Multilevel modeling an innovative tool for analyzing clustered data: application to education and its projection on environmental management

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Abstract. The objective of this article is to show how multilevel modeling is a tool that is most appropriate to analyze clustred data in many field (education, business, environment, energy consumption etc.). Thus, we used this approach to analyze students' achievements in morocco using TIMSS database. The results show that several factors influence the academic performance of Moroccan students in mathematics such as student's gender, Student's SES and the principal's emphasis on students' success.

Keywords. Multilevel modeling, cluster, education, environment

1 Introduction

Individuals can be nested in schools as they can be voters living in neighborhoods or employees in companies (Albright & Marinova, 2010).
Likewise, children who live in a community are also pupils in a given class and belonging to a school. Thus, limiting the determinants of school performance to only factors at the aggregate level or the reverse may distort the results of the analysis
Indeed, the existence of correlation between aggregated data leads to results on entire populations.This is what Courgeau, (1997) calls "ecological error" or "aggregation bias". In contrast, explaining facts at the individual level by the characteristics of the individual alone leads to what Lucke, (2004) calls "atomistic error" and therefore to the non-validity of the assumptions of the model at one level.
As a result, the multilevel models developed in particular, by H. Goldstein and JJ Hox, articulate in the same analysis models different levels of observation and therefore simultaneously take into account the individual variables (elementary level) and those of the context (aggregation level). These models therefore have the advantage of going beyond the limits of aggregation or disaggregation.
In this sense, our research aims to highlight the variety of factors explaining the academic performance of Moroccan students using the multilevel modeling. The variables used exhibit the character of being nested, (students at different SES, who are taught by different teachers in different schools, influenced by peer effects). This therefore assumes a hierarchical linear econometric modeling (HLM) called multilevel.

2 Theoretical framework:

The variables that influence students' academic performance have been debated for many years by educators and researchers. While some argue that the determinants of students' academic performance may vary according to the country's level of development (Duru-Bellat, Mons, & Suchaut, 2004), other studies suggest that students are independent of their social context and that schools have little influence on academic success (Coleman et al., 1966).
On the other hand, other contributions suggest that factors such as socio-economic status (SES), intrinsic characteristics of the students, the qualification of teachers and other school variables may play an important role in what students learn.
To this end, we propose to study in detail the effect of social capital and school capital in improving students' outcomes.

2.1. Socio-economic status (SES) of the student and academic performance

Several empirical studies have shown that poor academic performance is closely correlated with the home environment. These works generally tend to estimate the family environment by the SES, which is influenced by several factors such as family social class, occupation, wages, education and material resources, etc. (Rodríguez-Hernández et al., 2019; Li et al., 2021)
In addition to these elements, Nechyba, McEwan, & Older-Aguilar (1999), point out that family and parental

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characteristics also include elements as diverse as genetic endowments, which could be passively transmitted to the child through the hereditary process.

Tissington & Lacour (2011), argue that a family's resources are financial, emotional, mental, spiritual and material resources as well as support systems, relationships and knowledge of hidden rules (i.e. say knowledge of the inner workings of the system).

.2.2 Students' characteristics

Student characteristics generally refer to several elements such as age, gender, perception of the school environment, motivation, involvement in school activities, work, self-confidence, self-esteem and optimizes the student etc. The effect of these elements on student performance has been widely debated. Several contributions suggest that educational outcomes are disparate between girls and boys and that, in sum, gender differences also influence students' academic performance between levels and within classes (Ranjeeth et al., 2020).

Despite growing evidence of gender similarities in school performance, the belief in stereotypes that girls perform less in quantitative domains still persist: ((Sherman & Fennema, 1977); (Hopp, Frost, Ryan, Fennema, & Hyde, 1990b); (Spencer & Steele, 1999); (Nosek, et al., 2009), Lamon, Fennema, & Hyde, (1990), Fuchs & Wößmann (2004), Linn, Hyde, & Else-Quest (2010), Peterson, Hyde, & Lindberg (2010), Nosek, et al. (2009), Murphy (2000), Halpern et al. (2007), Ian, Armstrong, & Rounds (2009) etc.

In addition to the gender of the student, the age of first enrollment in school is as decisive as other factors. The age at which a child begins school has attracted a lot of attention from educational policy makers, parents and researchers. In addition, the effect of the age of schooling on educational achievement remains mixed Black, Devereux, & Salvan (2008), Moussa (2012), Datar (2006), Cascio & Lewis (2006) etc.

At the same time, other elements important for academic performance were highlighted such as school activities, free time and individual effort. It should be noted that in addition to the SES and the intrinsic characteristics of the student, other researchers are more specifically interested in schools characteristics.

2.3 The school effect and peer effect

Coleman's report (1966) is believed to be the source of the first discussion of academic factors and student performance. However, this report, like the first works in this direction, considers that the effect of school factors on the performance of pupils is not as important as the effect of the socio-cultural origin of families and of the individual characteristics of the child. Student.

As a result, an abundant literature has flooded in order to refute or confirm the hypothesis that the establishment has no influence on school performance. The literature review of this aspect reveals the analysis of several elements in relation to school performance, namely:

- school resources: Barro & Lee (1996), Greenwald & Hedges (1996), Hægeland, Raaum, & Salvanes (2005), Al Samarrai (2002) and Häkkinen, Kirjavainen, & Uusitalo (2003), Heyneman & Loxley, 1983), Fuller & Clarke (1994) and Michaelowa (2001), Dufur & Parcel (2001) etc.
- Class size: Hanushek (1997; 2003; 2006), Hoxby (2000), Kingdon & Altinok (2012), Woessmann & West (2006), Lavy & Angris (1999), Krueger (1999), Häkkinen, Kirjavainen, & Uusitalo (2003), Somer & Willms (2001)).

The concept of peer effects refers to theories of social interaction. In education, this concept means that the student evolves within the school with a population that influences and is influenced by him.

Indeed, it is thanks to the study of American schools by Coleman, et al. (1966), that the effect of group influence was highlighted. However, the idea behind Coleman's study is that inequalities in performance across institutions were conditioned by resource and funding gaps between institutions.

In addition, the explanation of inequalities in school performance goes beyond the social and economic status of the individual. In other words, the characteristics of the group have to be taken into consideration.

3 Methodology :

In this work, we use data from TIMSS surveys (2011) for Morocco and relating to mathematics. The TIMSS surveys are considered an international benchmark in the assessment of learning achievement in mathematics and science around the world. The variables used show the character of being nested, (students at different SES, which are taught by different teachers in different schools, influenced by peer effects). This therefore assumes a hierarchical linear econometric modeling (HLM) called multilevel. The model adopted is as follows:.

$$Y_{ij} = \alpha_0 + \boldsymbol{\beta} X_{ij} + \Upsilon \; K_j + u_{0j} + e_{ij} \qquad (1)$$

K_j = school characteristics

u_{0j} = unobserved heterogeneity of schools.

According to Spencer & Fielding (2000), it is not unusual for a multilevel model to suffer from an endogeneity problem. Therefore a resolution of this problem is necessary. Otherwise, the estimates are considered inconsistent or biased and therefore a resolution of this problem is essential. The estimation therefore involves the adaptation of the Hausman-Taylor instrumental variable method IV.

4 Results and discussion

The results of the multilevel model presented in the table 1 suggest that boys performs better than girls in mathematics. Regarding the SES, results show that students with higher SES achieve better than students with low SES.

the location of school (urban) is positively linked with academic achievement in mathematics.

This means that the mathematics achievements of students in urban schools (are better from their peers in rural schools. This can be explained by the fact that schools located in urban areas are more likely to have infrastructure and resources to facilitate practical learning than theoretical learning.
Regarding the peer effects represented by the social composition of the school, the analysis shows that the latter is positively linked to academic achievement in mathematics. Thus, a school in which the majority of students come from a less advantaged background will therefore have a negative influence on the academic performance of the students.
In contrast, the number of students enrolled in the same level of education seems to have a negative effect on student achievement. Indeed, a large number of students can make the management of the classroom a difficult task for the teachers.
In contrast, the results of the analysis show that the principal's emphasis on students' academic success is a main determinant of their performance. Indeed, this variable provides information on five elements: The teaching objectives understanding by the teachers, the curricula implementation, the expectations of the teachers, parents' engagement and finally students' aspiration.
Thus, this last result prompts us to say that the involvement of all the actors concerned with the education of the student is an irrevocable predictor in the performance of the achievements of Moroccan students.
In sum, the multilevel modeling is an innovative tool for analyzing clustered data. It can be used to analyze education, business (employees in a firm) and on environmental management.
Indeed, the existence of correlation between the aggregated data leads to results on entire populations, that it would be incorrect to interpret at the individual level. This is what Courgeau, (1997) calls "ecological error" or "aggregation bias". On the other hand, explaining facts at the individual level alone leads to what Lucke, (2004) calls "atomistic error" and therefore to the non-validity of the assumptions of the model at only one level.
As a result, the multilevel models developed by H. Goldstein and JJ Hox, articulate in the same analysis models, different levels of observation and therefore simultaneously take into account the individual variables (elementary level) and those of the context. (level of aggregation). These models therefore have the advantage of going beyond the limits of aggregation or disaggregation.
The HLM make it possible to measure the "cluster effects" and represent one of the best statistical solutions in the processing of quantitative information at several levels of nesting.

Table 1. Results of the multilevel model with resolution of the endogeneity bias

Variables	**Coef.**	**P>|t|**
Age	-15.75	0,000
Gender	-12.76	0,000
Personal Computer	8.61	0,000
Desk	6.23	0,000
Internet	10.94	0,000
Books	11.40	0,000
Parents educational level (primary)	-15.89	0,000
Homework (more 3 hours)	10.31	0,000
Shcool location (urban)	14.27	0,000
School social composition (advantages)	14.16	0,003
Principal's emphasis on sucess	4.16	0,000
PEV*Erreur ! Source du renvoi introuvable.***(%)**	**86%**	

Conclusion

This research corroborates the findings of the empirical literature review that the educational performances of students are influenced jointly by many factores such as students' characteristics, student's SES, school' characteristics and peer effect.
Indeed, regarding student's characteristics results show that Girls perform less well than their peers in scientific disciplines, especially math.
In addition, the family environment and, more specifically, the level of education of the parents, is decisive in the promotion and enhancement of children's achievements. Generally, the educational level of parents has a positive impact on children's academic performance.
Regarding peer or composition effects, these negatively influence the academic performance in mathematics of Moroccan students. Indeed, if the students in a school are mainly from disadvantaged backgrounds, the expected academic performance will necessarily be less promising.
The analysis of the characteristics of the school shows that school location (urban Vs rural) and school resources have a positive impact on students' outcomes.
Finally, the results of the analysis show that the principal's emphasis on students' academic success is a main determinant of their performance.
We conclude that several determinants intervene in the assessment of the level of academic excellence of the Moroccan student in mathematics. These factors refer to the intrinsic talents of the student, the family environment and the location of the school attended. In addition, the joint commitment of the student, parents' associations and the school board would constitute the keystone of the performance of the Moroccan educational system.
We believe that apart our findings there is many other factors that affect education in morocco.

Indeed, the Moroccan educational system suffers from a lack of training dedicated to environmental management and rational management of energy resources. This generates the need for the implementation of a project whose objective is to promote programs with the capacity to train competent people with the ability to help actors to respect their commitments in terms of sustainable development, environmental preservation and optimal use of energy

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