8	g_9
w_j	0,10	0,15	0,10	0,10	0,15	0,15	0,15	0,05	0,05

Table 1: Criteria weights w_j

For each g_j criterion considered, we have defined three priority classes C_1, C_2 and C_3 to which we have associated for simplicity the labels of LOW (C_1), MEDIUM (C_2), and HIGH (C_3). Classes define the performance of high schools. Therefore in the High (C_3) the schools with the best performances will be sorted, in the Low class (C_1) those with the worst performances. In Table 2, we report the central profiles cp_{ij} defined by the DMs, for each class C and each criterion g_j.

	g_1	g_2	g_3	g_4	g_5	g_6	g_7	g_8	g_9
Low (C_1)	65,79	1	17,4	0,33	0,2	21,26	20	10	1
Medium (C_2)	75,71	4	53,8	0,64	0,55	54,4	24,44	19	26,14
High (C_3)	80	6	80	0,8	0,8	80	28	26	50

Table 2: Central profiles cp_{ij} for each criterion g_j

As suggested by Abastante et al. [2019], we have built the reference profiles $rp_{sj} = (rp_{1j}, \ldots, rp_{6j})$. We report in Table 3 the rp_{sj} for each criterion g_j.

	g_1	g_2	g_3	g_4	g_5	g_6	g_7	g_8	g_9
rp_{1j}	0	0	0	0	0	0	0	0	0
rp_{2j}	17,12	1,4	18,04	0,192	0,18	17,50	4	5,6	10,25
rp_{3j}	34,25	2,8	36,08	0,384	0,36	35,01	8	11,2	20,51
rp_{4j}	51,38	4,2	54,12	0,576	0,54	52,52	12	16,8	30,77
rp_{5j}	68,50	5,6	72,16	0,768	0,72	70,03	16	22,4	41,03
rp_{6j}	85,63	7	90,2	0,96	0,9	87,54	20	28	51,29

Table 3: Reference profiles rp_{sj} for each criterion g_j

Moreover, we have defined in Table 4 the local priorities p_{sj} and in Table 5 the local priorities p_{oj}.

	p_{s1}	p_{s2}	p_{s3}	p_{s4}	p_{s5}	p_{s6}	p_{s7}	p_{s8}	p_{s9}
rp_{1j}	0,020	0,032	0,030	0,025	0,023	0,022	0,027	0,023	0,030
rp_{2j}	0,031	0,045	0,043	0,038	0,034	0,034	0,038	0,034	0,042
rp_{3j}	0,041	0,058	0,054	0,067	0,063	0,059	0,051	0,062	0,055
rp_{4j}	0,069	0,090	0,092	0,088	0,089	0,087	0,065	0,085	0,090
rp_{5j}	0,104	0,197	0,187	0,155	0,147	0,156	0,086	0,150	0,154
rp_{6j}	0,280	0,234	0,259	0,267	0,297	0,298	0,128	0,300	0,261

Table 4: Local priorities p_{sj}

	p_{o1}	p_{o2}	p_{o3}	p_{o4}	p_{o5}	p_{o6}	p_{o7}	p_{o8}	p_{o9}
C_1	0,084	0,036	0,033	0,046	0,045	0,042	0,128	0,042	0,032
C_2	0,174	0,091	0,083	0,108	0,104	0,102	0,193	0,103	0,084
C_3	0,196	0,217	0,218	0,205	0,198	0,198	0,282	0,200	0,252

Table 5: Local priorities p_{oj}

After, define the local priority p_{ij} with the use of (1), we calculate the global priority p_i. In Figure 2, in Appendix, we report the ranking of the high school.

Finally, we obtained the classification of the high schools in terms of performance; the results are shown in Table 6.

	North	Center	South	Italy
High	27	26	23	76
Medium	57	52	60	169
Low	2	3	1	6

Table 6: Schools performance sorted in geographical areas

In Figure 3, in Appendix, it's shown how the different typologies of high schools have been sorted into the different performance classes.

5 Discussion

As shown by the results obtained, it emerges that the schools that obtain the best performance throughout Italy are the SLs and the CLs with the best positions for those in the south follow. A portion of CL is positioned in medium-sized performances mainly in northern and central Italy. In the medium classes the LL, HSL, CTHS and TTHS converge in order. A few CL from the north, south and center are included in the performance of the lower class. SL have the best performance regardless of the geographical area. Moving from North to South the first class is almost exclusively composed by SL, in the North, by a great number of SL and a few CL, in the Center, and fifty-fifty by SL and CL, in the South. Comparing the results with those obtained by Mancini and Marcarelli [2019] and Mancini and Marcarelli [2022], an inversion of ordering emerges in the first positions between SL and CL. The other positions are confirmed. It should be noted that in the works of Mancini and Marcarelli [2019] and Mancini and Marcarelli [2022] the initial data are represented by the average performance values by type of school for each criterion considered. In this paper, however, the performances are evaluated for individual schools. In this sense, the difference in the overall results may be due to the influence of anomalous values in the calculation of the average values by type of school. For a more detailed comparison, we also checked the ranking of schools for each criterion. Figure 4, in Appendix, shows in particular the ranking of the SL and CL for each criterion, geographical area and class considered. As can be seen in the Figure 4, SLs obtain higher performances for all the criteria except for the g_3 criterion for the CLs of northern Italy.

6 Conclusions

This paper investigates the performance of Italian high schools in order to derive a ranking considering the typology and the geographic area. Using AHPSort II, we obtain a classification of Italian high schools into different categories. The results show that the ranking among the types of schools does not vary moving from North to South: scientific lyceums are all in the first class regardless the geographic area. However, the limit of this work is the lack of a model validation. The model may assist students in selecting the type of school to attend; the information makes it possible to make an appropriate choice according to their academic perspectives.

Our future works will address a comparative analysis to test the model proposed: ELECTRE TRI [Corrente et al., 2016] may provide a classification of high schools into different categories such as ‘over-performing schools’, ‘average-performing schools’ and ‘weak-performing schools’; then we may compare results with those obtained by our model. Furthermore, if the decision makers are not sure about the correct level of reference profiles, it could be interesting to perform a sensitivity analysis with several limiting profiles to test the robustness of the process. Finally, when applied to small territorial districts, our model may be a useful tool to help public administrations distribute additional financial resources to public schools based on their performance rank.

Declarations

Conflict of interest . The authors declare that they have no conflict of interest.

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Appendix A

T	S	Area	g_1	g_2	g_3	g_4	g_5	g_6	g_7	g_8	g_9
SL	a_1	North	80,20	6	61,9	0,94	0,88	80,2	27,33	27	9,7
SL	a_2	North	78,61	3	67,9	0,90	0,80	74,6	26,62	21	18,7
SL	a_3	North	76,47	4	59,2	0,90	0,81	69,1	25,89	23	16,3
SL	a_4	North	74,87	4	59,2	0,92	0,74	48,2	24,91	24	27,2
SL	a_5	North	72,85	4	38,0	0,83	0,68	52,4	24,07	24	25,2
SL	a_6	North	77,94	7	65,6	0,94	0,89	87,2	28,62	26	16,3
SL	a_7	North	80,68	7	59,3	0,93	0,87	85,6	28,62	23	7,8
SL	a_8	North	77,29	6	62,8	0,95	0,89	82,0	27,57	26	11,7
SL	a_9	North	75,02	4	59,1	0,93	0,84	74,2	26,20	22	14,5
SL	a_{10}	North	75,70	4	40,7	0,88	0,76	67,1	25,02	21	17,3
SL	a_{11}	North	72,22	4	44,0	0,91	0,80	66,5	24,73	22	23,7
SL	a_{12}	North	70,66	4	46,9	0,78	0,61	46,3	25,53	21	27,7
SL	a_{13}	North	78,54	3	68,2	0,92	0,86	75,8	27,09	22	24,6
SL	a_{14}	North	76,10	5	67,6	0,87	0,79	67,6	26,55	21	5,8
SL	a_{15}	North	78,91	7	69,1	0,94	0,90	87,5	28,81	22	12,2
SL	a_{16}	North	76,66	4	52,1	0,92	0,84	75,8	26,71	24	11,7
SL	a_{17}	North	68,76	4	37,7	0,86	0,72	55,7	23,56	22	39,0
SL	a_{18}	North	79,52	5	74,6	0,93	0,90	87,2	28,89	24	22,3
SL	a_{19}	North	75,18	5	57,4	0,91	0,86	76,1	27,51	19	38,5
SL	a_{20}	North	75,54	4	46,3	0,92	0,84	62,6	25,04	23	11,8
SL	a_{21}	Center	81,37	5	70,3	0,84	0,80	77,2	27,61	22	14,3
SL	a_{22}	Center	78,38	6	62,9	0,93	0,86	72,1	26,81	23	19,8
SL	a_{23}	Center	78,03	4	60,0	0,90	0,83	70,7	26,59	21	20,6
SL	a_{24}	Center	80,23	6	76,6	0,93	0,87	76,7	27,92	25	6,2
SL	a_{25}	Center	81,64	5	72,6	0,92	0,85	71,5	27,57	20	17,9
SL	a_{26}	Center	81,01	6	56,3	0,90	0,84	82,7	28,47	25	7,1
SL	a_{27}	Center	77,34	5	56,6	0,93	0,86	78,1	27,59	22	7,5
SL	a_{28}	Center	77,44	3	65,4	0,90	0,81	76,6	27,51	24	10,6
SL	a_{29}	Center	77,35	5	60,2	0,93	0,86	77,4	27,10	24	16,7
SL	a_{30}	Center	77,78	2	62,4	0,91	0,82	71,3	26,56	23	15,6
SL	a_{31}	Center	78,45	6	65,8	0,91	0,83	73,1	26,27	23	23,0
SL	a_{32}	Center	76,15	6	66,1	0,90	0,81	73,5	26,21	22	12,9
SL	a_{33}	Center	77,36	5	57,1	0,91	0,85	73,0	26,01	23	7,6
SL	a_{34}	Center	77,11	2	49,9	0,90	0,76	71,1	26,15	24	20,5
SL	a_{35}	Center	73,94	5	53,1	0,84	0,71	56,1	24,99	24	20,5
SL	a_{36}	Center	77,02	3	59,9	0,89	0,76	64,3	25,18	22	9,7
SL	a_{37}	Center	75,24	3	53,2	0,80	0,68	55,0	25,33	22	18,2
SL	a_{38}	Center	75,8	4	65,1	0,88	0,74	59,9	25,23	23	18,1
SL	a_{39}	South	81,32	4	76,9	0,90	0,81	66,7	25,87	22	9,6
SL	a_{40}	South	82,01	6	74,6	0,93	0,85	68,4	26,09	22	4,9

T	S	Area	g_1	g_2	g_3	g_4	g_5	g_6	g_7	g_8	g_9
SL	a_{41}	South	77,97	5	66,1	0,94	0,84	74,9	28,12	18	16,7
SL	a_{42}	South	81,79	5	57,1	0,93	0,87	80,0	27,29	24	6,8
SL	a_{43}	South	79,05	2	62,4	0,94	0,87	76,3	26,67	23	16,5
SL	a_{44}	South	78,65	6	61,1	0,90	0,75	61,6	25,44	21	3,4
SL	a_{45}	South	81,41	5	55,7	0,78	0,68	65,8	25,42	18	5,9
SL	a_{46}	South	79,16	6	59,2	0,89	0,79	68,3	25,95	22	10,0
SL	a_{47}	South	79,86	2	52,6	0,87	0,77	67,9	25,94	21	5,2
SL	a_{48}	South	74,06	3	20,6	0,80	0,60	43,3	22,65	14	21,2
SL	a_{49}	South	81,07	4	84,6	0,93	0,85	74,9	26,15	27	2,7
SL	a_{50}	South	79,60	2	61,7	0,96	0,87	68,9	25,57	23	10,0
SL	a_{51}	South	82,32	5	77,9	0,93	0,85	74,1	25,89	21	4,3
SL	a_{52}	South	78,27	5	62,3	0,91	0,85	76,5	26,57	24	4,3
SL	a_{53}	South	77,21	4	50,5	0,83	0,79	69,4	25,18	21	6,4
SL	a_{54}	South	72,66	1	39,8	0,80	0,66	53,3	23,32	21	0,0
SL	a_{55}	South	78,94	4	51,3	0,91	0,84	74,5	26,88	20	9,9
SL	a_{56}	South	74,99	4	50,3	0,84	0,72	58,5	25,38	21	11,9
CL	a_{57}	North	78,96	6	66,9	0,95	0,86	75,0	28,31	22	16,9
CL	a_{58}	North	79,47	5	67,3	0,86	0,77	67,7	26,48	24	30,8
CL	a_{59}	North	79,26	6	61,9	0,93	0,88	80,2	27,89	24	14,0
CL	a_{60}	North	79,90	6	68,2	0,94	0,88	78,5	28,41	22	10,1
CL	a_{61}	North	74,10	5	55,5	0,91	0,81	64,8	26,41	23	34,4
CL	a_{62}	North	65,79	2	73,3	0,86	0,73	55,1	26,08	19	25,0
CL	a_{63}	North	75,87	3	74,6	0,88	0,80	66,8	26,88	22	24,6
CL	a_{64}	North	80,86	4	65,3	0,87	0,79	68,9	27,76	21	14,7
CL	a_{65}	North	80,55	5	72,2	0,95	0,88	72,7	27,73	21	29,6
CL	a_{66}	North	78,82	5	68,8	0,92	0,84	64,6	26,63	22	21,2
CL	a_{67}	North	79,53	6	72,7	0,93	0,87	71,3	28,29	23	7,7
CL	a_{68}	Center	81,30	6	60,1	0,92	0,84	71,4	28,27	21	24,6
CL	a_{69}	Center	79,34	5	69,4	0,91	0,82	60,3	26,98	22	14,3
CL	a_{70}	Center	83,12	7	75,9	0,92	0,86	67,7	26,80	24	7,0
CL	a_{71}	Center	84,57	6	88,5	0,95	0,86	65,8	27,62	23	31,9
CL	a_{72}	Center	81,25	6	59,4	0,92	0,85	76,0	28,86	24	13,3
CL	a_{73}	Center	78,85	6	62,6	0,90	0,85	73,1	28,23	24	7,0
CL	a_{74}	Center	82,45	6	73,9	0,93	0,86	78,5	27,54	23	8,6
CL	a_{75}	Center	82,77	3	62,6	0,95	0,82	69,3	27,28	23	8,6
CL	a_{76}	Center	82,4	4	64,4	0,87	0,77	68,5	27,19	23	13,1
CL	a_{77}	Center	81,29	2	72,4	0,93	0,83	69,5	27,07	23	15,0
CL	a_{78}	Center	81,41	2	78,9	0,79	0,74	56,7	25,80	23	15,5
CL	a_{79}	Center	80,06	2	66,5	0,90	0,77	55,2	25,09	23	20,8
CL	a_{80}	Center	75,70	3	67,5	0,86	0,71	50,7	24,62	23	15,8

T	S	Area	g_1	g_2	g_3	g_4	g_5	g_6	g_7	g_8	g_9
CL	a_{81}	Center	81,39	4	83,9	0,95	0,90	66,2	27,06	23	5,4
CL	a_{82}	South	83,77	5	90,2	0,95	0,88	68,0	26,30	22	8,5
CL	a_{83}	South	83,78	5	72,2	0,94	0,87	80,0	27,77	25	9,9
CL	a_{84}	South	81,21	6	78,3	0,95	0,89	77,3	27,41	22	6,8
CL	a_{85}	South	79,67	6	57,1	0,88	0,74	68,7	26,36	21	3,4
CL	a_{86}	South	74,90	3	73,0	0,83	0,68	55,9	25,83	19	12,4
CL	a_{87}	South	79,90	3	80,5	0,76	0,62	42,3	25,69	23	26,4
CL	a_{88}	South	82,55	6	83,4	0,91	0,83	67,4	26,12	23	0,0
CL	a_{89}	South	85,2	4	80,0	0,96	0,82	60,5	26,23	14	3,7
CL	a_{90}	South	84,13	5	86,7	0,93	0,84	63,0	24,70	20	3,2
CL	a_{91}	South	80,54	5	71,3	0,88	0,80	69,4	26,63	22	3,4
CL	a_{92}	South	79,32	5	63,30	0,75	0,62	53,0	24,78	17	23,0
CL	a_{93}	South	81,20	3	67,5	0,88	0,79	64,4	26,71	19	2,7
CL	a_{94}	South	77,03	3	45,6	0,84	0,73	46,8	23,38	19	14,4
LL	a_{95}	North	80,33	5	50,8	0,86	0,77	66,3	26,31	23	0,0
LL	a_{96}	North	77,98	4	55,4	0,78	0,72	58,6	25,08	19	11,1
LL	a_{97}	North	73,42	6	63,7	0,7	0,56	41,0	24,09	22	37,2
LL	a_{98}	North	75,23	4	59,5	0,83	0,76	69,9	26,06	23	10,8
LL	a_{99}	North	76,91	7	75,4	0,78	0,74	64,0	25,46	23	11,6
LL	a_{100}	North	73,4	4	40,6	0,75	0,65	40,6	24,12	21	27,7
LL	a_{101}	North	78,8	3	53,5	0,78	0,63	48,2	24,04	21	33,8
LL	a_{102}	North	78,78	4	67,6	0,76	0,70	65,0	24,15	24	20,8
LL	a_{103}	North	79,1	4	64,8	0,8	0,71	61,4	26,39	21	14,7
LL	a_{104}	North	80,05	4	70,3	0,73	0,61	51,3	24,05	24	7,4
LL	a_{105}	North	82,81	4	77,9	0,78	0,74	73,6	26,19	24	21,1
LL	a_{106}	North	78,27	3	54,4	0,75	0,64	50,8	24,96	23	17,2
LL	a_{107}	Center	81,49	5	66,4	0,79	0,71	64,9	26,87	22	14,3
LL	a_{108}	Center	78,25	5	44,3	0,74	0,66	54,9	25,73	22	12,5
LL	a_{109}	Center	75,69	3	35,3	0,63	0,50	43,5	25,54	20	25,8
LL	a_{110}	Center	80,3	4	63,5	0,72	0,64	59,0	25,22	23	4,5
LL	a_{111}	Center	78,86	5	60,0	0,74	0,65	55,2	24,93	20	17,9
LL	a_{112}	Center	80,25	3	56,0	0,79	0,71	62,2	26,00	23	15,8
LL	a_{113}	Center	76,92	6	52,5	0,72	0,66	64,6	25,49	23	14,66
LL	a_{114}	Center	76,42	4	56,1	0,73	0,65	67,9	24,78	21	13,01
LL	a_{115}	Center	82,52	4	66,7	0,8	0,62	53,3	25,33	24	20,95
LL	a_{116}	Center	76,91	4	70,8	0,76	0,63	52,7	24,63	23	16,13
LL	a_{117}	Center	78,09	6	63,0	0,67	0,56	54,2	25,27	24	26,35
LL	a_{118}	Center	75,51	4	47,3	0,71	0,60	44,9	23,91	22	28,24
LL	a_{119}	Center	73,76	3	55,2	0,7	0,55	37,1	24,55	21	23,36
LL	a_{120}	Center	74,28	3	41,8	0,64	0,51	41,4	23,01	20	26,32

T	S	Area	g_1	g_2	g_3	g_4	g_5	g_6	g_7	g_8	g_9
LL	a_{121}	Center	79,18	4	69,4	0,72	0,64	53,9	24,88	23	5,41
LL	a_{122}	South	80,26	5	67,8	0,77	0,75	74,8	25,95	22	9,17
LL	a_{123}	South	79,24	4	74,5	0,86	0,78	64,3	26,10	21	13,73
LL	a_{124}	South	80,25	3	39,6	0,72	0,67	67,6	25,53	22	7,95
LL	a_{125}	South	78,5	4	54,6	0,8	0,66	51,3	25,82	28	3,97
LL	a_{126}	South	79,12	3	60,0	0,7	0,58	56,8	24,71	22	13,43
LL	a_{127}	South	72,71	4	30,0	0,52	0,41	37,8	24,12	20	2,70
LL	a_{128}	South	81,31	5	40,0	0,56	0,44	40,5	23,43	18	5,94
LL	a_{129}	South	76,84	4	54,7	0,49	0,35	43,0	25,21	16	4,23
LL	a_{130}	South	78,93	5	62,9	0,83	0,72	53,4	24,27	20	6,67
LL	a_{131}	South	85,63	6	71,3	0,76	0,72	61,1	24,97	20	7,29
LL	a_{132}	South	78,32	3	67,3	0,52	0,49	69,8	24,12	21	19,72
LL	a_{133}	South	74,38	4	41,3	0,56	0,47	40,9	23,39	18	29,89
HSL	a_{134}	North	78,25	5	63,9	0,76	0,65	55,8	24,11	19	18,62
HSL	a_{135}	North	76,15	4	65,0	0,76	0,59	39,8	23,62	23	27,2
HSL	a_{136}	North	75,85	4	46,7	0,75	0,65	62,2	25,74	23	24,81
HSL	a_{137}	North	75,31	4	68,0	0,84	0,64	37,4	23,04	21	28,57
HSL	a_{138}	North	72,69	4	59,5	0,61	0,52	53,3	24,46	24	20,8
HSL	a_{139}	North	73,27	3	46,2	0,71	0,56	46,7	24,60	19	26,94
HSL	a_{140}	North	76,43	4	51,7	0,73	0,69	59,6	24,48	23	11,8
HSL	a_{141}	North	73,01	2	47,0	0,76	0,65	46,5	24,43	22	36,80
HSL	a_{142}	Center	74,40	5	58,8	0,77	0,71	54,7	24,65	22	14,29
HSL	a_{143}	Center	77,24	4	59,5	0,77	0,67	50,9	24,37	23	4,5
HSL	a_{144}	Center	79,55	6	65,7	0,77	0,65	45,1	24,67	23	31,9
HSL	a_{145}	Center	75,58	4	64,2	0,8	0,68	52,2	24,70	23	16,13
HSL	a_{146}	Center	78,21	4	42,8	0,67	0,58	50,3	23,55	23	13,1
HSL	a_{147}	Center	73,24	4	56,6	0,69	0,59	52,1	23,40	22	28,24
HSL	a_{148}	Center	75,46	3	61,8	0,55	0,43	45,2	23,12	23	21,43
HSL	a_{149}	South	76,32	6	81,6	0,64	0,57	43,0	23,88	19	16,43
HSL	a_{150}	South	75,13	4	70,3	0,83	0,66	34,3	24,25	23	5,41
HSL	a_{151}	South	73,61	3	56,3	0,55	0,47	54,4	25,53	22	13,43
HSL	a_{152}	South	77,02	4	61,8	0,80	0,65	44,9	23,58	21	13,73
HSL	a_{153}	South	78,46	5	55,1	0,49	0,35	51,6	22,87	18	5,94
HSL	a_{154}	South	73,78	3	34,3	0,44	0,33	33,7	23,59	18	13,6
HSL	a_{155}	South	77,18	4	66,9	0,52	0,44	53,9	24,67	20	4,82
HSL	a_{156}	South	78,76	3	65,9	0,80	0,70	56,1	24,42	22	0,00
HSL	a_{157}	South	80,11	6	70,0	0,69	0,61	54,7	23,84	20	7,29
HSL	a_{158}	South	74,91	4	52,9	0,67	0,54	47,7	24,02	20	16,45
HSL	a_{159}	South	78,07	4	32,4	0,57	0,43	22,1	21,22	18	29,89
CTHS	a_{160}	North	72,22	5	42,4	0,51	0,41	43,6	24,14	19	18,62

T	S	Area	g_1	g_2	g_3	g_4	g_5	g_6	g_7	g_8	g_9
CTHS	a_{161}	North	73,57	5	38,9	0,56	0,44	42,1	24,18	18	27,41
CTHS	a_{162}	North	73,75	3	32,1	0,50	0,42	44,1	22,47	19	23,97
CTHS	a_{163}	North	75,78	6	54,4	0,48	0,37	32,0	23,52	21	13,50
CTHS	a_{164}	North	74,27	3	27,2	0,42	0,36	61,0	24,47	21	22,92
CTHS	a_{165}	North	74,13	4	34,7	0,47	0,42	57,0	24,33	21	28,57
CTHS	a_{166}	North	74,98	4	37,0	0,45	0,34	52,0	23,41	21	27,71
CTHS	a_{167}	North	73,82	4	53,5	0,51	0,37	41,4	24,28	19	26,39
CTHS	a_{168}	North	71,55	2	35,0	0,52	0,40	35,2	22,30	21	22,22
CTHS	a_{169}	North	70,75	4	36,6	0,38	0,27	23,7	22,98	25	20,69
CTHS	a_{170}	North	76,60	2	60,1	0,39	0,33	47,9	24,13	20	12,96
CTHS	a_{171}	North	74,22	3	34,5	0,47	0,38	47,5	24,33	18	0,00
CTHS	a_{172}	North	74,99	4	58,3	0,61	0,50	54,5	23,94	24	7,41
CTHS	a_{173}	North	72,10	3	35,1	0,47	0,27	24,1	23,29	17	50,29
CTHS	a_{174}	North	74,51	5	55,1	0,55	0,45	58,5	24,02	21	38,5
CTHS	a_{175}	North	74,55	4	49,6	0,64	0,54	46,8	23,47	22	26,00
CTHS	a_{176}	Center	75,49	3	42,9	0,63	0,53	51,3	25,73	22	37,14
CTHS	a_{177}	Center	74,04	4	44,8	0,56	0,42	34,5	23,27	21	25,81
CTHS	a_{178}	Center	74,71	5	49,6	0,54	0,49	60,7	24,57	20	24,24
CTHS	a_{179}	Center	78,75	5	52,6	0,64	0,61	56,4	25,03	20	17,86
CTHS	a_{180}	Center	73,78	3	47,0	0,36	0,30	57,3	24,67	21	24,66
CTHS	a_{181}	Center	75,37	4	32,6	0,45	0,36	52,5	24,72	21	20,39
CTHS	a_{182}	Center	75,27	2	49,4	0,42	0,28	47,2	24,57	19	9,93
CTHS	a_{183}	Center	72,25	4	57,4	0,50	0,30	34,3	24,37	15	25,30
CTHS	a_{184}	Center	73,75	2	57,7	0,43	0,38	53,0	21,91	22	13,16
CTHS	a_{185}	Center	75,93	5	37,9	0,35	0,22	32,0	22,22	20	27,97
CTHS	a_{186}	Center	71,22	3	58,3	0,36	0,23	30,2	21,72	21	34,52
CTHS	a_{187}	Center	71,99	5	53,8	0,53	0,40	32,6	20,95	26	20,55
CTHS	a_{188}	Center	80,18	4	75,8	0,67	0,50	35,1	24,75	19	17,47
CTHS	a_{189}	South	73,81	3	61,5	0,47	0,42	53,8	24,17	20	11,82
CTHS	a_{190}	South	76,48	2	43,2	0,43	0,34	50,7	24,35	20	15,38
CTHS	a_{191}	South	74,61	4	27,2	0,43	0,33	44,5	23,95	20	16,67
CTHS	a_{192}	South	73,44	3	36,1	0,40	0,31	42,0	22,98	20	21,58
CTHS	a_{193}	South	75,22	3	50,4	0,38	0,29	36,8	23,24	22	10,58
CTHS	a_{194}	South	76,45	4	38,4	0,36	0,26	25,7	23,32	17	9,70
CTHS	a_{195}	South	69,12	2	33,8	0,38	0,26	31,0	20,00	15	0,00
CTHS	a_{196}	South	73,76	5	59,5	0,48	0,39	52,8	24,27	22	6,40
CTHS	a_{197}	South	76,97	4	49,9	0,53	0,43	52,7	23,90	20	9,40
CTHS	a_{198}	South	73,45	5	49,9	0,58	0,48	49,6	22,36	16	6,67
CTHS	a_{199}	South	76,37	5	62,0	0,49	0,42	47,4	22,60	18	17,20
CTHS	a_{200}	South	74,49	5	36,0	0,56	0,50	60,5	22,89	16	0,00

T	S	Area	g_1	g_2	g_3	g_4	g_5	g_6	g_7	g_8	g_9
CTHS	a_{201}	South	73,75	4	21,8	0,35	0,29	44,4	22,77	17	5,00
CTHS	a_{202}	South	74,72	4	31,3	0,49	0,37	36,1	23,14	17	4,39
TTHS	a_{203}	South	71,06	3	31,6	0,52	0,37	50,6	25,04	19	23,97
TTHS	a_{204}	North	71,6	4	32,0	0,45	0,36	55,0	24,15	23	27,23
TTHS	a_{205}	North	73,32	4	39,9	0,70	0,58	49,4	24,52	20	11,11
TTHS	a_{206}	North	73,78	4	37,1	0,36	0,27	35,7	22,47	22	29,81
TTHS	a_{207}	North	74,79	6	39,4	0,37	0,26	43,7	22,99	21	22,40
TTHS	a_{208}	North	74,99	4	36,5	0,77	0,67	68,8	25,97	21	27,69
TTHS	a_{209}	North	69,93	5	38,8	0,37	0,27	46,2	26,39	21	3,64
TTHS	a_{210}	North	67,97	4	30,3	0,41	0,35	58,4	24,64	19	28,28
TTHS	a_{211}	North	72,2	4	43,9	0,50	0,37	41,9	24,59	20	35,00
TTHS	a_{212}	North	70,51	5	26,8	0,48	0,35	51,3	23,42	21	17,65
TTHS	a_{213}	North	69,62	4	34,7	0,35	0,24	39,5	23,62	20	24,81
TTHS	a_{214}	North	70,55	4	52,4	0,36	0,20	30,4	25,26	19	26,39
TTHS	a_{215}	North	73,92	4	28,3	0,40	0,28	39,6	23,93	21	15,61
TTHS	a_{216}	North	76,79	6	48,4	0,65	0,57	64,6	26,16	23	23,26
TTHS	a_{217}	North	74,27	3	48,6	0,33	0,25	46,7	24,91	18	36,46
TTHS	a_{218}	North	79,65	6	73,2	0,37	0,24	42,4	24,86	10	40,38
TTHS	a_{219}	North	72,53	4	32,1	0,61	0,49	53,0	25,41	23	32,82
TTHS	a_{220}	North	73,00	3	55,6	0,45	0,32	39,3	25,17	18	23,40
TTHS	a_{221}	North	73,55	4	43,0	0,51	0,43	56,6	26,87	22	26,00
TTHS	a_{222}	North	74,49	4	39,5	0,44	0,37	60,1	25,41	22	29,72
TTHS	a_{223}	Center	71,38	4	30,2	0,43	0,37	62,1	25,65	21	21,71
TTHS	a_{224}	Center	73,81	3	33,8	0,49	0,38	47,4	24,36	21	25,84
TTHS	a_{225}	Center	73,48	6	39,4	0,44	0,30	39,9	23,52	20	10,29
TTHS	a_{226}	Center	77,89	3	41,9	0,68	0,59	53,5	24,47	19	20,00
TTHS	a_{227}	Center	75,76	4	54,8	0,58	0,47	52,7	25,36	18	28,42
TTHS	a_{228}	Center	71,09	3	46,0	0,33	0,23	48,9	26,39	19	8,85
TTHS	a_{229}	Center	72,35	4	45,8	0,50	0,38	52,4	25,59	16	19,53
TTHS	a_{230}	Center	73,03	3	28,3	0,45	0,33	54,7	24,67	22	24,66
TTHS	a_{231}	Center	70,88	3	47,9	0,53	0,36	33,7	24,48	20	36,36
TTHS	a_{232}	Center	72,64	3	30,7	0,41	0,29	38,4	23,84	20	20,35
TTHS	a_{233}	Center	71,8	5	46,1	0,50	0,32	40,4	23,50	20	11,67
TTHS	a_{234}	Center	68,81	5	31,8	0,33	0,21	36,9	23,11	21	18,60
TTHS	a_{235}	Center	73,21	5	50,5	0,42	0,24	26,1	22,66	19	25,81
TTHS	a_{236}	Center	70,51	3	23,8	0,37	0,31	49,5	23,32	18	8,48
TTHS	a_{237}	South	71,06	3	70,8	0,35	0,32	65,0	25,87	20	11,82
TTHS	a_{238}	South	79,55	3	46,7	0,51	0,44	70,8	24,43	20	21,58
TTHS	a_{239}	South	77,18	3	42,3	0,40	0,24	39,9	25,48	17	21,70
TTHS	a_{240}	South	77,84	5	48,4	0,36	0,23	43,3	24,63	19	14,86

T	S	Area	g_1	g_2	g_3	g_4	g_5	g_6	g_7	g_8	g_9
TTHS	a_{241}	South	76,68	4	26,0	0,34	0,26	48,7	24,03	22	16,17
TTHS	a_{242}	South	74,62	3	31,7	0,63	0,47	48,5	23,42	16	6,06
TTHS	a_{243}	South	74,07	4	35,9	0,39	0,26	37,3	23,39	20	6,09
TTHS	a_{244}	South	80,27	3	24,5	0,47	0,27	41,5	21,07	18	21,24
TTHS	a_{245}	South	74,97	3	35,2	0,38	0,29	50,5	24,48	19	9,65
TTHS	a_{246}	South	72,50	4	40,8	0,48	0,39	54,3	24,08	17	0,73
TTHS	a_{247}	South	76,93	4	48,2	0,53	0,40	48,2	23,44	18	8,33
TTHS	a_{248}	South	71,41	3	25,8	0,34	0,29	49,8	26,01	19	9,33
TTHS	a_{249}	South	72,75	4	17,4	0,50	0,42	43,0	22,34	17	5,00
TTHS	a_{250}	South	75,08	5	24,7	0,36	0,30	58,6	23,12	16	27,91
TTHS	a_{251}	South	76,04	4	31,7	0,52	0,26	21,3	22,60	17	29,89

Table 7: Evaluation table of $g_j(a_i)$.
Legend: T=Type; S=School; Area=Geo-position.

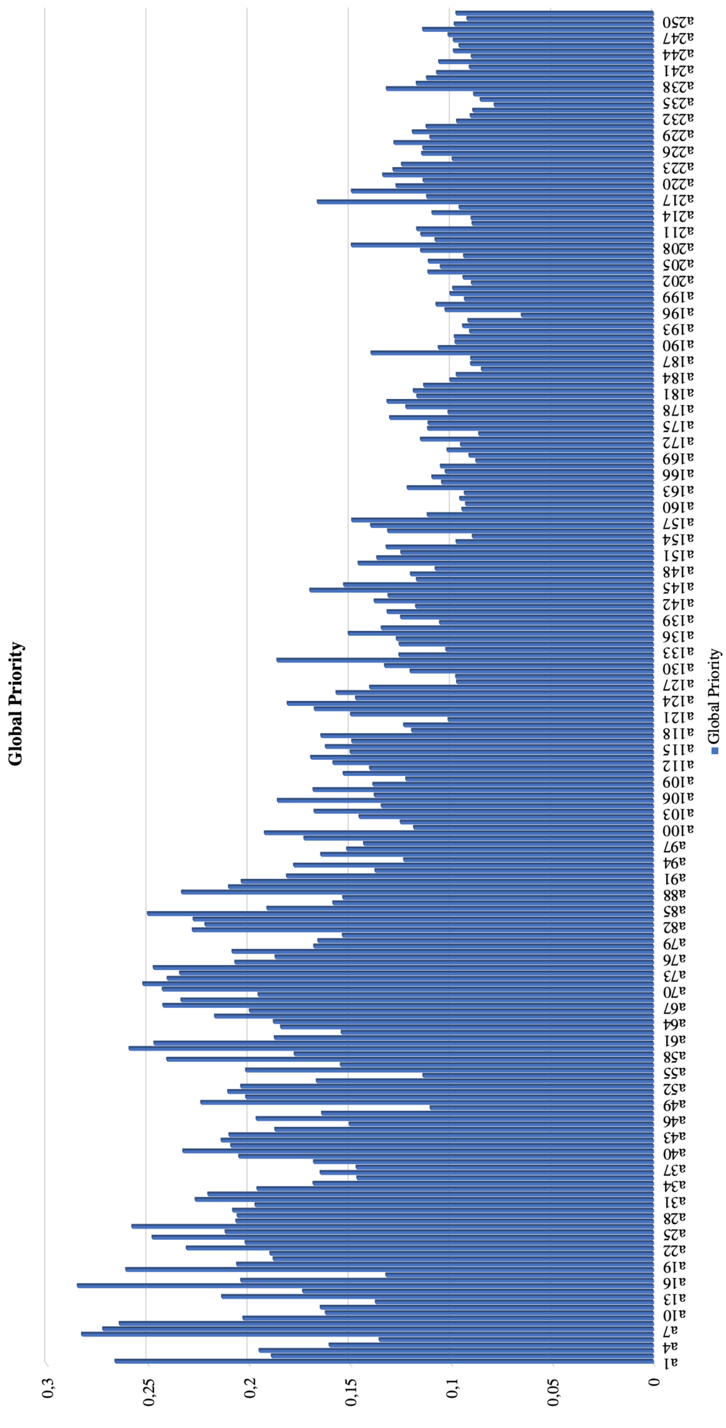

Figure 2: Ranking of school defined by p_i

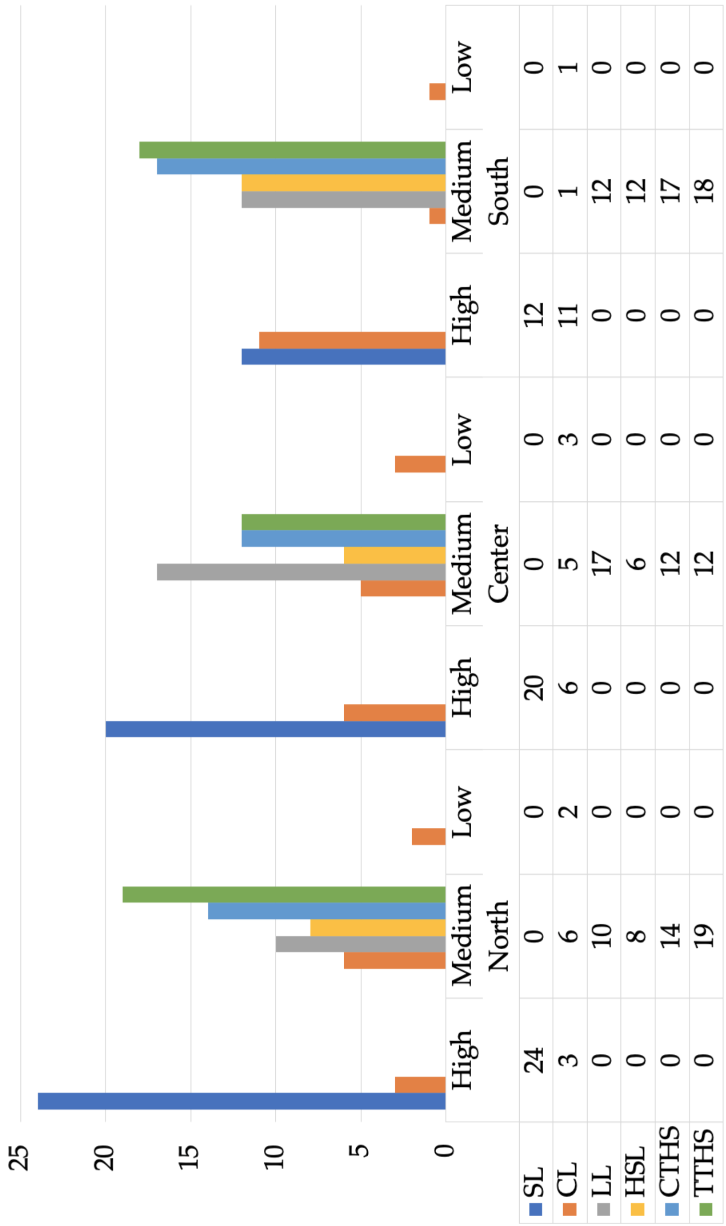

Figure 3: Performance of School sorted for typology and geographical areas

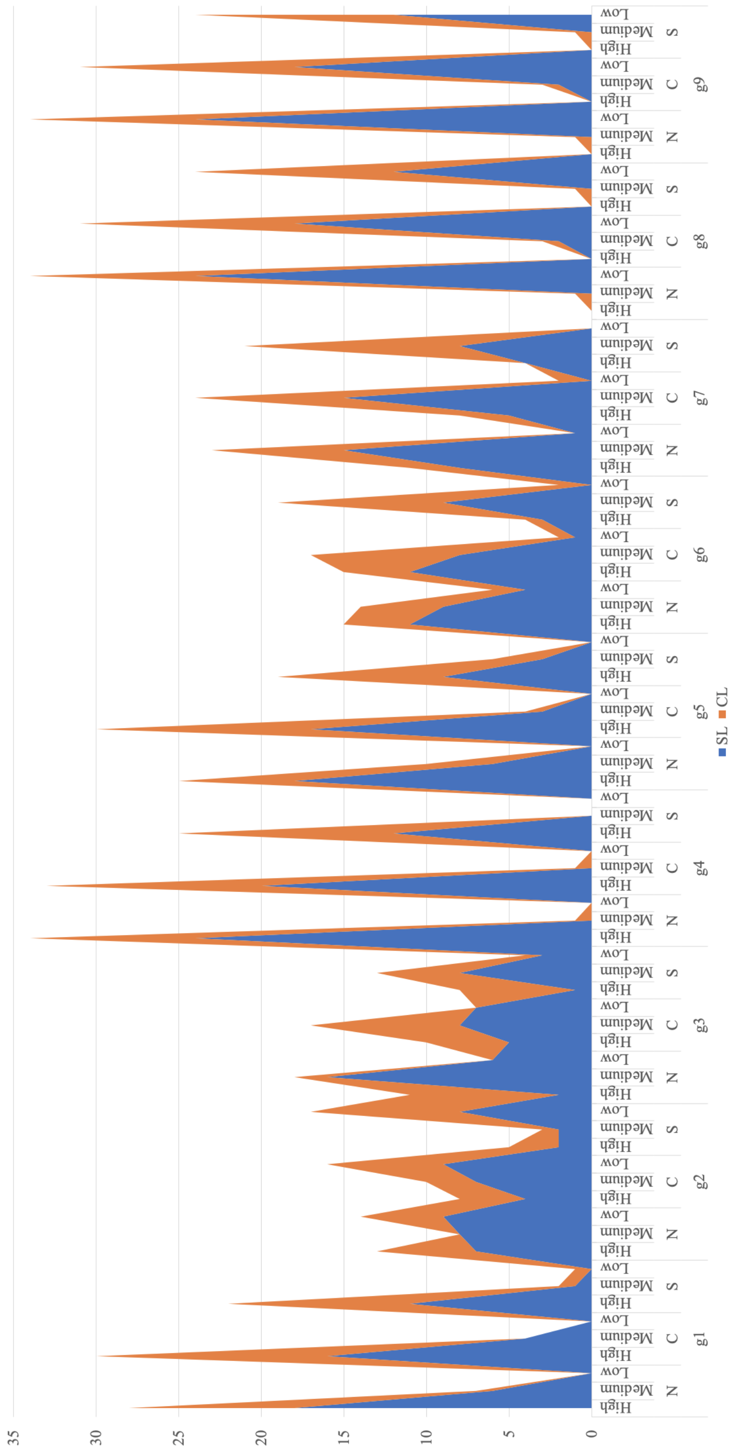

Figure 4: Performance of SLs and CLs sorted for criteria and geographical areas