Varia

The school effect on mathematics performance in PISA 2012: A comparison between two cantons in Switzerland

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Through this research, we explored the relationship between student achievement and school environment. We compared mathematics scores from the PISA test in Ticino and Geneva. We discovered that in both cantons there is a significant but moderate school effect on student mathematics performance (around 7% of the variance is attributable to school affiliation). Based on our results, we rejected the hypothesis that the context effect was a social and/or academic compositional one. We identified other factors, related to the teaching staff (seniority) and to the organization (class size), which may partly explain the between-school variance. However, we did not identify a systematic effect, since none of the variables analyzed were found to be statistically significant in both cantons.

1. Introduction

Since the publication of the Coleman report in 1966, the topics of school context and equity in teaching have been widely explored. The existence of a school effect is well established: a student's learning is not neutral relative to the learning environment (Daily et al., 2019; Dumay & Dupriez, 2009; Moreira et al., 2018).

A number of elements are still to be defined, however, particularly the nature of the school effect. Although it has been demonstrated that school context has an effect on student performance, it is not clear what drives the between-school differences. The literature has shown the exploration of four main elements to establish the nature of the school effect (Bressoux, 1994): resources (material, financial and human), school climate, management and school composition.

The principal aim of this research study is to examine this fourth element: the school population composition. More specifically, we explored the academic and social composition of the school population. We used PISA 2012 data on students at the end of their compulsory schooling (ISCED level 2), and compared the results of two Swiss cantons, Ticino and Geneva, as their school systems are organized differently (in Switzerland, education is governed by the cantonal authority).

In Ticino, the system is homogenous (or integrative), meaning that there is no tracking at middle school level. Students attend all lessons in heterogeneous classes, but in the second cycle of middle school, they are divided into classes of different levels for mathematics and German, according to their performance (level A is the higher level, B is the lower).

In Geneva, on the other hand, students are streamed from the beginning of middle school, depending on their achievements at the end of the primary school cycle. In the first year of middle school there are 3 streams; in the second year, two streams are merged into one: at the end of middle school, students can be in the lower (Regroupement B) or the higher stream (Regroupement A).

Our research is part of the already well-explored domain of the school effect. The original aspect of this study lies in the use of cantonal-level databases that we merged with the PISA data. Using this comprehensive database, we defined a strong research design that allowed us to estimate the compositional effect correctly, and we were able to follow most of the methodological recommendations made by Thrupp and colleagues (2002); in particular, we could control for prior achievement, allowing a more robust estimation.

2. Theoretical framework

2.1 Context effect on achievement

There is consensus within the scientific community regarding the importance of context factors in explaining differences in student skill acquisition. Research conducted on the school effect, which first emerged in Anglo-

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Saxon countries in the 1960s, support Bressoux's (1994) statement: "It is now accepted that not everything is played out in the family environment and that the school plays an autonomous role on students' achievement." (p. 127). The school therefore operates in the same way as the classroom, as a contextual unit pertinent for analyzing acquisition inequalities to the extent that, in itself, it could even be the source of these inequalities (Dumay, 2004). In other words, there is the idea that schools themselves could be contributing to social inequality in student achievement, by defining the student grouping methods within the institutions and generating social segregation. Although the existence of a school effect on student results has now been established, the form and extent of this effect remain a topic to explore, giving rise to multiple lines of research.

Regarding the nature of this effect, there is already abundant scientific literature on the subject, and the results are mixed. As Bressoux (1994) states in a relatively complete literature review, the paths investigated with the aim of characterizing the nature of the institution effect cover various aspects, such as resources (human, financial, material), school environment, principal's role ("leadership" style) or school composition. We are particularly interested in this last aspect here, and it is the focus of our research study.

2.2 Social and academic composition effect

As mentioned above, the nature of the school effect is considered from the perspective of the composition effect, defined by Dumay and Dupriez (2009) as the impact of the accumulated characteristics of the students after its effect at the individual level has been taken into consideration. In other words, it will be a question of determining "to what extent two similar students at the beginning of a period of study will develop differently depending on the characteristics of other students in their school" (Dumay & Dupriez, 2009, p. 463). Learning is influenced by context, and one of the most important parameters of the school context is student characteristics.

This research study is therefore in line with current thinking regarding school mix, which emerged in the '80s. These theories set out to investigate school characteristics from the perspective of their composition, and how it influences student behavior and learning. These characteristics are specifically the academic and social mix of the pupils, which will affect their academic progress. The school effect, which impacts student performance, is therefore above all a combined social and academic effect.

As Duru-Bellat and his colleagues (2004) emphasize, the composition effect in itself does not play a role, but it generates specific pedagogical and psychological mechanisms that are the real causal variables. There are three types of processes through which this effect operates:

- influence on the organization, management and general school climate;
- influence on the quantity and quality of instruction delivered in class;
- influence on the attitudes, aspirations and behavior of students.

According to Duru-Bellat (2003), based on previous work by Caldas and Bankston (1997),

> some of the advantage that children from a privileged environment enjoy does not entail a 'cultural heritage' but access to better educational contexts. The same applies in reverse for children from an underprivileged environment, whose educational 'disadvantage' can be partially explained by the fact that their classmates often come mostly from an underprivileged environment as well (p. 200).

Here, it is easy to measure how school grouping systems constitute a major factor for the school authorities, to the extent that they shape the educational context, and in fact impact on the fairness and effectiveness of the educational systems.

There have been many studies on the composition effect, but the results are mixed, and as Dumay, Dupriez and Maroy (2009) state, there is currently no absolute consensus in the scientific literature about the concept of such an effect. These authors attribute this lack of consensus partly to the diversity of methodologies implemented, and to the lack of pertinence in some of them. In the past few years, several researchers have considered the various methodological and statistical problems posed by assessing such an effect (Bressoux, 2020; Gorard, 2006; Thrupp et al., 2002). Dumay et al. (2009), who support the recommendations made by Thrupp et al. (2002), have therefore devised an ideal research model for studying the composition effect on student performance. This involves a minimum of two measurements of prior achievement (including a measurement of the initial level of the students), appropriate sampling and a multilevel analysis model. As will be shown in section 3, we followed most of these recommendations in our research.

3. Research questions and hypothesis

3.1 Research questions

This research study aims to answer the following questions:

To what extent do the results in mathematics, achieved by students from Ticino and Geneva in the PISA 2012 tests, depend on the characteristics of the individual student and on those of the school they attend? In other words, is there a school effect on student skills acquisition in both cantons? If so, what is the size of this effect?

If such an effect exists, what type is it? More specifically, is it a composition effect that is particularly social and academic, or another kind? It should be noted that the comparison of the Ticino and Geneva results will allow us to see to what degree the answers to these questions are the same in both systems, since both cantons have opted for rather different ways of organizing secondary education, as explained earlier.

3.2 Hypothesis on social and academic composition

The hypothesis that we would like to test in this research study is that there is a social and/or academic composition effect of the schools on student performance. If this is the case, not only should it be possible to prove that this effect exists in individual student performance, but also, and principally, that it mainly corresponds to student level (academic mix) and sociological level (social mix). This hypothesis therefore implies that segregating students with learning difficulties, or those from underprivileged socio-economic backgrounds, creates certain group dynamics that are unfavorable for learning and, other things being equal, lead to lower academic achievement.

4. Data and methods

4.1 Data

4.1.1 PISA

The Program for International Student Assessment (PISA) is an international survey promoted by OECD which measures the skills of 15-year-old students in the domains of science, mathematics and reading. PISA has been conducted every three years since 2000, and in each survey, one of these domains is classified as the major domain. In PISA 2012, the major domain was mathematics, hence it is the focus of our research.

After the test session, students also complete a questionnaire ("student questionnaire") about their life both in school and outside it. In addition, the principal of each school completes a questionnaire ("school questionnaire") about the school, the infrastructure, the management, etc. In this research study, we used the data collected in both these questionnaires.

4.1.2 Cantonal databases

To complement the PISA 2012 database, we used data from the cantonal databases of Ticino and Geneva and traced the students who participated in PISA 2012 and the schools in which they were enrolled.

We integrated these data sets for two main reasons. Firstly, we needed data about the whole student population of the schools of the sampled students. It is clear that if a student's performance is affected by the student population composition, it would be affected by the composition of the entire population and not just a sample. Consequently, in order to assess the social and academic composition, we used the cantonal databases to reflect the whole school population and calculate the real social and school composition. Having complete data on the school population allowed us to calculate the social and school composition, and not just estimate it using the PISA sample.

Secondly, we needed to define the student entry level. According to Thrupp et al. (2002), it is extremely important to have a set of measures about students' entry level in order to have a robust estimation of the compositional effect. Since the PISA surveys do not include data of this type, we managed to find the salient information in the cantonal databases (see paragraph 4.2.3 for further details regarding the construction of these variables).

4.1.3 Samples

Two samples were extracted from the PISA 2012 survey, in Switzerland:

- The international sample composed of 15-year-old students, allowing comparisons with other countries.

- The Swiss national sample composed of students in the 11th year of schooling (ISCED level 2), the last year of compulsory education in Switzerland. Since the beginning of PISA, OECD offers the participating countries the opportunity to amplify their sample for internal comparison. In Switzerland, each canton manages its own educational system, so the PISA committee in Switzerland has opted to complete the international sample with regional and cantonal samples that are comparable with those in other participating countries (Consorzio PISA, 2014).

For the purposes of this research, we used the national sample for the two cantons. The sample consisted of 1,081 students enrolled in 35 schools in Ticino, and 920 students enrolled in 19 schools in Geneva.

4.2 Method

4.2.1 Multi-level analysis

OLS regression is not suitable for measuring the school effect on students' mathematics achievement, since hierarchically structured data cannot be modelled. Our data are organized in a two-level structure, with students as the micro-units and the schools as the macro-units. Moreover, it is not possible to assume, firstly that there may be variously effective schools and, secondly, that the relationship between the dependent and independent variables varies between schools. When estimating the composition effect, we therefore used the multilevel model (to find out more about this method, see Snijders and Bosker (2012), as also recommended by Thrupp et al. (2002)).

A multilevel analysis follows a three-step procedure. The first step is the null model, or empty model. The total variance may be divided into two components: the variance attributable to the students' characteristics, i.e. the within-school variance, and the variance attributable to the school characteristics, i.e. the between-school variance. The null model makes it possible to assess if the latter has a significant impact on student performance, and if so, the size of this effect.

In the second step (first stage), the individual level variables are included. These variables should correlate with performance, so it is important to check for them. This step may be divided into two stages: in the first only, prior achievement variables are included; in the second, the other individual level variables are added. As our prior achievement variables are added as control variables - i.e. we want to establish if students already performed differently, explaining the variance on the PISA score - we decided to combine those two stages and we will expose only the explained variance for the two stages.

In the third and final step (second stage), the school-level variables are included to define the nature of the school effect. The aim of this stage is to specify which characteristics drive the differences between the schools, and which can be linked, not in a causal way, to the differences in performance.

4.2.2 Robustness of the research design

Thrupp et al. (2002) defined different criteria, some of which are discussed above, in order to estimate robustly the composition effect; in this study, we followed most of these recommendations, as will be demonstrated briefly below.

Firstly, according to Thrupp et al. (2002), "the sample should include schools from both ends of the socio-economic spectrum" (p. 488). In our case, for Ticino we included all the middle schools in the territory, and for Geneva only one middle school in the canton was excluded from the sample. This guarantees that our data will display differences in socio-economic composition.

Another previously mentioned recommendation is that "a full set of entry-level variables, including prior achievement variables, needs to be included to establish whether compositional variables are acting as proxies for other variables" (Thrupp et al., 2002, p. 488). We collected these variables from the cantonal databases, as shown in section 4.1.

In the model, it is also advisable to add variables that may correlate with the compositional variables. The aim is to control that the estimated composition effect actually comes from the interaction between pupils and not from other school characteristics. We were able to obtain theses type of variables from the PISA school questionnaire (see 4.2.3 for details).

4.2.3 Variables

The dependent variable is the mathematics score achieved in the PISA test. This score is standardized by OECD "to fit approximately normal distributions, with means around 500 score points and standard deviations around 100 score points" (OECD, 2019, p. 19).

The independent variables are from both the individual and school levels.

The individual level variables were sex, age, language spoken at home, migration status and economic, socio and cultural status (ESCS). This variable is a normalized index resulting from the variables regarding the highest parental occupation, the highest educational level of the parents and home possessions.

The two other individual-levels variables added to the model are those regarding the prior achievement of students, obtained from the cantonal databases.

The first variable about the entry level is the mathematics grade attributed by the teacher at the end of the school year prior to PISA, both in Ticino and in Geneva. This end-of-year grade is the result of different aspects considered by the teacher at the end of the school year (for instance, all tests taken during the school year, the student's attitude, discipline, etc.). In order to control for the prior achievement, the optimum would have been a grade from a PISA test, obtained at the beginning of the 11th year of schooling. However, this information is not available because PISA provides only one measure of the competences of each student taken at the end of the academic year. To control that the grade of the previous academic year is an adequate measure of prior achievement, we calculated the correlation between the grade and the PISA score: for Geneva, we found a 0.62 Pearson correlation coefficient, and for Ticino, 0.44. We can therefore conclude that the mathematics grade at the end of the 10th year is adequate as a prior achievement variable.

The second variable is the school stream in which students are enrolled. As mentioned above, in Ticino students attend classes of different levels in mathematics and German, according to their grade at the end of the previous year. We grouped students into three categories: students with two levels A, with mixed levels (A in mathematics, B in German, or vice versa) and students with two levels B.

In Geneva, students are divided into different school streams from the beginning of lower-secondary level. We created two categories: students in the highest profile ("Regroupement A") and students in the lowest one ("Regroupement B").

We added this last variable for two reasons. Firstly, Thrupp et al. (2002) recommend using more than one variable to better control the entry level of students. Secondly, we are aware that the same grade given in one school stream does not have the same meaning in both streams. For instance, a good grade given in the the highest stream has a different value from the same grade received in the lowest one (as demonstrated by Petrucci et a l., 2015).

The second level variables are the teaching staff, management, climate, infrastructure and the composition of the school population. With the exception of the compositional variables, the other variables are extracted from the PISA school questionnaire completed by school principals, in which they answered questions regarding the teaching staff, school infrastructure and leadership. These continuous variables were recoded in order to obtain categorical variables. To do this, we selected the schools that were outside the interval resulting from the mean plus/minus the standard deviation. Schools with a mean higher by more than the standard deviation were classified as "over-the-mean schools", and those with a mean lower by more than the standard deviation were classified as "below-the-mean schools". The remaining schools were categorized as "average". The aim of this categorization was to have a stronger contrast between the schools to identify those that differed greatly from the average. This categorization enabled us to detect the schools that had some particularity, in a mainly homogenous context.

Specific to our hypothesis, we constructed the social and academic composition, taking into account the whole student population of each school.

The social composition variable was constructed using the "displacement indicator" applied by Duru-Bellat et al. (2004) which was calculated on the highest profession of the parents available in the cantonal database. This index estimates the percentage of students who should be moved to achieve an equal distribution inside each school (i.e. each school will have a social composition similar to that observed for the whole population).

For each canton, we then ranked the schools according to the index, and recoded them into three categories: schools with a disadvantaged background (2 for Geneva, 4 for Ticino), mixed schools (15 for Geneva, 26 for Ticino) and schools with a privileged background (2 for Geneva, 5 for Ticino). We applied the same criteria as the other index (mean +/- the standard deviation) to categorize the schools. As the "displacement indicator" does not give an indication about the social tonality of the school, to establish whether the school has a disadvantaged or a privileged background, we compared the percentage of "white-collar high-skill" parents of each school and defined the privileged schools (and vice versa).

To determine the academic composition, we used the proportion of students in the highest school track. We therefore have, for Ticino, the proportion of students with two level A and for Geneva, the proportion of students in "Regroupement A". We then ranked the school according to this proportion, and selected the top 10% as having a high academic profile, and the bottom 10% as having a low academic profile in order to extrapolate the schools situated at the edge of the distribution. We classified the remaining schools as having a mixed-academic composition.

4.2.4 *Model and software*

For the analysis, we used HLM 7 software, which allowed us to work with the five plausible values that define the PISA mathematics score, and to weight the data. The advice of the OECD (2014) is: "survey weights must be incorporated into the analysis to ensure that each sampled student appropriately represents the correct number of students in the full PISA population" (p. 132)[1].

After a number of tests, we used a model with a random intercept and non-random slopes. We did not assume that the relationship between the test score and any of the independent variables was not the same in all the schools.

To determine the final model, we added each variable from the second level one at a time; when it was significant, we would keep it in the model, if not, it was removed. This way of proceeding is also given by the multilevel model constraints, which does not allow the addition of a high number of variables to achieve a valid and stable estimation (Bressoux, 2010; the rule of thumb would be that for one variable at level 2, it is necessary to have at least 10 groups, see also Center for Multilevel Modelling, 2007).

5. Results and discussion

5.1 Null model

Table 1

Null model for Ticino and Geneva

	Math			
	Ticino		Geneva	
Fixed effects	Coefficient *(s.e)*	P-value	Coefficient *(s.e)*	P-value
Intercept	514.31 *(4.23)*	<0.001	500.58 *(5.89)*	<0.001
Random effects				
Level 2 (school): between-school variance	433.68	<0.001	465.89	<0.001
Level 1 (student): within-school variance	5,626.14		6,247.92	
Proportion of level 1 variance (in %)	92.80%		93.10%	
Proportion of level 2 variance (in %)	7.20%		6.90%	
Total	100%		100%	

As mentioned above, the first step of a multilevel analysis is the null model. This allowed us to divide the mathematics score variance into two components: the within-school variance and the between-school variance.

We found that, for both cantons, approximately 7% of the variance in the PISA test performance in mathematics is attributable to school affiliation. This between-school variance is statistically significant (see Table 1). We can thus assert that performance differences between students are due much more to differences in individual characteristics than to school characteristics. This result is consistent with those found in other contexts: Duru-Bellat et al. (2004) affirm that, in several studies, the school effect varies between 8% and 15%, depending on the context.

Different explanations may be proposed in order to understand why the between-school variance is quite low. Bressoux (1994) supposes that there is much greater heterogeneity between schoolmates than between schools. Moreover, Crahay and Monseur (2006) hypothesize that the school effect somehow reflects characteristics of the national education system. In Ticino and Geneva, this low low between school variance may be due to a rather homogenous middle school structure.

Although schools in both cantons have some autonomy, many of the main factors linked to their operation (study programs, level of teacher training, class size, resources, etc.) are determined by legislation, and apply equally throughout the cantonal territory. As a result, the variability between schools diminishes, and there is a lower likelihood of seeing a higher contextual effect emerge.

1 The HLM 7 software applies the Pfefferman et al. (1998) method and then normalizes the weights on a normal distribution with the mean equal to 1.

To explore this issue, we used other data from a standardized test in Geneva to compare the between-school variances of a two-level model and a three-level model. In Geneva, students who participated in the PISA test also took a standardized cantonal test in mathematics at the same time. These data made it possible to distinguish between classes (second level) and between schools (third level). We found that the differences in student performance due to the school attended varied from 2% to 3.5%, with the former difference referring to the between-school variance in a null-model with three levels (students, classes and schools), and the latter difference referring to the between-school variance in a null-model with two levels (students and schools).

Finally, Opdenakker and Van Damme (2000) also demonstrated that, in similar situations, introducing a third level such as the class would significantly change the result.

5.2 First stage

The first stage of the analysis consists of adding the individual level variables to the model and can be divided into two steps, the first one with just the prior level achievement variables, the second with the socio-demographic variables. As we consider the prior level achievement variables as our control variables, we decided to unify those two steps. We did however estimate the variance explained by the prior achievement variables only, and found this to be the main individual level predictor of the PISA test score. In Geneva, 49.3% of the within-school variance is explained by the prior-level achievement, and 50.5% of the between-school variance. In Ticino, these percentages are 39.9% and 20.3% respectively.

In terms of the coefficients, the initial level in mathematics has a similar effect in both cantons with also the other level 1 variables are added (see Figure 1 and 2). In both Geneva and Ticino, there is a positive effect associated with the final year school grade, which means that a student who achieves a high school grade is more likely, on average and within schools, to achieve higher results in the PISA test, with the other variables held constant. Moreover, in Geneva, when compared with students in the highest stream, students in a lower stream tend to have lower scores in PISA, *ceteris paribus*. Similarly, in the canton of Ticino, students who attend mixed level classes (one level A and one level B), or two levels B classes, are more likely to achieve lower results in PISA than those who attend both levels A, all other things being equal.

When the other level 1 variables are introduced at this stage, i.e. the socio-demographic variables, they explain 53% of the between-students variance in Geneva and 42% in Ticino. Moreover, more than 50% of the between-school variance in Geneva is explained by the students' individual characteristics, and in Ticino the figure is 20%. Interestingly, when comparing the explanatory power of the two models, it seems that individual characteristics have more relevance in the score differences in Geneva than in Ticino. These differences may be linked to the differences between the two educational systems of these cantons, as explained above. Felouzis and Charmillot (2017), who researched the topic of inequalities in Switzerland using PISA data from 2003 and 2012, assumed that equity is linked to the system organization. They maintain that an integrative system, like the one in Ticino, is more equitable than a system where students are streamed at an early stage according to their academic abilities; this would explain why the individual characteristics have less weight on performance in Ticino than they do in Geneva.

Although the explanatory power of these variables (both within- and between-school) is low, compared to that of the entry-level variables, the effect of the socio-demographic variables is mostly significant, therefore it is important to include them in the model to obtain a robust estimation. In fact, sex has a statistically significant effect, meaning that within schools, boys are more likely on average to record better results than girls, in both Geneva and Ticino, all other things being equal. Age has a negative impact on the PISA results, which implies that on average, *ceteris paribus*, and within school, older students perform on average worse than younger ones. We can hypothesize that this result is coherent since older students may have experienced difficulties during the previous school years, leading to grade repetition. Lastly, immigration status and the language spoken at home do not have any statistically significant impact on performance.

The only difference between the two cantons in terms of these individual characteristics is in the socio-economic status. In the canton of Geneva, it appears that students from a high socio-economic level are more likely to achieve better results. In Ticino, this variable does not have any statistically significant impact once the students' entry-level has been controlled.

Figure 1

Multilevel analysis of PISA 2012 mathematics results – canton of Geneva

	Model 1 (empty)			Model 2 (level 1 variables)			Model 3 (levels 1 and 2 variables)		
	Coeffi-cient	(s.e.)	P-value	Coeffi-cient	(s.e.)	P-value	Coeffi-cient	(s.e.)	P-value
Fixed effects									
Intercept	500.58	(5.898)	**<0.001**	507.45	(6.299)	**<0.001**	509.00	(6.369)	**<0.001**
Initial level end of 10th year Cycle d'Orientation									
Maths mark				50.57	(2.980)	**<0.001**	50.65	(2.978)	**<0.001**
Profile of 10th year Cycle d'Orientation									
(ref. Group A or similar)									
Group B or similar				-54.53	(7.511)	**<0.001**	-54.51	(7.543)	**<0.001**
Sex									
(ref. Female)									
Male				19.17	(4.301)	**<0.001**	19.08	(4.302)	**<0.001**
Age				-17.51	(4.723)	**<0.001**	-17.45	(4.714)	**<0.001**
Socioeconomic and cultural status (ESCS)				9.35	(3.230)	**0.004**	9.40	(3.200)	**0.004**
Migrant status									
(ref. Native)									
2nd/1st generation				-4.75	(6.463)	0.463	-4.53	(6.471)	0.484
Language									
(ref. Francophone)									
Allophone				1.68	(5.688)	0.768	1.99	(5.620)	0.723
Average age of Maths teachers									
School with a low average age of teachers							-18.22	(6.581)	0.013
Random effects									
Level 2 (schools)									
Between-school variance	465.89		**<0.001**	209.88		**<0.001**	179.17		**<0.001**
Level 1 (students)									
Within-school variance	6247.92			2918.69			2919.32		
Explanatory power of the model									
Pseudo R2 Level 1 (students)				53.26%			53.27%		
Pseudo R2 Level 2 (schools)				54.93%			61.54%		

Figure 2

Multilevel analysis of Pisa 2012 mathematics results – canton of Ticino

	Model 1 (empty)			Model 2 (level 1 variables)			Model 3 (levels 1 and 2 variables)		
	Coeffi-cient	(s.e.)	P-value	Coeffi-cient	(s.e.)	P-value	Coeffi-cient	(s.e.)	P-value
Fixed effects									
Intercept	514.31	(4.238)	**<0.001**	534.29	(4.253)	**<0.001**	533.78	(4.323)	**<0.001**
Initial level end of 10th year									
Maths mark				34.9	(3.263)	**<0.001**	35.02	(3.264)	**<0.001**
Level in Maths and German									
(ref. Two level A)									
Level AB				-47.09	(6.238)	**<0.001**	-47.11	(6.241)	**<0.001**
Level BB				-73.21	(4.270)	**<0.001**	-73.19	(4.274)	**<0.001**
Sex									
(ref. Female)									
Male				14.21	(4.234)	**0.001**	14.22	(4.234)	**0.001**
Age				-9.37	(4.512)	**0.039**	-9.46	(4.505)	**0.037**
Socioeconomic and cultural status (ESCS)				4.68	(2.634)	**0.076**	4.73	(2.633)	**0.073**
Migrant status									
(ref. Native)									
2nd/1st generation				-8.30	(4.762)	0.092	-8.24	(4.768)	0.095
Language									
(ref. Italophone)									
Allophone				5.60	(5.051)	0.269	5.51	(5.046)	0.276
Average class size									
Schools with a lower class size than the average							19.75	(8.282)	0.023
Random effects									
Level 2 (schools)									
Between-school variance	433.68		**<0.001**	344.95		**<0.001**	334.55		**<0.001**
Level 1 (students)									
Within-school variance	5626.14			3259.33			3259.36		
Explanatory power of the model									
Pseudo R^2 Level 1 (students)				42.07%			42.07%		
Pseudo R^2 Level 2 (schools)				20.46%			22.86%		

Note: in bold, p-value < 0.05. The associated coefficients have a 0.05 significance level

5.3 Second stage

In the final stage of the analysis, we added the second level variables to assess the school effect.

Our main hypothesis was that the school effect derives from the social and/or academic composition. When we added these two variables, however, we found no significant effect, meaning that we reject our hypothesis: these results are quite positive. The two educational systems considered in this research study do not seem to reproduce the social inequalities between students present in society: there is therefore no student segregation, which would influence performance.

Our research design probably does not lead to drawing erroneous conclusions concerning the existence of a composition effect, also thanks to the fact that we included a measure of students' entry level. Willms (1992) and Lauder and Hughes (1990) reasoned that, in some research studies, the school composition effect detected is an artefact linked to poor control of students' individual characteristics, particularly their entry level. In fact, for Geneva, we found that when the entry-level variables are not included in the model, the social composition variable becomes significant.

Using other second-level variables, we were able to partially identify the nature of this effect. We observed that in Geneva, teachers experience has a statistically significant impact on student performance: with individual characteristics (first stage) remaining constant, compared to the mean for the canton, on average students perform worse if they are in a school where teachers have less experience. One explanation could be that younger teachers do not have the same training as older teachers. This is consistent with previous research and teacher experience is a feature that is generally highly correlated with student skills (Greenwald et al., 1996; Gustafsson, 2003). However, we must observe that this variable does not have an effect in Ticino, or in the other PISA domains (reading and science) that were analyzed in the research from which we extract this article (Petrucci et al., 2018). We therefore cannot conclude that there is a systematic effect of teacher experience in other contexts, as Hanushek (2003) also noted.

In Ticino, the only school-level variable that explains student score differences is the one describing organizational setting. Students who attend a school where class sizes are smaller than the cantonal mean (16-17 students rather than 20) are more likely on average to achieve better results in mathematics in PISA, *ceteris paribus*. This is consistent with the findings of other researchers. In fact, it seems that a reduction in class size allows students to achieve better results (Meuret, 2001; Piketty & Valdenaire, 2006). However, in our case, it is not as straightforward as it would appear to interpret this result because the schools with smaller classes seem to be rather atypical compared to the other schools in the territory. These schools are located in geographical zones that can be defined as peripheral. Hereafter, we can presume that students in these schools benefit from different education conditions, which may influence performance. We therefore cannot exclude that this positive effect on PISA performance is more strongly linked to other unexplored variables relating to these peripheral schools, rather than class size.

6. Conclusion

In this article, we have attempted to answer the question about the relationship between student achievement and school environment.

PISA 2012 data and cantonal datasets allowed us to set up an appropriate research design to estimate the school effect (we followed most of the recommendations made by Thrupp et al., 2002). In Switzerland, the PISA national sample - composed of students in their 11th year of schooling, i.e. the last year of compulsory school - allowed us to obtain comparable measures of competences between the cantons of Ticino and Geneva in three domains (science, mathematics and reading). For this article, we focused on mathematics, which was the major domain in PISA 2012.

Cantonal datasets enabled us to measure student entry levels, which is an indispensable element in verifying the existence of a school effect on student performance. Moreover, we were able to characterize the entire student population of the schools (the social and academic composition), and not just extract the composition variables from the PISA sample.

The school effect in our study must be understood as a difference in student performance due to the school attended, and not as the importance of the school in general in the students' development. Our analysis shows that in Geneva and Ticino, there is a small but significant school effect on student mathematics performance. For both cantons, 7% of the variance in PISA test performance is due to school affiliation. As expected, differences between students are mainly attributable to their individual characteristics and schools have the same impact on student performance. In other words, it is not school affiliation that explains the variance on the PISA score, but the socio-demographic characteristics of students. Indeed, the small-school effect can be considered as a positive result in terms of equity in the Ticinese and Genevan school systems. It means that, in these cantons, irrespective of the school attended, students have almost the same opportunities to grow and thrive equally as each other, and their performance depends mainly on their socio-demographic characteristics, behavior and attitudes.

It should however be noted that the modest school effect may also be due to the small number of schools, which limits variability. Nonetheless, this is the reality of the field, as we included all available schools in the territory and could add no other groups. Moreover, neither the students nor the school itself can choose its population as the main criteria is for enrolment is geographical; this also prevents having school segregation which that could produce different results from a similar analysis in another context.

Although the school effect is small, it is interesting to determine its specific nature. In Ticino and Geneva, we can conclude that there is no such thing as a social and/or academic composition effect. We have identified other factors, related to the teaching staff (seniority) and to the organization (class size) of the schools, which may to some extent explain why some schools are more efficient than others. However, we could not find a systematic effect, since none of the variables were found to be statistically significant in both cantons or in all the domains (Petrucci et al., 2018).

This research work has probably enabled us to identify atypical schools in both cantons, and particular schooling contexts, which clearly have an impact on student performance.

In conclusion, we must highlight that, in both cantons, the variables inserted at the second stage, that showed a statistically significant effect, are more of a reflection of the class context than the school context. It is thus plausible to assume that the class context is more appropriate for studying variations in competence acquisition. In a literature review on the differences between the class effect and the school effect, Duru-Bellat (2003) stated that "contexts' effects are more likely to be strong at the class level to explain student's results and performance whereas at the school level we may find more explanations on career development and socialization of students" (p. 191). Further research studies should therefore investigate the relationship between class context, school context and student performance.

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Keywords: Composition effect; multilevel modelling; PISA 2012; mathematics achievements; school effect

Der Schuleffekt auf die Mathematikleistung in PISA 2012: ein Vergleich zwischen zwei Kantonen in der Schweiz

Zusammenfassung

In dieser Studie haben wir den Zusammenhang zwischen Erfolg und Schulumfeld untersucht. Wir haben die Mathematikergebnisse im PISA-Test in den Kantonen Tessin und Genf verglichen. In beiden Kantonen besteht ein signifikanter, aber gemäßigter institutioneller Einfluss auf die Mathematikleistung (etwa 7% der Abweichung sind auf die Schule zurückzuführen). Aufgrund unserer Ergebnisse haben wir die Hypothese abgelehnt, dass der Kontext-Effekt ein Effekt der sozialen und/oder akademischen Zusammensetzung ist. Wir haben andere Faktoren in Bezug auf Lehrpersonal und Organisation identifiziert, die zum Teil die Unterschiede zwischen den Institutionen erklären können. Wir konnten jedoch keinen systematischen Effekt finden; keine der Variablen waren in beiden Kantonen statistisch signifikant.

Schlagworte: Zusammensetzungseffekt; Multi-Level-Modelle; PISA 2012; mathematische Leistungen; Schuleffekt

Effet établissement sur les performances en mathématiques à PISA 2012 : une comparaison entre deux cantons suisses

Résumé

Dans cette recherche, nous avons exploré la relation entre la réussite et le contexte scolaire. Nous avons comparé les résultats en mathématiques au test PISA au Tessin et à Genève. Dans ces deux cantons, il y a un effet établissement significatif mais modéré sur les performances en mathématiques (environ 7% de la variance est attribuable à l'établissement). D'après nos résultats, nous avons rejeté l'hypothèse que l'effet établissement était un effet de composition sociale et/ou académique. Nous avons identifié d'autres facteurs, liés au personnel enseignant et à l'organisation des établissements, qui peuvent expliquer, en partie, la variance inter-établissements. Cependant, nous n'avons pas trouvé d'effet systématique ; aucune des variables n'était significative dans les deux cantons.

Mots-clés : Effet de composition ; modèles multiniveaux ; PISA 2012 ; performances en mathématiques ; effet établissement

L’effetto del contesto scolastico sulle prestazioni in matematica in PISA 2012: un confronto tra due cantoni svizzeri

Riassunto

Attraverso questa ricerca, abbiamo esplorato la relazione tra le prestazioni degli studenti e il contesto scolastico. Abbiamo confrontato i punteggi in matematica ottenuti nel test PISA in Ticino e nel canton Ginevra. Abbiamo scoperto che in entrambi i cantoni vi è un effetto significativo ma moderato dell’istituto scolastico sulle prestazioni degli studenti (circa il 7% della varianza è attribuibile all’istituto). Secondo i nostri risultati, abbiamo rifiutato l’ipotesi che l’effetto di contesto fosse relativo alla composizione sociale e/o accademica. Abbiamo individuato altri fattori, legati al corpo docente (anzianità) e all’organizzazione (dimensione delle classi) delle scuole, che possono spiegare, in parte, la varianza tra le scuole. Tuttavia, non è stato possibile trovare un effetto sistematico, poiché nessuna delle variabili analizzate è risultata statisticamente significativa in entrambi i cantoni.

Parole chiave: Effetto composizione; modelli multilivello; PISA 2012; prestazioni in matematica; effetto-istituto

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