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Analysis of Demand-Side and Supply-Side Factors on Learning Outcomes in Cambodia

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The study applies the Hierarchical Linear Modeling (HLM) approach using the international learning assessment survey, PISA for Development (PISA-D), to examine the effects of demand-side and supply-side factors associated with academic performance in Cambodia. Findings from the study suggest that students' characteristics and family background are good predictors of students' test scores in Cambodia, while demand-side factors such as school size, class size, student grouping by ability, remedial class, and teacher absenteeism have little or no influence on student learning performance. The study also highlights how these predictors affect learning performance differently in rural and urban areas.

Keywords Education Policy, Quality of Education, International Learning Assessment, Hierarchical Linear Modeling (HLM), Cambodia

1 Introduction

Although the focus on quality and learning rather than expansion of access to education can be traced back to as early as the mid-1990s in the World Bank's Priorities and Strategies for Education (1995), the issue has become more prominent in recent years. UNESCO (2013) indicated in its annual Global Monitoring Report that a large number of children and young people leave the education system without competencies they need to lead productive and healthy lives. An increasing number of studies have confirmed this learning crisis, in particular, in developing countries (Pritchett, 2013; World Bank, 2018). In response to this learning crisis, the World Bank (2018) dedicated three chapters of its annual flagship report to highlight the

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issue that students around the world failed to get the skills and knowledge they need, providing some suggestions to fix the problems. Measuring learning is the first step to fix this learning crisis. Education systems need mechanisms to identify who are learning well and who remain illiterate after years of schooling, and what are the reasons behind it.

Basic education expansion has been one of the top development agendas in many developing countries including Cambodia. Over the past two decades, Cambodia has gradually expanded access to basic education. In primary schools, net enrollments increased from 76% in 1997 to 98% in 2018. Lower secondary enrollments also jumped from 23% in 1997 to 55% in 2018 (MoEYS, 2019). However, the results from a national assessment conducted in 210 schools in 2013 revealed that half of the students failed to obtain basic proficiency in Khmer language and mathematics (MoEYS, 2015). When the new Minister of Education Youth and Sports (MoEYS) made grade 12 national examination reform by eradicating cheating in the exams, the passing rate plummeted from around 80% to merely 43% in 2014 (Chhinh, 2016). The results from OECD's Programme for International Student Assessment (PISA) for Development or PISA-D also indicate that Cambodian students' performance is lower than other middle- and low-income countries. Less than ten percent of Cambodian students aged 15 years old are able to achieve a minimum level of proficiency in reading and mathematics (OECD, 2018a).

There are many factors that influence the learning outcomes, from the learners themselves to school management and the education system. Understanding the importance of monitoring progress of student learning, MoEYS established the Education Quality Assurance Department (EQAD) in 2009, a few years after the implementation of the national assessment at grades 3 and 6 in 2006 and 2007 (MoEYS, 2015). Yet, there is little evidence suggesting what the causes are behind the learning crisis in the context of Cambodia, as data from the national assessments are not available for public scrutiny. With strong encouragement from the World Bank, Cambodia with some reluctance joined the PISA-D pilot project and signed an agreement with the OECD in 2016 to further participate in the regular PISA after the pilot project (Auld et al., 2019).

Despite the fact that there are some existing studies predicting student learning in Cambodia, few have attempted to incorporate supply-side factors into their analysis frameworks using large-scale learning assessment data (Marshall & Fukao, 2019; Nguon, 2012; Song, 2012). Since PISA-D is the first large-scale assessment survey in Cambodia widely available for researchers, this study intends to examine the demand-side and supply-side factors that influence students' learning outcomes in Cambodia. It also aims at investigating how these factors influence learning outcomes differently in urban and rural areas.

The remaining sections of this study are structured as follows. Section 2 provides an overview of learning assessments in Cambodia, and Section 3 reviews the existing literature on factors associated with students' learning achievement. Section 4 outlines the data and methods employed in the study. Empirical results are provided and discussed in Section 5, and Section 6 discusses and concludes the study.

2 Overview of Learning Assessment in Cambodia

The student learning assessment is vital for policymakers and practitioners in forming new education policies and in guiding how policies should be implemented (Raudonyte, 2019). It provides evidence for policy options and strategies to improve education systems and to ensure students can acquire the needed skills and knowledge; it is also a tool to monitor and evaluate the country's progress in student performance, including the agreed Sustainable Development Goal (SDG) 4 targets. Besides the national examinations at grade 9 and grade 12, Cambodia also conducts school-based national and international assessments in sampled schools. Large-scale students' learning assessments include the national assessment at grades 3, 6, and 8 and the PISA-D. Cambodia is also a member of the Southeast Asian Primary Learning Metrics (SEA-PLM), a regional assessment initiated by the Southeast Asian Ministers of Education Association (SEAMEO) and the United Nations Children's Fund (UNICEF) in 2012. At the time of writing, SEA-PLM is yet to be conducted in Cambodia.

The Education Quality Assurance Department (EQAD) is in charge of monitoring and evaluating the quality and efficiency of education. One of the key EQAD tasks is the implementation of the national assessment at grades 3, 6, and 8 in Khmer language and mathematics. Prior to the establishment of the EQAD, the Inspection Department was in charge of the national assessment. The first national assessment was conducted with students at grade 3 in 2006. The results from grade 6 national assessment in 2013 indicated low performance of Cambodia students, as 76% of the students scored below basic writing proficiency and 39% of them are below basic reading proficiency.[1)]

With financial support from the Global Partnership for Education (GPE), Cambodia implemented two early grade reading assessments (EGRA) in 2010 and later in 2012 with students at grades 1 through 6. Similar to the national assessment results, the 2010 EGRA found that nearly half the sampled students could not understand what they read (Tandon & Fukao, 2014). After the successful implementation of the EGRA, the first early grade mathematics assessment (EGMA) was conducted in 2015 with students in grades 1, 2, and 3. Implementation of both EGRA and EGMA is led by the Primary Education Department, not the EQAD (RTI International, 2015). (Note: we tried to obtain the EGMA results but to no avail.)

PISA-D, a one-off pilot project directed by the OECD, is the first international standardized test in Cambodia that can be used for comparison with other countries. Seven countries around the world took part in the school-based PISA-D test in 2017. Less than 30% of 15-year-old children in Cambodia are considered to be eligible candidates to participate in the test, meaning more than two-thirds of them are either out of school or in grades 6 and lower (OECD, 2018a)[2]. It is much lower than the OECD average of 89% and the average across PISA-D countries at 43%. Results from PISA-D shown in Table 1 reveals that Cambodian performance in all three subjects is below the average of lower-middle-income countries and well below the OECD average. Cambodia outperforms two African countries, Senegal and Zambia, but underperforms compared to other Latin American countries. Even more worrisome, less than 10% (8% in reading and 10% in mathematics) of the students achieve the minimum level of proficiencies, set in the SGD 4 targets, that all children should obtain before leaving lower secondary. If all 15-year-old children including those ineligible children were included, the result could be much worse.

Table 1　PISA-D Performance in Reading, Mathematics, and Science by Country

				SDG 4 Indicators	
	Reading	Mathematics	Science	Minimum Level of Proficiency in Reading	Minimum Level of Proficiency in Mathematics
	Mean	Mean	Mean	%	%
Cambodia	321	325	330	7.5	9.9
Ecuador	409	377	399	49.4	29.1
Guatemala	369	334	365	29.9	10.6
Honduras	371	343	370	29.7	15.4
Paraguay	370	326	358	32.2	8.3
Senegal	306	304	309	8.7	7.7
Zambia	275	258	309	5.0	2.3
OECD	493	490	493	79.9	76.6
Lower-middle	378	368	392	37.7	28.7

Source: PISA-D Results in Focus

3 Literature Review

3. 1 Demand-side Factors

The existing literature both in Cambodia and beyond suggests that females are likely to excel in reading but underperform in mathematics and science subjects in comparison to male students (Giannelli & Mangiavacchi, 2010; Marshall & Fukao, 2019; Nguon, 2012). Grade repetition and absenteeism are commonly found to be associated with low performance (Gones-Neto Hanushek, 1994). Almost 30% of the eligible students who participated in the PISA-D in Cambodia had repeated class one time or more. It is believed that pre-school experience helps prepare children for early grades in primary schools, but the quality of pre-school in Cambodia, especially in rural areas, is questionable. A recent impact evaluation study using randomized control trials (RCT) on the impact of community preschool construction in rural Cambodia could not find any significant short-term impact on child cognitive or socio-emotional outcomes (Berkes, et al., 2019). Since schools in Cambodia are operated in two shifts, students attend school only either in the morning or in the afternoon. While students from affluent families are likely to spend their free time attending extra classes, students from low socioeconomic status use the time to help their family generate extra income. Han and Fukui (2006) found that, in the case of Cambodia, combining school and work is not necessarily harmful to children's human capital accumulation as long as the working hours are not excessive. The majority of findings from the existing literature related to the effects of household resources and parental education are more consistent and are positively associated with student learning performance. Yet, some studies also suggest that parental education plays a less important role once students complete their primary or lower secondary education (Chea, 2019).

3. 2 Supply-side Factors

Beginning with the Coleman report (Coleman et al., 1966), the debate on the effects of school resources on student learning is still ongoing as studies on the topic have produced inconclusive results (Case & Deaton, 1999; Chowa, et al., 2015; Fuchs & Wößmann, 2008). Traditionally, it is believed that small class size is good for student learning; however, findings from empirical studies on the effect of class size on the quality of learning are not always positive. Studies in 11 countries using TIMSS data found the effect of class size only in some countries where teachers are not well paid (Wößmann & West, 2006). Applying a regression-discontinuity design (RDD) approach with the cut-off line at 40 students per class in Israel's public schools, Angrist and Lavy (1999) found the positive effect of smaller class size on learning achievement among students in grades 4 and 5 but not for third-grade students. A systematic review of the effect of school size on student learning suggests mixed results of its effect, as some studies suggest students learn better in small schools, while others detect the positive effect of school size on learning achievement (Greenwald, et al., 1996; Newman et al., 2006). In some cases, the relationship between school size and learning achievement is detected in inverse-U shaped form (Giambona & Porcu, 2018). School resources tend to be strongly associated with learning outcomes in developing countries, but it is found to have little or no effect on learning in developed countries (Glewwe et al., 2011). Grouping students by ability levels and provision of remedial classes are less common in other countries and less explored in comparison to other school-level variables.

4 Method

4.1 Sample and Data

Our empirical analysis is based on data from the PISA-D. Developed by the OECD in 1997, PISA is conducted every three years to assess the knowledge and skills in reading, mathematics, and science. In 2018, more than 600,000 15-year-old students from 79 countries and economies participated in the seventh PISA assessment (Crawfurd, et al., 2019). In 2014, the OECD initiated and launched the PISA-D in collaboration with interested countries to enable greater participation from low- and middle-income countries. It also aims at contributing to monitoring the progress toward the achievement of the Education Sustainable Development Goals (SDGs). Cambodia is one of the eight countries to join the PISA-D pilot project in 2017.

PISA-D uses a two-stage stratified sampling design to select the participants. In the first-stage sampling, 170 schools were sampled systematically from individual schools with eligible students. After schools are sampled, 5,162 15-year-old students in grade 7 and higher were selected from the sampled schools in the second-stage (MoEYS, 2018; OECD, 2018b). Two-hour tests in reading, mathematics, and science were administered in December 2017 at the sampled schools across Cambodia. PISA-D does not only provide information about students' learning performance, but also students' demographics and contextual variables such as gender, economic activities, parental education and occupation, and social-economic status. More importantly, through school and teacher surveys, PISA-D also collects information on the supply-side that is normally unavailable in household surveys.

Similar to other large-scale international assessments, PISA-D does not use the traditional

Table 2 Summary Statistics

Variables	Full Sample				Sub-sample		
	Mean	Std. Dev.	Min	Max	Urban	Rural	Dif
Learning Outcomes							
Reading	333.13	53.141	143	520	357.83	320.96	36.87
Mathematics	340.36	64.490	102	569	370.75	325.39	45.36
Science	340.41	41.460	144	508	356.03	332.72	23.31
Demand-side Factors							
Female	0.54	0.498	0	1	0.54	0.55	−0.01
Grade	9.76	1.099	7	12	10.09	9.60	0.48
Repeat	0.28	0.449	0	1	0.21	0.31	−0.10
Household Resources	5.26	0.834	3	9	5.82	4.98	0.84
Attend Pre-school	0.54	0.498	0	1	0.63	0.50	0.13
Long Absence	0.07	0.254	0	1	0.06	0.07	−0.01
Skip School	0.05	0.224	0	1	0.06	0.05	0.01
Paid Work	0.18	0.386	0	1	0.09	0.23	−0.13
Family Work	0.43	0.496	0	1	0.22	0.54	−0.32
Mother Literate	0.62	0.485	0	1	0.74	0.56	0.18
Father Literate	0.78	0.411	0	1	0.87	0.74	0.13
Supply-side Factors							
Urban	0.33	0.470	0	1	−	−	−
Class Size	44.27	12.548	13	53	44.89	43.97	0.92
School Size	1,344.68	938.648	67	5,111	1791.34	1124.68	666.66
Public School	0.90	0.303	0	1	0.74	0.97	−0.23
School Infrastructure	4.22	1.022	3	10	4.96	3.85	1.10
Ability Grouping	0.38	0.485	0	1	0.41	0.36	0.05
Remedial Classes	0.62	0.485	0	1	0.65	0.60	0.05
Teacher Absence	0.57	0.496	0	1	0.41	0.65	−0.24
Observations	**3,109**				**1,026**	**2,083**	

Source: Created by the authors based on the Cambodia PISA-D (2017)

scaling approach due to missing data from the observed item responses. Instead, PISA-D uses Item Response Theory (IRT) to impute ten plausible values (PVs) for each subject, based upon student responses to the test items they were given and the performance of students with similar characteristics. Each student was assessed using one of 12 possible versions of test booklets prepared based on a common pool of 195 test items. The use of different test booklets is to ensure that at the country level, it can measure a wide range of knowledge and skills for international comparisons (MoEYS, 2018). For the detailed scaling procedures, please see the OECD (2018b)'s PISA-D technical report.

In this study, learning achievement is measured by the test scores of reading, mathematics, and science. The averaged PVs of each subject are estimated from the ten PVs and used for the analysis. Table 2 presents the summary statistics of students' test scores, demand-side variables, as well as supply-side variables. Although 5,162 students from 170 schools participated in the PISA-D in Cambodia, after dropping observations with missing values or non-applicable values, only 3,109 students from 119 schools remain. This is because a large number of schools do not provide complete information. The average mathematics score is higher than reading and science scores, yet it is also the most dispersed. Graphs in Appendix 1-3 show that students' test scores are very scattered within school, and the average test scores at the school level also highly fluctuate in Cambodia. Simple mean comparisons between urban and rural subsamples suggest that there are regional disparities in learning performance in all three subjects. As expected, there are fewer students attending private schools, and teacher absenteeism in rural schools is much higher.

4.2 Methodology

In PISA-D, students are nested within schools. Since it is likely that school choices are influenced by students' social backgrounds or prior performances, the simple OLS method would not be able to deal with the hierarchical structure of the data. As recommended by the OECD, Hierarchical Linear Modeling (HLM) is more suitable for our analysis as it incorporates the existence of hierarchical structure by allowing residual components at each level (Aitkin & Longford, 1986; Raudenbush & Bryk, 2002). This study employed a two-level multilevel model and incorporated both demand-side and supply-side factors in the analysis framework. An important assumption of the HLM approach is that the residual or within-group errors should be normally distributed (Raudenbush & Bryk, 2002). To confirm whether the HLM approach is appropriate, the null model, also known as the empty model, in which only the intercept is tested to check if there is any significant between-school variation. The level 1 and level 2 equations of the null model can be expressed as follows:

$$\text{Level 1} \quad y_{ij} = \beta_{0j} + \varepsilon_{ij} \tag{1}$$

$$\text{Level 2} \quad \beta_{0j} = \beta_{00} + \mu_{0j} \tag{2}$$

where y_{ij} is the mean of plausible values of test scores of student i in school j, β_{0j} is the intercept of the level 1 model. The error terms at level 1 and 2 are denoted by the ε_{ij} and μ_{0j}. From the equation (1) and (2), two components, fixed part (β_{00}) and random part ($\mu_{0j} + \varepsilon_{ij}$) can be decomposed. Let's present σ^2 as the variance within schools at level 1, and τ^2 as the variance between schools at level 2. Intraclass correlation (ICC) ρ can be estimated as:

$$\rho = \frac{\tau^2}{\tau^2 + \sigma^2} \tag{3}$$

The Intraclass correlation (ICC) ρ ranges from 0 to 1. A high ρ closed to 1 indicates that a large proportion of total variance can be explained by between-school differences, while a low ρ closed to 0 means there is little difference in between-school variances as most variance differences are within schools at the student level. When $\rho \neq 0$ the traditional OLS regression is not recommended for its results can be misleading (Goldstein, 1999).

The two-level random intercept regression model for student i in school j can be written as follows:

$$y_{ij} = \beta_{00} + \sum_{m=1}^{p} \beta_m Student_{mij} + \sum_{n=1}^{s} \beta_n School_{nj} + \mu_{0j} + \varepsilon_{ij} \quad (4)$$

where $Student_{mij}$ is a set of m observed variables of student i in school j observed at student-level and $School_{nj}$ is a set of n observed school-level variables of school j.

5 Results

This section begins with the reports of the null model, also known as the empty model, that contain only the fixed effect (intercept) and variances at student and school levels. The null models are used to decompose total variances in test scores of each subject into variances at school and student levels, based on which the intraclass correlations (ICCs) ρ are calculated. Table 3 presents the school-level and student-level variances in reading, mathematics, and science test scores. The ICCs in the reading, mathematics, and science models are statistically different from zero at 0.34, 0.38, and 0.31, respectively. This implies that over 30% of the differences in test scores can be explained by the between-school differences. The results from the null models confirm that it is more appropriate to use the HLM models for our main analysis.

Table 3 Results of Null Models

	Reading		Math		Science	
Fixed Effect						
Intercept	312.40***	(2.799)	314.51***	(3.507)	323.70***	(2.098)
Random Effects						
School Level	1228.52***	(145.324)	1947.12***	(227.335)	681.68***	(81.817)
Student Level	2320.56***	(46.456)	3185.23***	(63.760)	1502.30***	(30.078)
ICC	0.34***	(0.027)	0.38***	(0.027)	0.31***	(0.026)
Group	170		170		170	
Obs.	5,162		5,162		5,162	

Source: Created by the authors based on the Cambodia PISA-D (2017)
Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.10

5. 1 Factors Affecting Student's Learning Achievement

The HLM results of demand-side and supply-side factors associated with students' test scores by subject are reported in Table 4. Models with only demand-side variables are reported in columns (1), (3), and (5), while in columns (2), (4), and (6), supply-side variables are added to the models. When demand-side variables are incorporated into the models, between-school variances captured by ICC values are roughly halved to 0.168, 0.175 and 0.156 for reading, mathematics, and science models, respectively. The between-school variances further decrease after supply-side factors are added to the models. However, the coefficients of the ICC remain statistically significant in all models.

Our results indicate that females are likely to perform better in reading but are outperformed by their male counterparts in mathematics. In science, although the female coefficient is negative, the difference is not statistically significant. PISA-D targets only students aged 15 years old regardless of the grade they attended at the time of the survey. As late entrance and repetition are quite common in Cambodia, the grade of 15-year-old students in our sample varies from grade 7 to grade 12. In the PISA-D survey, students below grade 7 are excluded from eligible students. The results indicate a strong association between student grade and learning achievement. An increase in one grade can lead to an increase of 18 score points in reading, 22 score points in mathematics, and 15 score points in science.

Grade repetition is found to be negatively correlated with the test scores of all the three subjects. The effect of grade repetition on performance is even more noticeable in reading than in mathematics and science subjects. From our results, pre-school experience before entering primary school shows some long-term effects on mathematic test scores, but it fails to show any statistically significant effect on reading and science test scores. School participation— represented by a dummy variable of long absence (whether the student misses his/her class more than three months in a row or not) and a dummy variable of skipping schools in the last two weeks—are both found to adversely influence student's learning achievement.

As documented in many other studies, this study confirms that child labor can impede the learning of children, while family resources help contribute to better learning outcomes of children. The study categorizes economic activity into paid work and unpaid family work and finds that both types of economic activities have similar adverse effects on student learning performances in all three subjects. Family resources, the proxy of socioeconomic status in this study, is an index calculated based on weighted likelihood estimates (WLEs) using the score of household possessions, such as shared toilet, books at home, television, washer, computer, and car.

Table 4 HLM Results on Student's Academic Performance

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Reading		Math		Science	
Female	10.489***	10.600***	-7.864***	-7.770***	-1.839	-1.859
	(1.477)	(1.474)	(1.776)	(1.772)	(1.189)	(1.188)
Grade	17.805***	17.553***	22.161***	21.577***	15.128***	14.901***
	(0.844)	(0.848)	(1.013)	(1.023)	(0.675)	(0.688)
Repeat	-8.992***	-8.824***	-4.481**	-4.101**	-5.055***	-4.973***
	(1.731)	(1.725)	(2.081)	(2.075)	(1.392)	(1.392)
Attend Preschool	-0.170	-0.685	4.580**	4.113**	0.236	-0.037
	(1.554)	(1.545)	(1.868)	(1.860)	(1.250)	(1.247)
Long Absence	-16.194***	-15.680***	-18.082***	-17.595***	-12.411***	-12.113***
	(2.936)	(2.922)	(3.530)	(3.515)	(2.362)	(2.357)
Skip School	-16.098***	-16.115***	-15.444***	-15.404***	-9.178***	-8.967***
	(3.285)	(3.278)	(3.950)	(3.942)	(2.644)	(2.643)
Paid Work	-9.615***	-9.123***	-6.433***	-5.911**	-9.112***	-8.930***
	(2.022)	(2.012)	(2.431)	(2.420)	(1.627)	(1.623)
Family Work	-6.423***	-5.512***	-5.803***	-4.695**	-4.922***	-4.425***
	(1.589)	(1.591)	(1.910)	(1.914)	(1.277)	(1.284)
Family Resource	6.045***	4.443***	9.260***	7.408***	3.224***	2.322**
	(1.123)	(1.146)	(1.349)	(1.379)	(0.900)	(0.925)
Mother Literate	6.389***	6.588***	9.826***	10.059***	5.722***	5.835***
	(1.721)	(1.714)	(2.069)	(2.062)	(1.385)	(1.383)
Father Literate	7.712***	7.735***	15.732***	15.605***	7.882***	7.836***
	(1.962)	(1.955)	(2.359)	(2.351)	(1.579)	(1.576)
Urban		9.226**		11.773**		4.429
		(3.843)		(4.775)		(3.301)
Class Size		0.022		0.207		0.048
		(0.113)		(0.140)		(0.096)
School Size		-0.000		-0.000		-0.001
		(0.002)		(0.002)		(0.002)
Public School		-17.993***		-20.850***		-11.561**
		(5.763)		(7.169)		(4.962)
School Infrastructure		5.624***		5.456***		3.247**
		(1.683)		(2.095)		(1.450)
Ability Grouping		-0.639		1.052		0.102
		(2.851)		(3.547)		(2.455)
Remedial Class		-6.914**		-0.505		0.532
		(2.930)		(3.644)		(2.521)
Teacher Absence		1.751		1.695		5.010*
		(3.121)		(3.880)		(2.684)
Constant	120.213***	122.968***	64.674***	62.027***	173.080***	171.742***
	(9.431)	(13.701)	(11.321)	(16.819)	(7.533)	(11.501)
Random Effects						
School Level	316.863	142.287	472.347	227.251	185.098	110.873
	(46.201)	(27.651)	(69.249)	(42.874)	(26.893)	(20.364)
Student Level	1562.037	1557.772	2,220.476	2254.937	999.046	1011.205
	(35.737)	(40.294)	(50.837)	(58.326)	(22.833)	(26.152)
ICC	0.168	0.083	0.175	0.091	0.156	0.099
	(0.0208)	(0.015)	(0.0216)	(0.016)	(0.0195)	(0.017)
Observations	3,109	3,109	3,109	3,109	3,109	3,109
Number of Groups	119	119	119	119	119	119

Source: Created by the authors based on the Cambodia PISA-D (2017)
Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.10

Ranking from 0 to 10, a higher score in family resources indicates a wealthier family. Based on the magnitude of the coefficient, the effect of family resources becomes smaller when supply-side factors are incorporated into the models. It is worth noting that the influence of family resources on mathematics performance is larger than on reading and science.

Students in urban schools score higher than their rural counterparts in reading and mathematics tests; however, there is no significant difference between the two groups in science performance. Class size and school size measured by the number of students per class and school seem to have no influence on student learning in Cambodia. Other supply-side factors found to be influential on students' learning achievement are the type of school (public vs private) and school infrastructure. Student's enrolled in public schools show lower performances in all three subjects in comparison to their peers studying in private schools. Similar to family resources, school infrastructure is constructed using the WLEs method based on basic and advanced infrastructural features and facilities reported by school principals or administrators. These reported infrastructures include the condition of the school roof, floors, classrooms, toilets, running water, electricity, cafeteria, and sports facilities. An increase in one unit of school infrastructure can lead to an increase of 5.62 score points in reading, 5.46 score points in mathematics, and 3.25 score points in science. Although it is not compulsory, 27% of the 170 surveyed schools group their students by ability, organizing instruction differently for students with different ability levels for some subjects or all subjects. The full-sample analysis does not detect any significant difference in learning performances associated with this ability grouping practice in Cambodia. More than half of the surveyed schools offer remedial classes to slow learners, so that they can catch up with others. Our results show that remedial classes are negatively associated with reading performance but have no correlation with student performance in mathematics and sciences. We detect a link between teacher absenteeism and science test scores, but no association between teacher absenteeism and student performances in reading and mathematics subjects.

5. 2 Regional Differences in Factors Affecting Learning Achievement

Another key research question in this study is how demand-side and supply-side factors influence learning achievement differently in urban and rural areas. Table 5 presents the HLM results on learning outcomes by the regional sub-sample and subject. ICC results indicate that the between-school variances are relatively larger among rural schools in comparison to urban schools. The sub-sample analysis suggests some similarities and differences in effects of the

Table 5 HLM Results on Student's Academic Performance by Sub-sample

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Reading		Math		Science	
	Urban	Rural	Urban	Rural	Urban	Rural
Female	7.199***	11.989***	-9.438***	-7.321***	-3.522*	-1.196
	(2.513)	(1.808)	(3.075)	(2.164)	(2.081)	(1.446)
Grade	15.300***	18.680***	19.261***	22.608***	14.701***	15.188***
	(1.516)	(1.018)	(1.834)	(1.223)	(1.263)	(0.819)
Repeat	-12.503***	-7.407***	-7.574*	-2.739	-4.004	-5.117***
	(3.311)	(2.011)	(4.048)	(2.409)	(2.742)	(1.611)
Attend Preschool	0.601	-1.133	1.180	5.857***	-0.385	0.220
	(2.682)	(1.876)	(3.278)	(2.247)	(2.223)	(1.503)
Long Absence	-10.659**	-17.144***	-11.137*	-19.668***	-9.812**	-12.944***
	(5.390)	(3.453)	(6.585)	(4.135)	(4.467)	(2.764)
Skip School	-15.461***	-15.384***	-11.373*	-16.371***	-6.918	-9.796***
	(5.529)	(4.050)	(6.761)	(4.848)	(4.579)	(3.239)
Paid Work	-15.527***	-7.828***	-13.195**	-4.596*	-11.015***	-8.572***
	(4.551)	(2.234)	(5.560)	(2.676)	(3.772)	(1.789)
Family Work	-4.712	-5.409***	-5.822	-3.836*	-4.080	-4.252***
	(3.099)	(1.842)	(3.786)	(2.205)	(2.569)	(1.474)
Family Resource	11.046***	-1.363	13.385***	2.286	5.604***	-0.575
	(1.675)	(1.564)	(2.036)	(1.874)	(1.392)	(1.252)
Mother Literate	4.671	7.956***	9.751**	10.974***	2.831	7.085***
	(3.360)	(1.983)	(4.102)	(2.374)	(2.786)	(1.587)
Father Literate	5.196	8.680***	11.851**	16.694***	10.148***	7.470***
	(4.234)	(2.194)	(5.175)	(2.627)	(3.509)	(1.755)
Class Size	0.093	0.060	0.175	0.299*	0.038	0.140
	(0.211)	(0.133)	(0.232)	(0.164)	(0.187)	(0.113)
School Size	-0.001	-0.001	-0.002	-0.001	0.000	-0.005**
	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)	(0.002)
Public School	-11.570*	-20.563*	-11.722*	-22.184	-12.275**	-6.976
	(6.273)	(11.612)	(6.768)	(14.360)	(5.618)	(9.908)
School Infrastructure	7.375***	4.540	8.620***	2.932	3.207*	4.704*
	(1.919)	(2.845)	(2.042)	(3.518)	(1.732)	(2.427)
Ability Grouping	-10.620**	3.924	-13.419***	7.564*	-6.273	3.660
	(4.401)	(3.526)	(4.691)	(4.357)	(3.966)	(3.004)
Remedial Class	-6.488	-7.930**	-8.804*	1.694	-1.249	1.545
	(4.644)	(3.546)	(4.950)	(4.379)	(4.186)	(3.017)
Teacher Absence	-2.585	3.280	-1.907	2.447	5.287	5.609*
	(5.318)	(3.675)	(5.685)	(4.540)	(4.785)	(3.130)
Constant	112.083***	142.566***	64.433***	78.457***	162.280***	170.138***
	(20.767)	(21.758)	(24.165)	(26.708)	(17.803)	(18.299)
Random Effects						
School Level	86.362	144.176	78.5149	226.381	77.224	110.3706
	(38.176)	(32.730)	(46.678)	(49.694)	(29.306)	(23.965)
Student Level	1541.852	1542.986	2314.811	2209.42	1055.833	985.638
	(69.530)	(48.748)	(104.736)	(69.787)	(47.505)	(31.149)
ICC	0.053	0.085	0.032	0.092	0.068	0.100
	(0.022)	(0.018)	(0.019)	(0.019)	(0.024)	(0.020)
Observations	1,026	2,083	1,026	2,083	1,026	2,083
Number of Groups	36	83	36	83	36	83

Source: Created by the authors based on the Cambodia PISA-D (2017)

Standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.10$

factors on the test scores.

Similar to the full-sample analysis, female students seem to perform better in reading than male students, but are outperformed in mathematics both in urban and rural areas. In addition, female students in urban areas are likely to score less in science, although in rural areas the difference is not statistically significant. The effects of grade attended, long absence from school, and skipping class among students in urban and rural areas are very similar to the aggregate sample. Nevertheless, the sub-sample results do not detect significant negative association between repetition and learning outcomes in mathematics test scores among students of rural schools and in science among students of urban schools. Paid work is found to be harmful to learning of students both in urban and rural areas; however, the adverse effect of family work on learning is detected only among students living in rural areas. For students in urban schools, family resources is an important factor to help them achieve higher performance, but it fails to show any significant influence among students in rural areas in the three subjects. The results suggest that in rural areas, mother's and father's education measured by their ability to read and write is more important than in urban areas.

Related to the supply-side factors, there is no significant correlation between either school size or class size and learning outcomes in urban areas. We only find positive relationship between school size and student performance in mathematics in rural areas and minimal negative effect of class size on science test scores in rural areas. Urban students enrolled in public schools tend to score lower in all subjects in comparison to their peers in private schools. Nevertheless, results from the rural sub-sample are less clear-cut as the negative effect is statistically significant only in the model of reading tests. Grouping children by their abilities seems to produce different results as well. While ability group adversely affects learning outcomes (reading and mathematics) in urban areas, it helps improve mathematics learning in rural areas. For the effect of remedial class, it is found to be negatively associated with reading test scores among rural students and with mathematics test scores among urban students. The results do not show any noticeable association between teacher absenteeism and learning outcome even when the sample is divided by urban-rural areas.

6 Discussion and Conclusion

This study presents some evidence that student learning achievement is strongly associated with demand-side factors but less so with supply-side factors. The variance decomposition reveals that differences in Cambodian PISA-D's test scores can be explained by between-school variation around 30-40%. Overall the findings in this study suggest that females perform better in reading but worse in mathematics in comparison to their male peers; this is consistent with previous studies (Chowa et al., 2010; Giannelli & Rapallini, 2019). The findings from the sub-sample analysis are also similar both for students in urban and rural schools. It is understandable that females are likely to have more interest in reading. A study conducted at 35 Cambodian high schools reveals that females have lower self-efficacy in mathematics and science than male students (Keo et al., 2019). Our results show that grade repetition, long absence from school, and skipping class are found to adversely affect students' learning. In Cambodia, there is no automatic promotion policy, hence students repeat their grade if they cannot achieve the required minimum score or are absent from school for too long. In other words, it can also be said that repetition is a result of low-performance and vice versa.

Both paid work and family work are found to impede students' learning in Cambodia, but our sub-sample analysis reveals the negative effect of family work is statistically significant only among students in rural areas. Family work in this study is a dummy variable, whether an individual student is involved in family work or not. There is no information about the duration or intensity of the work. It is very likely that the duration of family work in rural areas is longer than in urban areas, which explains the adverse effect of family work among students in rural areas. Interestingly, the sub-sample analysis reveals that family wealth can contribute to students' learning in urban areas only. In Cambodia, private tutoring or fee-based extra classes after school are well distributed in urban areas, especially in the Phnom Penh capital (Tandon & Fukao, 2014). Students from better-off families are likely to benefit from the extra investment of private tutoring, while students in rural areas have fewer opportunities to take advantage of extra classes even though they can afford the fees. As Marshall and Fukao (2019) suggest, achievement gaps in Cambodia are the result of private tutoring and being in rich or poor families is far less important. In other words, students from rich families are likely to perform poorly if they do not attend extra classes after school.

Related to supply-side factors, student learning achievement in Cambodia is well predicted by school type and school infrastructure, while the association between learning outcomes and other school-level predictors (school size, class size, ability grouping, remedial class, and teacher absenteeism) are either statistically insignificant or very weak. Results from the full-sample analysis indicate a strong effect of private school on learning outcomes, but its effect is rather weak in rural areas. A plausible explanation of this phenomenon could be that most of the private schools in rural areas are low-cost catering to low-income families and its quality is low.

In addition, based on the PISA-D data, only around 3% of students in rural areas are enrolled in private schools, while the private-school enrollment rate in urban areas is around 26%. The overall effect of school infrastructure on student's academic performance in Cambodia is positive in all three subjects. When the sample is grouped into urban and rural students, the effect in urban areas becomes larger, while the effect in rural areas disappears in reading and mathematics performance. Findings on the effect of school resources on student learning in other countries are mixed, yet oftentimes school resources are positively associated with student's learning outcomes in developing countries (Glewwe et al., 2011). The insignificant relationship between school infrastructure and academic performance in rural schools may suggest that resources are not effectively utilized in rural areas. Besides the type of school and school infrastructure, the study finds little or no association between other supply-side factors and student's learning performance.

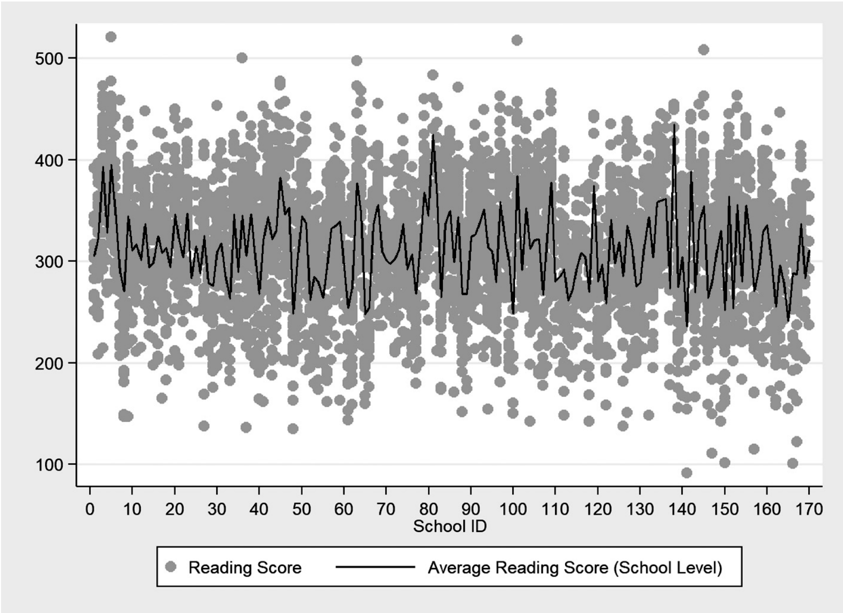
Notes

1) Students below basic reading could not comprehend even the most basic aspects of the reading curriculum, while students below basic writing scored less than 40% on the writing problems.

2) 15-years old students below grade 7 are excluded from eligible students

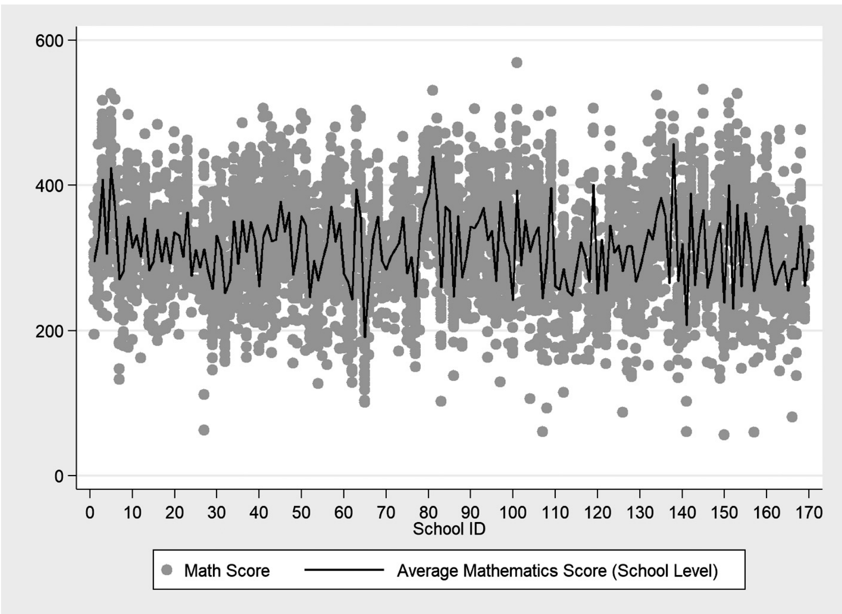
Appendix

Appendix 1 Scatter Plot of Reading Test Scores and Average Scores at School Level



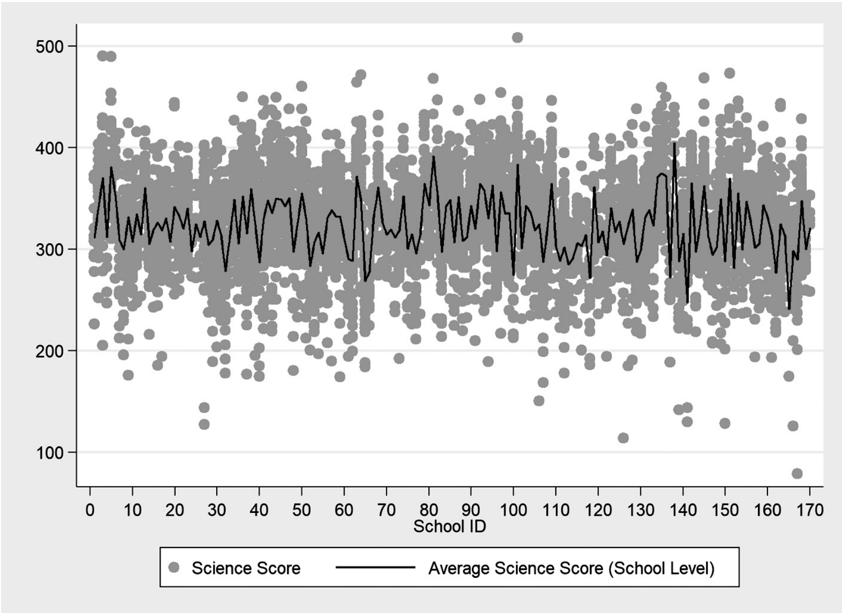
Source: Created by the authors based on the Cambodia PISA-D (2017)

Appendix 2 Scatter Plot of Mathematics Test Scores and Average Scores at School Level



Source: Created by the authors based on the Cambodia PISA-D (2017)

Appendix 3　Scatter Plot of Science Test Scores and Average Scores at School Level



Source: Created by the authors based on the Cambodia PISA-D (2017)

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