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Who Gains from Class Size Reduction? Another Look at Malaysia's "Lost Boys Phenomenon" in Student Achievement

(Siapa yang Mendapat Manfaat daripada Pengurangan Saiz Kelas? Satu Lagi Pandangan Fenomena "Lost Boys" Malaysia dalam Pencapaian Pelajar)

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ABSTRACT

In Malaysia, while the achievement gap between rural and urban schools is flattening over time, the gender achievement gap is widening. This study therefore re-examines the phenomenon of "Lost Boys" using data from the Trends in International Mathematics and Science Study (TIMSS. Gender differences in disruptive behaviour and disciplinary challenges may widen boy-girl academic performance difference and, if so, differential exposure to crowded classrooms can play a role. Alongside other hypothesis, therefore, we specifically explore the gender differentiated effects of class sizes on student achievement. Methodologically, we employ the two-step least squares and quantile regression methods. Findings show that decrease in class size statistically does not have a positive effect on student scores in mathematics and science regardless of gender. If anything, there is evidence that only high-achieving female students particularly from urban schools and advantaged socioeconomic backgrounds may benefit from reduction in class size incentive. While improving the quality of current teachers and certain school infrastructure such as school buildings, lightning systems, and classrooms as well as granting teacher incentives appears to improve boys' achievement scores, on the balance, it is unlikely that the boy-girl difference in maths and science test scores in Malaysia can be primarily explained by school level factors. We conclude by discussing alternative explanations related to our findings on class size as well as other cost-effective policy responses and non-school factors to tackling the "Lost Boys" phenomenon.

Keywords: Class size; student achievement; gender gap; school resources
JEL: I24, I28, C3

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ABSTRAK

Di Malaysia, sementara jurang pencapaian di antara sekolah luar bandar dan bandar semakin mendatar dari semasa ke semasa, jurang jantina adalah semakin ketara. Kajian ini oleh itu mengkaji semula fenomena "Lost Boys" menggunakan data daripada Trends in International Mathematics and Science Study (TIMSS). Jurang jantina dalam tingkah laku terganggu dan cabaran disiplin akan menambahkan perbezaan pencapaian akademik lelaki dan perempuan dan, jika itu berlaku, pendedahan berbeza dalam bilik darjah yang sesak mungkin memainkan peranan tertentu. Berpandukan kepada hipotesis yang lain, oleh itu, kami secara spesifiknya mengkaji kesan saiz kelas yang dibezakan berdasarkan jantina terhadap pencapaian pelajar. Secara metodologi, kami menggunakan kaedah kuasa dua terkecil dua langkah dan regresi kuantil. Dapatan menunjukkan bahawa pengurangan saiz kelas secara statistiknya tidak mempunyai kesan positif terhadap skor pelajar dalam matematik dan sains tanpa mengira jantina. Adapun, terdapat bukti bahawa hanya pelajar perempuan yang berprestasi tinggi terutamanya dari sekolah bandar dan latar belakang sosioekonomi yang berfaedah mungkin mendapat manfaat daripada insentif pengurangan saiz kelas. Sementara itu, meningkatkan kualiti guru semasa dan infrastruktur sekolah tertentu seperti bangunan sekolah, sistem pencahayaan, dan bilik darjah serta pemberian insentif guru dilihat mampu meningkatkan skor pencapaian lelaki, setaranya, adalah tidak mungkin bahawa perbezaan lelaki-perempuan dalam skor ujian matematik dan sains di Malaysia boleh dijelaskan secara utama oleh faktor tahap sekolah. Kami membuat kesimpulan dengan membincangkan penjelasan alternatif berkaitan dengan dapatan kami terhadap saiz kelas juga respon polisi yang kos efektif dan faktor-faktor bukan sekolah untuk menangani fenomena "Lost Boys" tersebut.

Kata Kunci: Saiz kelas; pencapaian pelajar; jurang jantina; sumber sekolah

INTRODUCTION

Inequality in student achievement despite the higher education budget is a long-debated issue among economics and education studies scholars (Blanden & Machin 2010; Hanushek 2006). In ASEAN countries, since the mid-2010s, there has been a substantial gender gap in the number of primary education completion rates (World Bank 2022a, 2022b). Malaysia, for instance, despite higher education expenditure (3.9% in 2020 of total GDP), the gender gap in primary education completion rates is consistently higher as compared to other ASEAN countries at 2 to 3 percent annually. Since the early 2000s, women has surpassed men in tertiary education in Malaysia (Asadullah 2020). Indeed, the Global Gender Gap report demonstrates that the enrolment ratio for tertiary education for Malaysia in 2020 between females and males is 1.23 to 1 (World Economic Forum 2019). Regarding academic achievement in international assessment, in all, two members of the ASEAN have participated in TIMSS: Malaysia from 1999 and Singapore from 1995, but Malaysia only participated in the Grade 8 assessment. Singapore has performed very well in TIMSS, while Malaysia has experienced a decline in performance. In 2011, the performance of Malaysian students dropped significantly and was lower than the benchmark, 440 points in mathematics and 426 points in science, similar performance has been observed in recent years. In addition, there is a pronounced gender differences in student attainment in both subjects, with the difference favouring girls, was 449 versus 430 and 434 versus 419 respectively. This trend may indicates that more actions is still needed to combat the challenges that reflects the "Lost Boys" issue as reported in the Malaysia Education Blueprint 2013-2025 (Preschool to Post-Secondary Education) and a study for Malaysia by Tienxhi (2017) and Asadullah (2020).

What is driving the boy-girl difference in educational achievements in Malaysia is not fully understood (for existing studies, see Nagaraj et al. (2014; 2016); Noman and Kaur (2022). In general, one can think of a number of gender differences in aspirations and behavioural traits and patterns (e.g. boys being more disruptive, lacking in focus and suffering from a range of other disciplinary issues compared to girls) which may combine to widen boy-girl academic performance difference. In addition, this may be also mediated through school level inputs. For instance, exposure to crowded classrooms can affected boys and girls differently. Several studies (Ballen et al. 2019; Ho & Kelman 2014) have shown that female students perform worse in large class sizes. This may be due to factors, for instance, a decrease in quality of teaching and incorporating controlled peer interactions in the classroom (Olagbaju & Nnorom 2019).

Indeed, there is a growing literature highlight the importance of smaller class sizes to tackle student achievement gaps (Alivernini et al. 2020; Pekkarinen 2012; Thijs et al. 2010). Recently in accordance to the Covid-19 pandemic, the Ministry of Education Malaysia has raised the issue of small class sizes after years of absence, since it was highlighted in the New Primary School Curriculum (NPSC) 1983 (Tee 2020). It was reported that the average class size for primary schools in Malaysia increased to 25.73 pupils per class in 2019 from 25.60 in 2018. Meanwhile, the number of pupils per class for secondary schools decreased to 20.94 pupils per class in 2019 as compared to 25.18 pupils per class in 2018 (Ministry of Education Malaysia 2020). This inconsistent up-and-down number of students per year in a class may affect student performance as argued by Mishel and Rothstein (2002) among others. Appropriate class size is important for student achievement and in turn can help improve school quality, human capital, and eventually, economic growth (Castelló-Climent & Hidalgo-Cabrillana 2012; Perera & Asadullah 2019; Hanushek 2013; Kenayathulla et al. 2019).

A number of studies have examined the impact of class size reduction on student achievement, see for instance Shen and Konstantopoulos (2021) and Kara et al. (2021) for recent studies, and the results were mixed. Most studies from developed countries find positive effects of small class sizes. See inter alia: Breton (2014) for Columbia and Cho et al. (2012) and Monks and Schmidt (2011) for the US. But, the effect of reducing class size was found to be small or insignificant in improving student attainment such as in studies by Breton (2014) for Columbia and Konstantopoulos (2008) for Tennessee. Similarly, existing studies in developing Asia context, see for instance, Asadullah (2005) for Bangladesh and Brown and Park (2002) for China, find a negative effect of reducing class size on student attainment even after controlling potential endogeneity for class size. The tentative findings have motivated this study to examine who benefits most from the effects of small class sizes in the Malaysian context? Taking lessons from the situation of e-learning due to the Covid-19 pandemic with the expectation of less interaction means small class sizes, positive effects are expected to be greater for students who are in the beneficial groups (Surianshah 2021). Are the boys in the group the most advantaged students?

This study mainly attempts to fill the gap in the literature on the issue of *"Lost Boys"* in Malaysia by examining the determinants of student achievement in maths and science scores with a particular focus on the effect of class size. More specifically, alongside class size variable, our models of student achievement by gender and school locations, also includes an extensive list of policy relevant variables as highlighted in the current Malaysian education policy documents such as

the 2013-2025 Malaysia Education Blueprint (MEB). In addition, the analysis acknowledges that there is an inverse causality effect between class size and student achievement due to school sorting effect.

In Malaysian public schools, the assignment of students in class may be random based on the institutional settings aside of students' prior achievement. While the ordinary least squares (OLS) is a common method to analyse the education production function of class size, a few studies attempted to extensively examine the model by addressing potential bias estimates in the baseline model (Borland et al. 2005; Gary-Bobo & Mahjoub 2013; Li & Konstantopoulos 2016). Asian studies context such as Asadullah (2005) and Brown and Park (2002) also emphasise the importance of controlling for endogenous effects of class size on student attainment. Asadullah (2005) found that reduction of class size in secondary schools in Bangladesh was inefficient. To the best of our knowledge, there is no research on this in Malaysian context and we chose to address the possible endogeneity problem of class size in this study. Since variables such as students' prior achievement are rarely available, in this study we focus on controlling for school factors that might directly affect the student sorting effect. Moreover, since finding credible instrument is a challenge, we only report two-step least squares method (2SLS) estimates for illustrative purposes. In addition, we report quantile regression estimates by gender to document who gains from small class size across the entire distribution of test scores.

We found that smaller class sizes did not improve student test scores in either subject, mathematics or science. However, it was found that only female students particularly from top scorers, urban schools and advantaged socioeconomic backgrounds tend to perform well in smaller class sizes. To tackle the *"Lost Boys"* issue, this research suggests schools especially with low-performing male students not to adapt small class sizes initiatives as they are found to benefit from other factors such as teacher quality and school infrastructure availability. Findings from this study perhaps may help the nation to achieve the Malaysia Education Blueprint 2013-2025: Preschool to Post-Secondary Education's aspiration of equity in education. In addition, action to reduce the performance gap for both subjects is crucial as they are among the STEM subjects that may drive economic growth towards the Industrial Revolution 4.0 (IR 4.0) (Hafni et al. 2020).

The rest of the paper is organized as follows. The next section presents the data and the descriptive analysis. It is followed by an outline of empirical strategy and the main empirical results. Finally, this paper concludes with a policy recommendation and conclusion section.

STUDY BACKGROUND

Education in Malaysia at public schools is generally free, with six years of free primary education and five

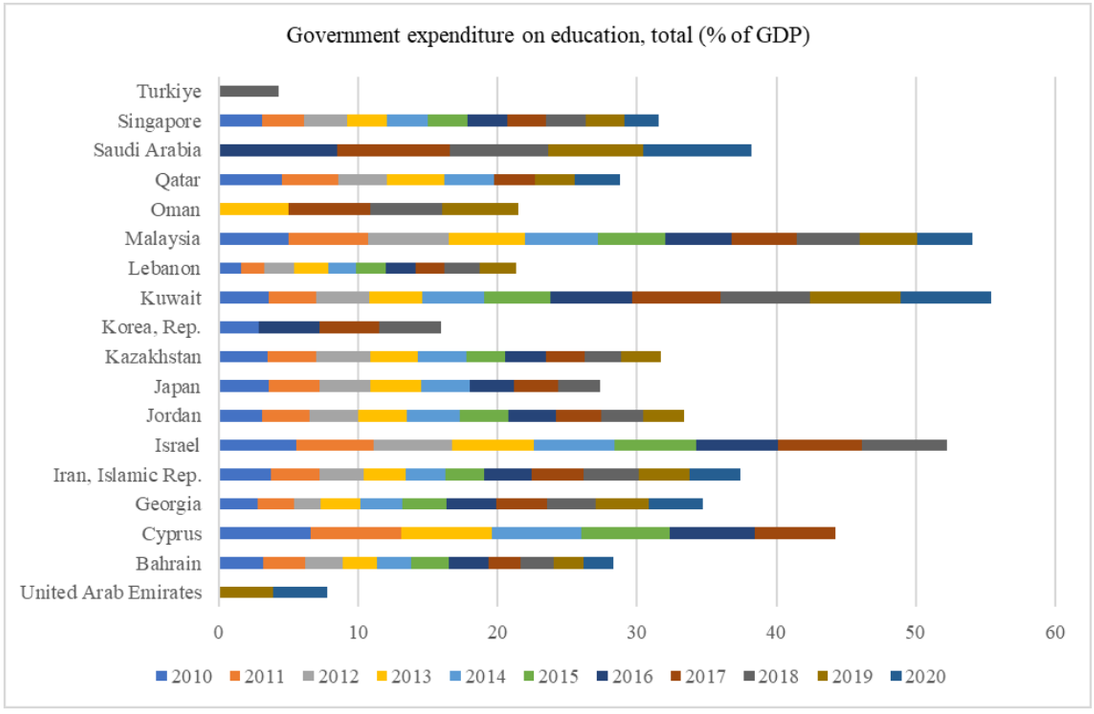

FIGURE 1: Government expenditure on education in Asia countries
Source: (World Bank 2022b)

years of free secondary education. Nevertheless, there are other contribution fees according to the requirement of schools such as activity fees, Parent-Teacher Association fees, and extra learning material fees. At the pre-university level, only small fees are required, with some institutions provide allowance and a level (i.e., certificate) with free of charge (StudyMalaysia.com 2020). However, at the university level, students are required to pay fees accordingly.

In the context of government spending, Figure 1 shows the comparison in government expenditure on education (as a percentage of GDP) in Asia. The figure confirms that Malaysia maintains in the top rank in spending on education in par with other developed and developing countries such as Kuwait, Saudi Arabia, Israel, and Cyprus, with at least 4 percent of GDP.

Despite high educational spending, compared to Cyprus and Israel, Malaysia has a low performance in the international assessment of Trends in International Mathematics and Science Study (TIMSS) throughout the year (see Table 1). The large gap in TIMSS test scores between Malaysia, and Cyprus and Israel may be due to differences in school quality- class size. In regards to gender gap in achievement, Table 1 shows the evidence that boys tend to perform lower than its counterpart girls in both subjects and in all of the Asia countries except Japan, Korea, and Singapore.

DATA AND DESCRIPTIVE STATISTICS

The dataset sourced from the Trends in International Mathematics and Science Study (TIMSS). This study uses the TIMSS 2011 dataset and is still relevant to refer to because it provides the last feedback for the educational policy of the Malaysian Education Blueprint 2006-2010. Findings from this study may provide some information to policy makers in improving current and future educational policies in Malaysia because policy formulation takes into account systematic analysis of evidence-informed policy formulation and implementation (Strehlenert et al. 2015). Data from the TIMSS 2011 is a dataset of eight-grade students from 180 public schools. In 2011, a total of 5,733 Malaysian students had participated in the survey. It shows that the average class size of the sample data set is 35 pupils. This is considerable high compared to the national average and implies the importance of further study on class size effects in Malaysia context in particular. In addition, the TIMSS dataset includes schools from all 13 states in Malaysia and consists of comprehensive information obtained from the students, teachers, and school principal in each participating school, making the data well suited for examining the educational production model in Malaysia.

TABLE 1. Average test scores in TIMSS versus class size by year and gender in Asia

Country Name	Mathematics						Science						Class size in 2019
	2011		2015		2019		2011		2015		2019		
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	
Bahrain	388	431	446	462	471	492	423	482	442	492	461	512	26
Cyprus					499	503					476	491	21
Georgia	430	432	453	454	457	465	415	425	443	444	446	447	24
Iran	411	418	435	438	440	453	472	477	454	459	441	459	28
Israel	512	520	510	512	514	525	512	519	504	510	515	512	26.5
Japan	574	566	585	588	595	593	562	554	571	570	575	565	33.5
Jordan	392	420	376	395	409	432	428	471	405	447	427	480	32
Kazakhstan	486	488			486	490	488	492			474	483	20
Korea	616	610	606	605	609	604	563	558	557	554	566	555	29
Kuwait			389	396	398	407			387	434	426	461	28
Lebanon	456	444	444	441	432	427	408	404	393	403	374	379	25
Malaysia	430	449	461	470	456	465	419	434	466	476	458	463	30
Oman	334	397	388	420	391	432	380	458	433	478	431	485	29
Qatar	404	415	434	440	440	447	406	432	441	471	461	488	25.5
Saudi Arabia	387	401	360	375	385	403	424	450	368	423	408	455	28.5
Singapore	607	615	616	626	614	617	591	589	597	596	611	604	35
Turkiye	448	457	455	461	490	501	475	491	484	503	510	520	27
United Arab Emirates	447	464	459	471	471	476	452	477	461	492	461	486	26

Source: IEA Trends in International Mathematics and Science Study TIMSS 2019

TABLE 2. Descriptive statistics

Variables	Boys		Girls		p-valuea
	Mean	SD/n	Mean	SD/n	
Test scores (mathematics)	431.75	93.46	449.58	82.10	0.00
Test scores (science)	419.85	102.61	433.63	90.30	0.00
Class size	34.50	6.71	35.39	6.37	0.00
Class size missing (1 = yes)	0.02	n=70	0.02	n=65	0.52
Instructional materials (base: a lot)					
Instructional materials (a little)	0.57	n=1608	0.56	n=1646	0.59
Infrastructure (base: a lot)					
Infrastructure (some)	0.31	n=860	0.27	n=787	0.00
Infrastructure (little)	0.28	n=775	0.31	n=912	0.00
IT staff (base: a lot)					
IT staff (a little)	0.45	n=1256	0.49	n=1427	0.00
IT staff missing	0.01	n=30	0.00	n=0	0.00
Computers per student	0.11	0.09	0.11	0.09	0.13
Computers missing (1 = yes)	0.02	n=64	0.03	n=74	0.52
Teacher incentives (1 = yes)	0.27	n=752	0.27	n=796	0.63
Teacher incentives missing (1 = yes)	0.01	n=17	0.00	n=11	0.22
Teacher hiring (base: difficult)					
Teacher hiring (easy)	0.48	n=1351	0.55	n=1605	0.00
No teacher hiring	0.41	n=1152	0.36	n=1058	0.00
Teacher hiring missing	0.01	n=33	0.01	n=18	0.03
Principal attendance in leadership activities (base: low)					
Principal attendance in leadership activities (high)	0.41	n=1156	0.42	n=1219	0.59
Principal attendance in leadership activities missing	0.00	n=9	0.01	n=16	0.19
Parental involvement in school (base: low)					
Parental involvement in school (high)	0.29	n=818	0.33	n=955	0.00
Parental involvement in school (medium)	0.53	n=1505	0.50	n=1461	0.01
Students come from disadvantaged homes (> 50)	0.41	0.49	0.41	0.49	0.48
Students come from disadvantaged homes missing	0.02	0.13	0.03	0.17	0.00
Rural	0.60	0.49	0.62	0.48	0.11
Instructional time (6 and more hours)	0.47	0.50	0.50	0.50	0.03
Instructional time missing	0.15	0.35	0.14	0.35	0.58
Student family background					
Mother‘s education (base: no formal or primary)					
Secondary	0.39	0.49	0.47	0.50	0.00
Tertiary	0.19	0.39	0.20	0.40	0.39
Child‘s does not know	0.33	0.47	0.21	0.41	0.00
Missing	0.01	0.10	0.01	0.08	0.10
Father‘s education (base: no formal or primary)					
Secondary	0.35	0.48	0.43	0.50	0.00
Tertiary	0.22	0.41	0.22	0.42	0.79
Child‘s does not know	0.36	0.48	0.26	0.44	0.00
Missing	0.01	0.10	0.01	0.09	0.90
Home possessions					
One and more bookcases	0.28	0.45	0.36	0.48	0.00

cont.

cont.

Books availability missing	0.00	0.06	0.00	0.04	0.15
Reading resources (low)	0.34	0.47	0.17	0.37	0.00
Reading resources missing	0.01	0.10	0.01	0.10	0.91
Technology resources (low)	0.63	0.48	0.65	0.48	0.12
Technology resources missing	0.01	0.12	0.02	0.14	0.12
Study room (low)	0.44	0.50	0.42	0.49	0.15
Study room missing	0.01	0.08	0.01	0.10	0.37
Number of observations	2815		2918		

Notes: *Significant at the 10% level. **Significant at the 5% level. *** Significant at the 1% level. The test scores refer to the average of students' five plausible values in the test. The plausible values refer to the range of competence that a student might have, given the student's item responses in an assessment. P-valuea is the value of the test of difference or the t-test, which is the test of mean difference of continuous variables by gender, and the Chi-squared test, which is the test of mean differences between the categorical variables and students' gender. A variable with the sentence "missing" on the back means that the variable's data is not available to the student.

The two-stage random sampling design was used to conduct the TIMSS survey (see TIMSS 2011 Assessment Design (2013) for further details on the sampling design). Briefly, the design begins with selecting a random sample of schools in Malaysia and then within each of these schools, one class in the eighth-grade is chosen randomly. Every student in the class was then assigned randomly with only one booklet of an assessment, and the TIMSS used all available data from the student's responses to the assessment, including the student's background and school characteristics to impute the student's test scores or "plausible values". According to Wu (2005), the plausible values refer to the range of competence that a student might have given the student's item responses in an assessment. The TIMSS chose to use the imputation process due to the complicated matrix-sampling design that has been used in the assessment.

This study uses the average of students' five plausible values in mathematics or science as a measure of students' achievement. It considers school factors that have been outlined within the Malaysia Education Blueprint 2013-2025 (MEB). These include the interested variable of class size and other factors such as school instructional materials, infrastructure, IT staff, computers per student, teacher incentives, teacher hiring, principal's attendance in leadership activities, and parental involvement in school.

Table 2 shows the descriptive statistics of the TIMSS sample. On average, girls achieve statistically significantly higher test scores than boys. They are more likely to be in a large class with approximately attended by 35 students. In terms of other school characteristics, we found that most students attend schools with an appropriate supply of school resources such as instructional materials (e.g., textbooks, papers, and pencils), infrastructure (e.g., school buildings, lightning systems, and classrooms), and IT staff, had no difficulty in hiring new teachers. However, most of them attend schools with limited principal attendance in leadership activities and parental involvement in school. All of the school variables also show a significant difference by gender except instructional materials, teacher incentives, and school principals' role, indicating the appropriateness of this research to analyse the education production model by gender.

In term of students' family background, a majority of the students have secondary education parents and low number of home possession such as books, technology resources and do not have their own study room. Overall, only parental education and reading resources show a significant difference based on student gender.

EMPIRICAL MODEL

This study estimates the education production function based on TIMSS data using the ordinary least squares (OLS) model. In addition, we report quantile regression estimates as well as the two-step least squares (also known as instrumental variable (IV) model) to address potential endogeneity problems in the baseline estimates.

In general, the education production function for each observation student i from school s can be written as follows:

$$T = \alpha_0 + \alpha_1 X + \beta_j D_j + \mu \quad (1)$$

where T is the measure of student achievement, student i's test scores in mathematics or science in eighth-grade class in school s and X is the vector of class size. D is the vector of j control variables such as school factors of school resources (i.e. instructional materials, infrastructure, IT staff, and computer availability), teacher incentives, teacher hiring, principal's role in attending leadership activities, and parental role in supporting their child's performance; student i's family background and school characteristics. μ is an error term.

The student test scores refer to student average plausible values, which is the range of competences that a student might have, given the student's item responses in an assessment (Wu 2005). Besides by gender, this study examines equation (1) for two blocks of common school location (urban-rural) with the aims in providing appropriate school policy responses according to the sub-samples. It also considers a weighted sampling in the OLS estimation to provide an educational production model which can be interpreted nationally. However, it is important to note that, the TIMSS dataset for Malaysia only considered one class for each school and this may give a small effect in the weighted estimations.

The quantile regression method was developed by Koenker and Bassett (1978). The method enables us to examine the effect of class size at different intervals throughout the student's test scores distribution. IV approach is used to handle possible endogeneity problem from measurement error in the model estimates. West and Wößmann (2006) and Lazear (2001) have shown that sorting practices may lead to measurement errors in estimation. This is because placement of students in class may be determined by factors such as students and teachers' characteristics as well as school environment. Unlike previous studies, this study focusses on handling the sorting effect problem from the school factors context as we try to include all relevant school factors embark by the government through its current educational policy, MEB 2013-2025. This measures perhaps may help the government to evaluate the effectiveness of the attributes in the policy.

The instrumental variable (IV) model with two-stage least squares (2SLS) estimator can be written as follows:

$$T = \alpha_0 + \alpha_1 X + \alpha_2 \hat{X} + \beta_j D_j + \mu \qquad (2)$$

where X is an endogenous variable, class size, and $\hat{X}$ is the predicted result from the following first-stage estimation of equation (3)

$$\hat{X} = \delta_0 + \rho_k Z_k + \delta_1 X + \gamma_j D_j + \varepsilon \qquad (3)$$

where Z_k for k = 1, …, q are the q instruments for the class size i.e. the eighth-grade size and school size. Evidence from IV studies of class size effects, for 11 countries in the TIMSS database and 649 elementary schools in the US respectively have shown the effect of grade size (Wößmann & West 2006) and school size (Hoxby 2000) instruments for the class size model. As there is one class per grade is tested in each school in Malaysia, we cannot compute the average class size of each grade directly. However, we have information from a school-principal questionnaire on the average class size of each grade in each school. Thus, as Wößmann and West (2006) concluded that there is no reason to expect that the average class size would affect students' performance than through its effect on the actual class size. In addition, a restriction on maximum class and school sizes in Malaysia with exceptional situations such as remote schools, presumably create a high correlation between them with the actual class size experience by the students in particular grade. Humlum and Smith (2015) have shown that the direct effect of school size on student performance is limited due to institutional settings. Therefore, with limited resources, schools generally do not have flexibility in allocating class size across grades in response to differences in the performance of students in a specific class.

Statistically, to check the validity of the instruments, we first look at the significant result of Wooldridge's (1995) robust score test, which shows whether class size is an endogenous variable or not. In other words, Wooldridge's (1995) score test that refers to the endogeneity test will tell whether the baseline OLS model yields bias estimates or not. We then identify the significant results of the F-statistic of the first-stage regression of equation (3), which affirms whether the selected instruments are not weak. A strong instrument is one that is highly correlated with the endogenous variable and satisfies Stock et al. (2002) suggestion of an F-statistic that should exceed ten to be reliable when there is one endogenous regressor. For an analysis with more than one instrument, we also report the overidentifying restrictions test of Wooldridge's robust score test. This tests whether the instruments are uncorrelated with the structural error term in equation (1). It also identifies whether our IV model is mis-specified and if one or more of the excluded exogenous variables should, in fact, be included in the structural equation.

In general, the key assumptions for the appropriateness of the IV estimates are that the instruments are highly correlated with the endogenous variables but uncorrelated with other determinants of the dependent variable of the education production model. The term uncorrelated with other determinants of the dependent variables is like saying $Cov(\varepsilon, Z_k) = 0$, is the exclusion restriction of the IV model (Angrist & Pischke 2009).

RESULTS AND DISCUSSIONS

In this section, we first present the estimated effects of the class size on student test scores disaggregated by student gender using two methods, OLS and IV. It is followed by reports on the estimated quantile regression model in the conditional distribution of test scores changes. We then report the estimated results of the class size on student achievement in sub-samples of school location (urban and rural). We end this section with the reports of the sensitivity analysis of the baseline models using alternative specifications. All

TABLE 3. Effects of class size and other school & family specific factors on student's mathematics scores

	(1) Boys	(2) Girls	(3) Boys	(4) Girls	(5) Boys	(6) Girls	(7) Boys	(8) Girls
Class size	3.12***	1.92***	3.02***	1.83***	2.02***	1.80***	2.50***	2.34***
	(0.23)	(0.22)	(0.65)	(0.58)	(0.53)	(0.43)	(0.51)	(0.40)
Instructional materials	-29.10***	-18.37***	-29.29**	-18.79*	-30.16***	-18.30***	-29.74***	-17.58***
(a little)	(3.82)	(3.45)	(11.26)	(9.55)	(3.79)	(3.35)	(3.79)	(3.35)
Infrastructure (some)	-14.25***	-11.59***	-12.21	-9.81	-12.71***	-11.56***	-13.35***	-12.22***
	(4.05)	(3.94)	(12.81)	(11.48)	(4.03)	(3.91)	(4.03)	(3.92)
Infrastructure (little)	-17.02***	-20.41***	-17.67	-20.20	-16.50***	-20.62***	-16.65***	-20.62***
	(5.26)	(4.62)	(16.28)	(13.93)	(5.09)	(4.55)	(5.10)	(4.56)
IT staff (little)	21.44***	19.26***	19.63*	18.08*	21.99***	19.42***	21.70***	18.71***
	(3.60)	(3.39)	(10.44)	(9.21)	(3.54)	(3.44)	(3.54)	(3.43)
Computers per student	17.57	7.93	22.53	11.88	0.46	7.13	7.77	16.60
	(17.39)	(15.16)	(50.71)	(42.70)	(18.96)	(16.40)	(18.79)	(16.34)
Receive teacher	2.86	2.76	2.27	2.24	1.52	2.88	2.07	2.97
incentives	(3.07)	(2.77)	(8.67)	(7.48)	(3.10)	(2.75)	(3.08)	(2.75)
Ease in teacher hiring	17.03***	-1.47	20.89	0.52	19.04***	-1.56	18.24***	-1.92
	(5.31)	(4.69)	(16.79)	(12.15)	(5.43)	(4.67)	(5.35)	(4.63)
No teacher hiring	19.74***	3.28	23.66	5.19	22.80***	3.40	21.52***	2.36
	(5.25)	(4.60)	(16.99)	(11.86)	(5.54)	(4.65)	(5.43)	(4.60)
Principal attendance in leadership activities (high)	-2.66	2.40	-1.73	3.08	-1.41	2.24	-1.92	1.92
	(3.23)	(2.73)	(9.83)	(7.44)	(3.22)	(2.67)	(3.21)	(2.67)
Parental involvement	41.87***	43.41***	41.81***	43.77***	40.11***	43.59***	40.83***	44.06***
in school (high)	(4.99)	(4.22)	(15.13)	(12.41)	(5.04)	(4.21)	(5.04)	(4.21)
Parental involvement	27.55***	28.60***	27.78**	28.97***	27.09***	28.79***	27.29***	28.57***
in school (medium)	(3.94)	(3.59)	(11.10)	(10.42)	(3.91)	(3.56)	(3.92)	(3.56)
Students come from disadvantaged homes (> 50)	-15.69***	-15.04***	-14.99	-14.78*	-17.02***	-15.25***	-16.41***	-14.42***
	(3.18)	(2.88)	(9.30)	(8.17)	(3.19)	(2.97)	(3.18)	(2.96)
Rural	-5.30*	-4.67*	-5.85	-5.97	-5.95*	-4.60	-5.69*	-4.24
	(3.18)	(2.82)	(9.91)	(8.03)	(3.16)	(2.82)	(3.15)	(2.82)
Instructional time	16.49***	11.26***	17.07	11.91	14.43***	10.62***	15.35***	11.54***
(6 and more hours)	(3.49)	(3.02)	(10.42)	(8.24)	(3.56)	(3.03)	(3.54)	(3.01)
Student family background								
Mother's education (base: no formal or primary)								
Secondary	4.34	10.10**	4.89	10.31**	3.71	10.17**	3.97	9.74**
	(5.64)	(4.20)	(5.13)	(5.22)	(5.68)	(4.17)	(5.63)	(4.14)
Tertiary	13.84**	20.85***	15.48**	21.01***	13.31*	21.07***	13.54**	20.78***
	(6.81)	(5.24)	(7.15)	(6.09)	(6.80)	(5.19)	(6.77)	(5.18)
Child's does not know	-0.98	2.24	0.24	3.70	-0.83	2.45	-0.89	1.93
	(5.97)	(5.14)	(6.19)	(5.76)	(6.00)	(5.10)	(5.96)	(5.08)
Father's education (base: no formal or primary)								
Secondary	2.62	-2.47	2.59	-2.60	3.44	-2.65	3.11	-2.39
	(6.63)	(5.17)	(6.70)	(5.37)	(6.64)	(5.13)	(6.61)	(5.10)
Tertiary	10.48	-0.28	10.98	0.63	11.94	-0.57	11.31	-0.31
	(7.33)	(6.00)	(8.87)	(6.73)	(7.33)	(5.94)	(7.31)	(5.92)

cont.

cont.

Child's does not know	0.83	-8.28	0.84	-9.21	1.44	-8.53	1.18	-8.20
	(6.76)	(5.74)	(8.38)	(6.62)	(6.76)	(5.70)	(6.73)	(5.67)
Home possessions								
One and more	28.27***	30.66***	29.48***	30.61***	29.00***	30.79***	28.70***	30.71***
bookcases	(3.38)	(2.74)	(4.10)	(3.61)	(3.39)	(2.72)	(3.38)	(2.73)
Reading resources	-28.35***	-32.89***	-28.37***	-33.83***	-29.53***	-32.88***	-29.03***	-32.35***
(low)	(3.14)	(3.51)	(4.33)	(5.06)	(3.17)	(3.49)	(3.16)	(3.47)
Technology resources	-42.04***	-32.77***	-42.63***	-32.69***	-43.51***	-32.98***	-42.87***	-32.31***
(low)	(3.30)	(2.89)	(4.53)	(3.99)	(3.38)	(2.91)	(3.37)	(2.91)
Study room (low)	7.87***	8.25***	8.22***	8.01***	8.10***	8.41***	8.00***	8.24***
	(2.86)	(2.57)	(3.00)	(3.01)	(2.86)	(2.55)	(2.85)	(2.55)
Constant	421.11***	434.08***	416.38***	432.14***	423.23***	435.41***	422.12***	433.60***
	(10.01)	(8.05)	(26.03)	(17.91)	(9.88)	(7.99)	(9.84)	(7.98)
First-stage IV estimates (Dependent variable: Class size)								
Eight-grade size					0.02***	0.02***	0.01***	0.01***
					(0.00)	(0.00)	(0.00)	(0.00)
School size							0.00***	0.00***
(enrolment)							(0.00)	(0.00)
Observations	2815	2918	2815	2918	2815	2918	2815	2918
Adjusted *R*-squared	0.40	0.37	0.40	0.37	0.39	0.37	0.39	0.37
P-value of endogeneity test					0.02	0.78	0.15	0.23
F-statistics of first-stage					455.96***	525.40***	278.26***	414.67***
P-value of overidentifying test							0.00	0.00

Notes: Standard errors in parentheses. * $p < .1$, ** $p < .05$, *** $p < .01$. The test score refers to plausible values or the range of competence that a student might have, given the student's item responses in an assessment. Base level for instructional materials, infrastructure, and IT staff is a lot. Base level for principal attendance in leadership activities and parental involvement in school is low. Missing variables are included in the model but omitted from the table for brevity.

models are estimated by student gender as an attempt to address the issue of gender gaps in student achievement and we focus in explaining school factors that proxied the current educational policy, MEB 2013-2025 as an attempt to present the impact of respective factors.

Columns (1) to (2) and (3) to (4) of both Tables 3 and 4 present the results for OLS models of unweighted and weighted sample, respectively. Whereas, the results using IV method is presented in columns (5) to (8). The IV method includes the models that use the instruments of eight-grade size and both eight-grade size and school size in the estimations. The post-estimation results for the IV method are reported in the bottom section of each table. These post-estimation results include the test of endogeneity, first-stage regression statistics, and test of overidentifying restrictions. As we specified a robust VCE as the variance estimator in each estimation, we then chose Wooldridge's score test as the endogeneity test and the overidentifying restrictions test. An advantage of Wooldridge's score test is that it can tolerate heteroskedastic and autocorrelated errors in the model estimates.

Overall, the IV results in both tables indicate that there is some evidence of an endogeneity problem in the OLS estimates, especially in the estimation using students' test scores in science. The evidence is supported by statistically significant results of the endogeneity test, that is Wooldridge's score test with a null hypothesis that the class size variable is exogenous. The instruments employed in the models of interest also have shown reliable or not-weak results with statistically significant results of the F-statistics of the first-stage regression and Wooldridge's robust score test of overidentifying restrictions. The significant results of the IV post-estimation indicate that the exclusion restriction of the method is satisfied.

Both tables show that class size has a positive and statistically significant effect on students' test scores, with the test scores approximately twice as high for boys as for girls when class size increases by one point.

TABLE 4. Effects of class size and other school & family specific factors on student's science scores

	(1) Boys	(2) Girls	(3) Boys	(4) Girls	(5) Boys	(6) Girls	(7) Boys	(8) Girls
Class size	3.77***	2.08***	3.73***	2.04***	0.33	0.34	0.61	0.47
	(0.25)	(0.24)	(0.73)	(0.65)	(0.62)	(0.49)	(0.60)	(0.47)
Instructional materials	-33.98***	-22.89***	-33.49***	-22.81**	-37.28***	-25.13***	-37.03***	-24.96***
(a little)	(4.21)	(3.54)	(12.40)	(9.65)	(4.32)	(3.55)	(4.30)	(3.55)
Infrastructure (some)	-12.45***	-11.13***	-9.43	-8.77	-7.62*	-9.05**	-7.99*	-9.21**
	(4.33)	(3.94)	(13.45)	(11.23)	(4.34)	(3.93)	(4.33)	(3.92)
Infrastructure (little)	-17.17***	-23.05***	-16.11	-21.16	-15.52***	-23.08***	-15.61***	-23.08***
	(5.93)	(4.68)	(18.88)	(13.86)	(5.74)	(4.59)	(5.73)	(4.59)
IT staff (little)	24.96***	26.27***	20.64*	23.33**	26.67***	28.52***	26.50***	28.35***
	(4.11)	(3.58)	(12.17)	(10.24)	(4.17)	(3.68)	(4.15)	(3.67)
Computers per student	58.44***	46.89***	61.34	48.11	4.95	16.97	9.24	19.25
	(17.86)	(15.45)	(53.16)	(43.17)	(20.44)	(17.31)	(20.22)	(17.19)
Receive teacher	8.02**	4.92*	8.29	5.39	3.82	4.63	4.14	4.66
incentives	(3.48)	(2.96)	(10.37)	(8.32)	(3.59)	(2.94)	(3.57)	(2.94)
Ease in teacher hiring	20.35***	2.71	22.98	3.51	26.64***	3.84	26.17***	3.75
	(6.07)	(5.53)	(19.46)	(15.96)	(6.52)	(5.64)	(6.46)	(5.62)
No teacher hiring	24.55***	8.10	27.30	8.43	34.14***	11.41**	33.39***	11.16**
	(5.99)	(5.40)	(19.75)	(15.57)	(6.61)	(5.57)	(6.53)	(5.55)
Principal attendance in leadership activities (high)	-2.54	3.24	-1.24	3.99	1.36	4.23	1.06	4.15
	(3.48)	(2.79)	(10.67)	(7.88)	(3.58)	(2.77)	(3.56)	(2.77)
Parental involvement	40.91***	51.56***	41.03**	51.33***	35.42***	50.11***	35.84***	50.22***
in school (high)	(5.51)	(4.52)	(16.49)	(13.67)	(5.65)	(4.55)	(5.64)	(4.55)
Parental involvement	26.97***	36.47***	27.93**	35.81***	25.52***	37.16***	25.64***	37.11***
in school (medium)	(4.51)	(3.80)	(13.21)	(11.01)	(4.57)	(3.82)	(4.56)	(3.81)
Students come from disadvantaged homes (> 50)	-12.74***	-14.38***	-12.31	-15.17*	-16.87***	-17.02***	-16.52***	-16.82***
	(3.52)	(3.00)	(10.35)	(8.75)	(3.64)	(3.09)	(3.61)	(3.07)
Rural	-4.01	-1.06	-4.64	-1.95	-6.06*	-2.17	-5.91*	-2.09
	(3.50)	(2.90)	(10.92)	(8.19)	(3.56)	(2.93)	(3.55)	(2.93)
Instructional time	21.79***	18.54***	21.60*	18.69*	15.34***	15.60***	15.89***	15.82***
(6 and more hours)	(3.85)	(3.29)	(11.66)	(9.50)	(4.06)	(3.33)	(4.03)	(3.31)
Student family background								
Mother's education (base: no formal or primary)								
Secondary	3.85	3.29	4.31	3.62	1.91	4.63	2.06	4.53
	(7.02)	(4.75)	(6.46)	(5.84)	(7.55)	(4.91)	(7.49)	(4.90)
Tertiary	19.96**	26.26***	21.56**	26.21***	18.32**	27.19***	18.45**	27.12***
	(8.11)	(5.72)	(8.78)	(6.74)	(8.53)	(5.81)	(8.47)	(5.79)
Child's does not know	-5.90	-9.54*	-5.15	-8.22	-5.43	-7.88	-5.47	-8.00
	(7.40)	(5.65)	(7.82)	(6.41)	(7.83)	(5.81)	(7.78)	(5.79)
Father's education (base: no formal or primary)								
Secondary	9.27	9.76	8.85	7.61	11.83	8.95	11.64	9.01
	(7.74)	(6.02)	(7.71)	(6.25)	(8.14)	(6.12)	(8.08)	(6.11)
Tertiary	30.77***	22.26***	30.87***	20.61***	35.32***	21.42***	34.96***	21.48***
	(8.43)	(6.79)	(9.90)	(7.81)	(8.78)	(6.84)	(8.72)	(6.82)

cont.

cont.

Child's does not know	10.68	4.98	10.74	2.22	12.61	3.90	12.46	3.98
	(7.94)	(6.59)	(9.34)	(7.61)	(8.29)	(6.69)	(8.24)	(6.68)
Home possessions								
One and more	27.44***	29.79***	28.96***	29.64***	29.71***	30.06***	29.53***	30.04***
bookcases	(3.66)	(2.92)	(4.43)	(3.37)	(3.73)	(2.93)	(3.71)	(2.93)
Reading resources	-49.20***	-57.54***	-49.17***	-58.58***	-52.87***	-59.20***	-52.57***	-59.07***
(low)	(3.51)	(3.80)	(4.93)	(5.39)	(3.71)	(3.88)	(3.69)	(3.86)
Technology resources	-14.95***	-7.62**	-15.12***	-7.75*	-19.52***	-9.73***	-19.15***	-9.57***
(low)	(3.61)	(3.11)	(5.21)	(4.60)	(3.84)	(3.17)	(3.82)	(3.17)
Study room (low)	7.05**	5.86**	7.15**	5.52*	7.74**	6.39**	7.68**	6.35**
	(3.12)	(2.71)	(3.61)	(3.12)	(3.21)	(2.72)	(3.20)	(2.71)
Constant	376.59***	375.35***	373.66***	378.40***	383.20***	381.18***	382.55***	380.74***
	(11.50)	(9.31)	(30.21)	(21.43)	(11.79)	(9.32)	(11.73)	(9.31)
First-stage IV estimates (Dependent variable: Class size)								
Eight-grade size					0.02***	0.02***	0.01***	0.01***
					(0.00)	(0.00)	(0.00)	(0.00)
School size							0.00***	0.00***
(enrolment)							(0.00)	(0.00)
Observations	2815	2918	2815	2918	2815	2918	2815	2918
Adjusted R-squared	0.39	0.42	0.40	0.42	0.35	0.40	0.36	0.41
P-value of endogeneity test					0.00	0.00	0.00	0.00
F-statistics of first-stage					455.96***	525.40***	278.26***	414.67***
P-value of overidentifying test							0.03	0.311

Notes: Standard errors in parentheses. * p < .1, ** p < .05, *** p < .01. See notes of Table 3.

This finding is inconsistent with previous studies such as Cho et al. (2012); and Monks and Schmidt (2011) who have examined the effects of the corresponding countries' policy of class size reduction. However, it is in line with Breton (2014), Konstantopoulos (2008), and Hoxby's (2000) findings of a positive class size effect. Hanushek et al. (2019) show that student achievement is more likely to be affected by family socioeconomic background than class size. The results, to some extent, are consistent even after the causality effect between the class size and student attainment has been addressed. However, it should be emphasised that the positive effect of the class size on student attainment is relatively small.

According to Hattie (2005), a potential explanation for the positive effect of large class size is that students in the class are probably taught by highly capable teachers that can handle a large number of students in a class. Rajaendram (2017) reports that teachers in small schools need to multitask to ensure their students receive the same school outcomes as their peers in other schools. The Parent-Teacher Association's (PTA) unwavering support was one of their biggest supports to perform the job well. In addition, a positive surrounding in the classroom may help the low achiever students, in particular, to perform better with the help of the high achiever students for the classroom, supporting the idea of positive peer effects (Lazear 2001, Blatchford et al. 2011, Duflo et al. 2011). Lastly, due to resource constraints, the opportunity cost for schools to have smaller class sizes may be higher compared to other options such as providing LCD projector for each of the large class sizes, which results in better student performance (Uline & Tschannen-Moran 2008).

The quantile regression results suggest some important differences across different points in the conditional distribution of math and science score changes (Tables 5 and 6). At the highest end of the distribution, the coefficient for class size especially for girls is negatives and significant, however, they are positive and significant for the rest points of distribution regardless of gender. This suggests that girls' performance at the top of the conditional distribution of math and science score changes is improved by a smaller class size while performance of boys and girls at the bottom of the distribution appears not to benefit

TABLE 5. Effects of class size and other school & family specific factors on student's mathematics scores using quantile regression

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	0.05		0.25		0.5		0.75		0.95	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
Class size	3.802***	2.873***	3.440***	2.781***	3.405***	2.227***	3.063***	1.301***	1.586***	-0.915**
	(0.324)	(0.241)	(0.240)	(0.261)	(0.301)	(0.236)	(0.344)	(0.341)	(0.298)	(0.358)
Class size squared	0.035	-0.033	0.004	-0.010	-0.020	-0.004	-0.044	0.010	-0.048	0.090**
	(0.028)	(0.021)	(0.019)	(0.027)	(0.027)	(0.022)	(0.030)	(0.034)	(0.038)	(0.038)
Instructional materials (a little)	-10.714**	-10.652***	-18.932***	-23.342***	-30.965***	-19.398***	-37.098***	-19.502***	-32.561***	-1.669
	(4.467)	(3.704)	(4.040)	(3.872)	(4.057)	(4.265)	(4.961)	(3.937)	(3.568)	(5.357)
Infrastructure (some)	-19.201***	-10.408***	-21.079***	-18.377***	-15.816***	-15.959***	-13.708**	-14.073***	-11.868***	-12.200**
	(4.244)	(3.723)	(4.069)	(4.089)	(4.103)	(4.579)	(5.387)	(4.029)	(3.612)	(5.799)
Infrastructure (little)	-45.999***	-21.444***	-30.444***	-24.172***	-18.335***	-27.644***	-7.971	-19.103***	0.040	-28.249***
	(5.845)	(5.779)	(5.763)	(4.607)	(5.739)	(5.503)	(7.242)	(4.556)	(6.606)	(6.795)
IT staff (little)	7.291	9.013**	21.413***	27.971***	28.846***	28.627***	26.129***	19.987***	30.198***	6.231
	(5.093)	(4.156)	(3.844)	(3.945)	(4.363)	(4.312)	(5.147)	(3.563)	(3.816)	(5.025)
Computers per student	-77.193**	-47.538*	-13.193	16.642	14.445	10.978	34.536	5.987	99.371***	11.780
	(32.974)	(26.290)	(22.534)	(18.945)	(23.119)	(19.572)	(25.551)	(17.307)	(25.891)	(18.583)
Teacher incentives (1 = yes)	17.981***	7.517**	4.635	7.127**	2.208	1.553	-3.468	4.151	-6.088*	2.114
	(3.962)	(3.554)	(3.317)	(3.302)	(3.310)	(3.399)	(4.502)	(3.055)	(3.601)	(4.632)
Ease in teacher hiring	23.514***	4.063	18.302***	-12.265**	19.271***	-7.929	17.567**	-3.007	1.500	-5.975
	(5.015)	(5.919)	(5.744)	(5.401)	(6.173)	(6.519)	(7.869)	(3.856)	(4.588)	(8.212)
No teacher hiring	19.160***	3.002	20.932***	-0.905	25.685***	-3.555	22.370***	7.107*	3.328	-0.322
	(5.126)	(6.112)	(5.685)	(5.076)	(6.318)	(6.472)	(8.035)	(4.162)	(3.979)	(7.431)
Principal attendance in leadership	3.727	-6.405**	-6.853*	-1.075	-1.624	4.032	-2.305	4.663*	0.234	7.333*
activities (high)	(3.709)	(2.860)	(3.585)	(3.041)	(3.598)	(3.365)	(4.378)	(2.821)	(3.473)	(4.255)
Parental involvement in school	33.047***	35.479***	32.447***	34.568***	41.209***	52.329***	54.554***	49.827***	52.809***	52.231***
(high)	(5.925)	(5.404)	(4.759)	(3.945)	(5.714)	(5.360)	(7.091)	(4.346)	(7.881)	(5.967)
Parental involvement in school	29.700***	22.732***	24.693***	22.039***	31.802***	34.587***	29.854***	31.564***	19.001**	38.717***
(medium)	(4.878)	(4.776)	(4.221)	(3.441)	(4.088)	(4.626)	(5.292)	(3.596)	(7.378)	(5.119)
Students come from	-32.623***	-17.806***	-20.161***	-19.113***	-19.481***	-13.636***	-8.874*	-13.851***	0.141	-13.883***
disadvantaged homes (> 50)	(2.959)	(3.515)	(3.424)	(2.849)	(3.416)	(3.471)	(4.582)	(2.975)	(3.549)	(3.989)

cont.

cont.

Rural	-2.599	1.534	-9.307***	-4.288	-11.222***	-3.911	-8.650**	-5.628**	4.239	-14.233***
	(3.958)	(3.310)	(3.440)	(2.787)	(3.725)	(3.421)	(4.179)	(2.868)	(2.955)	(4.353)
Instructional time	18.119***	16.896***	20.867***	19.496***	20.703***	13.384***	13.623***	4.328	7.084*	-17.737***
(6 and more hours)	(4.420)	(3.808)	(3.755)	(3.250)	(4.038)	(3.911)	(4.846)	(3.466)	(3.967)	(4.958)
Student family background										
Mother's education (base: no formal or primary)										
Secondary	5.786*	-0.654	-6.434	8.201**	-1.445	10.400*	-2.313	11.888**	16.812*	13.806
	(3.409)	(5.553)	(6.400)	(3.261)	(4.724)	(5.709)	(10.468)	(5.421)	(9.986)	(8.915)
Tertiary	-3.076	24.946***	5.741	18.680***	10.821*	21.684***	8.880	15.308***	16.708	9.442
	(7.196)	(6.674)	(7.688)	(5.653)	(6.100)	(7.259)	(10.923)	(5.875)	(10.263)	(9.792)
Child's does not know	-0.658	-15.841***	-7.974	2.470	-6.850	1.601	-6.730	7.186	14.694	9.345
	(4.647)	(5.879)	(6.988)	(4.738)	(5.322)	(6.721)	(10.960)	(6.115)	(10.035)	(9.382)
Father's education (base: no formal or primary)										
Secondary	1.959	5.928	11.446*	-8.489*	0.679	-2.635	3.378	-2.028	-7.261	-5.046
	(5.806)	(6.810)	(6.485)	(4.993)	(7.582)	(6.140)	(11.138)	(6.310)	(10.065)	(10.330)
Tertiary	11.576	-0.862	18.044***	-0.508	11.378	3.942	12.127	-1.490	-2.246	1.432
	(7.338)	(8.043)	(6.737)	(6.213)	(8.809)	(7.130)	(11.026)	(6.898)	(10.782)	(11.536)
Child's does not know	6.243	2.529	10.569	-14.267**	0.458	-0.410	-4.702	-7.072	-16.904	-15.566
	(6.466)	(7.309)	(6.856)	(5.796)	(7.974)	(7.198)	(11.266)	(6.569)	(10.365)	(10.589)
Home possessions										
One and more bookcases	19.341***	24.881***	26.810***	28.185***	29.129***	30.349***	37.066***	36.230***	26.216***	26.282***
	(5.039)	(3.538)	(3.731)	(3.667)	(3.474)	(3.234)	(4.012)	(2.782)	(3.004)	(4.156)
Reading resources (low)	-18.109***	-33.503***	-22.798***	-26.457***	-27.889***	-29.624***	-26.763***	-33.979***	-19.003***	-33.558***
	(3.141)	(3.529)	(3.066)	(3.831)	(3.359)	(4.051)	(4.428)	(3.300)	(3.732)	(6.315)
Technology resources (low)	-38.667***	-31.795***	-42.878***	-30.768***	-43.873***	-36.998***	-44.122***	-28.837***	-34.938***	-23.827***
	(3.717)	(3.074)	(3.102)	(2.895)	(3.591)	(3.404)	(4.113)	(2.720)	(3.008)	(4.945)
Study room (low)	6.912**	5.211*	7.056**	5.582**	5.674*	8.432***	8.956**	11.732***	12.205***	14.382***
	(2.729)	(2.942)	(2.908)	(2.715)	(3.102)	(3.195)	(3.787)	(2.496)	(2.989)	(3.591)
Constant	320.594***	344.911***	376.828***	404.177***	419.733***	428.406***	471.818***	471.391***	538.140***	554.846***
	(10.893)	(11.306)	(10.075)	(8.058)	(11.203)	(10.640)	(15.450)	(9.105)	(14.528)	(14.988)
Observations	2815	2918	2815	2918	2815	2918	2815	2918	2815	2918

Notes: Standard errors in parentheses. * p < .1, ** p < .05, *** p < .01. See notes of Table 3.

TABLE 6. Effects of class size and other school & family specific factors on student's science scores using quantile regression

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	0.05		0.25		0.5		0.75		0.95	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
Class size	4.933***	4.072***	4.996***	3.087***	3.984***	2.357***	2.855***	0.735***	1.081***	-0.924***
	(0.319)	(0.313)	(0.266)	(0.277)	(0.295)	(0.335)	(0.353)	(0.254)	(0.210)	(0.297)
Class size squared	0.038	-0.025	-0.018	-0.014	-0.026	-0.015	-0.065*	0.010	-0.017	0.073**
	(0.030)	(0.029)	(0.018)	(0.030)	(0.026)	(0.037)	(0.035)	(0.023)	(0.019)	(0.030)
Instructional materials (a little)	-27.212***	-32.809***	-27.572***	-20.119***	-28.968***	-17.260***	-43.184***	-19.609***	-53.258***	-16.206***
	(4.677)	(4.977)	(4.708)	(4.482)	(4.595)	(4.376)	(5.036)	(4.181)	(5.291)	(4.423)
Infrastructure (some)	-14.713***	-22.521***	-22.218***	-21.290***	-16.384***	-9.188**	-10.598**	-10.160**	-14.938***	-3.658
	(5.351)	(5.348)	(5.210)	(4.935)	(4.762)	(4.682)	(5.143)	(4.419)	(4.260)	(3.451)
Infrastructure (little)	-35.799***	-39.456***	-39.324***	-31.650***	-24.308***	-23.728***	-2.415	-27.790***	0.871	-20.385***
	(6.492)	(5.531)	(6.965)	(5.606)	(6.669)	(5.669)	(6.575)	(5.130)	(6.571)	(4.629)
IT staff (little)	13.294***	29.390***	24.358***	31.811***	29.857***	27.343***	26.870***	29.447***	42.887***	17.401***
	(4.332)	(5.077)	(5.071)	(4.614)	(4.573)	(4.471)	(4.738)	(4.172)	(5.162)	(4.215)
IT staff missing	188.676***		173.559***		144.906***		99.463***		64.489***	
	(18.711)		(10.995)		(9.278)		(11.992)		(11.973)	
Computers per student	43.768*	94.762***	80.262***	64.408***	74.853***	51.679**	57.007***	31.248*	40.144***	3.362
	(24.709)	(19.943)	(21.569)	(22.080)	(23.142)	(20.669)	(17.864)	(16.442)	(14.423)	(18.903)
Teacher incentives (1 = yes)	8.062*	1.119	8.522**	3.946	7.227*	5.911*	8.016*	5.519*	3.618	10.325***
	(4.145)	(5.476)	(3.851)	(3.608)	(4.368)	(3.522)	(4.522)	(3.337)	(4.568)	(3.909)
Teacher hiring (easy)	5.482	-0.589	28.096***	2.356	23.843***	-7.914	17.182*	-3.523	-5.751	4.005
	(6.505)	(7.953)	(6.095)	(7.029)	(6.547)	(6.283)	(9.756)	(5.384)	(10.350)	(5.418)
No teacher hiring	10.420*	12.498	30.678***	10.324	30.929***	-6.661	26.279***	2.015	10.746	9.185*
	(6.207)	(8.053)	(6.190)	(7.086)	(6.880)	(6.341)	(9.833)	(5.357)	(9.361)	(5.281)
Principal attendance in leadership	6.986*	11.744***	-6.087	-0.974	-6.168	2.586	1.078	1.657	2.870	4.253
activities (high)	(3.628)	(4.187)	(4.064)	(3.401)	(4.184)	(3.265)	(4.114)	(3.095)	(4.388)	(3.342)
Parental involvement in school	30.743***	35.969***	40.800***	46.202***	38.019***	56.624***	46.655***	56.128***	59.376***	63.785***
(high)	(5.813)	(5.101)	(6.447)	(4.897)	(6.545)	(5.416)	(6.613)	(5.304)	(6.194)	(5.762)
Parental involvement in school	34.759***	30.887***	35.607***	32.433***	22.849***	43.585***	27.247***	36.801***	34.008***	34.406***
(medium)	(5.038)	(4.422)	(5.826)	(4.647)	(4.819)	(4.679)	(5.232)	(4.585)	(5.750)	(3.645)
Students come from	-35.182***	-28.900***	-22.601***	-16.824***	-12.547***	-14.347***	-5.109	-11.745***	6.626	-19.474***
disadvantaged homes (> 50)	(3.727)	(3.895)	(4.054)	(3.505)	(3.977)	(3.591)	(4.347)	(3.286)	(4.151)	(3.798)

cont.

cont.

Rural	-3.327	-2.844	-5.351	-2.239	-6.508*	-5.154	-1.922	-0.111	-3.190	-0.172
	(3.342)	(3.800)	(4.253)	(3.407)	(3.808)	(3.382)	(3.993)	(3.013)	(4.154)	(3.246)
Instructional time	20.448***	23.770***	34.023***	28.388***	23.330***	17.496***	14.847***	10.006**	1.505	-5.065
(6 and more hours)	(3.604)	(4.510)	(4.811)	(3.927)	(4.297)	(3.823)	(4.604)	(3.982)	(4.841)	(4.298)
Student family background										
Mother‘s education (base: no formal or primary)										
Secondary	13.596*	-0.439	9.101	-7.225	3.029	1.374	-11.047*	11.476**	7.184	11.256***
	(7.518)	(7.667)	(5.556)	(6.062)	(7.330)	(4.159)	(6.104)	(5.286)	(6.487)	(3.956)
Tertiary	36.432***	25.931***	18.968**	16.112**	21.400**	20.693***	0.914	32.144***	19.643***	31.815***
	(8.353)	(9.029)	(7.948)	(7.553)	(8.370)	(5.452)	(6.721)	(6.333)	(5.700)	(5.563)
Child‘s does not know	5.697	-14.834*	-4.459	-20.907***	-8.598	-9.558*	-21.316***	0.392	-3.271	-2.840
	(7.417)	(8.641)	(6.150)	(7.321)	(8.435)	(5.688)	(6.871)	(6.211)	(7.060)	(5.687)
Father‘s education (base: no formal or primary)										
Secondary	15.496*	15.997**	0.396	17.572**	18.106***	7.977	17.885**	1.972	-4.312	-0.011
	(8.797)	(6.853)	(6.365)	(6.883)	(6.409)	(9.471)	(9.082)	(5.065)	(9.899)	(4.216)
Tertiary	22.949**	18.064**	25.557***	34.084***	44.352***	25.271**	39.615***	7.456	2.135	6.749
	(9.426)	(8.502)	(8.115)	(8.095)	(6.900)	(10.002)	(9.311)	(5.851)	(9.579)	(7.457)
Child‘s does not know	22.976**	16.216**	4.227	14.289*	17.107**	1.793	17.235*	-5.817	-9.242	-1.803
	(9.060)	(7.542)	(6.752)	(7.482)	(7.290)	(10.108)	(9.428)	(6.203)	(10.855)	(5.334)
Home possessions										
One and more bookcases	21.524***	20.909***	27.365***	28.616***	23.517***	31.248***	25.289***	30.413***	24.089***	29.722***
	(5.107)	(4.038)	(4.440)	(3.655)	(3.748)	(3.375)	(3.542)	(2.867)	(3.615)	(3.454)
Reading resources (low)	-40.649***	-55.737***	-48.950***	-57.462***	-47.631***	-58.409***	-46.261***	-52.193***	-30.872***	-44.741***
	(3.210)	(3.741)	(3.564)	(4.083)	(3.857)	(4.221)	(3.859)	(4.956)	(4.493)	(5.395)
Technology resources (low)	-0.524	1.246	-11.688**	-2.626	-16.665***	-10.918***	-20.990***	-9.562***	-23.888***	-8.572**
	(3.274)	(3.962)	(4.615)	(3.661)	(3.929)	(3.466)	(3.777)	(3.035)	(3.620)	(3.557)
Study room (low)	-1.567	3.686	2.164	2.811	5.926*	2.674	12.992***	5.742*	5.393*	13.116***
	(3.367)	(3.553)	(3.410)	(3.115)	(3.378)	(3.021)	(3.714)	(2.975)	(3.206)	(3.273)
Constant	248.461***	270.885***	316.738***	326.705***	369.257***	387.334***	438.575***	435.674***	531.386***	497.342***
	(13.000)	(10.808)	(10.483)	(11.348)	(11.624)	(12.614)	(13.986)	(9.155)	(16.657)	(7.512)
Observations	2815	2918	2815	2918	2815	2918	2815	2918	2815	2918

Notes: Standard errors in parentheses. * $p < .1$, ** $p < .05$, *** $p < .01$. See notes of Table 3.

TABLE 7. Effects of class size and other school & family specific factors on student's scores by school location

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Urban		Rural		Urban		Rural	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
Class size	-1.04	2.11**	4.18***	2.43***	-4.53***	-1.58	2.40***	1.11**
	(1.07)	(1.05)	(0.64)	(0.45)	(1.28)	(1.20)	(0.79)	(0.56)
Instructional materials (some)	-48.12***	-29.33***	-43.72***	-31.11***				
	(6.44)	(7.23)	(5.44)	(4.32)				
Instructional materials (little)	-38.67***	-29.98***	-5.70	9.32*	-62.08***	-43.10***	-31.36***	-24.13***
	(8.18)	(7.68)	(6.10)	(5.12)	(7.31)	(6.82)	(5.53)	(4.37)
Infrastructure (some)	-28.96***	-27.85***	-0.13	-3.17	-10.12	-18.47***	-0.24	4.31
	(5.72)	(6.90)	(6.11)	(5.07)	(6.74)	(6.87)	(6.50)	(5.41)
Infrastructure (little)	-45.92***	-41.43***	-11.38	-26.50***	-19.90*	-36.85***	-5.84	-11.96*
	(9.75)	(9.36)	(7.07)	(5.67)	(10.89)	(8.38)	(8.02)	(6.35)
IT staff (little)	34.75***	34.58***	11.43**	6.87	40.42***	52.26***	21.22***	20.99***
	(6.64)	(8.64)	(4.66)	(4.26)	(8.13)	(8.73)	(5.36)	(4.55)
Computers per student	8.15	-19.34	-0.92	30.96	6.37	-36.65	-15.64	21.74
	(24.66)	(22.27)	(32.04)	(27.12)	(28.60)	(24.47)	(37.06)	(28.84)
Teacher incentives (1 = yes)	15.31**	10.00*	-2.03	3.46	15.07**	13.80**	-1.51	3.29
	(6.41)	(5.35)	(3.81)	(3.32)	(7.68)	(5.82)	(4.44)	(3.63)
Teacher hiring (easy)	8.91	-4.66	14.12*	-2.64	21.29**	-4.08	20.37**	9.24
	(7.34)	(7.65)	(7.84)	(5.95)	(9.13)	(8.97)	(10.36)	(8.45)
No teacher hiring	24.93***	-2.50	11.03	1.52	57.87***	9.61	14.19	14.53*
	(7.69)	(7.09)	(7.97)	(6.35)	(9.27)	(7.96)	(10.43)	(8.80)
Principal attendance in	3.03	12.88***	-16.15***	-9.69***	7.47	8.52*	-5.71	-0.01
leadership activities (high)	(4.82)	(4.84)	(4.56)	(3.65)	(5.70)	(4.95)	(5.11)	(3.89)
Parental involvement in	-8.79	28.33***	67.32***	56.76***	-14.29	41.83***	56.22***	55.27***
school (high)	(9.11)	(8.50)	(6.40)	(5.21)	(10.36)	(7.79)	(7.08)	(5.73)
Parental involvement in	-3.80	9.87	52.46***	47.22***	2.60	23.74***	43.60***	46.99***
school (high)	(7.04)	(6.26)	(5.34)	(4.56)	(8.43)	(6.29)	(5.95)	(4.84)
Students come from	-16.30***	-6.18	-14.74***	-22.20***	-10.66*	-4.83	-13.87***	-23.71***
disadvantaged homes (> 50)	(5.32)	(5.94)	(4.07)	(3.60)	(6.13)	(5.99)	(4.78)	(3.90)
Instructional time	-5.61	16.54**	19.86***	12.10***	-8.53	13.53*	15.12***	18.69***
(6 and more hours)	(6.72)	(6.73)	(4.49)	(3.80)	(8.27)	(7.42)	(5.24)	(4.31)
Student family background								
Mother's education (base: no formal or primary)								
Secondary	7.40	12.66	4.41	7.32	15.09	4.49	-0.70	3.14
	(10.75)	(8.13)	(6.22)	(4.66)	(15.57)	(9.41)	(8.12)	(5.73)
Tertiary	14.82	21.09**	10.41	20.32***	27.34*	20.81**	17.63*	31.94***
	(11.78)	(9.13)	(8.12)	(6.34)	(16.49)	(10.49)	(9.93)	(7.17)
Child's does not know	3.11	13.27	-2.31	-6.51	9.74	-1.47	-7.57	-12.10*
	(11.61)	(9.22)	(6.73)	(5.82)	(15.97)	(10.90)	(8.77)	(6.85)
Father's education (base: no formal or primary)								
Secondary	4.81	-25.80**	2.79	2.83	27.63*	3.01	2.41	11.38
	(11.07)	(10.16)	(7.78)	(5.79)	(15.96)	(11.56)	(9.28)	(7.12)
Tertiary	22.39*	-15.78	2.38	-1.45	58.61***	23.64*	17.53*	18.96**
	(11.61)	(10.97)	(9.01)	(7.04)	(16.53)	(12.36)	(10.60)	(8.25)

cont.

cont.

Child's does not know	12.27	-27.74**	-6.16	-4.88	30.88*	1.99	-0.69	3.54
	(11.55)	(10.95)	(7.97)	(6.41)	(16.20)	(12.56)	(9.61)	(7.77)
Home possessions								
One and more bookcases	23.30***	31.99***	31.67***	28.66***	24.59***	32.30***	31.60***	28.19***
	(4.94)	(4.13)	(4.44)	(3.48)	(5.91)	(4.34)	(4.93)	(3.89)
Reading resources (low)	-27.74***	-17.51***	-26.81***	-33.95***	-58.74***	-43.14***	-46.36***	-62.91***
	(5.25)	(6.49)	(3.83)	(4.11)	(6.36)	(6.75)	(4.65)	(4.66)
Technology resources (low)	-40.34***	-26.47***	-35.97***	-33.79***	-16.00***	-6.94	-13.43***	-9.31**
	(4.96)	(4.33)	(4.37)	(3.77)	(5.96)	(4.57)	(5.19)	(4.31)
Study room (low)	8.70*	11.27***	3.16	4.47	4.20	7.78*	6.73*	4.72
	(4.56)	(4.21)	(3.56)	(3.09)	(5.45)	(4.40)	(4.04)	(3.41)
Constant	465.83***	462.02***	401.99***	423.14***	390.63***	398.44***	380.62***	367.70***
	(15.04)	(14.57)	(13.04)	(9.97)	(18.53)	(16.36)	(16.31)	(12.44)
First-stage IV estimates (Dependent variable: Class size)								
Eight-grade size	0.02***	0.02***	0.03***	0.03***	0.02***	0.02***	0.03***	0.03***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Observations	1114	1095	1701	1823	1114	1095	1701	1823
Adjusted R-squared	0.39	0.33	0.44	0.42	0.32	0.39	0.36	0.41
P-value of endogeneity test	0.00	0.40	0.82	0.82	0.00	0.00	0.00	0.00
F-statistics of first-stage	151.38***	151.61***	319.35***	577.89***	150.48***	152.04***	338.50***	595.22***

Notes: Standard errors in parentheses. * $p < .1$, ** $p < .05$, *** $p < .01$. See notes of Table 3.

from reduction in class size, other thing being held equal. This result is unchanged when we estimate for full sample cases (see Appendix Tables A1 and A2). Other than that, the results demonstrate that boys tend to achieve better math and science scores in larger class sizes, despite the fact that they are attended slightly smaller class size compared to girls as stated in Table 1. However, this condition largely applies to students at the bottom of the conditional distribution. We expect that students perceive higher levels of peer interaction and good competition in large classes, whereas students in the top quartile are less responsive to peer achievement (Burke & Sass 2013).

Another important result is the coefficient of other school resources. Table 3 to Table 6 shows that an adequate supply of instructional materials (e.g. textbooks, papers, and pencils) and infrastructure (e.g. school buildings, lighting systems, and classrooms) may improve students' test scores. These findings are consistent with studies by Demir et al. (2010) and Zhao and Glewwe (2010) among others. Both IT related resources, IT staff resources (a little), which refers to technologically competent staff, and computers per student also show positive and statistically significant effects on student attainment.

In regards to an attempt to reduce the gender gap between male and female students' attainment with boys performing worse than girls, this study suggests boys, especially in the lower end of the distribution of math score, should be in schools with larger classes, a high tendency to not easily hire new teachers, and that have an adequate supply of certain school resources such as school buildings, lightning systems, and classrooms as well as teaching and learning materials. In larger classes, Mas and Moretti (2009) argue that individual productivity may depend on the productivity of their counterparts in the same team. Besides, boys in the lower end distribution of science score were found to be benefited when attended class with teachers who received teacher incentives such as bonuses and housing. Incentives or bonuses to teachers probably elicit more effort from teachers in innovating their teaching methods in the laboratory (Figlio & Kenny 2007).

Table 7 presents the results of the IV model by school locations, urban and rural areas. The estimated results using student scores in mathematics presented in columns (1) to (4), while for science in columns (5) to (8). In this study, rural areas refer to the medium size city or large town, small town or village, and remote rural. The urban and suburban areas are referred to as the urban area with an estimated population of 10,000 or more people based on indicators by the (Department of Statistics Malaysia 2022).

Overall, the effect of class sizes on student achievement is mixed. However, all other school resource factors show an unchanged impact as in the previous results. The impact of class size changes when

we estimate the variable on students' scores in urban schools. In particular, male students in the urban schools tend to perform better as class size decreases, with a ten-unit decrease in class size will increasing boys' scores in science by about 50 points. This finding is consistent with many previous studies and economies of scale, where an institution becomes more efficient if the cost in purchasing capital, in here may be getting more empty classes, could be minimised.

HETEROGENEITY TEST OF CLASS SIZE

Table 8 shows evidence for the class size effects on students' achievement based on their socioeconomic backgrounds. It is an alternative measure to address the potential bias problem in the class estimates. The estimated class size effects on student attainment in mathematics and science are shown in columns (1) to (4) and (5) to (8), respectively.

The effect of large class sizes is positive and significant on male students' test scores who have high educated father and have attended rural schools. Whereas, the effect is negative particularly on females' attainment who have attended urban schools. The positive effect of class size shows the important role of parents to boost their children's motivation in schooling even though their children are attending school with limited resources.

Another noteworthy finding is that regardless of gender, in limited home resources and large class

TABLE 8. Heterogeneity in class size effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Mathematics				Science			
	Urban		Rural		Urban		Rural	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
Class size	4.58***	5.36***	3.64***	3.64***	5.77***	4.44**	4.97***	3.23**
	(1.45)	(1.77)	(1.16)	(1.07)	(1.84)	(1.95)	(1.34)	(1.26)
Interaction terms between class size X								
Mother's education (base: no formal or primary)								
Secondary	-0.54	-1.13	-1.05	-1.03	-1.16	-2.29	-2.68**	-1.44
	(1.35)	(1.27)	(0.92)	(0.79)	(1.75)	(1.49)	(1.13)	(0.92)
Tertiary	-0.71	-2.00	-2.04	-1.58	-3.14*	-2.81*	-3.46**	-2.51*
	(1.55)	(1.41)	(1.31)	(1.12)	(1.90)	(1.64)	(1.56)	(1.29)
Child's does not know	-2.10	-1.89	-0.54	-1.01	-2.52	-3.62**	-2.33*	-0.27
	(1.52)	(1.45)	(1.05)	(0.93)	(1.92)	(1.70)	(1.29)	(1.06)
Father's education (base: no formal or primary)								
Secondary	-3.23***	-2.05	2.47**	-0.13	-2.58*	-0.03	3.04**	0.80
	(1.23)	(1.48)	(0.99)	(0.88)	(1.44)	(1.67)	(1.21)	(1.06)
Tertiary	-2.50*	-4.54***	0.03	-1.36	-1.45	-2.07	1.30	0.20
	(1.32)	(1.71)	(1.22)	(1.23)	(1.51)	(1.88)	(1.49)	(1.41)
Child's does not know	-1.18	-2.58	2.02*	1.08	-1.48	0.13	3.46***	1.22
	(1.38)	(1.77)	(1.08)	(0.93)	(1.57)	(1.96)	(1.31)	(1.14)
Home possessions								
One and more bookcases	-0.56	0.79	0.36	-1.18**	-1.52*	0.55	-0.45	-1.14*
	(0.83)	(0.74)	(0.74)	(0.60)	(0.89)	(0.78)	(0.80)	(0.64)
Reading resources (low)	1.57**	0.16	1.23**	1.92***	2.33***	-0.11	2.12***	2.15***
	(0.74)	(1.04)	(0.58)	(0.61)	(0.81)	(1.03)	(0.63)	(0.70)
Technology resources (low)	0.02	0.38	-0.96	-0.71	-0.08	1.42*	-1.43**	-0.76
	(0.72)	(0.77)	(0.61)	(0.59)	(0.80)	(0.83)	(0.66)	(0.67)
Study room (low)	0.39	-1.19	-0.14	0.19	0.30	-1.02	0.35	-0.01
	(0.70)	(0.78)	(0.54)	(0.51)	(0.77)	(0.79)	(0.57)	(0.55)
Observations	1114	1095	1701	1823	1114	1095	1701	1823
Adjusted R-squared	0.43	0.34	0.43	0.41	0.48	0.43	0.39	0.43

Notes: Standard errors in parentheses. * $p < .1$, ** $p < .05$, *** $p < .01$. Other variables are controlled but omitted in the table for simplicity.

size, students in the rural areas tend to perform better than their advantaged peers. Factors such as financial constraints in low-income families may influence children's motivation to aspire for higher education even though they owned only few educational related resources and are allocated to large classes (a reverse causality effect).

These results provide evidence that class size reduction could be less effective in raising student scores in both subjects, mathematics and science. However, after tailoring class size to different groups of socioeconomic and demographics of students, it is found that smaller class sizes tend to benefit those from more advantaged backgrounds.

DISCUSSION: GOING BEYOND CLASS SIZE FOR ADDRESSING GENDER INEQUALITY IN EDUCATION

Gender inequality remains a key concern in many parts of developing Asia. For instance, Asadullah et al. (2019) for Afghanistan study show that fewer girls are in school compared to boys, and they are not learning. In Indonesia, a country with gender balanced progress in education, there is evidence of gender inequality in school choice (Asadullah & Maliki 2018). However, Malaysia is ahead of many of these countries in terms of advancing girls' education but this has apparently come at the expense of boys. The "lost boys" phenomenon however is not unique to Malaysia. The recently published UNESCO Global Education Monitoring Report 2021/2022 has documented this for a number of other Asian countries such as Afghanistan, India, and Nepal (UNESCO 2021). This has raised an important public policy question: how should governments address this new form of gender exclusion? And what are the key lessons from Malaysia for other Asian countries grappling with the issue?

Malaysia's resources intensive education strategy alone does not offer a clear solution. One of the most expensive educational inputs is class size. Yet as per Table 2 in this paper, if anything, there is already a boy advantage when it comes to exposure to small class size. Even then, we found that low ability boys did not benefit from further class size reduction and the results held when we address potential endogeneity in the class size model. Given the discussion on the positive impact of teacher quality (Rajaendram 2017) and peer effects (Duflo et al. 2011). Hence, Malaysian provision for education should consider to provide greater spending on teacher training to enhance teacher quality (Jepsen & Rivkin 2009) and reform the type of school assessment to increase student engagement among them (Surianshah et al. 2022).

However, our study shows that high-ability girls do benefit from reduced class sizes. This results also hold when we address potential endogeneity in the class size model. Ballen et al. (2019) and Ho and Kelman (2014) respectively demonstrate that large class sizes deteriorate female participation in Science, Technology, Engineering, and Mathematics (STEM) and Law subjects. Even though reducing class size further is less likely to help in tackling the "lost boys" issue, this research found evidence that boys may have better attainment when there is better availability of school infrastructure resources such as school buildings, lightning systems, and classroom conditions. Earthman (2002); Uline and Tschannen-Moran (2008) and Ramli and Mohd Zain (2018) argue that school facilities conditions including classroom temperature and noise level do affect student academic achievement as well as teacher teaching effectiveness.

Our regression models employing very detailed specification however hints at a number of variables that affect learning of boys more favourably compared to that of girls. These include non-class size factors which are i) not hiring new teachers, ii) having adequate school infrastructure, and iii) providing teacher incentives. To improve male students' test score in math, this study suggests for the students in the bottom 50 of the conditional distribution of math score change are located in classes with high school infrastructure and no new teacher recruitment. While to improve male students' test score in science, it is suggested for the students at the bottom of the conditional distribution of science score changes attend classes taught by teachers who receive teacher incentives and schools with no or less new teacher hiring. All-in all, these findings show that government policy to address the "lost boys" phenomenon through education needs to go beyond simple solutions since interventions such as moving boys to smaller sized classrooms does not work in the context of Malaysia. Hence it is suggested for policymakers to formulate policy strategies related to repairing depleted school infrastructure in order to ensure their adequacy, strategising teacher turnover to minimise students less interaction with new and less experienced teachers, and giving timely incentives to teachers in increasing the efforts of teachers in delivering innovative lessons (Figlio & Kenny 2007; Gibbons et al. 2018; Paola 2009).

But considering the overall balance of evidence presented in this paper, it is unlikely that the boy-girl difference in maths and science test scores in Malaysia can be primarily explained by school level factors. The answer may lie outside schools into family and community factors. Therefore it is suggested by some that the focus must shift to attitudinal and aspirational gender gap (Khattab 2015; Lundberg 2020; Sarker et al. 2017; Wang & Calvano 2022). Evidence on gender gap in education in Asia perspective such as a topic raise by Asadullah et al. (2020) for Vietnam and Singapore study should be conducted further for comparison purposes in Asia education context and eventually help in moving Asian countries towards the Sustainable Development

Goal 4 (SDG 4): quality education. In addition, the education inequality issue should be addressed seriously because even in a high resource educational regime like Malaysia's, the issue of inclusion clearly has gender dimensions. This suggests that investment in education alone should not be viewed as a panacea for other Asian countries striving for gender equality in school participation and achievements.

CONCLUSION

This study examines the effect of class size on student achievement in the Trends in International Mathematics and Science Study (TIMSS). The results of the education production model show that a large class size is paradoxically positively associated with student test scores even after we address the potential endogeneity problems. We also find evidence that advantaged high-achieving female students particularly tend to perform worse if schools have large class sizes, while this is not the case for male students. Thus, to reduce gender attainments gap in Malaysia, policymakers must look beyond interventions such as gender-targeted reduction in class size. In the international literature, alternatives suggested include gender-specific improvement in other school resources factors such as instructional materials and infrastructures especially schools located in urban areas. Studies in Asian countries by Jeong et al. (2017) and Zhao and Glewwe (2010) show that school resources such as sufficient science labs appear to have a positive and significant impact on student outcomes. Our own analysis highlights a number of nonclass-size related factors that benefit boys more than girls. School infrastructure, teacher recruitment, and teacher incentives are among the important factors that may improve male performance.

Overall, findings from this study suggest that an intervention such as class size reduction in Malaysian context is not cost-effective. With scarce school resources, improving the quality of teacher might be worth considering to improve the quality of education (Goldhaber et al. 2018). At the same time, for further research, as suggested by Breton (2014) longitudinal studies would be required to inclusively estimate the effects of the class size reduction. This is because this study does not consider students' outcomes in other grades which may be attended by different number of students. In addition, in Malaysia, transition to other grades for each student within the same class community is not guaranteed, hence possible variation in class sizes may be taking place for the students. Lastly, due to data limitation of this study, further research also is recommended to consider alternative class size measurements such as student-teacher ratio to examine the class size effects on student outcomes.

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APPENDIX

TABLE A1. Effects of class size and other school & family specific factors on student's mathematics scores in full sample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	IV		QUANTILE				
				0.05	0.25	0.5	0.75	0.95
Class size	2.59***	1.81***	2.36***	3.38***	3.07***	2.88***	2.31***	0.25
	(0.16)	(0.35)	(0.33)	(0.23)	(0.18)	(0.17)	(0.29)	(0.22)
Class size squared	-0.00			0.01	-0.01	-0.03**	-0.03	0.04**
	(0.02)			(0.02)	(0.02)	(0.01)	(0.03)	(0.02)
Instructional materials (a little)	-22.66***	-23.48***	-22.92***	-8.36***	-22.15***	-21.62***	-29.06***	-23.67***
	(2.54)	(2.51)	(2.51)	(2.96)	(2.97)	(3.11)	(3.27)	(4.43)
Infrastructure (some)	-13.59***	-12.58***	-13.27***	-16.00***	-19.48***	-18.52***	-11.59***	-12.31**
	(2.82)	(2.81)	(2.81)	(2.86)	(3.03)	(3.23)	(3.33)	(5.01)
Infrastructure (little)	-19.80***	-19.67***	-19.71***	-32.50***	-26.66***	-22.62***	-13.98***	-13.62**
	(3.46)	(3.38)	(3.38)	(4.41)	(3.83)	(4.12)	(4.29)	(6.22)
IT staff (little)	20.25***	20.93***	20.42***	7.83***	24.71***	25.51***	22.37***	19.23***
	(2.48)	(2.48)	(2.47)	(3.00)	(2.94)	(3.25)	(3.36)	(4.03)
Computers per student	12.70	-0.09	8.84	-62.25***	3.34	17.78	19.63	36.62
	(11.42)	(12.46)	(12.35)	(18.65)	(12.93)	(15.27)	(15.56)	(22.57)
Teacher incentives (1 = yes)	2.47	1.92	2.28	11.41***	4.95*	1.53	1.79	-5.00
	(2.06)	(2.06)	(2.05)	(2.32)	(2.64)	(2.56)	(2.92)	(3.38)
Teacher hiring (easy)	9.68***	10.78***	10.05***	13.57***	8.47	9.34*	4.53	-1.97
	(3.63)	(3.73)	(3.67)	(3.90)	(5.50)	(4.86)	(5.36)	(7.10)
No teacher hiring	13.31***	15.27***	13.92***	8.37**	15.43***	14.07***	12.63**	7.11
	(3.59)	(3.80)	(3.72)	(4.21)	(5.43)	(4.90)	(5.51)	(6.89)
Principal attendance in	-0.21	0.48	0.02	-0.56	-3.32	-0.22	2.50	7.13*
leadership activities (high)	(2.10)	(2.07)	(2.07)	(2.65)	(2.53)	(2.70)	(2.49)	(3.74)
Parental involvement	42.27***	41.30***	41.95***	29.35***	31.35***	44.04***	53.92***	53.09***
in school (high)	(3.21)	(3.24)	(3.24)	(4.44)	(3.47)	(4.08)	(4.02)	(7.67)
Parental involvement	28.21***	28.21***	28.20***	23.46***	23.86***	32.64***	31.54***	30.89***
in school (medium)	(2.63)	(2.62)	(2.62)	(4.08)	(2.92)	(3.16)	(3.10)	(6.91)
Students come from	-15.40***	-16.45***	-15.68***	-25.02***	-20.85***	-16.60***	-11.43***	-5.57
disadvantaged homes (> 50)	(2.12)	(2.16)	(2.15)	(2.49)	(2.52)	(2.55)	(2.72)	(4.02)
Rural	-4.67**	-5.16**	-4.84**	-2.91	-6.19**	-6.29**	-5.22**	-4.21
	(2.10)	(2.10)	(2.10)	(2.74)	(2.51)	(2.49)	(2.55)	(3.56)
Instructional time	13.51***	12.16***	13.16***	18.99***	19.64***	15.57***	9.53***	-4.08
(6 and more hours)	(2.29)	(2.33)	(2.31)	(2.66)	(2.85)	(2.79)	(2.95)	(4.18)
Student family background								
Mother's education (base: no formal or primary)								
Secondary	6.88**	7.02**	6.92**	-1.01	4.84	4.23	8.05*	14.76***
	(3.38)	(3.41)	(3.38)	(4.49)	(4.51)	(3.90)	(4.50)	(5.04)
Tertiary	17.24***	17.30***	17.25***	9.72*	14.74***	18.49***	16.06***	17.99***
	(4.20)	(4.20)	(4.18)	(5.27)	(5.72)	(5.05)	(5.05)	(4.94)
Child's does not know	0.43	0.91	0.57	-9.72*	0.29	-2.58	1.20	14.49***
	(3.85)	(3.88)	(3.85)	(5.67)	(5.02)	(4.49)	(5.09)	(5.12)

cont.

cont.

Father‘s education (base: no formal or primary)								
Secondary	0.33	0.43	0.38	7.98	-1.08	-5.37	-3.44	-5.58
	(4.10)	(4.12)	(4.09)	(6.77)	(5.94)	(4.73)	(5.70)	(5.35)
Tertiary	4.73	5.05	4.84	7.04	6.32	0.87	1.09	-7.93
	(4.67)	(4.67)	(4.65)	(7.11)	(6.36)	(5.54)	(6.14)	(5.19)
Child‘s does not know	-3.82	-3.87	-3.82	10.81	-3.76	-6.14	-9.06	-22.22***
	(4.37)	(4.39)	(4.36)	(7.20)	(6.18)	(5.29)	(6.07)	(5.98)
Home possessions								
One and more bookcases	29.85***	30.15***	29.93***	22.24***	28.05***	29.06***	33.23***	24.96***
	(2.14)	(2.14)	(2.14)	(2.33)	(2.87)	(2.47)	(2.42)	(3.16)
Reading resources (low)	-30.51***	-31.36***	-30.77***	-28.47***	-26.47***	-29.68***	-31.66***	-23.32***
	(2.34)	(2.37)	(2.36)	(2.54)	(2.28)	(2.81)	(2.65)	(3.99)
Technology resources (low)	-37.08***	-38.05***	-37.36***	-33.20***	-37.56***	-41.19***	-35.45***	-27.03***
	(2.19)	(2.23)	(2.23)	(2.77)	(2.24)	(2.44)	(2.42)	(3.15)
Study room (low)	7.90***	8.10***	7.94***	3.63*	3.49	7.49***	9.50***	10.62***
	(1.91)	(1.91)	(1.91)	(1.95)	(2.21)	(2.31)	(2.30)	(2.75)
Female	6.54***	6.99***	6.67***	15.49***	11.85***	7.42***	-2.69	-6.85**
	(1.94)	(1.95)	(1.94)	(2.01)	(2.24)	(2.28)	(2.48)	(2.81)
Constant	423.37***	424.94***	423.67***	327.76***	382.24***	424.89***	474.16***	547.90***
	(6.63)	(6.56)	(6.52)	(9.69)	(8.77)	(7.81)	(9.21)	(12.32)
Observations	5733	5733	5733	5733	5733	5733	5733	5733

Notes: Standard errors in parentheses. * $p < .1$, ** $p < .05$, *** $p < .01$. See notes of Table 3.

TABLE A2. Effects of class size and other school & family specific factors on student’s science scores in full sample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	IV		QUANTILE				
				0.05	0.25	0.5	0.75	0.95
Class size	2.99***	0.18	0.41	4.33***	3.99***	3.29***	1.82***	0.23
	(0.17)	(0.40)	(0.39)	(0.25)	(0.21)	(0.22)	(0.28)	(0.17)
Class size squared	-0.02			0.01	-0.04*	-0.05**	-0.04	0.04***
	(0.02)			(0.02)	(0.02)	(0.02)	(0.03)	(0.02)
Instructional materials (a little)	-27.05***	-30.15***	-29.92***	-28.99***	-20.84***	-22.05***	-30.76***	-30.27***
	(2.71)	(2.78)	(2.76)	(2.88)	(3.42)	(3.41)	(3.23)	(3.42)
Infrastructure (some)	-12.43***	-8.65***	-8.94***	-19.01***	-24.62***	-15.19***	-9.45***	-8.74**
	(2.93)	(2.95)	(2.94)	(3.69)	(3.62)	(3.55)	(3.45)	(3.43)
Infrastructure (little)	-21.25***	-20.59***	-20.61***	-38.81***	-38.05***	-23.32***	-15.86***	-12.72***
	(3.73)	(3.65)	(3.64)	(4.16)	(4.50)	(4.39)	(4.47)	(3.69)
IT staff (little)	25.33***	27.68***	27.48***	23.27***	28.71***	27.23***	27.39***	24.87***
	(2.73)	(2.80)	(2.79)	(3.34)	(3.56)	(3.31)	(3.38)	(2.83)
Computers per student	50.89***	3.99	7.66	76.59***	67.75***	65.70***	34.49**	27.17**
	(11.63)	(13.23)	(13.09)	(11.92)	(14.12)	(13.44)	(16.82)	(11.41)
Teacher incentives (1 = yes)	6.16***	4.09*	4.23*	3.74	6.58**	6.32**	4.92*	7.08**
	(2.27)	(2.29)	(2.28)	(2.82)	(2.61)	(2.67)	(2.90)	(2.87)
Teacher hiring (easy)	13.53***	17.69***	17.39***	7.87	22.41***	7.51	0.53	-1.62
	(4.19)	(4.50)	(4.47)	(5.90)	(4.39)	(5.54)	(5.28)	(7.58)

cont.

cont.

No teacher hiring	18.20***	25.43***	24.87***	16.88***	29.45***	11.20**	8.66*	8.38
	(4.14)	(4.55)	(4.51)	(6.07)	(4.37)	(5.62)	(5.26)	(7.41)
Principal attendance in	0.27	2.87	2.69	10.07***	-2.37	-1.45	0.64	2.91
leadership activities (high)	(2.20)	(2.23)	(2.23)	(2.70)	(2.56)	(2.68)	(2.63)	(2.38)
Parental involvement	46.20***	42.55***	42.81***	30.39***	42.94***	46.24***	51.75***	61.72***
in school (high)	(3.51)	(3.60)	(3.59)	(3.10)	(4.38)	(4.25)	(4.25)	(4.15)
Parental involvement	31.83***	31.79***	31.78***	30.07***	35.20***	30.19***	31.66***	33.48***
in school (medium)	(2.93)	(2.97)	(2.96)	(2.59)	(3.72)	(3.56)	(3.65)	(3.81)
Students come from	-13.69***	-17.43***	-17.11***	-30.38***	-21.10***	-12.99***	-8.75***	-9.99***
disadvantaged homes (> 50)	(2.30)	(2.38)	(2.36)	(2.56)	(2.79)	(2.76)	(2.76)	(2.91)
Rural	-2.00	-3.89*	-3.76	-4.24	-5.53**	-2.68	0.03	-1.01
	(2.25)	(2.30)	(2.29)	(2.60)	(2.63)	(2.69)	(2.56)	(2.49)
Instructional time	19.84***	15.15***	15.56***	21.65***	28.94***	18.84***	13.77***	-1.57
(6 and more hours)	(2.50)	(2.61)	(2.59)	(3.00)	(3.28)	(3.05)	(3.06)	(2.83)
Student family background								
Mother‘s education (base: no formal or primary)								
Secondary	2.51	3.02	2.98	5.99*	-2.03	-2.09	1.63	3.73
	(4.00)	(4.25)	(4.22)	(3.60)	(4.79)	(3.98)	(5.28)	(3.34)
Tertiary	22.70***	22.87***	22.85***	34.28***	14.75**	18.75***	21.47***	19.60***
	(4.77)	(4.96)	(4.94)	(4.65)	(5.93)	(4.74)	(5.73)	(3.75)
Child‘s does not know	-8.45*	-6.70	-6.85	-4.60	-14.34***	-12.11**	-12.01**	-1.40
	(4.49)	(4.73)	(4.71)	(4.09)	(5.35)	(4.88)	(6.04)	(4.33)
Father‘s education (base: no formal or primary)								
Secondary	10.52**	10.95**	10.93**	17.14***	12.99**	17.73***	7.00	-2.41
	(4.77)	(4.98)	(4.95)	(3.99)	(5.08)	(5.18)	(5.50)	(6.02)
Tertiary	26.66***	27.93***	27.84***	27.04***	35.30***	38.16***	15.39***	0.43
	(5.32)	(5.48)	(5.46)	(4.76)	(5.85)	(5.60)	(5.82)	(6.79)
Child‘s does not know	8.43*	8.33	8.35	23.61***	14.19***	13.30**	2.67	-9.58
	(5.08)	(5.28)	(5.25)	(4.40)	(5.43)	(5.78)	(6.03)	(6.17)
Home possessions								
One and more bookcases	29.23***	30.33***	30.24***	19.08***	29.35***	27.64***	28.33***	26.05***
	(2.31)	(2.35)	(2.34)	(3.15)	(2.74)	(2.32)	(2.52)	(2.55)
Reading resources (low)	-52.81***	-55.93***	-55.69***	-50.17***	-55.78***	-51.39***	-49.89***	-34.06***
	(2.59)	(2.72)	(2.71)	(2.18)	(3.14)	(2.75)	(3.27)	(2.95)
Technology resources (low)	-10.81***	-14.30***	-14.01***	0.68	-7.02**	-14.16***	-15.71***	-16.86***
	(2.38)	(2.50)	(2.49)	(2.93)	(2.99)	(2.54)	(2.54)	(2.51)
Study room (low)	6.20***	6.89***	6.82***	2.65	2.03	4.80**	9.47***	7.31***
	(2.07)	(2.11)	(2.10)	(2.07)	(2.44)	(2.38)	(2.38)	(2.19)
Female	-3.49*	-1.82	-1.95	13.29***	2.61	-5.03**	-10.42***	-17.72***
	(2.09)	(2.14)	(2.14)	(2.39)	(2.54)	(2.37)	(2.44)	(2.32)
Constant	376.61***	381.68***	381.16***	245.50***	314.05***	382.68***	452.56***	531.33***
	(7.67)	(7.79)	(7.77)	(7.89)	(8.38)	(9.09)	(8.98)	(10.56)
Observations	5733	5733	5733	5733	5733	5733	5733	5733

Notes: Standard errors in parentheses. * $p < .1$, ** $p < .05$, *** $p < .01$. See notes of Table 3.