A Thesis

entitled

Determinants of Educational Attainment in East and Southeast Asian Countries: Evidence From TIMSS 2015 Data

by

Muhammad Mosaddek Hossain

Submitted to the Graduate Faculty as partial fulfillment of the requirements for the Masters of Arts Degree in Economics

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An Abstract of

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The Trends in International Mathematics and Science Study (TIMSS) 2015 data shows that five high-performing East and Southeast Asian countries are not only maintaining their 20 years dominance in international educational assessment surveys, rather widening the gap. It has received incredible academic and policy attention as to what factors facilitate these Asian countries to continuously outpace their Western counterparts. This study employs a set of cluster robust linear regression model weighted by appropriate sampling probabilities to estimate the education production function for these high-performing Asian countries along with Thailand from the same region. Furthermore, a school fixed effect model is used to estimate the effect of student and family background variables under an alternative specification. Our result indicates individual and family background variables have stronger and consistent impact on student performance in against school resources, and teacher characteristics. The number of books at home, student's self-influence factors, and school emphasis on academic success are found to have a consistent positive impact; whereas school discipline problem and computer usage are found to have a consistent negative impact on student performance across the countries. The paper concludes with some policy implications with regards to the empirical findings.

Dedication

To my mother, for all the sacrifices she made for us in life. She has gone through more struggles than any person should have to. She had to raise me and my siblings on her own when I lost my father at the age of 5. She has taught me not to lose hope, fight back and stand still against all odds.

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I am grateful to the graduate coordinator Professor David Black for his pleasant support during my graduate study at the University of Toledo. I appreciate Professor Michael Dowd for designing the LaTex template which has made my thesis drafting a lot more fun than I could have hoped. I use the Trends in International Mathematics and Science Study (TIMSS) 2015 data for this project. TIMSS is conducted under the auspices of the International Association for the Evaluation of Educational Achievement (IEA) and managed by the National Center for Education Statistics (NCES). I am indebted to them for making their data available for download.

My final and deepest appreciation goes to my family, especially my wife Afroza Polin and my two and half year's old son Porartho Rayeed. Your unconditional love and sacrifice during my graduate study and thesis work made it possible for me to accomplish. Thank you.

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Chapter 1

Introduction

Educational attainment and it's role in human capital building add greatly to the productive part of a society. Some studies measure educational attainment by quantity, for instance years of education, college attendance, graduation from school or college (Wilson, 2001). As it happens, these measures represent school attainment rather than educational attainment and therefore may end up with misleading policy suggestions (Hanushek and Woessmann, 2008). Other studies use some measure of quality like school GPA, earnings in job, score in cognitive ability tests. School GPA is not always comparable across countries as the standard, content of education, and evaluation systems may vary substantially across countries. Earnings in job does not exclusively depend on education, it may be influenced by some external factors (Lee and Barro, 2001). Cognitive achievement scores better represent the quality measure of educational attainment and may be internationally comparable if the study is designed and implemented properly.

Three different conceptualizations of educational attainment are seen in the economics literature. A set of literature conceptualize education as an investment good. In these human capital literature individuals choose the level of education to attain as a function of the expected returns to education. A plentiful empirical literature estimate reduced-form equations and shows that there is a relation between educational attainment and the family and neighborhood characteristics, ignoring the theoretical underpinnings. A final set of literature constructs an educational production function which in its simple form sets some measure of educational attainment as outcome variable, and school resources, teacher quality, student characteristics and family background as predictor variables in an input output framework (Wilson, 2001). This study attempts to identify the factors that determine education in East and Southeast Asian countries within the context of Education Production Function.

Two broad sets of variables – student and family background variables, and school resources and teacher characteristics variables are analyzed in education literature as potential determinants of educational attainment. The role of student and family background variables in explaining educational attainment is not much of a debate. Although the size and significance of effect differs extensively; in general, student and family background variables are found to be consistent determinants of educational attainment across countries (Hill and Duncan, 1987; Hanushek, 1995; Lee and Barro, 2001; Woessmann, 2003, 2005; Ammermuller et al., 2005; Hanushek and Woessmann, 2010; Badr, 2012). However, the impact of school resources on student performance has long been disputed. Debate between Kruger and Hanushek on this issue is apparent in literature. For instance, using the National Assessment of Educational Progress (NAEP) data, Krueger (1998) finds that U.S. public school system is not broken; rather there exists a positive influence of school resources on test score. He therefore suggested an incremental school resource policy. By contrast, using the NAEP data, Hanushek (1998) concludes that "there is little reason to be confident that simply adding more resources to schools as currently constituted will yield performance gains among students". Increased school resources in different forms, such as smaller class size, paying for increased teacher professional development programs, or just pure spending programs, without altering the institutional set-up, will not stimulate student performance. One key reason for failure of school resource policies is that they are deficient in incentive (Hanushek and Woessmann, 2008). Another set of variables representing institutional arrangements such as centralized examination, school autonomy, teacher's influence on curriculum and teaching methods, competition from private schools is also included in some cross-country studies. As these institutional variables do not vary at the school level, rather vary only across countries, should not be a concern for country-level studies (Woessmann, 2003).

International educational assessment data reveals a clear dominance of five East and Southeast Asian countries in educational achievement for long time. The Trends in International Mathematics and Science Study (TIMSS) 2015 data shows that the average mathematics achievement score at eighth grade for five high performing Asian countries is more than four-fifths standard deviation higher than that of USA and UK, and more than 60% of a standard deviation ahead of the next highest country on the list. A suggested rule of thumb is average student learning in a year equals about one-quarter to one-third of a standard deviation. Under this rule of thumb, on average the gap between those five top performing Asian countries and the next highest performers, Russia is about 1.9 to 2.5 years of additional schooling, and gap with USA and UK is roughly equal to 2.5 to 3.3 years of additional schooling. Other international educational assessments also reflect that East Asian students outperform the world. Programme for International Student Assessment (PISA) 2012 results shows that students from Singapore, Hong Kong, Korea and Shanghai scored on average at least 40 points higher, which is more than one year of schooling, than their Australian, British and American peers (Jerrim, 2015).

Educational quality in the form of cognitive skills is deemed to have strong effect on the level of individual earnings, state of income distribution and overall economic growth (Hanushek and Woessmann, 2007). East Asian countries are about 9 times richer than they were two generation before. This ratio is only about 2.5 for Latin America. The East Asian Miracle thus can be well explained by the knowledge capital – growth relationship. Here, growth rate accounts for cognitive skills, which is true for other regions too (Hanushek and Woessmann, 2016). The longest running, international educational assessment study - TIMSS 2015 data shows that five high performing East and Southeast Asian countries are not only maintaining their 20 years dominance in international educational assessment surveys, rather widening the gap. This data has received incredible academic and policy attention throughout the world. Researchers are trying to figure out the factors that facilitate the East and Southeast Asian countries to continuously outpace their Western counterparts in educational attainment. Policy makers in UK are establishing maths hubs striving to replicate the East Asian model of mathematics education (The Telegraph, 2016). This study attempts to estimate the education production function for six East and Southeast Asian countries using TIMSS 2015 data to find out the determinants of educational achievement in these countries.

The remainder of the paper is structured as follows. In chapter 2, we review relevant literature. Chapter 3 focuses on data, variables and methodological approach used in the paper. Chapter 4 discusses the empirical results. Chapter 5 concludes the paper and outlines some policy implications of our findings.

Chapter 2

Literature Review

There exist bountiful multidisciplinary literature both in economics and education field explaining factors that determine education in different settings. Majority of the studies are conducted at the country level. Although education studies are primarily focused on U.S.A. and other developed countries, with the addition of data availability, many studies have been conducted for developing countries. Hanushek (1995) reviewed the education literature on developing countries and found no significant resource effect on student performance. It does not imply resources are not required, rather implies due to lack of incentives and organizational reform resources are ineffectively used (Hanushek, 1997). But need of money resources and need of reform are not mutually exclusive in these countries. Rather, sensible use of money resources such as those that respond to inefficiencies in schooling system can be most effective in such settings (Glewwe and Kremer, 2006). Lee and Barro (2001) compiled a panel of 214 observations using data from various sources. They concluded that family background variables such as parent's education and family income have a substantial effect on student performance. Pupil-teacher ratio is found to be negatively affecting student achievement score while teacher salaries and length of school term has weaker but positive effect.

Hanushek and Luque (2003) used the TIMSS 1995 micro-data but they aggregated the individuals to a classroom level. The study attempted to verify whether the earlier findings of ineffective resource policies in the United States hold across other developed and developing countries. By analyzing the available data on 37 developing and developed countries, the study concludes that although, in general, the impact of resource policies on academic achievement is found to be more positive across TIMSS countries than the corresponding US findings, the evidence is rather limited to generalize. Moreover, the study finds that the conventional view that in developing countries school and teacher quality have stronger impact on academic achievement than student's social status (Heyneman and Loxley, 1983), popularly known as Heyneman-Loxley effect, does not hold.

Woessmann (2003) used an international database of more than 260,000 students from 39 countries in TIMSS 1995 survey to study the effects of not only the family and resource variables but also the institutional features of different schooling systems on student performance. Variance decomposition reported in the paper shows that it allows him to account for almost two third of the total variation in student performance. This study also confirms the strong influence of family background variables and fails to show considerable effect from school resources. But more importantly, this paper shows, in a cross country setting, centralized examinations and control mechanisms, school autonomy in process and personnel decisions, individual teacher influence over teaching methods, limits to teacher unions' influence on curriculum scope, scrutiny of students' achievement, encouragement of parents to take interest in teaching matters, competition from private schools, and an intermediate level of administration performing administrative tasks plays a positive role in explaining student's performance. In another study, using cross-state data from a national extension of Programme for International Student Assessment (PISA-E) study in Germany, Woessmann (2010) checks the validity of cross-country findings on student achievement. The study confirms that higher mean student performance is positively associated with the existence of external exit exam, private school operation, and socio-economic background but not with the school resources. These findings are largely in line with the cross-country evidence in literature and reconfirmed by estimating the same model for a sample of OECD countries in this study.

Cross-country studies are in short supply mainly due to the scarceness of internationally comparable data at the country level (Lee and Barro, 2001). Moreover, use of student level data allows holding constant a large number of relevant observable characteristics typically not available at the national level. It allows comparing "observationally equivalent" students across countries at the country level studies (Woessmann, 2016). Using the Trends in International Mathematics and Science Study (TIMSS) 1995 data, Ammermuller et al. (2005) focused on seven Eastern European transition countries. The study employed a series of cluster-robust linear regression model and identified an extensive effect of student and family background variables on educational achievement of Seventh and Eighth grade students. School resources and institutional variables are rather found to have much weaker impact on student performance. The study reports the F-statistic from a test of the equality of coefficients of student background variables across countries. It reveals significant difference of coefficients across different combination of countries which justifies fitting regression for individual countries. The study also detects a distinction between two groups of countries with varying level of transition progress up to that point in time. One group of countries comprising Czech Republic, Hungary, Slovakia and Slovenia those were well advanced towards transition reveals higher mean and larger variance of test scores. In this group of countries returns to individual level factors especially family background variables are very significant and consistently higher than the second group which comprises Romania, and the Baltic States Latvia and Lithuania. This second group of countries is far behind in transition and characterized by lower mean score with a denser spread. The school resources and institutional variables are found to have much weaker and less significant effects for both groups with inconsistency even within groups. Using a school fixed effects - instrumental variable (SFE + IV) approach, this study fails to identify an unambiguous effect of class size on student performance.

Another group of countries those vary substantially among themselves in the reform approach they followed, and their education outcome despite high similarity in their language and culture is Middle East and North African (MENA) countries (World Bank, 2008). Badr et al. (2012) studied the educational attainment in 8 MENA countries, namely Algeria, Egypt, Jordan, Iran, Saudi Arabia, Syria, Turkey, and Tunisia. They estimated education production function in TIMSS data under the OLS estimation framework and finds that, in general, student characteristics affect educational attainment more significantly than the school resources with a large variability across the MENA countries. Using meta-regression analysis the study identifies that the most consistent effect is from home possessions across the countries. Meanwhile, three top performing countries, Tunisia, Jordan and Turkey experience most significant effect from family background proxies, parental education and number of bookcases at home. Surprisingly, computer usage is found to be negatively affecting student performance in six MENA countries, except Turkey and Iran. Quantile regression suggests that school resources affect educational achievement of 0.25 and 0.50 quantiles significantly in Iran and Turkey. In another study, using same TIMSS 2007 data, Badr (2012) identifies the determinants of educational attainment in Egypt. Overall, the study finds similar results as in MENA countries that the student and family background variables have stronger effect in against the school variables. The study also detects a link between student performance and school type based on gender composition and test language. Single sex and English schools tend to have higher achievement scores.

Studies on some poor Asian countries reveal some interesting findings as well.

Maitra (2003) studied the educational attainment situation in a least developed country, Bangladesh. He used two alternative measures of educational attainment, namely current school enrolment and highest grade attend, to find out the factors that determine the level of educational attainment. Employing standard probit model and censored ordered probit model to the Matlab Health and Socioeconomic Survey (MHSS) data, the study finds that parental income and parental education, especially mother's education has statistically significant positive effect on educational attainment. Using the National Socioeconomic Survey (SUSENAS), National Labor Force Survey (SAKERNAS) and Indonesia Family Life Survey (IFLS), Suryadarma et al. (2006) and Suryadarma and Suryahadi (2010) finds that student's cognitive skills, parental education and parental income significantly affects post-primary school enrollment in Indonesia. Moreover, the positive effect of cognitive skills is almost as large as the negative effect of poor family income (i.e. poverty) at the primary school/junior secondary level. But they do not find any effect of poverty on the senior secondary completion. The study suggests governmental policy to improve primary school quality and developing early childhood programs aimed at improving cognitive skills.

Dearden et al. (2002) focused on the effect of school quality on educational attainment and wages. They used the British National Child Development Study (NCDS) data. This is a panel survey that follows the lives of more than 17000 people born in England, Scotland and Wales during the week of 3-9 March 1958, therefore alternatively known as the 1958 Birth Cohort Study. The study controls for an extensive list of family background, individual ability, area or community, and neighborhood variables to deal with the endogeneity issues of school quality variables. The findings of the study reveal that pupil-teacher ratio has no effect on educational qualifications and students who attend selective schools (private and grammar schools) do statistically significantly better. Goldhaber and Brewer (1997) analyzed the factors that determine tenth-grade mathematics test scores using micro-level test and resource data from the National Educational Longitudinal Study (NELS) of 1988. The study employs random and fixed-effects model for teachers and schools. While the study does not find much effect of school-level variables, some teacher characteristics variables, such as teachers who are certified in mathematics, and those with bachelor's or master's degrees in math, are detected to pose substantial positive effect on student's achievement.

Endogeneity of some school resources has been an issue and is inevitable in observational data. Several studies made an effort to find suitable instrument especially for class size within the limitation of data but the outcome remains ambiguous. Krueger (1999) estimated the educational production function under the experimental framework - The Tennessee Student/Teacher Achievement Ratio experiment, known as Project STAR. 11,600 students from kindergarten through third grade and their teachers were randomly assigned to different size classes. The study finds a negative relation between class size and student performance with a larger effect for students belonging to minority groups and those on free lunch. Teacher characteristics are found to have minor effects. Applying the same intent-to-treat specifications as Krueger, Chetty et al. (2011) attempted to evaluate the long-term impacts of STAR project and concludes that students randomly assigned to smaller classes are 1.8 percentage more likely to be enrolled in college at age 20. However, Hanushek (2002) cast doubt over the Krueger's findings of small negative coefficient of class size by pointing to the flawed experiment design and implementation of STAR project that poses uncertainty over the estimate.

East and South-East Asian countries are consistently top performers in TIMSS. Using the student-level micro data from TIMSS 1995 survey Woessmann (2005) studied the impact of family background and schooling policies on student performance in five East and Southeast Asian countries Japan, Korea, Singapore, Hong Kong, and Thailand. Using cluster-robust linear regression framework the study estimate the educational production functions for each country. Overall, family background variables appear to be the key factors that determine educational achievement. But there are considerable heterogeneity among the countries in terms of size and significance of the coefficients. Korea and Singapore are found to have stronger effect of family background variables in against Hong Kong and Thailand. School resources and teacher characteristics are not seen to have consistent effect on student performance across the countries. Class size is instrumented by average class size in this study to avoid the potential endogeneity. Estimating a school fixed effects - instrumental variable (SFE + IV) model, the study concludes that class size does not predict student performance significantly in these countries. Jerrim (2015) studied the factors that may drive superior performance of 15 year old children with East Asian parents who were born and raised in Australia using Programme for International Student Assessment (PISA) 2012 data. His findings show that children of East Asian descent outperformed their Australian peers by more than 100 PISA test points which is equivalent of two and half years of schooling.

Release of TIMSS 2015 data shows that five East and South-East Asian countries have been maintaining their 20 year lead in this international comparative study of student achievement. It has always been an interesting research question what factors determine the high and consistent academic achievement of these East and South-East Asian countries. While, these five countries are consistently the top performers in different education assessment studies, internal variation within these countries may not follow the same pattern and thus should not be ignored. Moreover, out of six countries from this region those chose to attend in TIMSS study, Thailand lags 1.9 standard deviations behind the top achiever Singapore, and 1.7 standard deviations behind the average of the five remaining countries. Therefore, by estimating education production function for these six East and Southeast Asian countries, this study will allow us to identify the determinants of educational attainment in these countries, compare across them and to check the robustness of earlier findings. This study follows the methodology primarily suggested by Woessmann (2003) and later followed by many studies including Ammermuller et.al. (2005), Badr et al. (2012).

Chapter 3

Data, Variable and Methods

3.1 Data

This study uses the Trends in International Mathematics and Science Study (TIMSS) 2015 data. International Association for the Evaluation of Educational Achievement (IEA) and its TIMSS and PIRLS International Study Center at Boston College conducted TIMSS 2015. TIMSS is conducted on a regular 4-year cycle starting from 1995 and TIMSS 2015 is the 6th assessment (Foy, 2017). Data are collected at fourth and eighth grades for Science and Mathematics encompassing four different assessments of achievement. This study focuses on the eighth grade student and their performance is measured by their achievement score in Mathematics. All the students in the target grade (for this study eighth grade), as long as mean age at the time of testing is 13.5 years or more belong to the international target population.

TIMSS followed a stratified two-stage cluster sampling design. At first schools are arranged in strata based on different characteristics which includes geographic region, school type, language of instruction, level of urbanization etc. Then at the first sampling stage, schools are selected with probabilities proportional to their size (PPS). Size is measured by an up-to-date count of the number of student in that grade, when unavailable by total student enrollment in the school. At the second stage, following systematic random sampling procedure one or more intact class is selected from the target grade. For this purpose the Windows® Within-school Sampling Software (WinW3S) is used. Sampling precision is strictly maintained in TIMSS study. In a typical country sampling precision is met by selecting 150 school and a student sample of 4000 for the target grade. But to tackle the issues of non-response, quality sorting within school, and small class size most of the countries have drawn a much larger sample (Martin et al., 2016).

The TIMSS project collected data from 56 countries and 6 benchmarking participants. Across both grades 604,950 students, 55,345 teachers, 20,491 principals and the national research coordinators of each participating country were surveyed. At the eighth grade level 270,000 students, 31,000 teachers, and 8,000 schools from 39 countries and 7 benchmarking entities participated in the assessments (Mullis et al., 2016). A total of 32,518 students were surveyed at eighth grade from 6 Asian countries under study.

3.2 Variables

TIMSS provides data on student performance which can be matched with a very rich data set on background information from three types of background questionnaires. This comprehensive data source gives an exclusive chance of studying the determinants of education across countries. The dependent variable in this study is student's performance in mathematics which is measured by the achievement score of eighth grade students in mathematics. TIMSS uses a collaborative process to develop test items required for each assessment cycle and relies on item response theory (IRT) scaling to calculate achievement score. Test items cover content and cognitive dimensions. The mathematics content domains are number, algebra, geometry, and data and chance. The cognitive domains include knowing, applying, and reasoning.

Questions from both multiple-choice and free-response format are included. Since the students are assessed by a portion of the entire pool of assessment items, student's achievement score is calculated using multiple imputations (5 plausible values). And, student's test score is normalized with an international mean of 500 and an international standard deviation of 100 in TIMSS data.

Under the concept of Education Production Function an extensive list of predictor variables is used in analysis to asses their role on student's math performance at the eighth grade level. Variables of interest in this study are mainly chosen from existing education literature. TIMSS 2015 gives an unique chance to asses the influence of a long list of relevant student, family backgrounds, school resources, and teacher characteristics variables on educational achievement.

From the student and family level - sex of student , frequency of test language spoken at home, number of bookcases at home, availability of home educational resources, parent's highest level of education, computer use at home, school and other places, citizenship, absenteeism, weekly time spent on math homework, and students age are included. Most of these variables are constructed from student's response on a number of questions.

For parental education, each student is asked to report the highest level of education completed by his father and mother. An index is created for our analysis for parent's highest education level with four categories; university or higher, post-secondary but not university, upper secondary, and no schooling or up to lower secondary education as the base category. Students were asked if they have some educational resources in their home which includes digital information devices, computer or tablet, own study desk, internet connection, and some other country specific indicator of wealth. An index is constructed for these as home educational resources with three categories - many resources, some resources, and few resources as base category. Parent's education and home educational resources may have some differences in their measurement across the countries. Firstly, level of education may be defined differently across countries in terms of years and courses of education (Woessmann, 2005). Moreover, parents education is constructed by the highest level of education of father or mother. With this criteria, if in some family both father and mother have university degree is equivalent to another family which has only one parent with university degree and another with no education. It may create some problem in interpreting the proper causal relation in between parental education and student performance. Home educational resources are an open ended list which may vary substantially across countries and therefore might not be internationally comparable. We include another variable 'the number of books at home' in our analysis, which is internationally more comparable and may reflect the educational background of the family. 0 - 25 books are categorized as 'none or enough books to fill one shelf', 26 - 100 books are categorized as 'One bookcase', and more than 101 is categorized as 'two bookcases or more'.

TIMSS study asked students to report how frequently they speak test language at home. We re-categorize the four answer options into two - 'test language frequently spoken' and 'not or infrequently spoken' as the reference category. Computer use is grouped in three categories - computer usage either at home or school, computer usage both at home and school, and the base category is computer usage at other places or no computer usage. Gender is studied as a potential source of differential in educational attainment in literature. Especially, in many developing countries, when deciding to finance education, a parental bias in favor of boys is seen. Another reason for possible differential between boy's and girls' educational attainment might steam from supposed disparity of returns to education for male and female (Rosenzweig and Schultz, 1982). Therefore, gender is included in our analysis. Effectiveness of homework policy is seen to vary across different schooling system. Student's were asked two separate questions about homework; i) how often teacher gives homework and ii) when teacher gives homework, about how many minutes do they spend on homework. Based on these two questions a new variable is constructed to show weekly time spent on math homework.

Three more variables are specially included to closely investigate a paradoxical relation shown in TIMSS data. 20 years of TIMSS data shows that on the whole student's enjoyment and confidence with the subject is positively associated with their proficiency score. But when the data are aggregated to the national level, it shows a paradoxical relation. The high performing countries shows a larger percentage of students reporting negative sentiments. The correlation coefficients of TIMSS mathematics score and lack of confidence for eighth grade students are 0.68 in 1995 and 0.66 in 2015. A careful look shows that high performing Asian countries have a much larger share of students reporting lack of confidence. And excluding Japan, Korea, Hong Kong, and Singapore shrinks the correlation to 0.23 for 1995 and 0.33 for 2015 TIMSS data (Mullis et al., 2016). These correlations serve descriptive statistics purpose but are not able to justify causal relation between student performance and student confidence. To investigate this counter-intuitive findings from an econometric point of view this study includes student confidence in mathematics, aspirations, and student's sense of school belonging in our analysis. Student's confidence level in mathematics is measured in three categories - high, medium, and 'Not confident in mathematics' as the base category. To capture the aspirations we use student's response to a question about their desired level of education in future. We re-categorize their response in three categories - university, post-secondary, and up to secondary as the base category. Students were asked a series of questions on their perception about their school, classmates, school safety, teachers, and how proud they are to go to this school. Their response are collected on a likert scale from which school belonging index is constructed with three categories - high, medium, and little sense of school belonging.

From the school level data, school composition by economic background of student body, community size of the area where the school is located, an index of instruction affected by mathematics resource shortage, and an index of school discipline and safety are included in the model. A poverty measure is constructed by considering the schools with more than 50% students from economically disadvantaged group. The number of people live in the city, town, or area where the school is located; i.e. the community size is taken a proxy for rural - urban community type. More than 50,000 people is considered as cut-off point to be considered as urban area in this study. School Principals are asked to report the degree of some problems among the students of target grade in the school which includes arriving late at school, unjustified absences, classroom disturbances, cheating, profanity, vandalism, theft, intimidation, physical injury. From the responses to these questions, an index of discipline problem is constructed with 3 categories - hardly any problems, minor problems, and moderate to severe problems.

Teacher characteristics can also play an important role in student's performance. Therefore, a broad-ranging list of teacher background variables from their mathematics teacher data are included in the model those include teachers experience, sex, age, formal level of education, an index of teacher's job satisfaction, teacher's perception over school emphasis on academic success, whether the teacher majored in mathematics or mathematics education or both, class size, teacher's involvement in formal professional development.

3.3 Methods

3.3.1 Benchmark Models

To identify the determinants of education in East and Southeast Asian countries I estimate the education production function for each of the sample countries. First, to detect the student and family background factors that determine student performance I fit the following econometric model:

$$M_{ics} = \alpha + B_{ics}\beta + \eta_{ics} \tag{3.1}$$

Where M_{ics} is the math test score of student i in class c in school s. B_{ics} represents a vector of student and family background variables. η_{ics} is error term. Model 3.1 does not include school and teacher background variables. At this stage I am interested to see the total impact of student and family level variables (both direct and indirect) on educational achievement in six East and Southeast Asian countries. In TIMSS 2015, countries under study in most of the cases selected only one class per school which will simplify the notation to $_{is}$ in place of $_{ics}$.

Before estimating this model, we need to take care of some important features of TIMSS data. Complex survey design of TIMSS require us to take care of two important issues up front - i) unequal probability sampling and ii) multistage sampling. The stratified two-stage sampling design of TIMSS selected the schools with probability proportional to school size and then classes with probability inversely proportional to school size. All the students from the selected class were selected in the typical TIMSS situation. The overall sampling weight in TIMSS data comprises the selection probabilities at three levels - school, class, and student (Martin et al. 2016). Thus, Weighted analysis is necessary to get unbiased (or nearly unbiased) estimates of corresponding population parameters. Employing the appropriate sampling weights of this stratified sampling data, an Weighted Least Square (WLS) model is estimated which will produce consistent and asymptotically normal estimators of the population parameter (Wooldridge 2001; Solon et al. 2013).

Another very crucial feature of TIMSS data is clustered sampling design. Primary sampling unit is school in this survey. But data are available at student, class and school levels. Some of the variables only vary at the class and school levels. Therefore, the error term η_{ics} has three-level (school, class and student) error components

$$\eta_{ics} = \zeta_s + \nu_{cs} + \epsilon_{ics} \tag{3.2}$$

This nested structure of the data and survey design call for special treatment of the standard error. In case of standard OLS with homoscedasticity and no clustering in data -

$$Y_i = X_i^T \beta + \epsilon_i; \text{ where } \epsilon_i \sim (0, \sigma^2)$$

It implies

$$E[\epsilon\epsilon^T|X] = \Sigma = \sigma^2 I$$

And

$$\begin{aligned}
\text{Var}(\hat{\beta}) &= E[(X^TX)^{-1}X^T\epsilon\epsilon^TX(X^TX)^{-1}] \\
&= (X^TX)^{-1}E(X^T\epsilon\epsilon^TX)(X^TX)^{-1} \\
&= E(\epsilon\epsilon^T)(X^TX)^{-1} \\
&= \sigma^2(X^TX)^{-1}
\end{aligned}$$

Which is consistently estimated by the estimated variance matrix -

$$\hat{\text{Var}}(\hat{\beta}) = S^2(X^TX)^{-1}$$

But in TIMSS data, the unobservable of students belonging to the same school will be correlated while will not be correlated with students in other schools. This implies independence across clusters but correlation within clusters, and *iid* disturbance assumption is not valid. The variance -covariance matrix for clustered data appear as follow -

$$\Sigma = diag(\Sigma_s) = \begin{bmatrix} \sigma_{(11)1} & \dots & \sigma_{(1N_1)1} & 0 & \dots & 0\dots & 0\dots & 0 \\ \vdots & \ddots & \vdots & \vdots & \ddots & \vdots & \vdots & \vdots \\ \sigma_{(N_11)1} & \dots & \sigma_{(N_1N_1)1} & 0 & \dots & 0\dots & 0\dots & 0 \\ 0 & \dots & 0 & \sigma_{(11)2} & \dots\sigma_{(1N_2)2} & & & \\ \vdots & \ddots & \vdots & \vdots & \ddots & & & \\ 0 & \dots & 0 & \sigma_{(N_21)2} & \dots\sigma_{(N_2N_2)2} & & & \\ & & & & \ddots & \sigma_{(11)s} & \dots & \sigma_{(1N_s)s} \\ & & & & & \vdots & \ddots & \\ & & & & \ddots & \sigma_{(N_s1)s} & \dots & \sigma_{(N_sN_s)s} \end{bmatrix}$$

White's (1980) formula gives us a consistent estimate of the variance-covariance matrix of the estimated coefficients for our weighted least square matrix as follow -

$$\widehat{Var}(\hat{\beta}) = (X^TWX)^{-1}(\sum_{s=1}^{S} X_s^TW_s\hat{\epsilon}_s\hat{\epsilon}_s^TW_sX_s)(X^TWX)^{-1}$$

In TIMSS data, student's achievement score is calculated from 5 plausible values, which involves imputation error. Jackknife replication method is used in our analysis, as suggested in TIMSS technical guide to take care of that. This replication technique uses the differences between estimates from the full sample and a series of created sub-samples, i.e. replicates to calculate the correct standard errors.

To see the effect of school level variables and teacher characteristics on student performance a set of relevant school and teacher background variable is added to the model 3.1.But another feature of TIMSS study design need to be kept in mind here. A teacher could be teaching all or some of the students in a class. And in some countries, students at some schools may be taught by more than one teachers. In the data, each teacher is linked uniquely to a class and students who were taught by that teacher. It may create duplicate observations for some students, especially in Japan, with only varying teacher background data. Therefore, in our second specification we add only school resources and other variables that vary at the school level. And in our third specification, we add teacher characteristics and class size to the model 3.1.

$$M_{ics} = \alpha + B_{ics}\beta + S_s\gamma + \eta_{ics} \tag{3.3}$$

$$M_{ics} = \alpha + B_{ics}\beta + S_s\gamma + T_{cs}\delta + \eta_{ics} \tag{3.4}$$

Where S is a vector of school resources and other school level variables, T is a vector of teacher characteristics and class size. If the assumption hold that school resources, teacher characteristics, and class size are exogenous to student achievement, the estimated coefficient vector γ and δ will show the impact of school resource, class size, and teacher characteristics variables on student performance. Though the teacher characteristics can be factually assumed to be exogenous, but for at least some of the school resources and specially class size in many countries this assumption might sound too strict. Only in case of pure experimental study it can be possible to allocate students to different school types and avoid the possibility of between school sorting like (Kruger (1999)) did. But in observational data like TIMSS a potential bias may stem from between school sorting. In many countries we see different types of schools like public vs. private schools. Parents may move to some school district if they think that school would be better for their kids. Some parents may send their boys to mixed schools while girls to single-sex schools if they think it is a better choice. Again some schools especially private schools may select their students based on quality. Both of these leads to between school sorting and will cause bias in estimates of school resourecs and teacher characteristics. One simple way to tackle this bias can be to control for all the family and student level variables that might affect school selection (Dearden et al. 2002). That is what we did in our benchmark models.

Another reason for bias of some resource variables could be chance of endogeneity between those variables and student performance (Hoxby, 2000). Especially, class size in many cases is seen to be affected by school policies. There can be within school quality sorting which leads to non-random allocation of students to different class sizes. Some schools may put low-performing students in smaller class size. Such type of endogeneity is a common problem to non-experimental data. One of the valid option to avoid this potential endogeneity could be to employ instrumental variable technique. But unfortunately, for our specific data set it is very hard to justify that any of the available background variable which might explain some portion of school resources variable but have no direct predictive power over educational performance of the student. Therefore, finding an instrument for class size or other school resources satisfying both the inclusion and exclusion condition is highly disputed in literature. Akerhielm (1995) used total enrollment as an instrument for actual class size. But the validity of using total enrollment as an instrument is questionable as it might have a direct link with student performance outside of its potential relation through class size (Angrist and Lavy 1999).

3.3.2 School Fixed Effects Model

Non-random allocation of students between schools may stem from different sources, both from student's or school administration's side. For instances, some schools are single sex schools while others are mixed, some schools are grammar schools and follow different schooling systems. Some schools are international schools mostly admitting children of personnel of international companies, embassy staffs, and other international governmental or non-governmental organizations and follow either an international curriculum such as Cambridge International Examinations or some modified version of national curriculum. Again parents with higher education and/or higher resources may move to better school district to send their children to better quality schools with better school policies such as smaller class size, better student motivation and mentoring programs.

As the available measures of school resources are imperfect, there is a chance that some of the effects of school unobservable on educational outcome may be picked up by some student and family background variables. In other words, some of the family background variables may proxy for unobserved differences in school resources. It will result in overestimation in the direct effect of student and family background variables (Lee and Barro, 2001). Therefore, to capture the clean effect of student and family background variables we may fit a school fixed effect model. It will allow us to check the robustness of individual level variables under an alternative specification in explaining student performance.

$$M_{ics} = \alpha + B_{ics}\beta + D_s\lambda + \epsilon_{ics} \tag{3.5}$$

Where D_s represents a dummy variable for each school in a country which accounts for individual-invariant school factors. Inclusion of these school dummies allows us to control for the potential effect of omitted school level variables, those are not captured in data, belong exclusively to each school and accommodates school level heterogeneity. Since the school dummmies take care of all the observable and unobservable school level effects on student performance, the school and teacher level variables are excluded from this model.

Chapter 4

Empirical Result

4.1 Student and Family Background Variables

Table 4.1 reports the total effect of student and family level variables without controlling for school resources and teacher characteristics. To asses the impact of family educational and economic background on student performance three sets of dummy variables are included in our analysis; Parent's education, home educational resources and amount of books in home. The result shows that in all countries except Korea parent's education has some positive effect on student performance. The minimum effect is seen in Hong Kong where only children with parents completing university or higher degree do significantly better than the base category, but parents with post-secondary or upper-secondary does not have any significant impact on their child's educational achievement. In Japan and Chinese Taipei children of parents with upper-secondary and university or higher degree perform significantly better than the children of parents with no schooling or up to lower secondary education. The effect is most consistent and monotonic in Singapore and Thailand with the highest impact, 48.7 test score, in Thailand which implies children whose parents have university or higher level of education do almost half of a standard deviation better than the children whose parents have no education or up to lower secondary. For home educational resources, the most consistent and positive impact is seen in Chinese Taipei. In Japan, Korea, and Singapore the students with many home educational resources do better. In Hong Kong the effect appears to be only marginally significant. Surprisingly, in Thailand, students with some home educational resources perform worse then the students who have only few educational resources at home. A stronger and consistent effect is seen from the number of books at home. The result suggests that students who have one bookcase, or two bookcases or more in their home perform significantly better than the base category; i.e. students with books to fill only one shelf or none. The result is consistent and monotonic across all the countries; this result is in line with the other studies (Woessmann, 2005; Badr et al., 2012; Ammermuller et al., 2005).

Exposure to the test language at home is often considered to have some impact on student performance. In our analysis, test language spoken at home is found to be insignificant only in Japan. Less than 1% student speak test language frequently at home and may be due to this low variability we failed to capture any differential effect of test language in Japan. In Hong Kong students who speak test language frequently at home do worse which is contrary to intuition. Korea, Singapore, Chinese Taipei, and Thailand shows students who frequently speak test language at home perform significantly better than those who either does not or only infrequently speak test language at home. There is some debate on the role of computer usage in school. Our analysis does not show any significant effect of computer usage in Hong Kong and Thailand. But in Japan, Korea, Singapore, and Chinese Taipei we observe negative effect of using computer at home and school. Japan and Singapore shows more consistent negative effect of using computer at home and/or school.

Gender is not found to be a factor that determine education across the East and Southeast Asian countries. Woessmann (2005) in his study on East Asian countries using TIMSS 1995 data found being female is negatively and significantly associated with educational achievement in Hong Kong, Japan, and Korea. TIMSS 2015 data reflects that only in Hong Kong boys outperform girls. In Japan, the picture is reverse; i.e. girls outperform boys. In other countries no significant gender differential is seen. Whether the student is born in the country or not does not explain their educational achievement. Homework seems to have substantial effect on student performance. The result suggests that in Hong Kong, Singapore, Chinese Taipei, and Thailand students who spend more time doing math homework perform significantly better than students who spend only 45 minutes or less per week on math homework. But duration of math homework is not found significant in Japan and Korea. The age of the student is found to be positively related to student performance in Japan but negatively related in Hong Kong and Singapore.

Another important area which is mostly overlooked in education economics literature is student's self-influence factors. We believe that student's performance is not only motivated by external factors like family background, school resources, and teacher characteristics; rather student's self-influence has profound effect on their academic achievement. It is hard to precisely measure self-influence in data. Intrigued by the paradoxical confidence-achievement link in TIMSS data we tried to account for student's self-influence by considering the factors such as student's confidence in mathematics, aspirations, school belonging, and absenteeism.

Student's confidence level in mathematics is measured in three categories with 'Not confident in mathematics' as the base category. The result shows that in all the six countries students who have medium and high level of confidence in mathematics perform significantly and consistently better than the students in base category. Student's aspirations as characterized by expected level of future education is strongly positively and consistently associated with their academic achievement. The results are monotonic for both confidence in math, and level of aspiration across all the countries. School belonging is also found to be a strong determinant of educational attainment. Except in Chinese Taipei, school belonging is found to be positively explaining the academic achievement in five other countries. Absenteeism is another factor that works as an additional proxy for student's self-influence level and therefore included in the analysis. In all the countries students who are infrequently or never absent outperform students who are frequently absent in school with highest effect in Singapore.

Table 4.1: Student-Family Background and Educational Achievement :
WLS Regression with Cluster-Robust Standard Errors

	Japan		Korea		HongK		Singap		C.Taipei		Thailand	
Parent Upper-Sec	10.3	(8.97)	-5.43	(12.3)	0.30	(3.55)	12.3***	(4.08)	5.47	(3.53)	13.5***	(3.39)
Post-secondary	24.1***	(8.90)	-10.3	(13.1)	-1.90	(4.56)	14.5***	(4.08)	17.9***	(4.23)	16.7***	(5.04)
Univ or Higher	39.5***	(8.91)	-1.26	(12.6)	10.2*	(5.48)	29.8***	(4.15)	22.6***	(4.57)	48.7***	(6.51)
Some H.Edu Res	12.1*	(6.23)	7.29	(7.28)	6.81*	(3.97)	6.18	(4.04)	11.6***	(4.17)	-10.4***	(3.00)
Many H. edu Res	20.1***	(6.94)	17.8**	(7.97)	11.3*	(5.75)	16.3***	(5.59)	13.0**	(5.24)	3.91	(12.1)
One bookcase	18.8***	(2.64)	15.4***	(4.05)	16.5***	(3.17)	20.8***	(1.87)	21.4***	(2.51)	19.2***	(3.24)
Two Bk. or more	33.6***	(3.37)	31.1***	(3.45)	21.0***	(3.77)	22.4***	(3.31)	35.6***	(3.22)	38.4***	(7.33)
TL Freq spoken	19.8	(16.2)	50.0***	(18.7)	-10.4**	(4.39)	7.40***	(2.26)	35.1***	(3.55)	19.9***	(5.08)
Comp at HM/SL	-13.2***	(2.35)	0.13	(2.44)	3.03	(2.95)	-5.14**	(2.32)	2.53	(2.17)	-0.97	(3.70)
Comp at HM and SL	-23.2***	(4.95)	-14.5***	(3.22)	-1.44	(3.54)	-9.26**	(3.76)	-10.1***	(2.86)	1.86	(3.77)
Girl	7.60**	(3.00)	1.10	(2.27)	-6.77*	(3.55)	4.70	(3.60)	0.094	(2.07)	0.74	(3.23)
Citizen	0.70	(12.7)	13.1	(11.5)	-0.99	(3.32)	-3.77	(2.50)	12.0	(8.80)	13.4	(11.4)
HW 45 min−3 hrs	2.24	(3.36)	-2.29	(2.73)	16.3***	(4.22)	28.0***	(3.69)	19.4***	(2.51)	23.5***	(3.10)
More than 3 hrs	0.23	(9.98)	-7.89	(7.15)	17.2***	(5.51)	33.0***	(4.51)	18.2***	(4.18)	36.4***	(4.30)
Students Age	13.2***	(3.52)	0.94	(3.02)	-10.0***	(2.92)	-3.92*	(2.07)	3.38	(3.32)	-0.40	(2.60)
M. conf. in Math	50.0***	(2.28)	58.5***	(2.07)	36.0***	(2.42)	41.5***	(2.13)	67.3***	(2.11)	34.0***	(3.28)
High conf. in Math	84.2***	(4.24)	94.3***	(3.59)	75.1***	(3.64)	68.7***	(3.30)	100.1***	(3.01)	111.3***	(8.00)
Expect Post-sec	16.7***	(3.70)	30.6***	(4.64)	19.0***	(5.39)	24.7**	(9.70)	35.3***	(5.68)	18.0***	(3.66)
University	59.3***	(3.64)	65.9***	(4.10)	50.2***	(6.27)	56.4***	(10.1)	74.6***	(3.10)	44.4***	(3.75)
Med SL belonging	9.53***	(3.45)	22.4***	(4.16)	20.1***	(3.87)	12.2***	(3.16)	4.81	(3.57)	21.0***	(7.78)
High belonging	9.79**	(3.89)	21.1***	(4.59)	29.2***	(4.89)	16.9***	(4.18)	4.45	(4.09)	20.0**	(7.91)
Infr/Never absent	34.5***	(5.50)	40.2***	(10.4)	36.9***	(8.27)	58.2***	(5.40)	50.5***	(7.37)	30.6***	(3.05)
Constant	228.9***	(56.9)	360.9***	(49.3)	605.1***	(43.2)	482.6***	(33.3)	315.5***	(47.9)	286.3***	(43.7)

Jackknife cluster standard error are in parentheses

4.2 Resources and School level Variables

Table 4.2 presents the estimates of the resources and other school level variables after controlling for all the student and family background variables reported in previous section. School principals and department heads were asked a series questions to collect data on the resources and school level variables. The estimated coefficients of these variables may have important policy implications. Composition of students in the school in terms of their economic background, community size, instruction affected by resource shortage, and school discipline problems index are included in our analysis.

Composition of students in the school in terms of their economic background; i.e. percentage of poor student in the school is found to be an important factor in determining the student performance. Except Chinese Taipei, and Thailand, in all other countries, students in schools with more than 50% of students from economically disadvantaged group perform significantly lower, with the highest adverse effect in Singapore. In Japan, Chinese Taipei, and Thailand students of schools in urban area; i.e. community size greater than 50,000, perform better.

One of the variables which is of direct policy implication is school resource. No country is seen to have a significant association between instructional resource availability and student performance in East and Southeast Asia. This findings is in line with many other previous studies. School discipline problem is identified as one significant impediment for students to do better in school. Except Korea, all other East and Southeast Asian countries suffers in student performance from minor discipline problem in school in against the base category of schools with hardly any discipline problems. Although the effect becomes insignificant for schools with moderate to severe discipline problem in Japan and Hong Kong; it gets bigger in Chinese Taipei and Thailand with an effect size of 26 and 29 test scores.

Table 4.2: Resources, Other School Level Variables and Educational Achievement : WLS Regression with Cluster-Robust Standard Errors

	Japan		Korea		HongK		Singap		C.Taipei		Thailand	
>50 percent disadv.	-34.0*	(17.8)	-7.77*	(4.34)	-33.8***	(9.11)	-113.4***	(6.48)	-19.6	(35.0)	-9.78	(6.60)
Com size > 50k	8.48*	(4.68)	8.30	(5.03)	9.35	(18.0)	2046.3	(1327.9)	14.6***	(4.77)	20.1**	(8.61)
Aff. by res short	-2.24	(4.52)	0.16	(3.78)	-4.64	(7.62)	-4.17	(4.60)	-3.33	(4.37)	8.52	(19.8)
Minor Dis. prob	-12.9***	(4.65)	-2.56	(4.07)	-13.5*	(8.06)	-18.5***	(4.82)	-8.78**	(3.76)	-25.3***	(6.82)
Moderate/Severe prob	-8.64	(8.27)	-1.54	(5.67)	-7.16	(9.50)			-26.4***	(3.07)	-29.2***	(7.71)

Jackknife cluster standard error are in parentheses

4.3 Teacher Characteristics and Class Size

The effect of teacher characteristics and class size in East and Southeast Asian countries is shown in Table 4.3. Only in Singapore, female teacher is found to bring about higher student performance. In no other country a significant effect from teacher gender is seen in educational achievement. Teacher's experience is only marginally significant in Hong Kong and the effect size is very small as well. Another dummy variable is constructed to see whether the older teachers help students perform better. But no significant effect is seen for teachers being 50 years or older in any country. Only in Japan, teachers with a Master degree or higher affect student's performance positively. No other East and Southeast Asian countries show any significant effect from teacher having a Masters or higher degree on academic achievement. We checked in our analysis whether teachers majored in mathematics and/or mathematics education help students perform better. The result is mixed. Teachers majored in mathematics or mathematics education is found to have positive impact on student's achievement only in Singapore, but negative impact in Thailand. Whereas teachers with both majors influence student's achievement positively in Singapore and Chinese Taipei; but negatively in Hong Kong and Thailand which is counter-intuitive. Teacher's professional development is not also found to be effective to boost student's performance up. Rather in Singapore it is found to be significantly negatively affecting achievement. These counter-intuitive findings call for further investigation. It can be examined whether the professional development program in Singapore is properly content-focused or not and whether teachers who are increasingly attending in professional development programs belongs to the lowest quantile of the distribution of knowledge.

Teacher's individual level job satisfaction index does not seem to explain the variation in student performance in any country. But teacher's perception of school emphasis on academic success turns out to be a very good predictor of academic achievement of the students. It is significantly positive and consistent across the countries with highest impact in Hong Kong, showing a 34 test score gap between schools putting high emphasis on academic success in against the base category of only medium emphasis. Class size is another very important variable of direct policy implication and is highly debated in literature. Existing literature is divided as to what is the sign and significance of class size on student performance. Endogeneity issue with class size is more evident. Both between school sorting and within school sorting can affect affect class size. As explained in the literature review and methods sections, we tried to control for as many relevant variable as possible within the limitation of data availability to capture the true effect of class size. Our result suggests that, amongst the East and Southeast Asian countries only Korea experiences a small positive effect of class size implying that students in larger classes perform better. And, in Chinese Taipei class size exert very negligible positive effect on student performance after some point as implied by the coefficient of class size square.

Table 4.3: Teacher Characteristics, Class Size and Educational Achievement
: WLS Regression with Cluster-Robust Standard Errors

	Japan		Korea		HongK		Singap		C.Taipei		Thailand	
T.female	-2.67	(4.82)	4.81	(4.54)	1.73	(8.41)	13.9***	(3.91)	-0.29	(3.63)	1.48	(7.44)
Teacher's exp	0.40	(0.31)	0.30	(0.28)	1.06*	(0.58)	0.47	(0.32)	0.44	(0.31)	0.35	(0.42)
T.50 yrs or older	0.56	(9.78)	-1.60	(7.16)	-10.2	(16.0)	-15.8	(10.2)	-3.50	(6.66)	-11.1	(11.6)
T. Masters/higher	21.1**	(9.43)	-3.72	(3.83)	6.76	(7.31)	6.34	(6.77)	3.65	(3.37)	10.8	(8.89)
Math/MathEd	0.78	(6.27)	-4.38	(10.00)	-9.67	(10.5)	13.3*	(7.56)	8.05	(5.21)	-19.8**	(9.68)
Math and MathEd	-1.43	(5.98)	-0.29	(10.8)	-21.6*	(10.9)	15.2*	(8.43)	9.89*	(5.41)	-26.7***	(9.98)
T. Professional D.	-2.71	(5.24)	-4.22	(5.17)	0.56	(18.9)	-23.0***	(6.53)	-2.19	(9.03)	14.5	(10.6)
T. satisfied	3.08	(5.00)	4.15	(5.88)	0.71	(12.7)	-1.19	(5.69)	-3.20	(7.63)	-0.52	(35.2)
High emphasis	10.0**	(4.16)	13.6***	(4.10)	33.6***	(9.64)	22.2***	(3.64)	15.0***	(3.50)	16.0**	(7.04)
Class size	0.23	(2.17)	1.40**	(0.69)	0.80	(4.73)	1.05	(1.83)	-1.31	(1.32)	-2.97	(2.20)
Class size square	-0.0030	(0.041)	-0.014	(0.012)	0.032	(0.087)	-0.0010	(0.032)	0.042**	(0.018)	0.051	(0.037)

Jackknife cluster standard error are in parentheses

4.4 School Fixed Effect Estimates

In table 4.4, we present the estimated impact of student and family background variables under the school fixed effect specification. School fixed effect estimates eliminate all the effect of school-specific student-invariant variables. By removing any systematic between school variation, it gives us the clean effect of individual and family level variables on student performance.

The result is broadly similar under two specifications with lower level of impact and lower statistical significance in case of some variables under the school fixed effect specification. Parental education loses its significance in Singapore and Chinese Taipei. For upper secondary level of parent's education only Thailand and for post-secondary level only Japan has significant positive effect. For university or higher degree, only children of parents in Japan, Singapore, and Thailand perform significantly better. The size of the effect decreases in all of these cases. Home educational resources is now positively significant only in Chinese Taipei and negatively significant in Thailand. Parental education and home educational resources have much lower positive impact on student performance compared to our benchmark model outcome. This probably implies that family socio-economic status does not directly translates into superior student performance. Rather they send their children to better quality school and this is the unobserved school quality that works behind their better performance. However, number of books at home again turns out to be a very consistent predictor of student's superior performance across all countries.

Test language frequently spoken at home and computer usage are found to be positively and negatively affecting educational achievement respectively, as before. Gender effect remains negative and significant for girls in Hong Kong, but loses significance in Japan and gains in favor of girls in Korea. Within school, students born in country perform significantly worse in Hong Kong and Singapore and only marginally significantly better in Korea. Duration of time spend on homework is once again found to be positive and significant in Hong Kong, Singapore, Chinese Taipei, and Singapore; though the extent is much lower. Though it was not significant in Japan in our benchmark model, it becomes significantly negative now. Perhaps weaker students in Japan are given more homework, or they themselves spend more time on doing homework. As using this data we can not control for ability, we are unable to provide unique answer for this. Student's age gives mixed result just as before.

Confidence in mathematics and student's desired level of future education still remain significantly positive and consistent across the countries. School belonging still shows positive effect on student performance in general, though the effect size is much lower now. But it loses its significance in Thailand. May be students who go to better quality school show higher school belonging and eventually perform better. As we are taking care of all the between school variation in this model, the direct effect of school belonging is not as strong as before. However, the absenteeism of student exerts a strong and consistent negative impact on educational achievement, as is seen our benchmark model.

Table 4.4: Student-Family Background and Educational Achievement : School Fixed Effect Model with Cluster-Robust Standard Errors

	Japan		Korea		HongK		Singap		C.Taipei		Thailand	
Parent Upper-Sec	6.66	(8.44)	-3.87	(12.6)	-3.24	(2.24)	2.77	(2.96)	-5.31	(5.91)	11.3***	(3.58)
Post-secondary	21.1**	(8.21)	-10.4	(12.8)	-2.65	(2.48)	3.19	(2.97)	0.76	(6.89)	10.4	(7.15)
Univ or Higher	26.0***	(8.05)	-7.82	(12.2)	-2.32	(2.87)	6.80**	(3.00)	1.42	(7.23)	16.7***	(5.14)
Some H.Edu Res	6.58	(7.77)	-3.23	(9.72)	2.29	(2.33)	1.41	(2.82)	11.9**	(5.65)	-10.6***	(3.29)
Many H. edu Res	10.7	(8.33)	4.61	(11.3)	-1.47	(4.55)	2.07	(4.08)	18.0***	(6.82)	-19.4*	(9.88)
One bookcase	14.4***	(2.82)	18.1***	(4.31)	4.99***	(1.83)	11.0***	(1.57)	19.1***	(5.43)	6.35**	(2.93)
Two Bk. or more	31.4***	(3.10)	30.6***	(4.25)	6.68***	(2.52)	9.17***	(2.48)	26.1***	(3.94)	11.9	(7.29)
TL Freq spoken	16.9	(13.7)	63.7***	(21.4)	4.53	(2.94)	5.07***	(1.60)	28.2***	(4.69)	8.83***	(3.00)
Comp at HM/SL	-11.9***	(2.66)	-1.40	(2.41)	-2.30	(1.76)	-7.62***	(1.68)	-2.94	(3.10)	-7.98*	(4.57)
Comp at HM and SL	-23.9***	(4.05)	-12.6***	(3.41)	-7.18***	(2.04)	-15.4***	(2.09)	-11.4***	(3.71)	-8.83**	(4.16)
Girl	1.45	(2.01)	6.99***	(2.67)	-10.6***	(1.70)	0.76	(1.80)	-0.43	(3.28)	0.12	(2.74)
Citizen	6.49	(12.5)	20.9*	(12.0)	-11.6***	(2.49)	-5.97***	(1.85)	7.08	(9.11)	12.1	(14.8)
HW 45 min−3 hrs	-13.2***	(2.17)	-4.18	(2.78)	5.73**	(2.25)	12.9***	(2.77)	12.9***	(2.96)	10.4***	(3.15)
More than 3 hrs	-35.7***	(5.77)	-9.56	(6.97)	3.92	(2.78)	16.6***	(3.51)	-3.13	(3.65)	10.6***	(4.04)
Students Age	12.5**	(5.48)	-4.28	(4.72)	-5.08***	(1.59)	-3.08**	(1.42)	1.28	(3.97)	1.91	(2.21)
M. conf. in Math	48.9***	(2.50)	61.1***	(2.17)	35.0***	(1.96)	32.7***	(1.57)	62.4***	(3.09)	26.7***	(2.26)
High conf. in Math	87.4***	(4.14)	91.2***	(5.52)	69.5***	(2.83)	57.4***	(2.50)	95.8***	(4.15)	87.4***	(8.80)
Expect Post-sec	20.7***	(4.22)	27.6***	(5.22)	9.51**	(4.39)	9.01	(6.77)	34.2***	(9.44)	19.3***	(4.48)
University	52.6***	(3.31)	55.4***	(6.14)	18.5***	(4.43)	25.4***	(7.08)	70.3***	(5.24)	29.6***	(3.95)
Med SL belonging	4.75	(4.01)	18.4***	(4.77)	6.77**	(2.65)	6.57**	(2.71)	1.58	(5.35)	6.19	(12.1)
High belonging	6.11*	(3.53)	15.0***	(5.39)	3.62	(2.97)	2.68	(3.10)	-0.38	(6.35)	8.04	(12.7)
Infr/Never absent	32.2***	(6.20)	47.5***	(10.2)	14.5***	(4.64)	34.2***	(3.87)	40.4***	(7.00)	22.0***	(3.44)
Constant	268.1***	(83.2)	427.1***	(76.3)	621.7***	(26.8)	573.2***	(23.7)	387.1***	(61.2)	314.1***	(41.3)

Jackknife cluster standard error are in parentheses

Chapter 5

Conclusion

We employ a set of cluster robust linear regression model weighted by appropriate sampling probabilities to estimate the education production function for six East and Southeast Asian countries using TIMSS 2015 data. We also estimate the effect of student and family background variables under the school fixed effect specification. Our dependent variable is TIMSS mathematics test score, a measure of cognitive skills of eighth grade students. The analysis includes a long list of student, family background, school level, and teacher characteristics data.

Our results suggest that individual and family background variables have larger and consistent impact on student performance. Total effect of individual and family background variables, without controlling for possible correlation of some of these variables with unobserved school level factors, shows that student performance is strongly affected by these variables across the countries. Family socioeconomic status (SES) which is characterized in this study by parent's education, home educational resources, and number of books at home have substantial positive effect on student performance with large variability across the countries. It signifies firstly, the general importance of family socioeconomic status in determining student performance and secondly, the heterogeneity of school system across these high performing East and Southeast Asian countries. The effect of parental education and home educational resources is much lower in Korea and Hong Kong, which probably indicates the higher efficiency of schooling system in these two countries, since an effective schooling system is expected to ensure high student performance disregarding their socioeconomic background. Under the school fixed effect specification, the size and significance of parent's education and home educational resources goes down remarkably. The change is highest in Singapore which probably indicates the presence of higher 'between schools sorting' in Singapore. The most consistent family background variable is number of books at home with and without conditioning for school fixed effects. This implies that, given the same level of parental education, home educational resources, school effects and other observed factors, students of families who have more books in home perform consistently better in school. Number of books at home here better demonstrate the value that families places on education and a stimulating environment in home for education.

Homework policy seems to work favorably in Singapore, Thailand, Chinese Taipei and Hong Kong. But negative coefficient of homework in Japan begs for further research under different specifications. A quantile regression framework may better suggest whether it is true only at the certain point of the achievement distribution. Computer usage is found to be consistently negative across all the Asian countries which probably mirror the traditional education system of Asian countries. This can be a chicken or the egg situation. Whether usage of computer works as a distraction, student are cheating on their homework, using computer for nonacademic purposes and learning less or, they are doing poorly because computer is much less integrated in the learning process in Asian schools – it can be an interesting question for further research, but unfortunately beyond the scope of our present study.

School resource, teacher characteristics, and class size are not of much significance implying that observed school resources do not much explain the student performance. These findings are in line with many other earlier studies on different group of countries (Hanushek ,1995; Ammermuller et. al., 2005; Woessmann, 2005). Student's from schools in the high poverty area perform significantly worse in Japan, Korea, Hong Kong and Singapore. Moreover, student's self-influence factors, school discipline, and teacher's perception of school emphasis on academic success are found to be very strong and consistent determinants of educational attainment across the countries.

Thailand lags 1.7 standard deviations behind the average of the other five Asian countries in this study. We notice at least few differences in the pattern of educational production in between Thailand and other five countries. Thailand shows negative effect of home educational resources, highest rural - urban gap and highest effect of school discipline problems. Moreover, significant effect of parental education and home resources after conditioning for school fixed effect probably indicates that schooling system is less efficient in Thailand compare to its Asian counterparts.

While these high performing Asian countries are already leading the international educational assessment studies, our findings may have some policy implications for them. Scrutinizing the computer usage policy can be a worthwhile policy. But, whatever may be the reason, under the current setup, investing more in computer usage alone is not an effective policy in Asian countries. Though the school resources are found insignificant, channeling some school fund to further strengthen the school's promise on academic success, encourage student's school belonging, confidence in the subject, and attendance, and curb disciplinary problems may turn out to be effective. To help schools with higher share of students from disadvantaged group, some sort of policy support may work. In addition, Thailand may provide some support to their rural schools to close the achievement gap and may strive to improve the overall school efficiency.

This study has some obvious limitations. Firstly, missing value is a common problem for survey data. We did not impute missing values in this study. As the sample size is large enough and under the assumption of missing at random, the result of our analysis may remain unbiased. But any systematic pattern in the missing values may cause bias in our result. As we are dealing with cross-sectional data, another limitation is data available for a specific point in time. Therefore, we fit the model at the level under the assumption that only current inputs suffice or, inputs remain constant over time. But in cognitive skill analysis student's ability is an important factor, which we cannot control for in this study. Endogeneity of school resources, especially of class size could not be dealt sufficiently in this study. We controlled for an extensive list of student and family background variables that lower the bias from between school sorting, but still there can be within school sorting that our study could not deal with. Despite these limitations, our study can be considered as a systematic first attempt to analyze the TIMSS 2015 data (released on January 19, 2017) to identify the factors that determine educational attainment in high performing Asian countries. It contributes to the contemporary education economics literature with findings from latest data. Future studies could impute the missing values, and try to take care of the endogeneity issue under alternative specifications. Also, further studies might want to look at how the results vary across the achievement distribution.

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