RISE

RESEARCH ON IMPROVING SYSTEMS OF EDUCATION

RISE Working Paper 20/036
March 2020

What Explains Vietnam's Exceptional Performance in Education Relative to Other Countries? Analysis of the 2012 and 2015 PISA Data

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Abstract

On the 2012 and 2015 PISA assessments, Vietnam's performance ranks much higher than that of all other developing countries, and even ahead of richer countries such as the U.S. and the U.K. This is especially remarkable since Vietnam was the poorest or second-poorest PISA participant. We provide the first rigorous investigation of Vietnam's strong performance. Despite various corrections for potentially non-representative PISA samples, including bias due to Vietnam's large out-of-school population, Vietnam remains a large positive outlier conditional on its income. Possible higher motivation of Vietnamese students at most only partly explains Vietnam's performance. We also find that household- and school-level variables explain little of Vietnam's exceptional performance. Finally, Blinder-Oaxaca decompositions indicate that the gap in average test scores between Vietnam and the other participating countries is due not to differences in students' and schools' observable characteristics, but is mostly caused by the greater "productivity" of those characteristics in Vietnam.

JEL Classifications: H0, I2, O1, P3

Keywords: education, student learning, test scores, enrolment, PISA, Vietnam

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Acknowledgements:

We thank Francesco Avvisati, Luis Felipe Saenz, and Nic Spaull, as well as seminar participants at Columbia University (Teachers College), the City University of New York, the University of Copenhagen, the 2017 LACEA conference in Buenos Aires, the 2017 RISE conference, the University of Hawaii, and the OECD, for helpful comments.

This is one of a series of working papers from "RISE"—the large-scale education systems research programme supported by funding from the United Kingdom's Department for International Development (DFID), the Australian Government's Department of Foreign Affairs and Trade (DFAT), and the Bill and Melinda Gates Foundation. The Programme is managed and implemented through a partnership between Oxford Policy Management and the Blavatnik School of Government at the University of Oxford.

Please cite this paper as:

Dang, H., Glewwe, P., Lee, J., and Vu, K. (2020). What Explains Vietnam's Exceptional Performance in Education Relative to Other Countries? Analysis of the 2012 and 2015 PISA Data. RISE Working Paper Series. 20/036. https://doi.org/10.35489/BSG-RISE-WP_2020/036

I. Introduction

Vietnam's rapid economic growth in the last 30 years has transformed it from one of the world's poorest countries to a middle-income country (World Bank, 2013). While Vietnam's economic achievements have attracted much attention, in more recent years its accomplishments in education have also generated a great deal of international interest.

Vietnam's high performance in the "quantity" of education is exemplified by its high primary school completion rate of 97%, and its high lower secondary enrollment rate of 95%.[1] More striking still are the results of the 2012 PISA assessment: Vietnam's performance ranked 16th in math and 18th in reading out of 63 countries and territories,[2] ahead of both the US and the UK and much higher than that of any other developing country (OECD, 2014a). Its 2012 PISA mathematics and readings scores (at 511 and 508), for example, were more than one standard deviation higher than those of Indonesia (375 and 396), a nearby country whose GDP per capita is most similar to that of Vietnam among all countries that participated in the 2012 PISA.[3]

A visual depiction of Vietnam's performance on the PISA in 2012, given its income, is shown in Figures 1 and 2, which plot PISA scores in math and reading by the log of per capita GDP for all 63 countries. Vietnam is in the upper left in both figures, higher than any other country above the line that shows the expected test score given per capita GDP. Vietnam is also the largest positive outlier when PPP (purchasing power parity) GDP is used (see Figures B1 and B2 in Appendix B). More recently, Vietnam was again the largest positive outlier in the 2015 PISA assessment, as seen in Figures 3 and 4. Finally, if the sample is limited to the nine East

[1] The lower secondary rate is from Dang and Glewwe (2018), while the primary completion rate was calculated by the authors using the 2014 VHLSS data; the VHLSS data are described further below.
[2] This paper considers only countries, and thus excludes Shanghai, which is obviously not representative of China as a whole, and the territory of Perm, which not representative of Russia. For convenience, we refer to Hong Kong, Macao and Taiwan as countries, although the first two are Chinese territories, and Taiwan's status is disputed.
[3] The GDP per capita for Indonesia was $US 3,347 in 2015, which is about 50 percent higher than that of Vietnam ($US 2,110) in the same year (World Bank, 2017).

Asian and Southeast Asian participants in the 2012 PISA, Vietnam is still the largest positive outlier (see Figures B3 and B4 in Appendix B).

This paper uses the 2012 and 2015 PISA data to try to understand Vietnam's unusually high performance on these assessments of student learning. More specifically, it has three objectives. First, it examines whether Vietnam's impressive performance on these PISA assessments may be exaggerated because: i) the 15-year-old Vietnamese students who participated in these assessments are not representative of 15-year-old students in Vietnam; ii) the enrollment rate of 15-year-olds in Vietnam is much lower than those rates in other PISA countries; or iii) Vietnamese students put more effort into those assessments than other students. Second, it uses regression methods to investigate whether family, teacher or school characteristics in the PISA data can explain Vietnamese students' high performance. Third, it applies the Oaxaca-Blinder decomposition to disaggregate the difference in average test scores between Vietnamese students and students in the other countries that participated in the 2012 and 2015 PISA assessments.

This paper's first finding is that Vietnam's striking performance on the 2012 and 2015 PISA assessments is at most only partially reduced by adjustments to reduce the possible sources of upward bias discussed above. In particular, adjusting Vietnam's PISA scores to control for possible oversampling of wealthier, more urban students reduces its scores by only 20-24 (14-15) points in 2012 (2015). Moreover, three different methods to adjust for Vietnam's low coverage (enrollment) rates (after correcting the OECD coverage rates for Vietnam) have little effect on its outlier status. Finally, back-of-the-envelope calculations to account for possible higher motivation of Vietnamese students on the PISA account for less than half of Vietnam's outlier status.

The second finding it that accounting for household- and school-level variables in the PISA data explains little of Vietnam's high performance on the 2012 and 2015 PISA assessments relative to its income level. A third finding is that Oaxaca-Blinder decompositions show that the gap in average test scores between Vietnam and the other countries in the 2012 and 2015 PISA is *not* due to differences in observable child, household and school characteristics; it is mostly due to Vietnam's higher "productivity" of those characteristics relative to the other PISA countries.

This paper focuses on Vietnam, and is most relevant to education policies in that country. But to the best of our knowledge, it also the first study to offer a rigorous and detailed analysis of the performance of one PISA country participant in comparison with the others.[4] As such, the framework of analysis used here may be useful for studies of other countries' performance in a similar context, not only for the PISA but also other skill assessments of multiple countries.

This paper consists of five sections. It examines the possible mechanisms that could exaggerate Vietnam's performance in the next section, before employing regression methods to investigate the role of family, teacher and school characteristics in explaining this performance in Section III. It then provides in Section IV Oaxaca-Blinder decompositions of the test score gap between Vietnam and the other PISA participants, focusing on child, household and school characteristics. Conclusions are offered in Section V.

II. Is Vietnam's Performance on the 2012 and 2015 PISA Assessments Exaggerated?

Some observers, both Vietnamese and international, of Vietnam's high performance on the 2012 and 2015 PISA assessments have expressed surprise that Vietnam could perform so well.[5] This section investigates three possible mechanisms that could exaggerate Vietnam's

[4] For a recent investigation of the qualitative aspects of the PISA, see Waldow and Steiner-Khamsi (2019).
[5] See, for example, the comments by Deputy Minister of Education Nguyen Vinh Hien in *Thanh Nien News* (2013).

performance: 1. The 15-year-old Vietnamese PISA participants in 2012 and 2015 were not representative of 15-year-old Vietnamese students in those years; 2. Vietnam's relatively low enrollment rate for 15-year-olds selects higher-performing PISA participants; and 3. Vietnamese students exert more effort when participating in the PISA assessments.

A. Were Vietnam's PISA Participants "Better than Average" 15-year-old Students?

Were the Vietnam's PISA participants in 2012 and 2015 representative of the students that those assessments were intended to sample? Consider the 2012 PISA. In each participating country, the 2012 PISA participants were to be a random sample of all children born in 1996 (and thus were 15 years old in January of 2012) who were enrolled in school in 2012 (OECD, 2014b).[6] Whether the students who participated in the 2012 PISA in Vietnam are a representative sample of individuals born in 1996 who were students in 2012 can be considered using data from the 2012 Vietnam Household Living Standards Survey (VHLSS), which Vietnam's General Statistical Office conducts every two years on a sample of about 9,000 households in Vietnam. The 2012 VHLSS can be used to compare Vietnamese children in that survey who were born in 1996 and were students in 2012 with the Vietnamese students who participated in the 2012 PISA.

Table 1 uses data from the 2012 PISA assessment and the 2012 VHLSS to assess the representativeness of Vietnam's PISA participants in 2012. These two data sources have several discrepancies. Compared to the VHLSS data, the students who participated in the 2012 PISA are more likely to be from urban areas (50% vs. 26%),[7] are slightly more likely to be in grade 10

[6] Most PISA countries, including Vietnam, conducted testing on April 12-14 of 2012. Thus children born in 1996 would be from 15 years and 3 (completed) months of age (born in December of 1996) and 16 years to 2 (completed) months (born in January of 1996). The target population was defined as "all students aged from 15 years and 3 completed months to 16 years and 2 completed months at the beginning of the assessment period" (OECD, 2014b, p.66).

[7] PISA's urban classification refers to schools, not students. Some students may live in rural areas and attend urban schools; they would be classified as urban in the PISA but as rural in the VHLSS and so may explain some of the urban/rural difference in the two samples. Yet this cannot explain the other differences in these samples in Table 1.

(86% vs. 84%) and less likely to be in grade 9 (10% vs. 14%), have more educated fathers (9.0 vs. 7.2 years of schooling) and mothers (8.3 vs. 6.8 years), and are more likely to live in homes with air conditioners, cars, computers and televisions, and so are from wealthier families.

The discrepancy regarding the likelihood of being in grades 9 and 10 is larger if one notes that the 2012 PISA assessment was administered in Vietnam in April of 2012, which is a time when 22% of the children born in 1996 are still in grade 9, as seen in the third column of Table 1. More specifically, of the children born in 1996 who were still in school and were interviewed between March and July in the 2012 VHLSS (and thus had not yet reached the next grade of schooling in September of 2012),[8] 76% were in grade 10, while 22% were in grade 9; in contrast, of PISA participants in April of 2012, 86% were in grade 10 and only 10% were in grade 9. The distinction between grades 9 and 10 is important in Vietnam, because almost all children complete grade 9, but in many provinces, students must pass provincial entrance exams to enroll in grade 10. Thus 86% of the students in the PISA sample are students who have passed an exam that selects better performing students for upper secondary school, but the VHLSS data indicate that only about 76% of children in Vietnam who were eligible to participate in the PISA exam when it was administered (in April of 2012) were in grade 10 and thus had passed that exam.

Similar patterns are seen in the last four columns of Table 1, which compare the students in the 2015 PISA (who were 15 years old when they took that test, and so should be a random sample of students born in 1999) to an average of students who were 15 years old in 2014 (more precisely, born in 1998) in the 2014 VHLSS data and students who were 15 years old in 2016 (more precisely, born in 2000) in the 2016 VHLSS data (this average is used because there is no

[8] Of the 236 15-year-old students interviewed in the first two rounds of the 2012 VHLSS, about half were interviewed in March or April, and about half were interviewed in June. Only 5 were interviewed in May, and 4 in July.

VHLSS for 2015). Relative to the averaged VHLSS data (focusing on those interviewed between March and July), the 2015 PISA participants are more likely to be in urban areas (50% vs. 29%), have more educated mothers (8.4 vs. 6.9 years of schooling) and fathers (7.9 vs. 6.4 years), and are more likely to live in homes with air conditioners, cars, computers and televisions. In contrast to the findings for 2012, the students in the 2015 PISA assessment are only slightly more likely to be in grade 10 (85.5%) relative to their counterparts in the averaged VHLSS data (84.3%).

The differences in Table 1 between the PISA and the VHLSS data raise a question: How would Vietnam's students have scored on the PISA if the PISA sample had had the same student characteristics as the VHLSS sample? This can be assessed by using the PISA data for Vietnam to predict Vietnamese students' performance on the PISA, assuming that this predictive power of the student-level characteristics is valid for the same characteristics as measured by the VHLSS.

More specifically, consider an ordinary least squares (OLS) regression that uses the PISA data for Vietnam to predict students' scores on that assessment based on the variables in Table 1:

$$\text{PISAscore}_i = \boldsymbol{\beta}'\mathbf{X}_i + u_i \qquad (1)$$

where $\mathbf{X}_i$ is a vector, for student *i*, of the student characteristics in Table 1. The regressions for the 2012 and 2015 PISA data, using Equation (1), are shown in Tables B1 and B2, Appendix B.[9]

A convenient property of OLS regressions is that the mean values of the explanatory variables perfectly predict the mean value of the dependent variable. That is:

$$\overline{\text{PISAscore}} = \hat{\boldsymbol{\beta}}_{OLS}'\overline{\mathbf{X}}_{PISA} \qquad (2)$$

where the horizontal bars indicate mean values and $\hat{\boldsymbol{\beta}}_{OLS}$ is the OLS estimate of $\boldsymbol{\beta}$. This is shown in the top halves of Tables 2 (math) and 3 (reading); the first columns depict $\overline{\mathbf{X}}$ from the 2012 PISA data in Table 1, the fourth column shows the $\boldsymbol{\beta}$ coefficients (from Table B1, Appendix B),

[9] These regressions have high predictive power; for example, the R^2 is 0.341 for reading and 0.310 for math for the 2012 PISA data. Most variables are highly significant, and almost all of the signs are in the expected direction.

and the fifth column shows the product of each variable with its respective coefficient. Summing the fifth column produces the actual PISA scores, 512.7 for math and 509.8 for reading.

These regression coefficients can also be used to predict what the 2012 PISA score would have been if $\bar{\mathbf{X}}$ had been the means in the 2012 VHLSS data. The 2012 VHLSS means for the interviews conducted from March to July of 2012 (since the PISA was administered in April of 2012), from the third column of Table 1, are shown in the second column of Tables 2 and 3, the products of these variables and their coefficients are in the sixth column, and the predicted 2012 PISA scores are at the bottom of that column. When the 2012 VHLSS means are used to predict the PISA scores, the math score by about 24 points, to 489.0, and the reading score declines by about 20 points, to 489.5. Almost half of the difference between the 2012 PISA score and the predicted score that adjusts for the potential non-representative sample is due to the larger percentage of grade 10 students in the PISA sample, as seen in the last columns of Tables 2 and 3.

A similar analysis based on equation (2) for the 2015 PISA data and the average of the 2014 and 2016 VHLSS data is shown in the bottom of Tables 2 and 3. Using the means $\bar{\mathbf{X}}$ from the averaged VHLSS data (the households interviewed from March to July), instead of the 2015 PISA data, Table 2 shows that the math score decreases by 13.6 points, and Table 3 shows that the reading score decreases by 14.7 points. These are smaller than the drops for the 2012 data.

The overall message from this exercise is that the differences in child, parent and household characteristics seen in Table 1 between the 2012 PISA sample and the 2012 VHLSS sample imply a drop of only about 20-24 points (or 0.20-0.24 standard deviations) of Vietnam's performance on the 2012 PISA. Yet a quick glance at Figures 1 and 2 shows that Vietnam is still an outlier even after doing this adjustment. A similar adjustment comparing the 2015 PISA with the 2014 and 2016 VHLSS has an even smaller effect on Vietnam's outlier status in Figures 3 and 4.

B. Correcting, and Three Methods to Adjust for, Vietnam's Low Enrollment Rate. Another possible explanation for Vietnam's strong PISA performance is that many Vietnamese 15-year-olds are not enrolled in school, and those who are not in school are likely to have lower academic skills than those who are. Thus, one possible explanation for Vietnam's strong performance on the PISA assessments is that, relative to other PISA countries, a larger proportion of Vietnam's less academically inclined 15-year-olds did not participate in the PISA assessment, which includes only 15-year-olds enrolled in school. Indeed, Vietnam's "coverage index" indicates that only 55.7% of its 15-year-olds participated in the 2012 PISA, primarily because of this age group's low enrollment rate (OECD, 2014a, Table A2.1). This is the third lowest coverage rate of the 63 countries that participated in the 2012 PISA assessment; only Albania (55.2%) and Costa Rica (49.6%) had lower rates.[10] Vietnam's lower coverage rate is even more extreme in the 2015 PISA assessment; of the 66 participating countries, Vietnam's coverage rate was the lowest, at only 49% (OECD, 2016, Table I.6.1). The next lowest country, Mexico, had a much higher rate of 62%. This subsection first corrects the Vietnam coverage rates reported by the OECD, and then presents three different methods to adjust for Vietnam's (corrected) lower coverage rate. Even after this correction and these adjustments, Vietnam still remains a positive outlier, given its low income, in its performance on the 2012 and 2015 PISA assessments.

1. Correcting PISA Coverage Rates. Analysis of the PISA data demonstrates that Vietnam's coverage rates were incorrectly calculated, and correcting these errors leads to

[10] Albania's coverage rate, which is much higher for both the 2009 and 2015 PISA assessments, could be an error. We thank Francesco Avvisati for pointing this out.

sizeable increases in those rates. As explained in Appendix A, census data from Vietnam were incorrectly used to calculate the number of 15-year-olds in Vietnam in 2012 and 2015. Correctly applying the census data to the school enrollment data in the OECD reports shows that the correct PISA coverage rates for 2012 and 2015 are, respectively, 65.9% and 65.6%. Yet even after these corrections, 34.1% of 15-year-olds in Vietnam did not participate in the 2012 PISA assessment, and 34.4% did not participate in the 2015 PISA assessment. These individuals were likely weak students before leaving school, since most of the PISA participants were in grade 10 and, unlike grade 9, grade 10 students are a selected group, as explained above. The rest of this subsection applies three different methods to adjust PISA scores for differences in countries' coverage rates.

Method 1: Focus on Top 50%. One way to adjust each country's performance to account for differential participation in the PISA is to focus on the "top 50%" of 15-year-olds. This can be done by assuming that non-participating 15-year-olds would have scored in the lowest 50% of the distribution of test scores among all 15-year-olds in their respective countries if they had participated in the assessment, and then excluding the bottom 50% of 15-year-olds for all countries. In fact, for countries with a lower coverage rate, such as Vietnam, this assumption leads to underestimation of the performance of the top 50% of students since, for these countries, it is more likely that some not in school would be in the top 50% if they were in school, which means that some 15-year-olds classified as in the top 50% for these countries were in fact in the bottom 50%. The results of doing so for the 2012 PISA assessment are shown in Table 4A.

The first two columns of Table 4A show the widely reported scores in the PISA reports, which include all test participants (and, of course, exclude nonparticipants).[11] Vietnam ranks 16

[11] These differ slightly from the numbers in OECD (2014a) because sample weights were not used, for comparability with columns 3 and 4, which cannot use sampling weights to exclude 15-year-olds who did not participate.

out of 63 in math and 18 out of 63 in reading. However, when 15-year-olds in the bottom 50% of the population of all 15-year-olds are excluded, using the method described above,[12] the performance of Vietnam's "top 50%" of 15-year-olds is less impressive, ranking only 34 out of 63 in math and 39 out of 63 in reading (see the third and fourth columns of Table 4A).

The same exercise using the 2015 PISA results yields a similar conclusion. As seen in Table 4B, Vietnam ranks 24 out of 66 countries in math and 28 out of 66 in reading. While these rankings are not as high as the 2012 PISA rankings, this is still a very strong performance given that Vietnam is the second poorest of all participating countries (see Figures 3 and 4). However, when 15-year-olds in the bottom 50% of Vietnam's 15-year-olds are excluded, as shown in the third and fourth columns of Table 4B, the performance of Vietnam's "top 50%" of 15-year-olds is less impressive, ranking only 37 out of 66 in math and 41 out of 66 in reading.

Yet these lower rankings are still impressive when one recalls Vietnam's relatively low income. First, it still outperforms almost all other developing countries in the PISA, the sole exception being that Chile's top 50% of 15-year-olds outperformed Vietnam's top 50% on the 2015 reading assessment (and note that Chile is much wealthier than Vietnam). Second, as Figures 5 and 6 show, given that Vietnam was the poorest of the 63 countries in the 2012 PISA it is still by far the largest positive outlier when the scores of the "top 50% of all 15-year-olds" are plotted against log of per capita GDP. Although Vietnam's "top 50%" scores in mathematics and reading are not much higher than their "unadjusted" scores, and the increase in test scores of the "top 50% of 15-year-olds" was much higher for other countries, the increases were highest in

[12] Table 4A shows the mean scores of the top 50% of 15-year-olds under the assumption that those who did not participate would not have scored in the top 50% had they participated. Mathematically, denote the coverage rate by c, which is ≥ 50 for all countries except Costa Rica (its 49.6% rate is set to 50%). The goal is to drop the d% of the test participants who were not in the top 50%, thus d = c - 50. Thus one must drop (d/c)×100%, i.e. ((c-50)/c)×100%, of test participants. For each country the bottom ((c-50)/c)×100% of test takers were dropped, separately for each test.

the wealthier countries, which usually have high PISA participation rates. This increases the slope of the lines in Figures 5 and 6, relative to Figures 1 and 2, and since Vietnam is at the far left in these figures the higher slope makes it more of an outlier. This is also the case for the 2015 PISA assessment, as shown in Figures 7 and 8.

Method 2: Bounds Analysis – Inferring Full Distribution Mean from Truncated Distribution Mean. A second method to correct for Vietnam's relatively low enrollment rate is to build on the intuition of Method 1 that individuals not in school have lower academic skills in order to estimate bounds on the average test score of all 15-year-olds for the countries that participated in the PISA. To begin, assume that the PISA test scores follow a normal distribution when the entire population of 15-year-olds is included. Figure B5 in Appendix B shows that this assumption is reasonable for four 2015 PISA countries from different regions of the world that had enrollment (coverage) rates above 90%: Australia, Germany, South Korea and Tunisia. One can derive a lower bound for the mean of the distribution of the test scores of all 15-year-olds (students and non-students) by making a second assumption: that the test scores of all children not in school, if they had participated in the PISA, would be lower than those of all children in school. This assumption is illustrated in Figure B6. Under these two assumptions, PISA participants constitute a normal distribution that is truncated from below (as in Figure B6).

However, assuming that the test score of each 15-year-old PISA participant is higher than the test scores of all 15-year-old non-participants is quite extreme. It is almost certain that some PISA non-participants would have scored higher on that assessment than some participants. If so, the adjustment described below would *underestimate* (and so provide a lower bound for) the true mean (for all 15-year-olds). To see the intuition, consider Figure B6. Suppose that some 15-year-olds to the right of the truncation point did not participate in the PISA, and that some 15-

year-olds to the left of that point did participate. This would reduce the extent to which the mean of the distribution of the PISA participants overestimates the mean of the distribution for all 15-year-olds; applying the truncation formula that is proved below in Proposition 1 overcorrects and so provides a lower bound of that mean.

While standard formulas for the mean of a truncated normally distributed variable obtain that mean using the mean of the overall (untruncated) distribution, our goal is to go in the other direction; we want to obtain the mean of the overall distribution using the mean of the truncated distribution. Proposition 1 below provides the formulas for doing this.

Proposition 1: Estimating lower bounds and upper bounds of test scores

Assume that the test scores of the entire population of 15-year-olds follow a normal distribution with mean μ and standard deviation σ. The truncated mean of this distribution is given by the sample mean test scores $\bar{T}_k$, where k indexes truncation from above (a) or below (b), with τ being the truncation point. Define α as $\frac{\tau-\mu}{\sigma}$, and let r represent the given school enrollment rate.

1.1. If the PISA's tested samples capture only academically better-performing children (as in Figure B6) the true mean test scores, denoted by μ_{lt} (lt denotes lower truncation), is given by:

$$\mu_{lt} = \bar{T}_b - \lambda_b(\alpha)\frac{\bar{T}_b - T_{min}}{\lambda_b(\alpha)-\alpha} \quad (1)$$

where $\bar{T}_b = E(T|T > \tau)$, $\alpha = \Phi^{-1}(1-r)$, $\lambda_b(\alpha) = \frac{\phi(\alpha)}{1-\Phi(\alpha)}$, and the truncation point τ is given by T_{min}, the lowest observed test score in the data.

1.2. If the PISA's tested samples capture only the academically worse-performing children, the true mean test scores, denoted by μ_{ut} (ut denotes upper truncation) is given by

$$\mu_{ut} = \bar{T}_a + \lambda_a(\alpha)\frac{T_{max} - \bar{T}_a}{\lambda_a(\alpha)+\alpha} \quad (2)$$

where $\bar{T} = E(T|T < \tau)$, $\alpha = \Phi^{-1}(r)$, $\lambda_a(\alpha) = \frac{\phi(\alpha)}{\Phi(\alpha)}$, and the truncation point τ is given by T_{max}, the highest observed test score in the data.

The proof is given in Appendix A. Yet, since the assumptions that the PISA's tested samples capture only either the academically better-performing or the academically worse-performing children in Proposition 1 are rather extreme, Equations (1) and (2) would provide, respectively, lower bound and upper bound estimates of the true mean test scores. Equation (1) is the derivation of interest given that the mean test score of the PISA participants is almost certainly higher than the mean of the PISA non-participants (this is also shown below for the Young Lives data from Vietnam). We show Equation (2) only for mathematical completeness.

Applying Equation (1) of Proposition 1 to the PISA math test, Figure 9 shows these estimates, as well as the sample means of the scores of the observed (truncated) distributions of 2012 PISA participants, which one can view as upper bounds, as explained above. Figure 10 shows the same for the 2015 PISA assessments. The gap between these two bounds is a decreasing function of the enrollment (coverage) rate, and will equal zero when the enrollment rate is 100%. The bounds in Figures 9 and 10 for Vietnam, and for some other countries, are rather wide. A "natural" approximation of the test score means that would be observed if all 15-year-olds in each country were tested is the mid-point between the lower bound derived in Proposition 1 and the upper bound given by the observed mean for the truncated sample, that is the midpoints of the gaps in Figure 9. These mid-point values are shown in Figures 11-14, where the countries are again plotted against their log of per capita GDP. Vietnam still stands out as an outlier, especially for math.

Method 3: Adjustment with Auxiliary Data. A third way to adjust the mean of the test scores for Vietnamese students to include the scores of the PISA non-participants is to use the Young Lives data.[13] This is done only for Vietnam, because only one other PISA country has such data;[14] yet doing this adjustment only for Vietnam will be biased against Vietnam being an outlier. The younger cohort in the Young Lives Study were 15 years old in Round 5 of that study. This round, which took place in 2016, included administration of math and reading

13 For more information on the Young Lives data, consult its website: www.younglives.org.uk
14 The only other PISA country for which there are Young Lives data is Peru.

comprehension tests to all 15-year-olds in that sample, about 1,940 15-year-olds, both those in, and those not in, school; as expected, those not in school had lower average math (9.4 out of 21) and reading (10.9 out of 25) scores than those in school (15.5 and 14.8). Assuming that the Young Lives reading and math scores rank 15-year-olds in a way that is similar to the PISA test rankings, one can adjust the observed PISA test scores to include 15-year-olds who are not in school; see Appendix A for the details of this method. Making this adjustment to the 2012 PISA scores reduces the mean math score for Vietnam by about 13 points, from 511.2 to 498.4, and the mean reading score by about 11 points, from 508.2 to 496.9. The same adjustment for the 2015 PISA has similar reductions, about 12 points for math and 11 for reading. These relatively small changes do not change the overall finding that Vietnam's PISA performance was exceptional.

C. Were Vietnamese Students More Motivated and Better Prepared for the PISA?

A final possible explanation for Vietnam's performance in the PISA assessments is that Vietnamese students really did outperform those of most other countries, but not due to higher skills; rather, they were highly motivated when they took the PISA tests, and they received extensive preparation for those tests.[15] No studies have examined the motivation of Vietnamese students when taking international tests, but there are many anecdotes that Vietnamese students (and their teachers) are very competitive test takers. In contrast, there is evidence that students in developed countries exert little effort on tests for which there are no consequences.

Gneezy et al. (2019) administered tests based on questions from previous PISA math tests to Chinese students and U.S. students. The Chinese students scored much higher than U.S.

[15] Another possibility is that Vietnamese teachers provided answers to students, along the lines that Jacob and Levitt (2003) found in Chicago public schools. Unfortunately, we cannot apply most of the methods that that paper used to check for such cheating because we do not have panel data. Also, students taking the PISA exam are given many different versions of the test so that any given student does not have the identical questions as the students sitting nearby. Multiple versions of the test also make it much harder for teachers to provide students the correct answers.

students under standard conditions. However, randomly selected U.S. students who were offered financial incentives for high scores on the exam performed much better (22-24 points higher), while Chinese students performed no differently. The lack of an effect for Chinese students suggests that they are highly motivated to take tests despite no direct benefits. Vietnamese culture has many similarities to Chinese culture, and thus it is possible that Vietnamese students' intrinsic motivation to do well on tests increased their PISA scores by 22-24 points relative to U.S., and perhaps other, students.

There is also evidence that teachers and schools prepared Vietnamese students to take the 2012 and 2015 PISA tests.[16] Studies in the U.S. and elsewhere have shown that preparation sessions for academic tests can greatly increase students' scores. For example, Bangert-Drowns et al. (1983), summarizing a large number of studies, found that programs involving coaching sessions of more than nine hours total duration increased average test scores by 0.39 standard deviations (of the distribution of test scores, which for the PISA is equivalent to 39 points).

A rough estimate of the combined impact of intrinsic motivation and preparation for the PISA exam would be 62 points (23 from being more motivated, and 39 from exam preparation). This would explain about half of Vietnam's exceptional performance in terms of the positive residuals discussed below (Table 5, columns 1 and 2), assuming that all other countries that participated in the PISA took no steps to increase their students' test scores and had students as unmotivated as U.S. students. Yet this assumption is rather extreme, and anecdotal evidence

[16] When Vietnamese students took a draft version of the PISA exam in 2011 in preparation for the 2012 PISA, their performance was lower than expected, and Vietnam's Ministry of Education and Training took several steps to increase their performance. This does not violate rules of the PISA assessment; schools can have students practice, using old exams, to become "accustomed" to PISA exams. In each country, the schools that participate in the PISA exam are selected several months before the exam, and the students who participate are selected 3-4 weeks before the exams. The selected Vietnamese students were told that a strong performance would bring honor to Vietnam, and were given special t-shirts indicating that they were PISA participants. The information on the implementation of the PISA in Vietnam is based on emails and discussions with Francesco Avvisati, who works on the PISA for the OECD.

suggests that other countries also try to increase their students' performance on the PISA.[17] Thus these two factors together likely explain less than half of Vietnam's exceptional performance.

III. What Observed Variables in PISA Explain the Gaps Conditional on Income?

The evidence in Section II shows that 15-year-old students in Vietnam scored unusually high on the 2012 and 2015 PISA assessments given Vietnam's low GDP per capita, even after adjusting for the possibility that the PISA sample was not representative of the 15-year-olds enrolled in school and for the low enrollment rate of 15-year-olds in Vietnam. Presumably there is some reason why Vietnamese students outperform those in other countries conditional on per capita GDP. This section uses the PISA data to investigate Vietnam's performance on the PISA.

A. From Country Level to Student Level Regressions. Figures 1-4 in Section II are based on the following simple linear regression equation:

$$\text{Test Score} = \beta_0 + \beta_{gdp} \times \text{Log(GDP/capita)} + u \qquad (3)$$

In these figures, the gap between any country's actual performance on the test and its predicted performance given its (log) GDP per capita is given by u in equation (3). These figures show that Vietnam has a very high value of u. The regressions that generated these figures have one observation per country, yet analogous regressions with one observation per student for each country participating in the PISA assessments yield the same finding. Such regressions, which regress the student-level PISA test score data on a constant term and the log of per capita GDP, are shown for the 2012 PISA data in the first two columns of the top half of Table 5. As expected, the coefficient on GDP per capita is positive: countries with a higher GDP tend to have higher scores. However, Vietnam's test scores in the 2012 PISA are much higher than those

17 For example, when presenting an earlier version of this paper in Colombia, we were told that Colombia has made similar efforts to increase its students' performance on the PISA, but their efforts were not particularly effective.

predicted by this regression. In particular, for the math regression Vietnam's average value of u (the residual, shown in bold in the fifth row of Table 5) is 135.8, and for the reading regression it is 119.0. These are the highest values among all the countries included in the regression, as indicated by the "Residual Rank" row in Table 5, just as Vietnam is the largest positive outlier in the country-level regressions that generated Figures 1-4.

The question is: Why is Vietnam's residual so high? In particular, would adding more variables to the regression result in a "better fit" in which the (average) residual for Vietnam would not be so high? This question is addressed in the rest of this section, first by adding household and student level characteristics, and then adding by school characteristics, using information from the 2012 and 2015 PISA data, which not only administered reading and mathematics tests but also collected data from students, parents and schools.

The remaining columns in Table 5 explore the simple relationship between student test scores and national and household level income and wealth. One disadvantage of the regressions in the first two columns of that table is that the variable for the log of GDP per capita does not vary over students in the same country; ideally, it would be useful to have a wealth or income variable that varies within countries, which should provide more explanatory power in student-level regressions. A wealth variable can be generated from the PISA data by using information on students' households from the student questionnaire. This was done by applying principle components analysis to the following household level variables in the PISA: internet connection, dishwasher, DVD, number of cell phones, number of televisions, number of computers, and number of cars.[18] The first estimated principle component is used as a wealth variable in the analysis of this section. The third and fourth columns of Table 5 show that, for the 2012 PISA,

[18] Air conditioner could not be used since it was collected for some countries (including Vietnam) but not others.

when this variable is used instead of the log of GDP per capita, Vietnam is still the largest outlier in the math regression, though it is only the second largest outlier in the reading regression, after Hong Kong. The rest of the analysis of this paper will use this wealth variable instead of log of GDP per capita because the former varies across students within each country in the PISA data.

Before adding other variables to equation (3), which is the focus of this section, the last four columns of Table 5 explore two aspects of the wealth variable that was generated by principal components analysis. First, the third and fourth columns in Table 5 use country averages of the wealth variable, for comparability with the first two columns in that table, which are based on the log of GDP per capita. In contrast, the fifth and sixth columns allow each student to have his or her own household-specific value of wealth, instead of the national average. This allows the wealth variable to explain not only the differences in test scores across countries but also within countries. This reduces the coefficients on the wealth variable somewhat, but it is still highly significant. More interesting is that Vietnam falls slightly in terms of its outlier status. For math it is now the fourth highest outlier, while for reading it is the second highest. The main reason for this is that the predictive power of the wealth variable falls by about one fifth when it varies within countries, which indicates that it has a stronger role to play when explaining differences between countries than within them. This drop in the coefficient in effect leads to a less steep slope in the fitted lines in Figures 1-4, reducing the size of Vietnam's residual and increasing the size of the residuals for the wealthiest top performers, such as Hong Kong, Singapore and South Korea. Yet Vietnam is still a large outlier, and much poorer than these other outlier countries.

Second, the last two columns of Table 5 add country fixed effects, which again reduces the impact of wealth somewhat. The reported residuals in those two columns are simply the estimated country fixed effects. Again, Vietnam is still an outlier, although slightly less of an outlier in that it has the fifth highest fixed effect for math and the third highest for reading.

A similar analysis is done for the 2015 PISA data in the bottom half of Table 5. The overall pattern is the same. The average residual for Vietnam slightly decreases when the average wealth variable is used instead of GDP per capita, and decreases slightly more when the wealth variable is allowed to vary at the student level, but Vietnam is still one of the largest, if not the largest, outlier. This is also the case when country fixed effects are used. Again, the countries that occasionally are larger outliers than Vietnam are much wealthier than Vietnam.

B. Adding Other Variables to Explain Vietnam's Performance. The student-level regressions with country fixed effects in the last two columns of Table 5 are a useful starting point for a more systematic analysis to find characteristics of Vietnamese students, households, teachers and schools that explain Vietnam's outlier status in the 2012 and 2015 PISA assessments. To begin, assume that the underlying skill (e.g. math) measured by the PISA test score of student i in country c, denoted by S_{ic}, is a linear function of the characteristics of that student, of his or her household, the teachers he or she has had, and the school(s) he or she has attended:

$$S_{ic} = \boldsymbol{\beta}'\mathbf{x}_{ic} + \varepsilon_{ic} \qquad (4)$$

where the $\mathbf{x}_{ic}$ variables are *all* the student, household, teacher and school characteristics that affect students' underlying skills, $\boldsymbol{\beta}$ measures the causal impacts of those characteristics on that skill, and ε_{ic} is measurement error in the PISA test. The linearity assumption is not very restrictive since $\mathbf{x}_{ic}$ could include higher order and interaction terms.

An important distinction to make is between the observed and unobserved $\mathbf{x}_{ic}$ variables:

$$S_{ic} = \boldsymbol{\beta}_{\mathbf{o}}'\mathbf{x}_{ico} + \boldsymbol{\beta}_{\mathbf{u}}'\mathbf{x}_{icu} + \varepsilon_{ic} \qquad (5)$$

$$= \boldsymbol{\beta}_o' \mathbf{x}_{ico} + \boldsymbol{\beta}_u' \bar{\mathbf{x}}_{cu} + \boldsymbol{\beta}_u' \mathbf{x}_{icu,d} + \varepsilon_{ic}$$

where the superscripts o and u indicate observed and unobserved, respectively. The second line of equation (5) disaggregates $\mathbf{x}_{icu}$ into its country specific mean, $\bar{\mathbf{x}}_{cu}$, and the within-country deviation from that mean for student i, $\mathbf{x}_{icu,d}$, where the superscript d indicates that deviation. This disaggregation implies that the within-country mean of $\mathbf{x}_{icu,d}$ equals zero for all countries.

In a regression with country fixed effects, the fixed effect for country c would be $\boldsymbol{\beta}_u' \bar{\mathbf{x}}_{cu}$, and the error term would be $\boldsymbol{\beta}_u' \mathbf{x}_{icu,d} + \varepsilon_{ic}$. The last two regressions in Table 5 have only one observed variable, the wealth indicator. The goal of the rest of this section is to add additional variables to equation (5), which in effect moves those variables out of $\mathbf{x}_{icu}$ and into $\mathbf{x}_{ico}$ in that equation, to see whether Vietnam's outlier status can be explained by observed variables in the PISA data. This approach was used by Fryer and Levitt (2004) to investigate the gap in test scores between black and white students in the U.S., and by Singh (2019) to explain differences in test scores of primary and secondary school age children across Ethiopia, India (Andhra Pradesh), Peru and Vietnam. If the PISA data contain the key factors that explain Vietnamese students' success, then adding them as regressors will yield small and statistically insignificant country fixed effect for Vietnam by removing the variables that contribute to the $\boldsymbol{\beta}_u' \bar{\mathbf{x}}_{cu}$ term in the second line of Equation (5). If all variables are included that explain the performance of *all* the countries in the PISA data set, then *all* country fixed effects will become insignificant and the error term will become the (within-country) variation in the measurement error, ε_{ic}.

Even if the PISA data lack some of the key variables that explain Vietnam's success, and more generally explain student learning in all the countries that participated in the 2012 and 2015 PISA assessments, it may be that the country fixed effects, while statistically significant, are greatly reduced and thus at least part of the reasons for Vietnam's success would be explained by the PISA data. Even if Vietnam is still one of the largest outliers, it may be a much smaller outlier – relative to the overall variation in the PISA test score data – after adding the variables available in the PISA data. In contrast, if the student, household, teacher and school variables that explain Vietnam's success are for the most part *not* in the PISA data, then Vietnam will continue to be a large, positive outlier and the reason(s) for its outlier status will be due to factors that are not measured, or at least not well measured, in the PISA data.

To begin, student and household level variables from the 2012 PISA assessment are added to the regression equation in Table 6A. The first two columns of that table show regressions identical to those in the last two columns of Table 5, except that the sample size is reduced so that the sample is identical to that in the third and fourth columns of Table 6A, which add four additional household variables. The estimates in the first two columns of Table 6A are very similar to those in the last two columns of Table 5; the rank of Vietnam's estimated country fixed effects is the same, and the countries with larger fixed effects are also the same.

The third and fourth columns of Table 6A add four additional household characteristics that are "pre-determined" and may also explain students' test performance: a dummy variable for girl students, an index of the number of siblings in the home (0 = none, 1 = brothers but no sisters, or sisters but no brothers, and 2 = sisters and brothers); and mother's and father's years of schooling. Each of these household variables has some missing values, which reduces the sample size to 401,489, compared to 455,971 in the last two columns of Table 6.[19]

The key question for Table 6A is whether adding these additional household-level variables "explains" much of the very large country fixed effect found for Vietnam when household wealth is the only regressor. The third and fourth columns in Table 6A shows that adding

[19] Missing values were particularly common for the sibling index. To avoid losing observations due to that variable being missing, missing values were assigned its average value and a variable was added indicating that it is missing.

these four variables to the regression reduces the explanatory power of the wealth index variable by about one third (although it is still highly significant) but it has very little impact on the Vietnam country fixed. Indeed, these fixed effects increase slightly, from 78.2 to 80.6 for the math test and from 68.3 to 70.7 for the reading test. Vietnam's outlier status is also largely unchanged; its fixed effect in the math regression drops from fifth place to sixth place, but increases from third place to second place in the reading regression.

Thus, these four household-level variables in the PISA data do not explain Vietnam's strong performance on the 2012 PISA assessment. This is not surprising when the means of these variables are compared for Vietnam and these other countries. In particular, Table 8 shows that the average of Vietnam's sibling index is almost identical to that of the other PISA countries combined (1.048 vs. 1.086, respectively), and that Vietnamese parents have, on average, fewer years of schooling (8.3 for mothers and 8.9 for fathers) than do parents in the other PISA countries (11.0 for mothers and 11.1 for fathers), so these variables cannot explain why Vietnam outperforms other countries; indeed, its lower parental education levels make its performance all the more remarkable.

The 2012 PISA data contain several variables that are directly related to students' education, such as the grade they are in, years of preschool, several educational inputs, days of school attendance (in the past two weeks), books in the home not related to the child's schooling, and hours per week in tutoring classes. These variables are likely to be endogenous (parents may provide more educational inputs to children not doing well at school, or perhaps to their most promising children), so adding them to the regression analysis likely produces biased estimates of the causal impacts of these variables. Despite this possible bias, these variables may provide informative explanatory power that may shed light on why Vietnamese students perform so well on the PISA. For example, Table 8 shows that, on average, Vietnamese students spend more hours per week in tutoring classes (1.3 for reading, 2.7 for math) than do students in other PISA countries (0.9 for reading, 1.3 for math), so even if one cannot estimate the causal impact of these classes on student test scores, even biased estimates may reduce Vietnam's outlier status.[20]

The last two columns of Table 6A add these more education-focused child and household variables to the regression that had only gender, parental education and the sibling index variable (this reduces the sample size, so the fifth and sixth columns show the results with only household wealth but the same samples as in the last two columns). Adding these variables further reduces the coefficient on household wealth, and reduces Vietnam's estimated country fixed effect (from 79.1 to 65.0 for math, and from 68.9 to 55.1 for reading), but it does not reduce Vietnam's outlier status: it remains the fifth highest outlier for math and the third largest for reading. Again, the reason for this is that, for some education variables added to the regression, Vietnamese students have lower average values than do the students in the other PISA countries. For example, Vietnamese students have fewer educational inputs[21] and fewer books at home (see Table 8).

A similar analysis for the 2015 PISA data is presented in Table 6B. The overall results are similar. The country fixed effect for Vietnam changes very little when additional household-level variables are added to the regression, and Vietnam is always one of the top five positive outliers. Also, all of the other top five outliers are much wealthier than Vietnam.

Since child and household variables in the PISA data do little to explain Vietnam's exceptional performance (outlier status) in education, perhaps that performance is due to better schools and teachers. This is examined in Tables 7A and 7B, which add school and teacher

[20] Unfortunately, data on tutoring classes and on hours studying at home were not collected for Vietnam for the 2015 PISA, so those variables can be used only for the 2012 analysis.

[21] The education input index is the first principal component of the following variables: quiet place to study, desk, educational software, classical literature books, poetry books, educational books, technical books, and a dictionary.

characteristics to the regressions. As before, the first two columns show, for comparison purposes, regressions that include only the wealth variable, but have the same samples as the regressions that include the school and teacher variables.

The third and fourth columns of Tables 7A and 7B show regression results that add not only child and household variables (which are not shown to reduce clutter) but also school and teacher variables. The school and teacher variables are: class size; the proportion of teachers who have the required qualifications; computers per student; a variable indicating whether student performance is used to assess teachers' performance (a higher value indicates a "no" response); an indicator of teacher absenteeism; an index of whether parents put pressure on teachers (2012 only); two variables indicating whether school principals and outside inspectors, respectively, observe teachers in the classroom; an indicator of the extent to which student performance determines teacher pay (2012 only); and an index that measures teacher mentoring. Most of these school characteristics have the expected signs, but the key question is whether they can "explain" at least part of Vietnam's outlier status as measured by its country fixed effect.

The results for the 2012 PISA in Table 7A show that adding school and teacher variables reduces Vietnam's outlier status in the sense that Vietnam's estimated fixed effects are reduced by nearly one fourth (from 76.7 to 58.1) for math and almost one third (from 66.1 to 44.7) for reading. Yet little has changed in the sense that adding these variables to the math test yields only a small reduction in the rank of Vietnam's estimated fixed effect (from five to eight), and its rank for the reading test (four) is unchanged.

The same analysis using the 2015 PISA data is shown in Table 7B, and the results are similar. In particular, adding school and teacher variables reduces Vietnam's country fixed effects by about one fifth for math (from 71.4 to 59.2) and for reading (from 59.2 to 46.5), but its relative rank declines by only one for math and five for reading.

To summarize, this section shows that the observed child, household, school and teacher variables in the PISA data explain very little of Vietnam's impressive performance on the 2012 and 2015 PISA assessments relative to its income level. At most, adding these variables explains one fourth of Vietnam's exceptional performance in math and one third of its exceptional performance in reading. Thus, most of the explanation for that performance must be found elsewhere.

IV. What Can Be Learned from Oaxaca-Blinder Decompositions?

The analysis in the previous section assumed that the impact of each variable on test scores is the same for all 63 countries in the analysis. But perhaps Vietnam's exceptional performance is partly due to it being "more effective" in using various "inputs". For example, it may be that each year of Vietnamese parents' years of schooling represents a higher level of cognitive skills than does the average year of parental schooling in the other PISA countries.

To explore this possibility, a Oaxaca-Blinder decomposition (Blinder, 1973; Oaxaca, 1973) is applied to differences in test scores between Vietnam and all other countries. Test scores (S) are assumed to be linear functions of the variables used in the last two columns of Tables 7A and 7B, again denoted by **x**. The impacts of these variables on test scores, denoted by **β**, are allowed to differ between Vietnam and the other countries in the PISA assessment. This yields the following regression equations (omitting the i subscript to reduce clutter):

$$S_{vn} = \boldsymbol{\beta}_{vn}'\mathbf{x}_{vn} + u_{vn} \quad \text{(Vietnam)} \qquad (6)$$

$$S_{o} = \boldsymbol{\beta}_{o}'\mathbf{x}_{o} + u_{o} \quad \text{(Other countries)} \qquad (7)$$

The constant term in both of these equations can be normalized so that the means of the residuals equal 0. Taking the mean of both sides of each regression equation gives the following expressions for the average test scores in Vietnam, $\bar{S}_{vn}$, and in the other 62 PISA countries, $\bar{S}_{o}$:

$$\bar{S}_{vn} = \boldsymbol{\beta}_{vn}'\bar{\mathbf{x}}_{vn} \qquad (8)$$

$$\bar{S}_{o} = \boldsymbol{\beta}_{o}'\bar{\mathbf{x}}_{o} \qquad (9)$$

The standard Oaxaca-Blinder decomposition uses equations (8) and (9) to express the difference in the mean test scores between Vietnam and the other PISA countries as follows:

$$\begin{aligned} \bar{S}_{vn} - \bar{S}_{o} &= \boldsymbol{\beta}_{vn}'\bar{\mathbf{x}}_{vn} - \boldsymbol{\beta}_{o}'\bar{\mathbf{x}}_{o} \qquad (10) \\ &= \boldsymbol{\beta}_{vn}'\bar{\mathbf{x}}_{vn} - \boldsymbol{\beta}_{o}'\bar{\mathbf{x}}_{o} + \boldsymbol{\beta}_{o}'\bar{\mathbf{x}}_{vn} - \boldsymbol{\beta}_{o}'\bar{\mathbf{x}}_{vn} \\ &= \boldsymbol{\beta}_{o}'(\bar{\mathbf{x}}_{vn} - \bar{\mathbf{x}}_{o}) + (\boldsymbol{\beta}_{vn} - \boldsymbol{\beta}_{o})'\bar{\mathbf{x}}_{vn} \end{aligned}$$

Thus, the difference in the average test scores in Vietnam and the average scores in the other countries has two components. The first is the difference in the means of the **x** variables between Vietnam and the other countries, multiplied by the **β** for the other countries (denoted by $\boldsymbol{\beta}_{o}$). The second is the difference between Vietnam and the other countries in the "effectiveness" of the **x** variables, $\boldsymbol{\beta}_{vn} - \boldsymbol{\beta}_{o}$, multiplied by the means of Vietnam's **x** variables (denoted by $\bar{\mathbf{x}}_{vn}$).

One criticism of equation (10) is that the differences in the means of the explanatory variables ($\bar{\mathbf{x}}_{vn} - \bar{\mathbf{x}}_{o}$) are "weighted" by the coefficient for the other 62 countries ($\boldsymbol{\beta}_{o}$) while the differences in the coefficients ($\boldsymbol{\beta}_{vn} + \boldsymbol{\beta}_{o}$) are weighted by the means of the explanatory variables for Vietnam ($\bar{\mathbf{x}}_{vn}$). Intuitively, it seems unbalanced that these weights are all from one group or the other group; it may be better for the weights to be weighted averages of the **β**'s and the $\bar{\mathbf{x}}$'s of both groups. One way to do this is to take the average of the two vectors of **β** coefficients and use that **β** as the weight for the differences in the means; this yields the following decomposition:

$$\bar{S}_{vn} - \bar{S}_{o} = \boldsymbol{\beta}_{vn}'\bar{\mathbf{x}}_{vn} - \boldsymbol{\beta}_{o}'\bar{\mathbf{x}}_{o} \qquad (11)$$

$$= \bar{\boldsymbol{\beta}}'(\bar{\mathbf{x}}_{vn} - \bar{\mathbf{x}}_o) + [(\boldsymbol{\beta}_{vn} - \bar{\boldsymbol{\beta}})'\bar{\mathbf{x}}_{vn} + (\bar{\boldsymbol{\beta}} - \boldsymbol{\beta}_o)'\bar{\mathbf{x}}_o]$$

where $\bar{\boldsymbol{\beta}} = (\boldsymbol{\beta}_{vn} + \boldsymbol{\beta}_o)/2$.[22] The first term, $\bar{\boldsymbol{\beta}}'(\bar{\mathbf{x}}_{vn} - \bar{\mathbf{x}}_o)$, weights the influence of the differences in the **x** variables by the simple average of the two **β** coefficients. The second term, $(\boldsymbol{\beta}_{vn} - \bar{\boldsymbol{\beta}})'\bar{\mathbf{x}}_{vn} + (\bar{\boldsymbol{\beta}} - \boldsymbol{\beta}_o)'\bar{\mathbf{x}}_o$, accounts for the influence of the differences in the $\boldsymbol{\beta}_{vn}$ and $\boldsymbol{\beta}_o$ coefficients by splitting that difference into two parts, the difference between $\boldsymbol{\beta}_{vn}$ and $\bar{\boldsymbol{\beta}}$, weighted by $\bar{\mathbf{x}}_{vn}$, and the difference between $\bar{\boldsymbol{\beta}}$ and $\boldsymbol{\beta}_o$, weighted by $\bar{\mathbf{x}}_o$. As in the original Oaxaca-Blinder decomposition, the first term "explains" how much of the difference in the mean test scores between Vietnam and the other countries is due to Vietnamese students having different characteristics than the other students, and the second term "explains" how much of the difference stems from the differences in the *impacts* of the various **x** variables, as measured by the difference between $\boldsymbol{\beta}_{vn}$ and $\boldsymbol{\beta}_o$.

In addition to decomposing the differences in the mean test scores, $\bar{S}_{vn} - \bar{S}_o$, into the above two components (the "explained" part due to differences in the **x**'s and the "unexplained" part due to differences in the **β**'s), both components can be further decomposed into the contributions of the individual variables, which sum up to equal the overall component. For example, one variable used below measures hours per week that children receive math tutoring, which for the 2012 PISA is much higher in Vietnam (2.7) than the average for the other PISA countries (1.3), as seen in Table 8. This tutoring could explain Vietnam's strong performance by contributing to the first component, $\bar{\boldsymbol{\beta}}'(\bar{\mathbf{x}}_{vn} - \bar{\mathbf{x}}_o)$. That is, part of this component is $\bar{\beta}_t(\bar{x}_{vn,t} - \bar{x}_{o,t})$, where the t subscript indicates that this is the tutoring variable. Similarly, the impact of tutoring could also contribute to the second component via the difference in the β_t coefficients; its contribution to the second component is $[(\beta_{vn,t} - \bar{\beta}_t)'\bar{x}_{vn,t} + (\bar{\beta}_t - \beta_{o,t})'\bar{x}_{o,t}]$.

[22] Note that this decomposition holds algebraically even when $\bar{\boldsymbol{\beta}}$ is replaced by *any* vector **β** of the same dimension; the arithmetic average is used here for its intuitive appeal. Other **β**'s have been suggested in the literature. See Fortin *et al.* (2011) and Jann (2008) for further discussion of this decomposition.

However, there are some potential problems with determining the roles played by specific variables in these decompositions. First, sets of categorical variables, such as region or ethnic group codes, require an omitted (base) category, and different base categories can produce different results when assessing the impacts of the differences in the mean values of the **x** variables across the two groups. Fortunately, this is not a problem here because this paper does not use any sets of categorical variables. Second, variables that do not have "natural" zero points can yield different results when assessing the impacts of the differences in the values of the **β** terms across the two groups; adding an arbitrary constant to such variables will change the contribution of the difference in the **β** terms because that difference is multiplied by the mean of that variable, and the mean has changed. While almost all variables in the regressions have natural "zeros", as explained above the wealth index and the education inputs index were constructed by using principal components analysis, and the first principal components for both of these variables take both positive and negative numbers. Both of these variables are "re-centered" by adding a constant that ensures that their minimum values are close to zero.

Table 8 shows the means of the **x** variables separately for Vietnam and for the other PISA countries for both PISA assessments. The 2012 means are also shown in the second and fifth columns of Table 9A (and Table 10A). The bottom of the Table 9A shows the mean math test score for Vietnam, 516.5 (in the third column), which is $\bar{S}_{vn}$, and the mean math test score for the other 62 countries, 462.8 (the sixth column), which is $\bar{S}_{o}$.[23] The gap between these two means is 53.7. Similarly, Table 10A shows that the gap between the two mean reading scores is 40.3. These gaps are smaller than the average residuals for Vietnam in Table 5 because those residuals effectively compared Vietnam to a hypothetical "typical" other country that had the same level

[23] These means are for the sample for which the Oaxaca-Blinder composition is implemented. Observations with missing values for the **x** variables are dropped, and so the means are slightly different from those in previous tables.

of wealth as Vietnam, while the gaps in Tables 9A and 10A compare Vietnam, which has a relatively low wealth of 4.14, with the other 62 countries, that have a higher wealth of 6.10.

Returning to Table 9A, the **x** variables that have higher means in Vietnam than in the other 62 countries, and for which the corresponding $\bar{\boldsymbol{\beta}}$ coefficients are positive, can potentially explain part of the gap between the mean test scores in Vietnam and the other 62 countries in the 2012 PISA assessment. That is, the contribution of such variables to the $\bar{\boldsymbol{\beta}}'(\bar{\mathbf{x}}_{vn} - \bar{\mathbf{x}}_{o})$ component in equation (10) is positive. The contribution is also positive when the mean for Vietnam is lower than for the other 62 countries and the corresponding $\bar{\boldsymbol{\beta}}$ coefficient is negative. An example of the former is the teacher mentoring variable. This is higher in Vietnam than in other countries, and as expected mentoring of teachers is estimated to increase students' test scores.[24]

In contrast, if Vietnam's mean is higher but the corresponding $\bar{\boldsymbol{\beta}}$ coefficient is negative, or Vietnam's mean is lower and the corresponding $\bar{\boldsymbol{\beta}}$ coefficient is positive, this widens the gap and thus makes the gap even harder to explain. For example, the mean years of schooling of mothers and of fathers is lower in Vietnam than in the other 62 countries, and as expected the corresponding **β** coefficients are positive, so the parent education variables cannot explain why Vietnamese students' scores are higher than those of other countries' students, and so these variables "increase the burden" on other variables to explain that gap.

Table 9A provides the results of the Oaxaca-Blinder decomposition for the 2012 PISA mathematics test. Recall that the overall gap to explain is 53.7 points. The differences in the **x** variables, which are expressed as the $\boldsymbol{\beta}_{o}'(\bar{\mathbf{x}}_{vn} - \bar{\mathbf{x}}_{o})$ component of the decomposition, cannot explain the gap. Indeed, summing over all of the **x** variables shows that the values of the **x**

[24] The impact of this variable is similar in both Vietnam (6.77) and in the other 62 countries (7.72), although it is statistically significant only for the 62 countries, which reflects the much larger sample size for that estimate.

variables lead one to expect a slightly larger gap, with an overall contribution of -1.6 (see the bottom of the second to last column in Table 9A). Instead, the decomposition indicates that the entire gap is due to the difference in the β coefficients; on average, Vietnam is "more efficient" in "converting" **x** variables into higher test scores; this is seen in the last column in Table 9A.

Given that it is the differences in the **β** coefficients that "explain" Vietnam's remarkable performance on the 2012 PISA assessment, it is of interest to see which specific variables seem to contribute the most to this component of the decomposition. The variable in the last column of Table 9A that plays the most important role is the percentage of students in grade 10, which accounts for about seven eighths (88%) of this differential efficiency of the **β** coefficients. Quite simply, on average for other 2012 PISA countries, moving a student from grade 9 to grade 10 without changing any other characteristic increases his or her test score by 18.9 points, but in Vietnam this increases a students' score by 85.9 points. This almost certainly reflects the fact that movement from grade 9 to grade 10 in Vietnam is a selection process based on province-level exams, which removes the grade 9 students with the weakest academic performance. But it is also likely that, apart from this selection effect, an additional year of school in Vietnam leads to more learning than an addition year in other countries; recall from Section II that correcting for the very low "coverage rate" in Vietnam explained only a small part of its exceptional performance. Moreover, as seen in the next paragraph, additional days of attendance have a larger impact in Vietnam than in the other 2012 PISA countries (on average).

The other variables for which the higher **β** coefficient for Vietnam explains a substantial portion of the gap (a contribution greater than 20 points) are: 1. Using student performance as part of the formal process to evaluate teachers' effectiveness; 2. Number of days attended in the past two weeks; and 3. Proportion of teachers who are "qualified". It is important to keep in mind that these effects do *not* reflect that these variables have higher mean values in Vietnam; the 25 point impact using student performance to assess teacher effectiveness in the last column of Table 9A does not reflect that Vietnam is more likely to use student performance when assessing teachers' performance,[25] but rather the results suggest that this policy is more effective in Vietnam than in other countries. Similarly, the role played by student attendance is not so much due to higher student attendance in Vietnam, but due to students learning more per day of school attended. Finally, note that the third largest contributor is in fact negative: While, as one would expect, having more "qualified" teachers increases student learning, the estimated impact of such teachers in Vietnam (18.2) is much *lower* than the estimated impact for the other countries that participated in the 2012 PISA assessment (46.1).

Table 10A yields similar results for the reading decomposition using the 2012 PISA data, although they are somewhat more difficult to interpret. The overall gap to be explained is 40.3 points. As with the math score, the differences in the **x** variables explain little, and in fact they slightly widen the gap to be explained by 1 point. In contrast, the "greater efficiency" of the **x** variables explains virtually all of the gap by accounting for 41.3 points in that gap. Two **x** variables stand out as making the biggest contribution to explaining this gap. First, as with the mathematical results, the differential efficiency of being in grade 10 can account for virtually all of the gap (42.7 points). Again, this may reflect not only differential efficiency but also a screening process between grades 9 and 10 that removes the weakest students from the overall population of 15-year-old students. Second, the differential impact of school attendance makes an even larger contribution, unlike the results for the math exam. The contribution of this differential school attendance, 80.5 points, is so large that it requires some variable to have a

[25] In fact, Vietnam *is* more likely to use student performance to evaluate teachers, but the effect of this variable's difference in means (second to last column of Table 9A) is much smaller (3.0) than its differential effect (25.0).

large negative effect, and that variable is the constant term, which is much larger in the other countries than in Vietnam, a result also not seen with the math test. This somewhat puzzling result for the reading decomposition, and unfortunately it is difficult to interpret this large difference in the constant terms between Vietnam and the other 62 countries in the 2012 PISA assessment.[26]

These Oaxaca-Blinder decompositions were also done for the 2015 PISA data, and the results are similar. The relevant tables for these results are Tables 9B and 10B. Note first that, as seen in Table 8, there are seven fewer variables in the 2015 PISA with which to do this decomposition, but that still leaves 15 variables.

The decomposition of the difference in the mathematics scores for the 2015 PISA assessment is shown in Table 9B. As in the 2012 PISA, the differences in the **x** variables do not explain the 44.6 point gap in the mean test score between Vietnam and the 65 other countries that participated in the 2015 PISA. Indeed, those differences add 16.7 points to the gap. Thus, all of the differences are due to the differences in the **β** terms for Vietnam and for the other countries. The decomposition of the difference in the reading scores is shown in Table 10B, and the results are very similar to those in Table 9B; the differences in the **x** variables do not explain the 27.0 point gap in the mean test score between Vietnam and the 65 other countries, and instead they in effect widen the gap. Again, the entire explanation for the gap must come from the differences in the **β** terms between Vietnam and the other countries.

[26] The application of the Oaxaca-Blinder decomposition in this paper could be misleading in that the estimated **β** terms for Vietnam are based on only within-country variation in the variables, while the estimates of **β** for all other countries are based on both within-country and between-country variation. It is possible that the decomposition results could change if the latter estimates were also based on only within-country variation, which can be done by estimating $\boldsymbol{\beta}_o$ using a country-fixed-effects specification. This was done, and the main results still hold, as seen in Appendix Tables B.4 and B.5. In particular, the contribution of the difference in the **x** variables, as measured by $\overline{\boldsymbol{\beta}}'(\bar{\mathbf{x}}_{vn}-\bar{\mathbf{x}}_o)$, remains very small.

To summarize this section, the Oaxaca-Blinder decompositions for both 2012 and 2015 indicate that Vietnam's exceptional performance on the PISA assessment in both years is not due to Vietnam having "better" observable child, household or school characteristics. Instead Vietnam seems to be more effective in transforming those factors into test scores. In other words, these decompositions indicate that virtually all of Vietnam's strong performance in these two PISA assessments comes from the "unexplained" portion of this decomposition method, and thus this decomposition sheds very little light on the underlying reasons for that performance.

V. Conclusion

Vietnam's very high performance on the 2012 and 2015 PISA assessments has raised the question of why Vietnam does so well, and whether other countries can improve their student learning outcomes by applying what works well in Vietnam. This paper has used the 2012 and 2015 PISA data to do three types of analysis to explore the reasons behind Vietnam's apparent success. The analysis done thus far has led to three sets of general results.

First, one important, albeit partial, explanation of Vietnam's very strong performance on the 2012 and 2015 PISA assessments is that the weakest students are excluded from grade 10. In particular, only about 66% of Vietnamese 15-year-olds participated in the 2012 and 2015 PISA assessments, presumably because most or all of the other 34% were no longer in school. (Note that the OECD reports even lower participation rates, but this paper corrects those erroneous rates.) Yet applying three different methods to adjust for Vietnam's low coverage (enrollment) rates has little effect on its outlier status. Moreover, back-of-the-envelope calculations to account for possible higher motivation of Vietnamese students on the PISA account for at most less than half of Vietnam's outlier status. A related point is that the 15-year-old students who participated in the PISA assessments appear to be better off when compared to the 15-year-olds enrolled in school in the 2012, 2014 and 2016 Vietnam Household Living Standards Surveys. Yet even after adjusting Vietnam's test scores for these differences between the two datasets, those scores are still well above what one would predict based on Vietnam's income alone. A similar result also holds for the 2015 PISA scores. Thus, even after accounting for these apparent differences between the PISA and VHLSS data, Vietnam still performs unusually well on the PISA assessments relative to what one would expect given its income level.

Second, taking the PISA data at face value, this paper has used regression methods to investigate which family, teacher or school characteristics in the PISA data can "explain" the high performance of Vietnamese students. The general finding of this analysis is that accounting for household level and school level variables in the PISA data explains at most only one fourth or one third of Vietnam's high performance on the 2012 PISA relative to its income level. Moreover, adding these variables to an initial regression of PISA test scores on household wealth does very little to Vietnam's "outlier" status. Similar results are found for the 2015 PISA.

Third, this paper has applied the Oaxaca-Blinder decomposition method to better understand the difference in average test scores between Vietnamese students and students in the other countries that participated in the 2012 and 2015 PISA assessments. Unlike the analysis discussed in the previous paragraph, this approach is more flexible in that it allows the impacts (the $\boldsymbol{\beta}$'s) of the household and school variables (the $\mathbf{x}$ variables) to differ between Vietnam and all other countries that participated in the PISA assessments. The decompositions indicate that *all* of the gap in average test scores between Vietnam and the other countries (62 in 2012 and 65 in 2015) is due to the greater "productivity" of various household and school variables in Vietnam, relative to the "productivity" of those variables in other countries, especially the greater "productivity" that occurs when grade 9 students in Vietnam are enrolled in grade 10. This could reflect the fact that only Vietnamese students who pass an entrance exam are allowed to proceed from grade 9 to grade 10, which is the first grade of the upper secondary cycle in Vietnam. This is most clear for the mathematics results; the reading results show a similar pattern but also have other factors at work (in particular, more productivity from each day of school attendance). In contrast, differences in household and school characteristics explain none of the gap between Vietnam and the other countries that participated in the PISA assessment; indeed, they add to the gap to be explained.

While the analysis in this paper has shed some light on the reasons for Vietnam's exceptional performance on the 2012 and 2015 PISA assessments, in the end the main contribution of this paper is that it has shown what does *not* explain that exceptional performance. In particular, it does not appear to be due to the low participation of Vietnam's 15-year-olds, nor to any possible selection of "better" students (as measured by urban location, parental education and household wealth) into the PISA assessments. Observable child, household, and school characteristics explain little or none of the differential performance; in particular the Oaxaca-Blinder decompositions attribute none of the gap in test scores to such factors, and instead attribute all to the "unexplained" differences between Vietnam and the PISA participants in the coefficients that determine the impacts of these observed factors. Future research on Vietnam's exceptional performance will need to use different data, and perhaps different methodologies, to understand that country's impressive performance in education.

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Figure 1. Mean Age 15 Math Scores in 2012 PISA, by 2010 Log Real GDP/capita

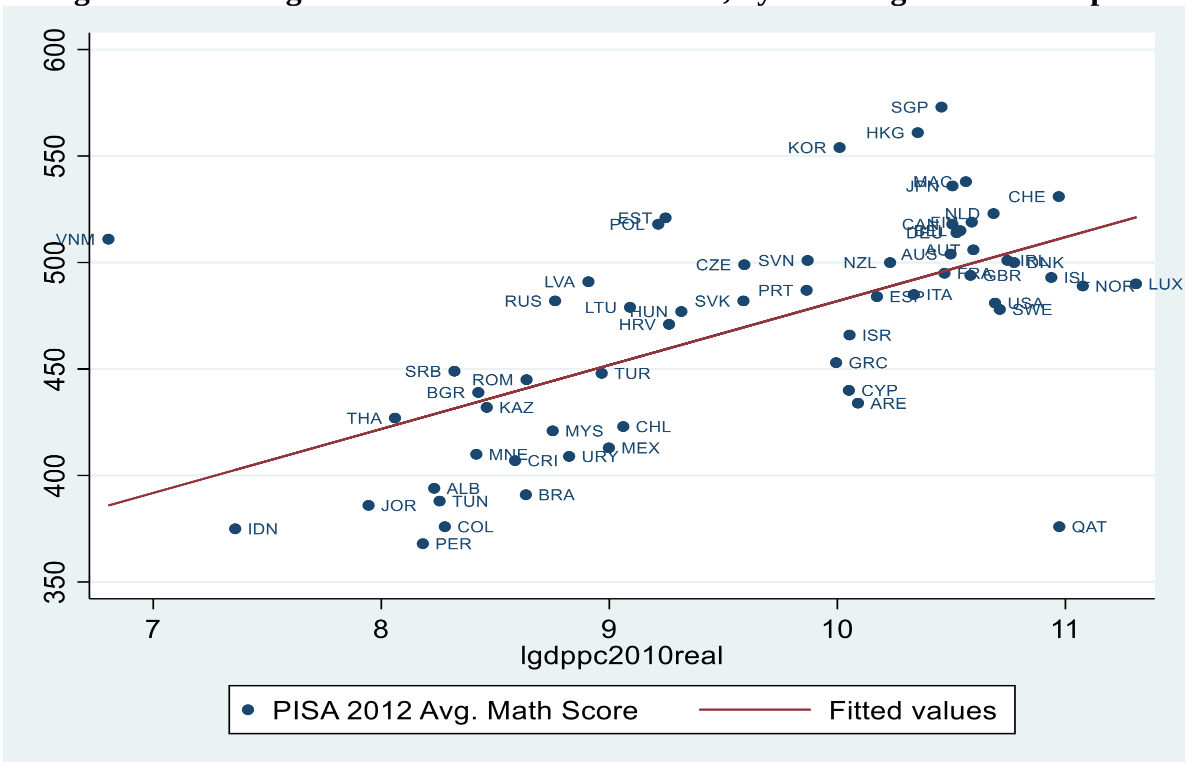


Figure 2. Mean Age 15 Reading Scores in 2012 PISA, by 2010 Log Real GDP/capita

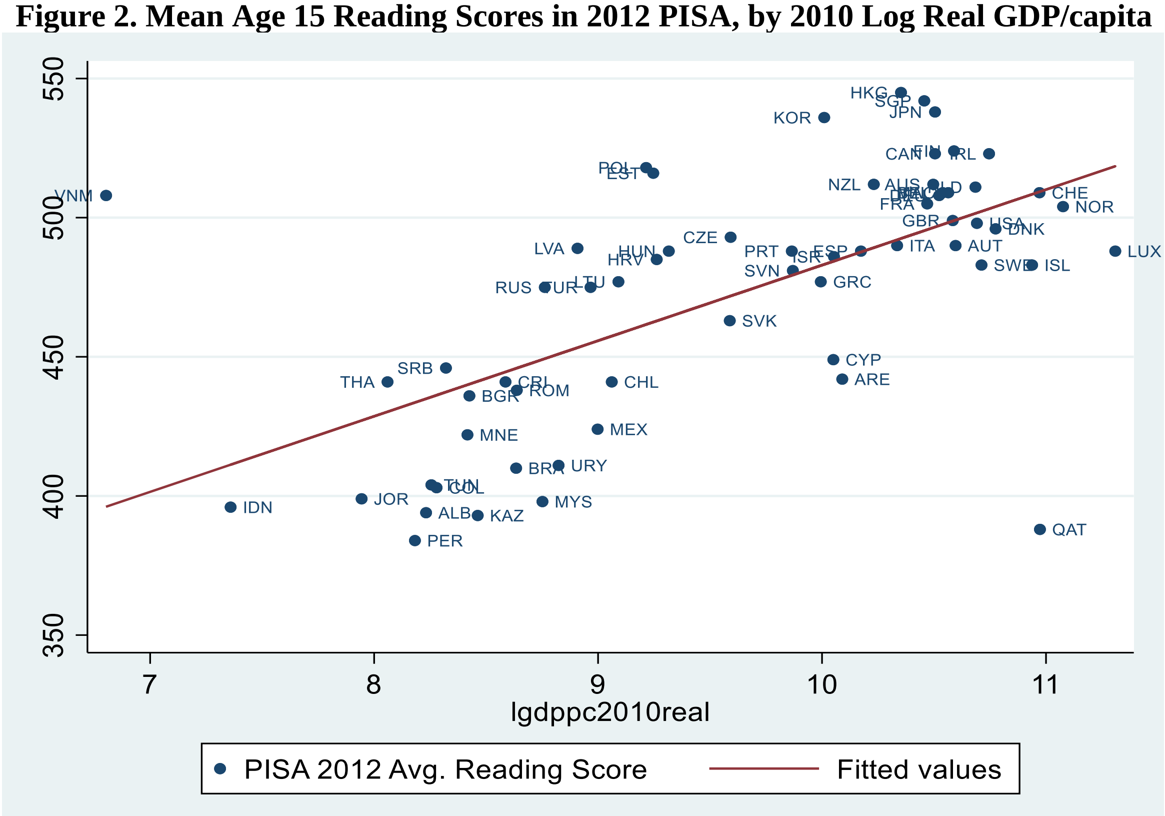


Figure 3. Mean Age 15 Math Scores in 2015 PISA, by 2015 Log Real GDP/capita

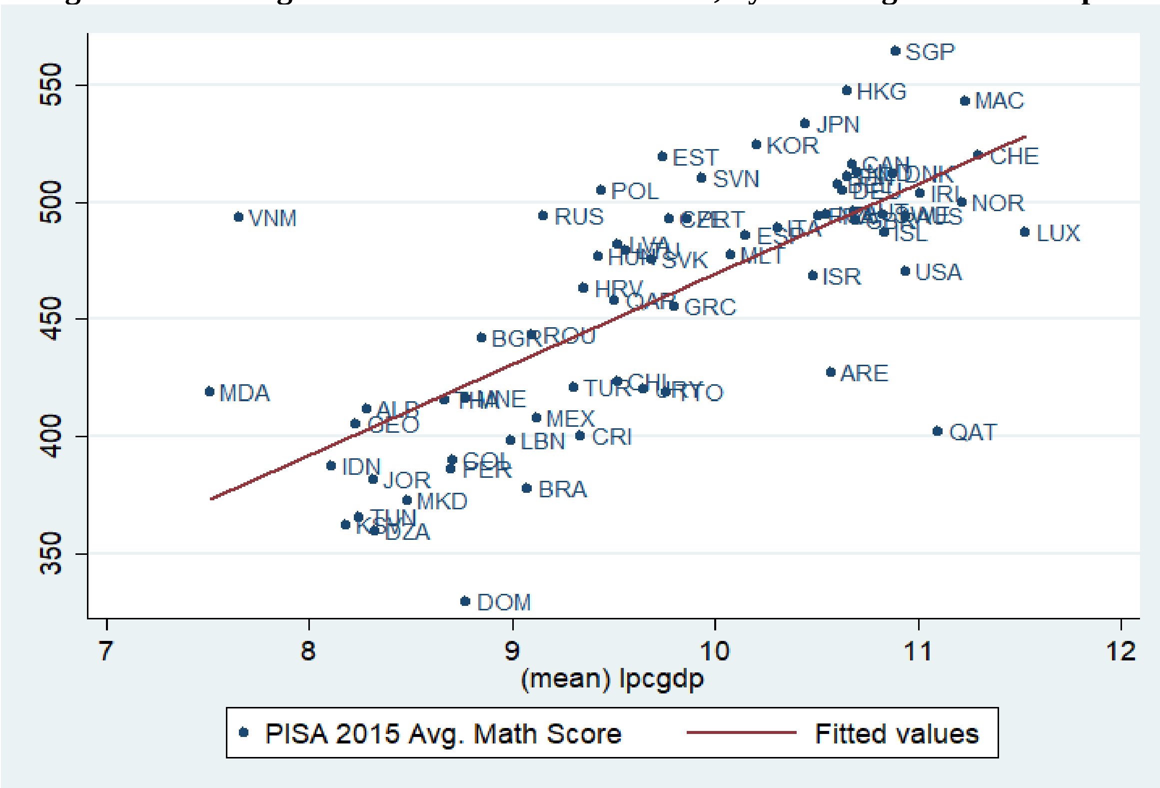


Figure 4. Mean Age 15 Language Scores in 2015 PISA, by 2015 Log Real GDP/capita

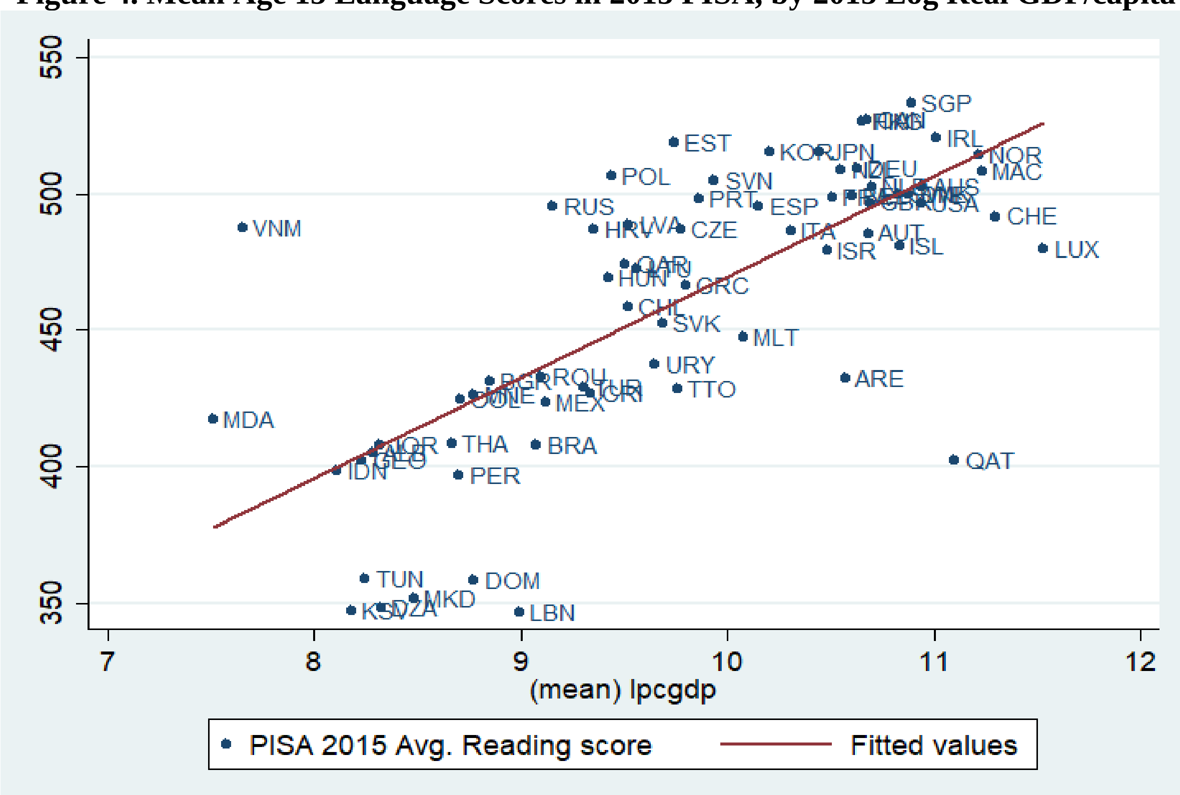


Figure 5. Mean Age 15 Top 50% Math Scores in 2012 PISA, by 2010 Log Real GDP/capita

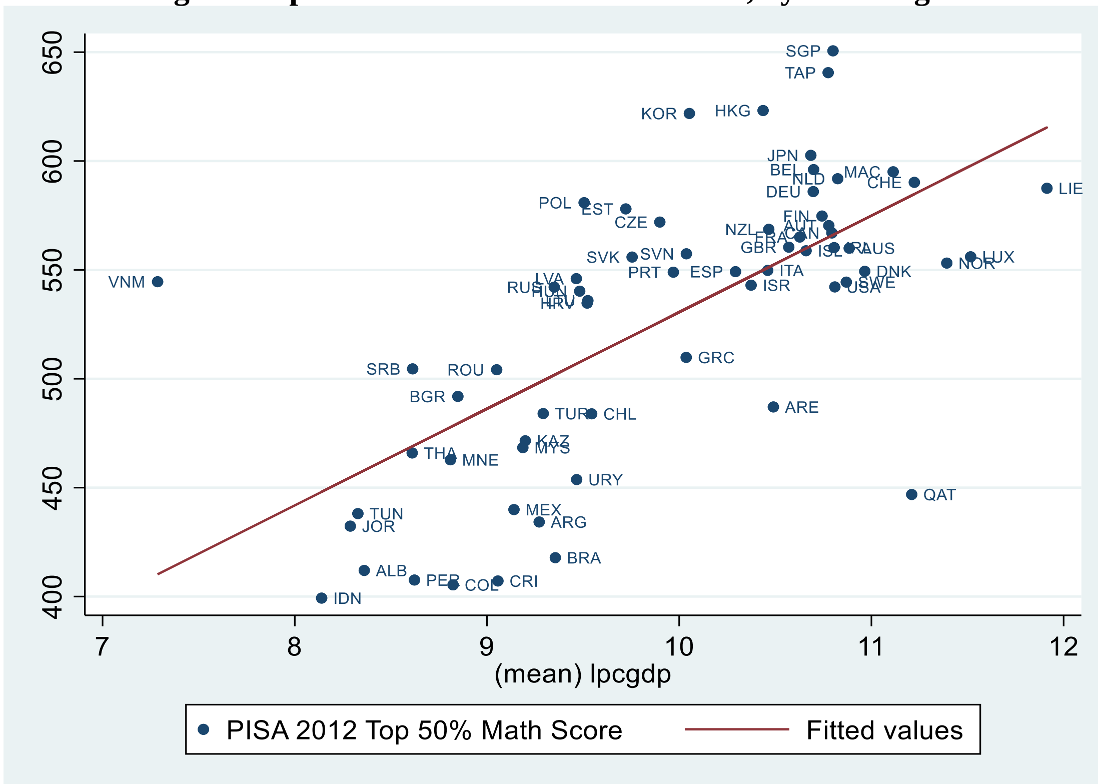


Figure 6. Mean Age 15 Top 50% Reading Scores in 2012 PISA, by 2010 Log Real GDP/capita

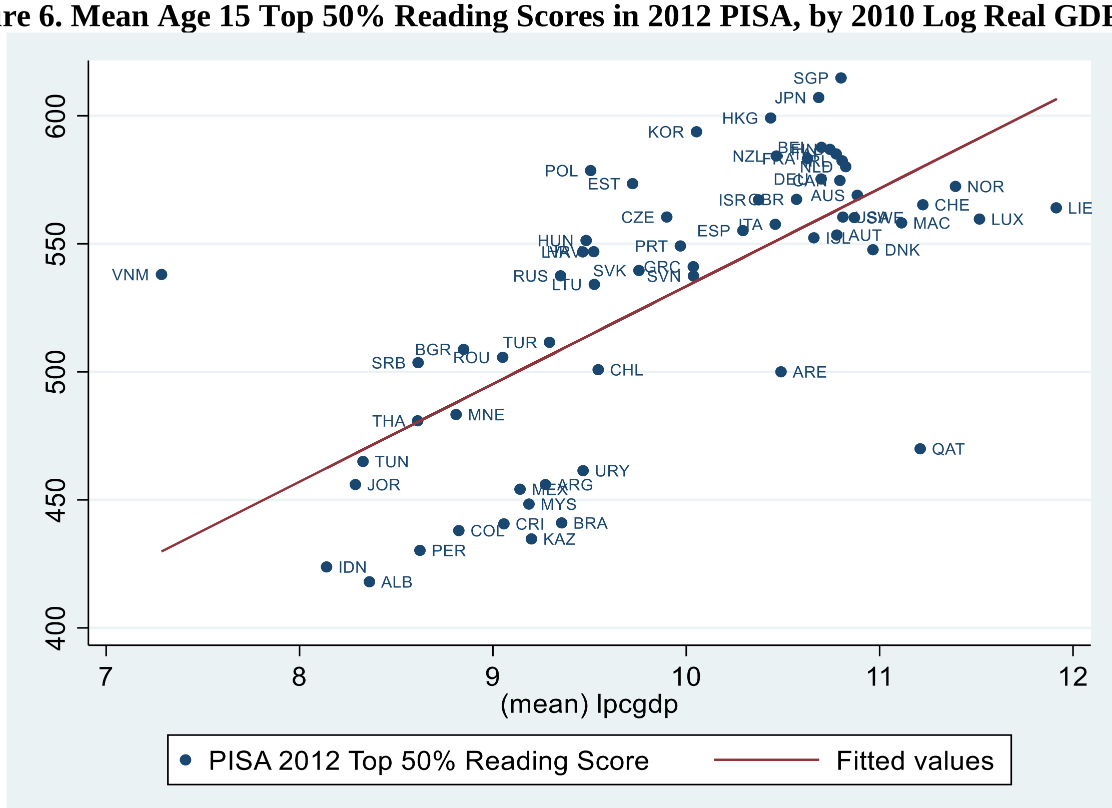


Figure 7. Mean Age 15 Top 50% Math Scores in 2015 PISA, by 2015 Log Real GDP/capita

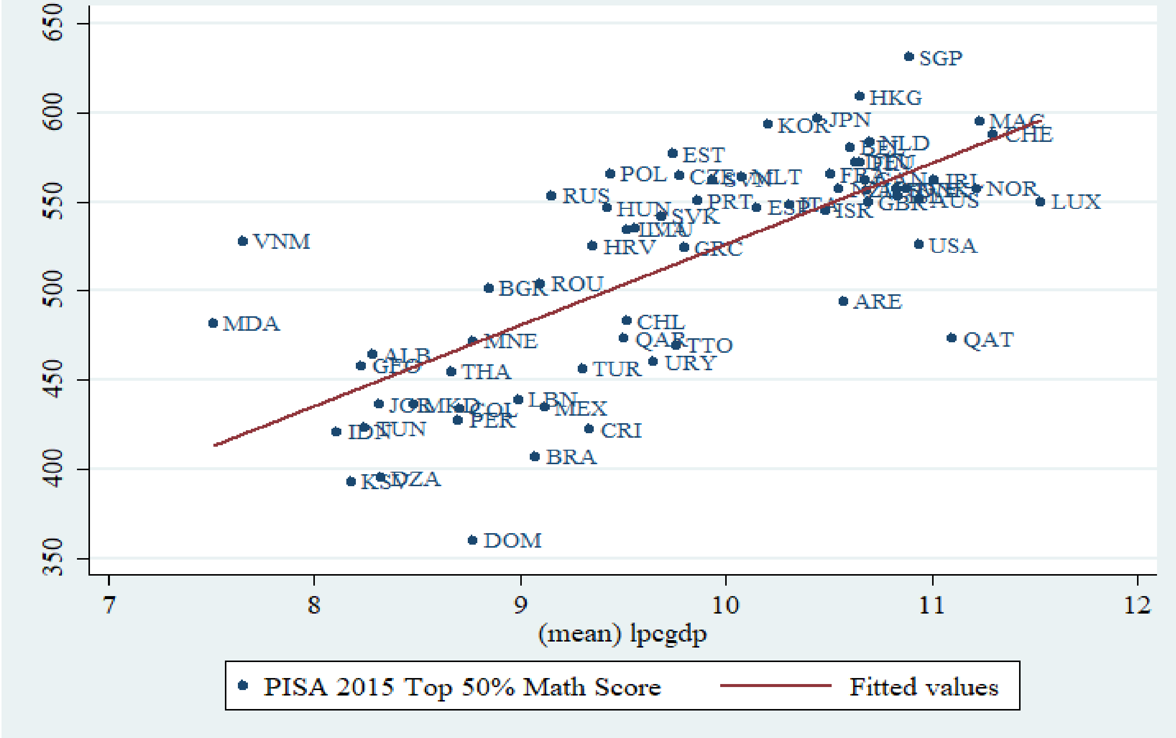


Figure 8. Mean Age 15 Top 50% Reading Scores in 2015 PISA, by 2015 Log Real GDP/capita

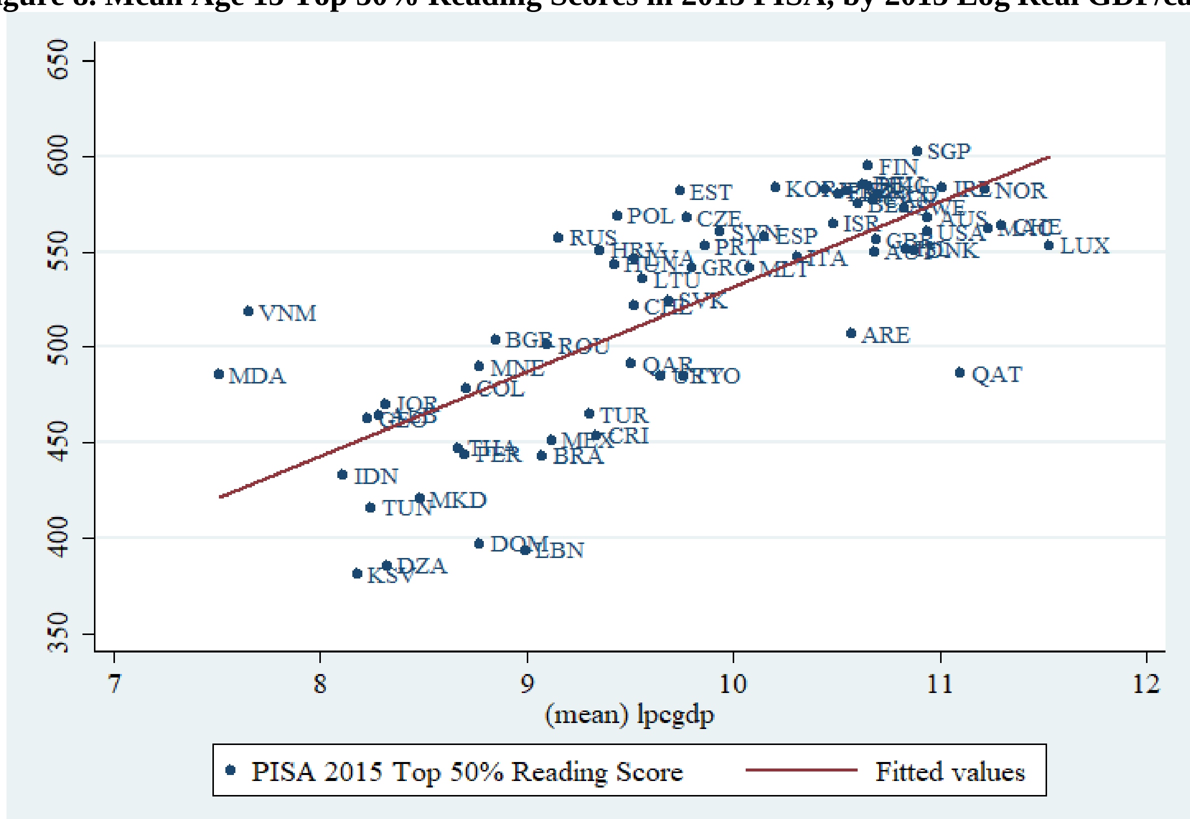
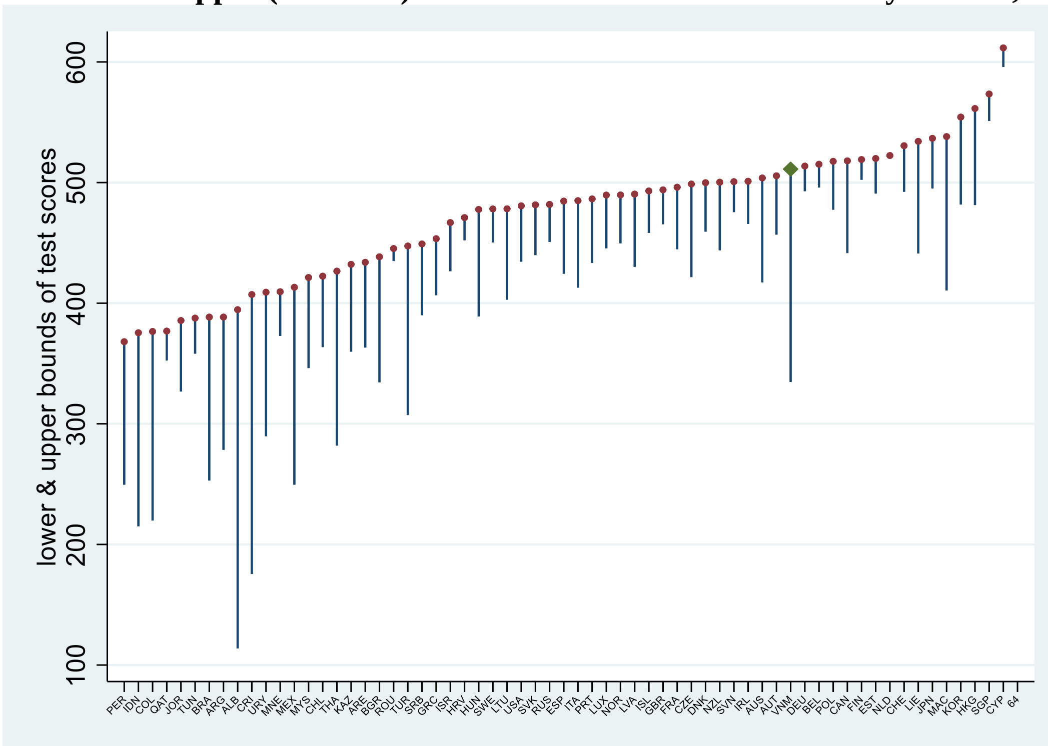
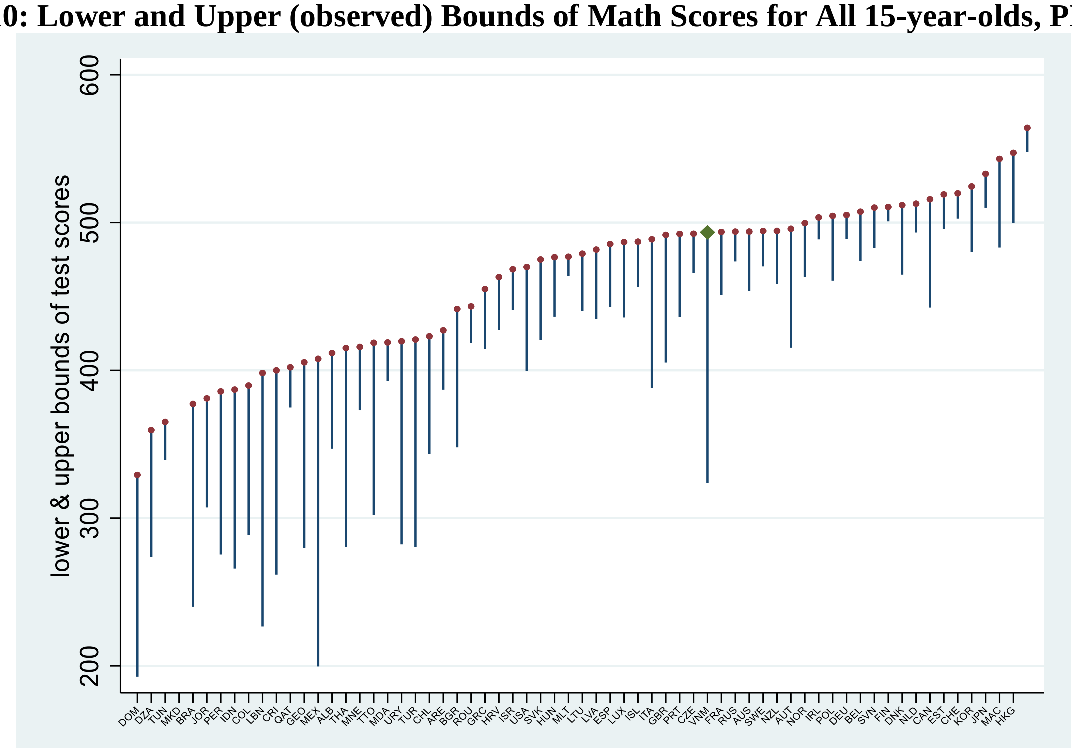


Figure 9: Lower and Upper (observed) Bounds of Math Scores for All 15-year-olds, PISA 2012



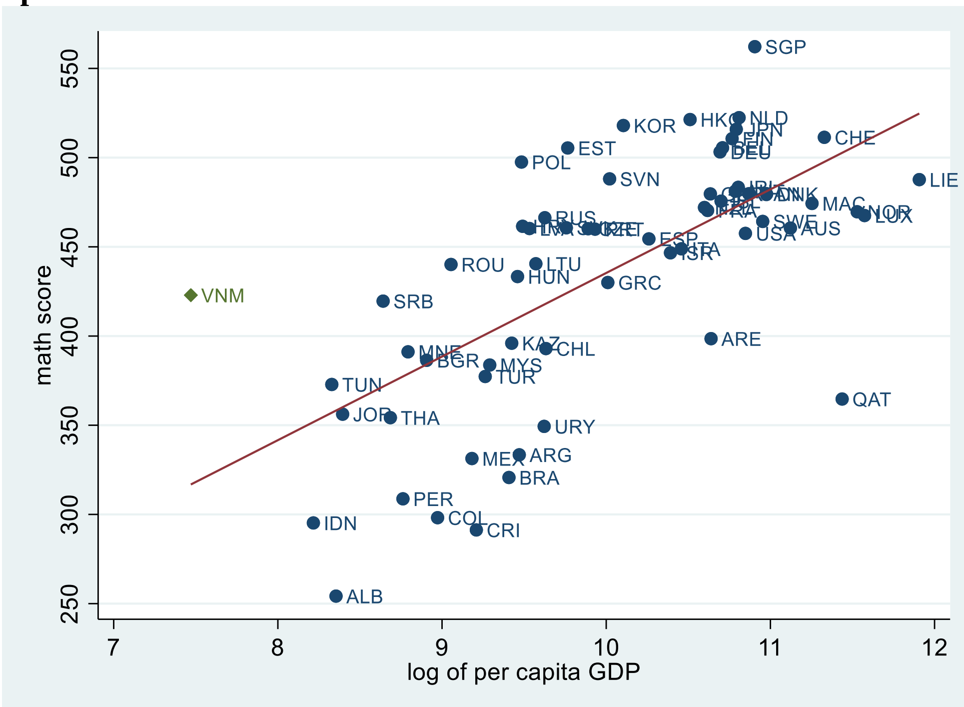
Note: All countries are sorted in an increasing order of the upper bound (observed mean from PISA participants) of test scores. The dots represent the observed mean test scores. Vietnam is indicated by the larger diamond.

Figure 10: Lower and Upper (observed) Bounds of Math Scores for All 15-year-olds, PISA 2015



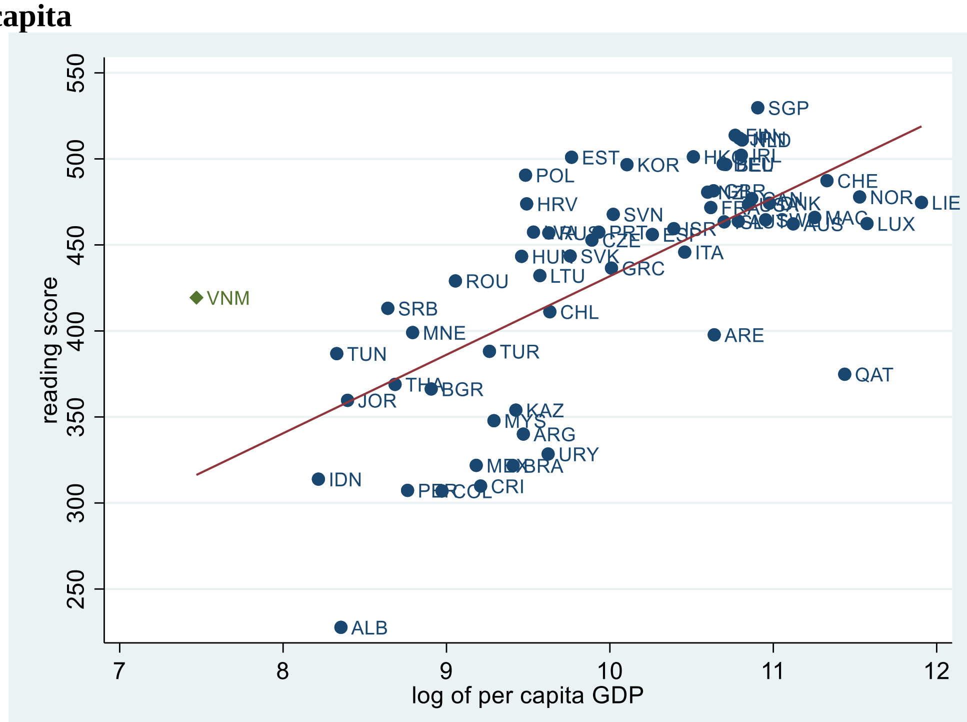
Note: All countries are sorted in an increasing order of the upper bound (observed mean from PISA participants) of test scores. The dots represent the observed mean test scores. Vietnam is indicated by the larger diamond.

Figure 11: Midpoint of Upper and Lower Bounds of 2012 PISA Math Scores, by Log of GDP/capita



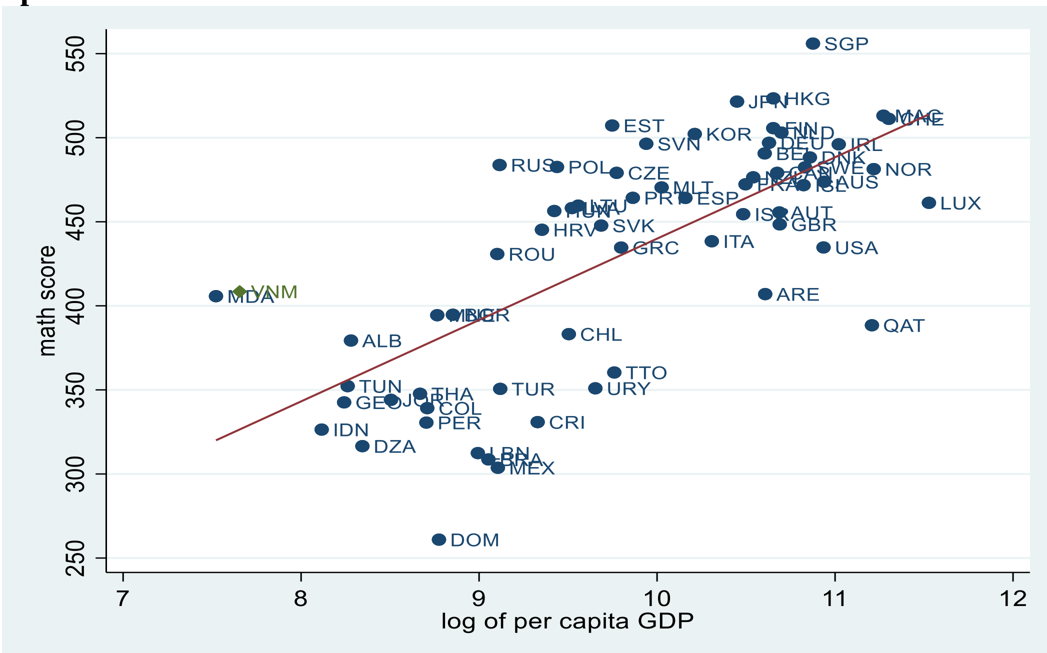
Note: Adjusted test scores for each country are the mid-point value of the observed test scores and the theoretical lower bounds based on Proposition 1.

Figure 12: Midpoint of Upper and Lower Bounds of 2012 PISA Reading Scores, by Log of GDP/capita



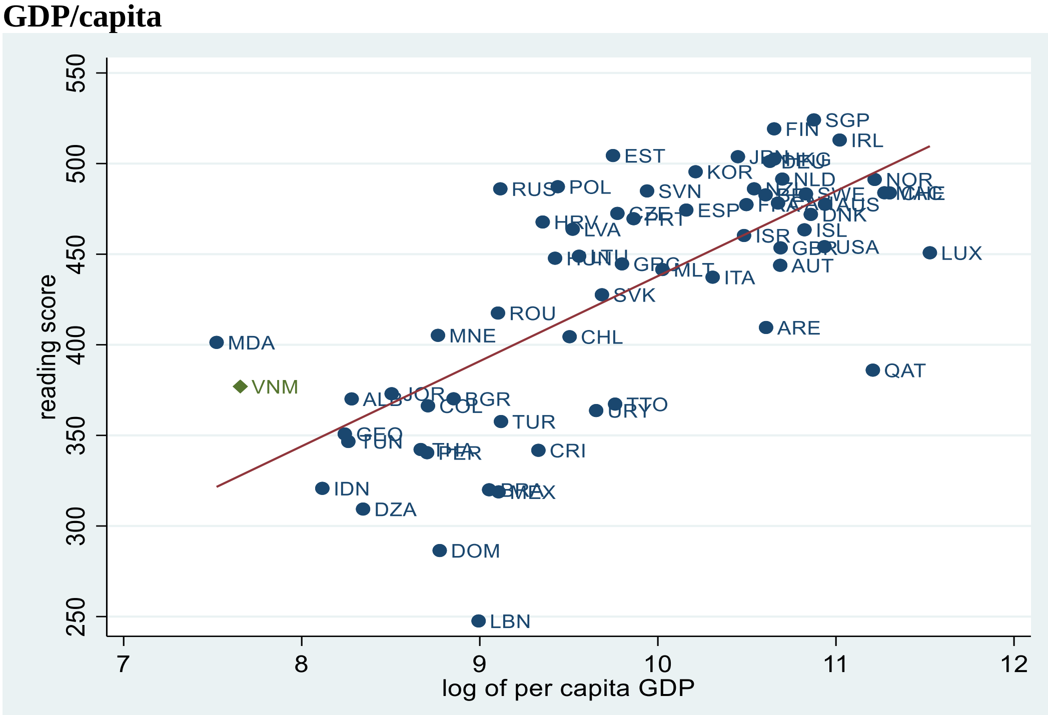
Note: Adjusted test scores for each country are the mid-point value of the observed test scores and the theoretical lower bounds based on Proposition 1.

Figure 13: Midpoint of Upper and Lower Bounds of 2015 PISA Math Scores, by Log of GDP/capita



Note: Adjusted test scores for each country are the mid-point value of the observed test scores and the theoretical lower bounds based on Proposition 1.

Figure 14: Midpoint of Upper and Lower Bounds of 2015 PISA Reading Scores, by Log of GDP/capita



Note: Adjusted test scores for each country are the mid-point value of the observed test scores and the theoretical lower bounds based on Proposition 1.

Table 1: Student Characteristics in 2012 (born in 1996) and 2015 (born in 1999): PISA vs. VHLSS

	2012 PISA and 2012 VHLSS				2015 PISA and 2014 & 2016 VHLSS			
	PISA	VHLSS (PISA-eligible only)			PISA	VHLSS (PISA-eligible only)		
Variable	(1)	All (2)	Mar.-July (3)	Difference (3) – (1)	(4)	All (5)	Mar.-July (6)	Difference (6) – (4)
Urban	50.3%	26.0%	25.3%	-24.9***	49.6%	30.5%	28.6%	-21.0***
	(4.2)	(2.3)	(3.2)	(5.2)	(4.0)	(1.9)	(2.7)	(4.9)
Female	53.8%	51.7%	51.7%	-2.1	51.4%	51.4%	47.1%	-4.3
	(0.8)	(2.6)	(3.5)	(3.6)	(1.0)	(1.9)	(2.6)	(2.8)
Current grade: 10 or higher	86.1%	84.3%	75.7%	-10.4***	85.5%	90.5%	84.3%	-1.2
	(2.6)	(1.8)	(3.0)	(3.9)	(3.0)	(1.0)	(1.8)	(3.5)
Current grade: 9 or lower	10.3%	14.0%	22.2%	11.9***	9.0%	8.5%	15.1%	6.2**
	(2.2)	(1.7)	(2.8)	(3.6)	(2.2)	(1.0)	(1.8)	(2.8)
Current grade: unknown/other a/	3.6%	1.7%	2.1%	-1.5	5.5%	1.0%	0.6%	-4.9**
	(1.5)	(0.7)	(1.3)	(2.0)	(2.3)	(0.4)	(0.4)	(2.3)
Father's years of schooling	8.95	7.18	7.19	-1.76***	8.4	7.1	6.9	-1.47***
	(0.17)	(0.22)	(0.32)	(0.37)	(0.17)	(0.17)	(0.23)	(0.29)
Mother's years of schooling	8.34	6.80	6.93	-1.41***	7.9	6.6	6.4	-1.41***
	(0.19)	(0.19)	(0.26)	(0.32)	(0.20)	(0.15)	(0.22)	(0.29)
Owns an air-conditioner	16.0%	7.1%	7.1%	-8.8***	20.7%	19.2%	15.2%	-5.5**
	(2.1)	(1.4)	(2.1)	(3.0)	(1.6)	(1.7)	(2.2)	(2.8)
Owns a motorbike	93.1%	91.0%	90.7%	-2.4	93.9%	94.0%	93.8%	-0.2
	(0.5)	(1.4)	(2.0)	(2.1)	(0.5)	(0.8)	(1.3)	(1.4)
Owns a car	7.3%	0.7%	1.0%	-6.3***	7.9%	2.0%	2.6%	-5.3***
	(0.8)	(0.3)	(0.7)	(1.1)	(0.7)	(0.5)	(0.9)	(1.1)
Owns a computer	39.1%	24.5%	25.1%	-14.1***	44.1%	29.5%	28.5%	-15.6***
	(2.2)	(2.3)	(3.2)	(3.9)	(1.9)	(1.8)	(2.4)	(3.1)
Number of televisions owned	1.39	1.00	1.00	-0.38***	1.42	1.09	1.05	-0.36***
	(0.03)	(0.02)	(0.03)	(0.04)	(0.03)	(0.02)	(0.03)	(0.04)
Sample size	4,771	455	236		5687	849	415	
PISA coverage/eligibility rate	56%	75%	78%		49%	76.4%	77.8%	

Robust standard errors, clustered at school level in the PISA sample and at commune level in the VHLSS sample, are shown in parentheses.

The difference column reports mean differences between the PISA sample and the VHLSS subsample interviewed from March to July, as well as their standard errors; t-tests are conducted to test whether the mean difference of each variable is significantly different from zero, for which: *** p<0.01, ** p<0.05, * p<0.1.

a/ In the PISA sample, this category consists of observations originally categorized as "Ungraded", with no further information; in the VHLSS sample, this category consists of observations originally categorized as "Attending vocational schools".

Table 2: Predicted PISA Math Scores Based on VHLSS Data, Decomposed by Variable (Using March – July Means of VHLSS data)

A. 2012 PISA Data and 2012 VHLSS Data

Variable	Variable Means				Math Coefficient Multiplied by:		
	PISA	VHLSS	Difference in Means	Math Coeff.	PISA Mean	VHLSS Mean	Difference in Means
Rural	0.497	0.747	-0.250	-18.04	-9.0	-13.5	4.5
Female	0.538	0.517	0.021	-16.58	-8.9	-8.6	-0.4
Grade 10	0.861	0.757	0.104	105.8	91.0	80.1	11.0
Dad Yrs. Sch.	8.81	7.19	1.62	2.231	19.7	16.0	3.6
Mom yrs. sch.	8.23	6.93	1.306	1.879	15.5	13.0	2.4
Air condit.	0.160	0.071	0.089	5.456	0.9	0.4	0.5
Car	0.094	0.010	0.084	-6.723	-0.6	-0.1	-0.6
Computer	0.391	0.251	0.140	17.35	6.8	4.4	2.4
TVs	1.39	1.00	0.39	0.526	0.7	0.5	0.2
Constant	1.000	1.000	0.000	396.7	396.7	396.7	0.0
Column sum	--	--	--	--	512.7	489.0	23.7

B. 2015 PISA Data and 2014 and 2016 VHLSS Data

Variable	Variable Means				Math Coefficient Multiplied by:		
	PISA	VHLSS	Difference in Means	Math Coeff.	PISA Mean	VHLSS Mean	Difference in Means
Rural	0.504	0.714	-0.210	-9.822	-5.0	-7.0	2.1
Female	0.514	0.471	0.043	-8.461	-4.3	-4.0	-0.4
Grade 10	0.855	0.843	0.012	74.61	63.8	62.9	0.9
Dad yrs. sch.	8.40	6.446	1.410	2.041	17.1	9.4	2.1
Mom yrs. sch.	7.86	6.932	1.467	1.460	11.5	14.2	3.0
Air condit.	0.207	0.152	0.055	-2.685	-0.6	-0.4	-0.15
Motorbike	0.939	0.938	0.002	6.451	6.1	6.0	0.01
Car	0.079	0.026	0.053	-1.249	-0.1	0.0	-0.1
Computer	0.441	0.285	0.156	23.40	10.3	6.7	3.7
TVs	1.416	1.054	0.363	6.734	9.5	7.1	2.4
Constant	1.000	1.000	0.000	386.4	386.4	386.4	0.0
Column sum					494.7	481.2	13.6

Table 3 Predicted Reading Scores Based on VHLSS Data, Decomposed by Variable (Using March – July Means for the VHLSS data)

A. 2012 PISA and 2012 VHLSS Data

Variable	Variable Means				Reading Coefficient Multiplied by:		
	PISA	VHLSS	Difference in Means	Reading Coeff.	PISA Mean	VHLSS Mean	Difference in Means
Rural	0.497	0.747	-0.250	-11.56	-5.7	-8.6	2.9
Female	0.538	0.517	0.021	24.61	13.2	12.7	0.5
Grade 10	0.861	0.757	0.104	95.14	81.9	72.0	9.9
Dad Yrs. Sch.	8.81	7.19	1.62	1.536	13.5	11.0	2.5
Mom yrs. sch.	8.23	6.93	1.30	1.661	13.7	11.5	2.2
Air condit.	0.160	0.071	0.089	-0.626	-0.1	-0.0	-0.1
Car	0.094	0.010	0.084	-3.442	-0.3	-0.0	-0.3
Computer	0.391	0.251	0.140	10.86	4.2	2.7	1.5
TVs	1.39	1.00	0.39	2.977	4.1	3.0	1.1
Constant	1.000	1.000	0.000	385.2	385.2	385.2	0.0
Column sum	--	--	--	--	509.8	489.5	20.3

B. 2015 PISA Data and 2014 and 2016 VHLSS Data

Variable	Variable Means				Reading Coefficient Multiplied by:		
	PISA	VHLSS	Difference in Means	Reading Coeff.	PISA Mean	VHLSS Mean	Difference in Means
Rural	0.504	0.714	-0.210	-18.86	-9.5	-13.5	4.0
Female	0.514	0.471	0.043	15.97	8.2	7.5	0.7
Grade 10	0.855	0.843	0.012	69.85	59.7	58.9	0.9
Dad yrs. sch.	8.40	6.446	1.410	1.646	13.8	5.8	1.3
Mom yrs. sch.	7.86	6.932	1.467	0.893	7.0	11.4	2.4
Air condit.	0.207	0.152	0.055	-0.712	-0.1	-0.1	-0.04
Motorbike	0.939	0.938	0.002	15.83	14.9	14.8	0.03
Car	0.079	0.026	0.053	5.202	0.4	0.1	0.3
Computer	0.441	0.285	0.156	16.61	7.3	4.7	2.6
TVs	1.416	1.054	0.363	7.284	10.3	7.7	2.6
Constant	1.000	1.000	0.000	376.9	376.9	376.9	0.0
Column sum					489.0	474.3	14.7

Table 4A: PISA Assessment Country 2012 Rankings, Overall and Top 50% of Overall Population

	Math (all students)		Reading (all students)		Math (top 50% of pop.)		Reading (top 50% of pop.)	
Rank	Country	Avg. score	Country	Avg. score	Country	Avg. score	Country	Avg. score
1	Singapore	573	Hong Kong	545	Singapore	648	Singapore	612
2	Hong Kong	561	Singapore	542	Taiwan	639	Japan	607
3	Taiwan	559	Japan	538	Hong Kong	623	Hong Kong	599
4	South Korea	554	South Korea	536	South Korea	622	South Korea	594
5	Macao	538	Finland	524	Japan	602	Belgium	587
6	Japan	536	Canada	523	Belgium	596	Finland	585
7	Liechtenstein	535	Taiwan	523	Macao	595	Taiwan	585
8	Switzerland	531	Ireland	523	Netherlands	592	New Zealand	585
9	Netherlands	523	Poland	518	Liechtenstein	589	France	584
10	Estonia	521	Liechtenstein	516	Switzerland	586	Ireland	583
11	Finland	519	Estonia	516	Germany	586	Netherlands	580
12	Poland	518	New Zealand	512	Poland	583	Poland	580
13	Canada	518	Australia	512	Czech Republic	583	Germany	575
14	Belgium	515	Netherlands	511	Estonia	578	Estonia	573
15	Germany	514	Macao	509	Finland	573	Norway	572
16	**Vietnam**	**511**	Belgium	509	Austria	569	Czech Republic	571
17	Austria	506	Switzerland	509	New Zealand	568	Canada	569
18	Australia	504	**Vietnam**	**508**	France	566	Israel	567
19	Ireland	501	Germany	508	Canada	563	Australia	567
20	Slovenia	501	France	505	Ireland	560	United Kingdom	565
21	Denmark	500	Norway	504	Iceland	559	Liechtenstein	565
22	New Zealand	500	United Kingdom	499	Slovakia	558	Sweden	561
23	Czech Republic	499	United States	498	Australia	557	Switzerland	560
24	France	495	Denmark	496	United Kingdom	556	United States	560
25	United Kingdom	494	Czech Republic	493	Luxembourg	556	Luxembourg	560
26	Iceland	493	Austria	490	Spain	555	Macao	558
27	Latvia	491	Italy	490	Norway	553	Italy	557
28	Luxembourg	490	Latvia	489	Italy	551	Spain	555
29	Norway	489	Spain	488	Slovenia	549	Austria	553
30	Portugal	487	Luxembourg	488	Portugal	548	Iceland	553
31	Italy	485	Portugal	488	Denmark	547	Hungary	551
32	Spain	484	Hungary	488	Latvia	547	Latvia	549
33	Russian Federation	482	Israel	486	Sweden	544	Portugal	548
34	Slovakia	482	Croatia	485	**Vietnam**	**543**	Denmark	546
35	United States	481	Iceland	483	Russian Federation	543	Croatia	546
36	Lithuania	479	Sweden	483	United States	542	Slovakia	542
37	Sweden	478	Slovenia	481	Israel	541	Greece	541
38	Hungary	477	Greece	477	Hungary	540	Russian Federation	538
39	Croatia	471	Lithuania	477	Lithuania	536	**Vietnam**	**537**
40	Israel	466	Turkey	475	Croatia	533	Lithuania	534
41	Greece	453	Russian Federation	475	Greece	510	Slovenia	530
42	Serbia	449	Slovakia	463	Romania	504	Turkey	512
43	Turkey	448	Serbia	446	Serbia	503	Chile	511
44	Romania	445	United Arab Emirates	442	Bulgaria	492	Bulgaria	509
45	Bulgaria	439	Chile	441	Chile	499	Romania	505
46	United Arab Emirates	434	Costa Rica	441	United Arab Emirates	486	Serbia	503
47	Kazakhstan	432	Thailand	441	Turkey	486	United Arab Emirates	499
48	Thailand	427	Romania	438	Thailand	482	Thailand	492
49	Chile	423	Bulgaria	436	Kazakhstan	471	Montenegro	482
50	Malaysia	421	Mexico	424	Malaysia	468	Qatar	470
51	Mexico	413	Montenegro	422	Montenegro	460	Tunisia	464
52	Montenegro	410	Uruguay	411	Uruguay	453	Argentina	462
53	Uruguay	409	Brazil	410	Qatar	447	Uruguay	461
54	Costa Rica	407	Tunisia	404	Mexico	443	Mexico	456
55	Albania	394	Colombia	403	Argentina	440	Jordan	455
56	Brazil	391	Jordan	399	Tunisia	438	Malaysia	449
57	Argentina	388	Malaysia	398	Jordan	430	Colombia	443
58	Tunisia	388	Indonesia	396	Brazil	414	Costa Rica	441
59	Jordan	386	Argentina	396	Albania	412	Brazil	437
60	Qatar	376	Albania	394	Colombia	410	Kazakhstan	437
61	Colombia	376	Kazakhstan	393	Peru	406	Peru	429
62	Indonesia	375	Qatar	388	Costa Rica	406	Indonesia	423
63	Peru	368	Peru	384	Indonesia	399	Albania	419

Table 4B: PISA Assessment 2015 Country Rankings, Overall and Top 50% of Overall Population

	Math (all students)		Reading (all students)		Math (Top 50% of pop.)		Reading (Top 50% of pop.)	
Rank	Country	Avg score	Country	Avg score	Country	Avg score	Country	Avg score
1	Singapore	564	Singapore	533	Singapore	631	Singapore	603
2	Hong Kong	547	Canada	527	Hong Kong	609	Finland	595
3	Macao	543	Hong Kong	527	Japan	596	Germany	585
4	Japan	533	Finland	527	Macao	595	Hong Kong	584
5	South Korea	524	Ireland	520	South Korea	593	Ireland	583
6	Switzerland	520	Estonia	519	Switzerland	588	South Korea	583
7	Estonia	519	Japan	515	Netherlands	583	Norway	582
8	Canada	516	South Korea	515	Belgium	580	Japan	582
9	Netherlands	513	Norway	514	Estonia	576	New Zealand	582
10	Denmark	512	Germany	509	Germany	572	Estonia	582
11	Finland	511	New Zealand	509	Finland	572	France	580
12	Slovenia	510	Macao	508	Poland	565	Netherlands	580
13	Belgium	507	Poland	506	France	565	Canada	577
14	Germany	505	Slovenia	505	Czech Rep.	564	Belgium	575
15	Poland	505	Netherlands	503	Malta	564	Sweden	573
16	Ireland	503	Australia	503	Canada	562	Poland	569
17	Norway	500	Denmark	500	Slovenia	562	Czech Rep.	567
18	Austria	496	Sweden	500	Ireland	562	Australia	567
19	New Zealand	494	Belgium	499	Norway	557	Israel	565
20	Sweden	494	France	498	Sweden	557	Switzerland	563
21	Australia	494	Portugal	498	New Zealand	557	Macao	562
22	Russia	494	United Kingdom	497	Denmark	557	United States	560
23	France	494	United States	496	Austria	557	Slovenia	560
24	**Vietnam**	**493**	Russia	495	Russia	553	Spain	558
25	Czech Rep.	492	Spain	495	Iceland	553	Russia	557
26	Portugal	492	Switzerland	492	Australia	551	United Kingdom	556
27	United Kingdom	492	Latvia	489	Portugal	550	Luxembourg	553
28	Italy	489	**Vietnam**	**488**	Luxembourg	550	Portugal	553
29	Iceland	487	Czech Rep.	487	United Kingdom	549	Iceland	552
30	Luxembourg	487	Croatia	487	Italy	548	Denmark	551
31	Spain	486	Italy	487	Spain	547	Croatia	551
32	Latvia	482	Austria	486	Hungary	546	Austria	550
33	Lithuania	479	Iceland	481	Israel	545	Italy	547
34	Malta	477	Luxembourg	480	Slovakia	542	Latvia	546
35	Hungary	477	Israel	479	Lithuania	535	Hungary	543
36	Slovakia	475	Lithuania	472	Latvia	534	Greece	542
37	United States	470	Hungary	469	**Vietnam**	**528**	Malta	541
38	Israel	468	Greece	466	United States	526	Lithuania	535
39	Croatia	463	Chile	458	Croatia	525	Slovakia	524
40	Greece	455	Slovakia	453	Greece	524	Chile	521
41	Romania	443	Malta	448	Romania	504	**Vietnam**	**518**
42	Bulgaria	442	Uruguay	438	Bulgaria	501	United Arab Em.	507
43	United Arab En.	427	Romina	433	United Arab Em.	494	Bulgaria	504
44	Chile	423	United Arab Em.	432	Chile	483	Romania	501
45	Turkey	421	Bulgaria	431	Moldova	482	Montenegro	489
46	Uruguay	420	Turkey	429	Qatar	473	Qatar	486
47	Moldova	419	Trinidad & Tob.	428	Montenegro	472	Moldova	485
48	Trinidad & Tob.	419	Costa Rica	427	Trinidad & Tob.	469	Trinidad & Tob.	485
49	Montenegro	416	Montenegro	426	Albania	464	Uruguay	485
50	Thailand	415	Colombia	425	Uruguay	460	Colombia	478
51	Albania	412	Mexico	423	Georgia	458	Jordan	470
52	Mexico	408	Moldava	417	Turkey	456	Turkey	465
53	Georgia	405	Thailand	408	Thailand	455	Albania	464
54	Qatar	402	Brazil	408	Lebanon	439	Georgia	462
55	Costa Rica	400	Jordan	408	Macedonia	436	Costa Rica	454
56	Lebanon	398	Albania	405	Jordan	436	Mexico	451
57	Colombia	390	Qatar	403	Mexico	434	Thailand	447
58	Indonesia	387	Georgia	402	Colombia	434	Peru	444
59	Peru	386	Indonesia	398	Peru	427	Brazil	443
60	Jordan	381	Peru	397	Tunisia	423	Indonesia	433
61	Brazil	377	Tunisia	359	Costa Rica	422	Macedonia	420
62	Macedonia	372	Dominican Rep.	358	Indonesia	421	Tunisia	416
63	Tunisia	365	Macedonia	352	Brazil	407	Dominican Rep.	397
64	Kosovo	362	Algeria	348	Algeria	395	Lebanon	394
65	Algeria	360	Kosovo	347	Kosovo	393	Algeria	385
66	Dominican Rep.	329	Lebanon	347	Dominican Rep.	360	Kosovo	381

Table 5. Regressions of PISA Test Scores on Log(GDP)/capita or Wealth/capita: Student-Level Data

Variables	(1) Math	(2) Reading	(3) Math	(4) Reading	(5) Math	(6) Reading	(7) Math	(8) Reading
A. 2012 PISA Assessment								
Log of per capita GDP	34.14***	31.53***						
	(1.57)	(1.44)						
Wealth (national average)			28.84***	26.63***				
			(1.10)	(1.04)				
Wealth (student specific)					22.35***	20.82***	16.26***	15.16***
					(0.51)	(0.50)	(0.52)	(0.46)
Constant	126.08***	159.47***	454.86***	463.16***	458.27***	466.98***	--	--
	(15.47)	(14.13)	(1.18)	(1.11)	(1.06)	(0.99)		
Vietnam residual (average)	**135.8**	**119.0**	**111.6**	**96.7**	**98.2**	**83.6**	**82.8**	**73.4**
Residual rank	**1**	**1**	**2**	**1**	**4**	**2**	**5**	**3**
More highly ranked	**none**	**none**	**HK**	**none**	**HK S. Korea Singap.**	**HK**	**HK S. Korea Singap. Taiwan**	**HK S. Korea**
Observations	473,236	473,236	473,236	473,236	455,971	455,971	455,971	455,971
R-squared	0.117	0.103	0.126	0.111	0.155	0.140	0.350	0.280
B. 2015 PISA Assessment								
Log of per capita GDP	34.41***	34.95***						
	(1.242)	(1.170)						
Wealth (national average)			30.53***	30.58***				
			(1.004)	(0.951)				
Wealth (student specific)					22.89***	23.03***	16.24***	16.22***
					(0.445)	(0.440)	(0.476)	(0.443)
Constant	118.1***	123.4***	445.9***	456.3***	450.5***	461.1***		
	(12.06)	(11.29)	(1.096)	(1.042)	(0.957)	(0.901)		
Vietnam residual (average)	**114.6**	**99**	**106.2**	**89.7**	**89.7**	**72.8**	**73.2**	**63.4**
Residual rank	**1**	**1**	**1**	**1**	**3**	**1**	**4**	**3**
More highly ranked	**None**	**none**	**none**	**none**	**HK Singap.**	**none**	**Singap. HK Macao**	**HK Singap.**
Observations	464,518	464,518	460,701	460,701	428,716	428,716	428,716	428,716
R-squared	0.128	0.127	0.140	0.136	0.170	0.167	0.331	0.262
Country fixed effects	No	No	No	No	No	No	Yes	Yes

Robust standard errors, clustered at the school level, in parentheses *** p<0.01, ** p<0.05, * p<0.1

For fixed effects regressions, residual = fixed effect – constant in regression without fixed effects.

Table 6A: Regressions of 2012 Test Scores on Wealth/capita and Student and Household Variables

Variables	Math	Reading	Math	Reading	Math	Reading	Math	Reading
Wealth index	15.92***	14.66***	9.998***	9.548***	15.77***	14.49***	5.694***	5.080***
	(0.52)	(0.48)	(0.433)	(0.406)	(0.53)	(0.48)	(0.384)	(0.355)
Girl			-8.705***	33.31***			-15.39***	26.55***
			(0.767)	(0.757)			(0.697)	(0.677)
Sibling index			-1.905***	-2.457***			-1.930***	-2.392***
			(0.524)	(0.542)			(0.506)	(0.514)
Sibling index missing			-19.59***	-15.66***			-17.54***	-13.51***
			(0.798)	(0.843)			(0.763)	(0.799)
Mom years school			2.978***	2.872***			1.800***	1.702***
			(0.142)	(0.143)			(0.131)	(0.130)
Dad years school			3.310***	3.065***			2.046***	1.841***
			(0.131)	(0.133)			(0.120)	(0.121)
Grade10							22.87***	23.87***
							(1.36)	(1.379
Years of preschool							10.74***	10.05***
							(0.680)	(0.693)
Educational input index							7.432***	7.985***
							(0.286)	(0.306)
Attendance (past 2 weeks)							7.710***	7.638***
							(0.365)	(0.364)
Books at home							0.069***	0.0595***
							(0.003)	(0.003)
Hours of study							3.170***	3.017***
							(0.094)	(0.089)
Extra math classes (tutored)							-0.558*	
							(0.212)	
Extra math variable missing							-2.929***	
							(0.544)	
Extra read. classes (tutored)								-4.440***
								(0.2331)
Extra read. variable missing								-3.052***
								(0.577)
Vietnam fixed effect	**78.2**	**68.3**	**80.6**	**70.7**	**79.1**	**68.9**	**65.0**	**55.1**
Fixed effect rank	**5**	**3**	**6**	**2**	**5**	**3**	**5**	**3**
More highly ranked:	**HK S. Korea Singap. Taiwan**	**HK S. Korea**	**HK Macao Singap. S. Korea Taiwan**	**HK**	**HK S. Korea Singap. Taiwan**	**HK S. Korea**	**HK Macao Singap. Taiwan**	**Finland HK**
Observations	401,489	401,489	401,489	401,489	393,730	393,730	393,730	393,730
R-squared	0.366	0.295	0.399	0.350	0.360	0.291	0.464	0.421

Robust standard errors, clustered at the school level, in parentheses. All regressions use country fixed effects.
*** p<0.01, ** p<0.05, * p<0.1

Table 6B: Regressions of 2015 Test Scores on Wealth/capita and Student and Household Variables

Variables	Math	Reading	Math	Reading	Math	Reading	Math	Reading
Wealth Index	16.13***	16.03***	10.26***	10.76***	16.02***	15.89***	7.042***	7.222***
	(0.482)	(0.452)	(0.397)	(0.391)	(0.480)	(0.453)	(0.373)	(0.378)
Girl			-6.680***	23.62***			-9.667***	20.45***
			(0.671)	(0.691)			(0.636)	(0.669)
Mom years school			2.863***	2.658***			2.070***	1.841***
			(0.122)	(0.131)			(0.116)	(0.126)
Dad years school			3.151***	2.990***			2.327***	2.129***
			(0.121)	(0.127)			(0.114)	(0.122)
Grade 10							24.58***	25.17***
							(1.429)	(1.447)
Educational input index							7.580***	8.756***
							(0.283)	(0.302)
Books at home							0.063***	0.059***
							(0.002)	(0.003)
Vietnam fixed effect	**73.0**	**62.4**	**82.6**	**71.8**	**72.2**	**61.4**	**68.7**	**57.0**
Fixed effect rank	**5**	**3**	**4**	**2**	**5**	**3**	**4**	**3**
More highly ranked	**Singap. HK Macao Japan**	**HK Singap.**	**Singap. HK Macao**	**HK**	**Singap. HK Macao Japan**	**HK Singap.**	**Macao HK Singap.**	**HK Finland**
Observations	389,472	389,472	389,472	389,472	387,092	387,092	387,092	387,092
R-squared	0.341	0.276	0.372	0.314	0.338	0.273	0.404	0.348

Robust standard errors, clustered at the school level, in parentheses. All regressions use country fixed effects.
*** p<0.01, ** p<0.05, * p<0.1

Table 7A: Regressions 2012 Test Scores on Wealth/capita and Student, Household and School Variables

Variables	Math	Reading	Math	Reading
Wealth	15.32***	13.75***	5.436***	3.869***
	(0.57)	(0.51)	(0.414)	(0.387)
Class size (student/teacher ratio)			0.094	0.271***
			(0.087)	(0.082)
Ratio qualified teachers			13.28***	10.44***
			(3.33)	(3.30)
Qual. tchr. ratio missing			-1.370	-2.833
			(3.320)	(3.038)
Square root of computers/pupil			-2.087	-0.710
			(3.211)	(2.989)
Stud. perf. used to assess tchrs			1.728	2.049
			(1.841)	(1.803)
Teacher absenteeism			-3.302***	-2.961***
			(0.959)	(0.969)
Parents pressure teachers			11.59***	11.33***
			(1.25)	(1.22)
Principal observes teachers			-2.741	0.117
			(1.988)	(1.889)
Inspector observes teachers			-4.735***	-6.698***
			(1.746)	(1.790)
Tchr pay linked to stud perf			-2.232**	-2.501***
			(0.947)	(0.911)
Teacher mentoring index			5.244***	5.906***
			(1.745)	(1.784)
Vietnam fixed effect	**76.7**	**66.1**	**58.1**	**44.7**
Fixed effect rank	**5**	**4**	**8**	**4**
More highly ranked:	**HK**	**HK**	**HK**	**Finland**
	S. Korea	**S. Korea**	**Liecht.**	**HK**
	Singap.	**Singap.**	**Macao**	**Liecht.**
	Taiwan		**S. Korea**	
			Singap.	
			Switz.	
			Taiwan	
Observations	341,409	341,409	341,409	341,409
R-squared	0.354	0.286	0.460	0.405

Robust standard errors, clustered at the school level, in parentheses.
*** p<0.01, ** p<0.05, * p<0.1
Note: Student and household variables not shown. All regressions use country fixed effects.

Table 7B: Regressions of 2015 Test Scores on Wealth/capita and Student, Household and School Variables

Variables	Math	Reading	Math	Reading
Wealth Index	15.37***	15.12***	6.174***	6.302***
	(0.532)	(0.488)	(0.401)	(0.402)
Class size (student/teacher ratio)			0.574***	0.704***
			(0.104)	(0.108)
Ratio qualified teachers			9.323***	7.501***
			(3.031)	(2.905)
Qual. tchr. ratio missing			-4.036	-4.125
			(3.894)	(4.371)
Square root of computers/pupil			-0.435	0.759
			(2.884)	(2.856)
Stud. perf. used to assess tchrs			3.996	1.316
			(2.538)	(2.479)
Teacher absenteeism			-4.579***	-3.815***
			(1.122)	(1.093)
Principal observes teachers			-1.984	0.675
			(2.471)	(2.615)
Inspector observes teachers			-0.966	-2.204
			(1.764)	(1.885)
Teacher mentoring index			0.449	0.276
			(1.161)	(1.162)
Vietnam fixed effect	**71.4**	**60.6**	**59.2**	**46.5**
Fixed effect rank	**4**	**3**	**4**	**8**
More highly ranked:	**Singap.** **HK** **Macao**	**HK** **Singap.**	**Macao** **HK** **Singap.** **Switz.**	**Finland** **HK** **Germany** **Ireland** **N. Zealand** **Estonia** **Singap.**
Observations	317,006	317,006	317,006	317,006
R-squared	0.320	0.262	0.391	0.341

Robust standard errors, clustered at the school level, in parentheses.
*** p<0.01, ** p<0.05, * p<0.1
Note: Student and household variables not shown. All regressions use country fixed effects.

Table 8: Means of Regression Variables, for Vietnam and for Other Countries, 2012 and 2015

	2012 PISA Assessment		2015 PISA Assessment	
Variable (x)	**Vietnam**	**Other PISA Countries**	**Vietnam**	**Other PISA Countries**
Math test score	516.5	462.8	501.2	456.6
Reading test score	512.8	472.5	495.1	468.1
Wealth	4.143	6.101	3.21	5.63
Grade 10	0.874	0.584	0.89	0.59
Sibling index	1.048	1.086	--	--
Sibling index missing	0.149	0.238	--	--
Mom years schooling	8.313	10.98	8.03	11.45
Dad years schooling	8.883	11.09	8.53	11.54
Years preschool enrollment	1.600	1.487	--	--
Education inputs index (desk, books)	4.680	5.154	4.87	5.48
Books in home	57.59	114.1	69.17	113.15
Days attended in past 2 weeks	9.849	9.622	--	--
Hours of study per week	5.756	5.362	--	--
Extra reading classes (tutoring), hours/week	1.290	0.944	--	--
Extra reading classes variable missing	0.337	0.358	--	--
Extra math classes (tutoring), hours/week	2.741	1.325	--	--
Extra math classes variable missing	0.336	0.358	--	--
Class size	44.81	32.61	40.61	31.08
Proportion of teachers who are qualified	0.800	0.834	0.85	0.80
Proportion qualified teacher missing	0.069	0.188	0.07	0.08
Square root of computers/pupil	0.417	0.623	0.44	0.65
Student performance used to assess teachers	0.992	0.708	0.99	0.88
Teacher absenteeism	0.692	0.778	1.60	1.83
Parents pressure teachers	1.311	0.957	--	--
Principal observes teachers	0.965	0.802	0.99	0.87
Outside Inspector observes teachers	0.847	0.406	0.77	0.57
Teacher pay linked to student performance	1.487	0.703	--	--
Teachers are mentored	0.845	0.684	1.81	1.46
Sample size	4,421	336,988	4,895	312,111

Notes: 1. Averages over countries are weighted by country populations.

2. The following variables were not collected for all countries, or not for Vietnam, in 2015, and so are excluded from the analysis for that year: siblings, years in pre-school, days attended, hours of study per week, extra classes, parents pressure teachers, and teacher pay is linked to student performance.

Table 9A: Math Decomposition, 2012 (diff = 516.54– 462.80 = 53.74)

Variable	β_{vn}	$\bar{\mathbf{x}}_{vn}$	$\beta_{vn}'\bar{\mathbf{x}}_{vn}$	β_o	$\bar{\mathbf{x}}_o$	$\beta_o'\bar{\mathbf{x}}_o$	$(= (\beta_{vn}+\beta_o)/2$	$\bar{\beta}'(\bar{\mathbf{x}}_{vn}-\bar{\mathbf{x}}_o)$	$(\beta_{vn} - \bar{\beta})'\bar{\mathbf{x}}_{vn} + (\bar{\beta} - \beta_o)'\bar{\mathbf{x}}_o$
Wealth	6.764***	4.143	28.02	9.633***	6.101	58.77	8.198	-16.05	-14.69
Grade 10	85.85***	0.874	75.01	18.93***	0.584	11.05	52.39	15.19	48.76
Sibling index	3.152*	1.048	3.30	-1.697***	1.086	-1.84	0.728	-0.03	5.17
Sibling index missing	-0.576	0.149	-0.09	-17.87***	0.238	-4.25	-9.225	0.82	3.35
Mom years schooling	0.962**	8.313	8.00	1.786***	10.975	19.60	1.374	-3.66	-7.95
Dad years schooling	1.511***	8.883	13.42	2.390***	11.086	26.50	1.950	-4.30	-8.78
Years in preschool	6.533***	1.600	10.45	13.07***	1.487	19.43	9.799	1.10	-10.08
Education inputs index	4.397***	4.680	20.58	7.337***	5.154	37.81	5.867	-2.78	-14.46
Books in home	0.0089	57.59	0.51	0.0882***	114.07	10.07	0.049	-2.74	-6.81
Days attend past 2 wks	10.43***	9.849	102.72	8.094***	9.622	77.88	9.261	2.10	23.74
Hours study per week	2.920***	5.756	16.81	2.425***	5.362	13.00	2.672	1.05	2.75
Extra math class, hrs/wk	3.904***	2.741	10.70	-0.633**	1.325	-0.84	1.636	2.32	9.22
Extra math class missing	8.890***	0.336	2.98	-3.188***	0.358	-1.14	2.851	-0.06	4.19
Class size	0.0643	44.81	2.88	0.148*	32.61	4.82	0.106	1.29	-3.24
Proport. qualified tchrs	18.18**	0.800	14.55	46.08***	0.834	38.42	32.13	-1.09	-22.79
Prop. qual. tchr. missing	-17.15	0.069	-1.18	-23.14***	0.188	-4.35	-20.14	2.40	0.77
Square root comp/pupil	-0.0392	0.417	-0.02	4.925	0.623	3.07	2.443	-0.50	-2.58
Stud perf. to assess tchrs	25.08***	0.992	24.89	-4.267**	0.708	-3.02	10.40	2.96	24.95
Teacher absenteeism	-0.759	0.692	-0.53	-6.600***	0.778	-5.13	-3.679	0.32	4.29
Parents pressure tchrs	15.71***	1.311	20.60	6.686***	0.957	6.40	11.20	3.97	10.24
Principal observes tchrs	14.12	0.965	13.63	-3.816**	0.802	-3.06	5.154	0.84	15.85
Inspector observes tchrs	-16.73	0.847	-14.17	-10.15***	0.406	-4.12	-13.44	-5.93	-4.13
Tchr pay link stud. perf.	2.209	1.487	3.28	-2.279**	0.703	-1.60	-0.035	-0.03	-4.92
Teachers are mentored	6.766	0.845	5.72	7.722***	0.684	5.28	7.244	1.17	-0.73
Constant	154.46***	1.000	154.46	160.07***	1.000	160.07	157.26	0.00	-5.61
Column sum:	--	--	516.54	--	--	462.80	--	-1.62	55.36

Table 9B: Math Decomposition, 2015 (diff = 501.23– 456.61 = 44.62)

Variable	β_{vn}	$\bar{x}_{vn}$	$\beta_{vn}'\bar{x}_{vn}$	β_o	$\bar{x}_o$	$\beta_o'\bar{x}_o$	$\bar{\beta}$ (= $(\beta_{vn}+\beta_o)/2$	$\bar{\beta}'(\bar{x}_{vn}-\bar{x}_o)$	$(\beta_{vn} - \bar{\beta})'\bar{x}_{vn} + (\bar{\beta} - \beta_o)'\bar{x}_o$
Wealth	6.573***	2.275	14.95	10.590***	4.198	44.47	8.581	-16.51	-13.00
Grade 10	79.641***	0.894	71.20	22.482***	0.592	13.30	51.061	6.80	51.10
Mom years schooling	1.214**	8.030	9.75	2.493***	11.449	28.55	1.853	-8.53	-10.27
Dad years schooling	2.059***	8.532	17.57	3.005***	11.537	34.67	2.532	-9.03	-8.07
Education input index	8.585***	4.031	34.61	7.360***	4.415	32.49	7.972	-3.05	5.17
Books in home	-0.021**	69.165	-1.42	0.089***	113.154	10.10	0.034	-3.93	-7.59
Class size	0.045	40.612	1.81	-0.033*	31.084	-1.02	0.006	-0.31	3.14
Proport. qualified tchrs	-5.666*	0.850	-4.82	26.023***	0.805	20.94	10.178	1.19	-26.95
Prop. Qual. tchr. missing	-5.084	0.070	-0.36	-11.814***	0.085	-1.00	-8.449	0.17	0.47
Square root comp/pupil	11.477**	0.442	5.07	10.850***	0.649	7.05	11.163	-2.25	0.28
Stud perf. to assess tchrs	-19.137*	0.990	-18.94	-5.876***	0.879	-5.16	-12.507	-0.65	-13.13
Teacher absenteeism	-2.328	1.604	-3.74	-7.533***	1.833	-13.81	-4.931	1.72	8.35
Principal observes tchrs	42.505**	0.994	42.26	1.178**	0.875	1.03	21.842	0.14	41.09
Inspector observes tchrs	4.869*	0.766	3.73	-1.833***	0.568	-1.04	1.518	-0.36	5.14
Teacher are mentored	12.247***	1.808	22.15	-1.167***	1.462	-1.71	5.540	-0.40	24.26
Constant	307.41***	1.000	307.41	287.75***	1.000	287.75	297.58	0.00	19.66
Column sum:	--	--	501.23	--	--	456.61	--	-16.69	61.31

Table 10A: Reading Decomposition, 2012 (diff = 512.82– 472.52 = 40.30)

Variable	β_{vn}	$\bar{\mathbf{x}}_{vn}$	$\beta_{vn}'\bar{\mathbf{x}}_{vn}$	β_{o}	$\bar{\mathbf{x}}_{o}$	$\beta_{o}'\bar{\mathbf{x}}_{o}$	$\bar{\beta}$ (= ($\beta_{vn}+\beta_{o}$)/2	$\bar{\beta}'(\bar{\mathbf{x}}_{vn}-\bar{\mathbf{x}}_{o})$	$(\beta_{vn} - \bar{\beta})'\bar{\mathbf{x}}_{vn} + (\bar{\beta} - \beta_{o})'\bar{\mathbf{x}}_{o}$
Wealth	4.748***	4.143	19.67	9.305***	6.101	56.77	7.026	-13.75	-23.34
Grade 10	79.18***	0.874	69.18	20.58***	0.584	12.01	49.88	14.46	42.70
Sibling index	4.045**	1.048	4.24	-1.736***	1.086	-1.89	1.154	-0.04	6.17
Sibling index missing	-0.428	0.149	-0.06	-12.01***	0.238	-2.86	-6.217	0.55	2.24
Mom years schooling	0.721**	8.313	5.99	1.083***	10.975	11.88	0.902	-2.40	-3.49
Dad years schooling	0.694**	8.883	6.17	1.877***	11.086	20.81	1.286	-2.83	-11.81
Years in preschool	4.884**	1.600	7.81	10.98***	1.487	16.34	7.933	0.89	-9.41
Education inputs index	5.657***	4.680	26.47	8.061***	5.154	41.55	6.859	-3.25	-11.82
Books in home	0.00231	57.59	0.13	0.0741***	114.07	8.45	0.038	-2.16	-6.16
Days attend past 2 wks	16.08***	9.849	158.34	7.806***	9.622	75.11	11.94	2.71	80.52
Hours study per week	2.335***	5.756	13.44	2.786***	5.362	14.94	2.651	1.01	-2.51
Extra reading class hr/wk	-1.547***	2.741	-1.99	-4.887***	1.325	-4.61	-3.217	-1.11	3.73
Extra reading class miss.	0.712	0.336	0.24	-3.434***	0.358	-1.23	-1.361	0.03	1.44
Class size	0.258	44.81	11.58	0.358***	32.61	11.67	0.308	3.76	3.85
Proport. qualified tchrs	16.22***	0.800	12.98	35.92***	0.834	29.95	26.07	-0.88	-16.09
Prop. qual. tchr. missing	-17.21***	0.069	-1.19	-16.85***	0.188	-3.17	-17.03	2.03	-0.05
Square root comp/pupil	-4.467	0.417	-1.86	7.049***	0.623	4.40	1.291	-0.27	-5.99
Stud perf. to assess tchrs	1.901	0.992	1.89	-4.253**	0.708	-3.01	-1.176	-0.33	5.23
Teacher absenteeism	-1.489	0.692	-1.03	-5.874***	0.778	-4.57	-3.681	0.32	3.22
Parents pressure tchrs	9.980**	1.311	13.08	8.313***	0.957	7.96	9.146	3.24	1.89
Principal observes tchrs	34.74***	0.965	33.53	-1.893	0.802	-1.52	16.42	2.68	32.37
Inspector observes tchrs	-18.02**	0.847	-15.26	-11.80***	0.406	-4.79	-14.91	-6.57	3.90
Tchr pay link stud. perf.	3.676	1.487	5.47	-4.785***	0.703	-3.36	-0.555	-0.43	9.27
Teachers are mentored	9.211	0.845	7.78	7.342***	0.684	5.02	8.276	1.34	1.43
Constant	136.21***	1.000	136.21	186.68***	1.000	186.61	161.45	0.00	-50.47
Column sum:	--	--	512.82	--	--	472.52	--	-1.02	41.32

Table 10B: Reading Decomposition, 2015 (diff = 495.09– 468.06 = 27.03)

Variable	$\boldsymbol{\beta}_{vn}$	$\bar{\mathbf{x}}_{vn}$	$\boldsymbol{\beta}_{vn}'\bar{\mathbf{x}}_{vn}$	$\boldsymbol{\beta}_{o}$	$\bar{\mathbf{x}}_{o}$	$\boldsymbol{\beta}_{o}'\bar{\mathbf{x}}_{o}$	$\bar{\boldsymbol{\beta}}(=(\boldsymbol{\beta}_{vn}+\boldsymbol{\beta}_{o})/2$	$\bar{\boldsymbol{\beta}}'(\bar{\mathbf{x}}_{vn}-\bar{\mathbf{x}}_{o})$	$(\boldsymbol{\beta}_{vn} - \bar{\boldsymbol{\beta}})'\bar{\mathbf{x}}_{vn} + (\bar{\boldsymbol{\beta}} - \boldsymbol{\beta}_{o})'\bar{\mathbf{x}}_{o}$
Wealth	7.217***	2.275	16.42	11.487***	4.199	48.23	9.352	-17.99	-13.82
Grade 10	90.124***	0.894	80.57	21.122***	0.592	12.50	55.623	6.38	61.69
Mom years schooling	0.522*	8.030	4.19	2.399***	11.449	27.47	1.461	-8.20	-15.07
Dad years schooling	1.716***	8.532	14.64	2.252***	11.537	25.98	1.984	-6.77	-4.57
Education input index	6.883***	4.032	27.75	8.435***	4.415	37.24	7.659	-2.93	-6.55
Books in home	-0.019**	69.165	-1.30	0.077***	113.154	8.71	0.029	-3.39	-6.63
Class size	0.066	40.612	2.69	0.134***	31.084	4.17	0.100	1.28	-2.75
Proport. qualified tchrs	0.242	0.850	0.21	15.364***	0.805	12.36	7.803	0.70	-12.86
Prop. Qual. tchr. missing	-12.390***	0.070	-0.87	-5.350***	0.085	-0.45	-8.870	0.08	-0.49
Square root comp/pupil	23.429***	0.442	10.36	18.271***	0.649	11.87	20.850	-3.79	2.28
Stud perf. to assess tchrs	-28.768**	0.990	-28.48	-2.588***	0.879	-2.27	-15.678	-0.29	-25.91
Teacher absenteeism	1.231	1.604	1.98	-3.973***	1.833	-7.28	-1.371	0.91	8.35
Principal observes tchrs	37.289**	0.994	37.08	-0.191	0.875	-0.17	18.549	-0.02	37.27
Inspector observes tchrs	0.567	0.766	0.43	-4.498***	0.568	-2.55	-1.966	-0.89	3.88
Teacher are mentored	11.366***	1.808	20.56	-0.563**	1.462	-0.82	5.402	-0.20	21.57
Constant	308.871***	1.000	308.87	293.091***	1.000	293.09	300.981	0.000	15.78
Column sum:	--	--	495.09	--	--	468.06	--	-16.96	44.00

Appendix A: Further Derivations and Proof

A1. Re-calculations of the PISA Coverage Rates

The 55.7% coverage rate in the 2012 PISA report was obtained by taking Ministry of Education and Training (MoET) records, which showed a "weighted number of participating students" of 956,517 students enrolled in school who were 15 years old, divided by 1,717,996 15-year-olds in Vietnam (see Table 11.1 in OECD, 2014b). The 1,717,996 figure was obtained from the 2009 Census (General Statistics Office, 2010, Table 3); it is the number of 15-year-olds in Vietnam in 2009, and an implicit assumption was made that this number would be the same in 2012. Yet these 1,717,966 individuals would be 18 years old in 2012, not 15 years old. The same census report shows 1,450,815 12-year-olds in 2009, and these individuals would then be 15 in 2012. Thus the correct PISA coverage rate for 2012 should be 65.9% (956,517/1,450,815).

The discrepancy for the 2015 PISA is even larger. The OECD report states that there were 1,803,552 15-year-olds in Vietnam in 2015 (OECD, 2016, Table A2.1), which seems to be based on an assumption of slow population growth based on the 1,717,966 figure used for 2012. Yet the 2009 census shows only 1,332,822 9-year-old children in 2009, and these are the individuals who would have been 15 years old in 2015. The 2015 PISA report (OECD, 2016, Table A2.1) shows a "weighted number of participating students" of 874,859 students enrolled in school who were 15 years old in 2015, and dividing this figure by 1,803,552 gives a coverage rate of only 48.5% (874,859/1,803,552). Yet the correct coverage rate should be 65.6% (874,859/1,332,822).

A2. Proof of Proposition 1

Assume that the true test scores follow a normal distribution, with mean μ and standard deviation σ. The truncated mean from below is given by $\bar{T}_b = E(T|T > \tau)$. The given school enrollment rate is *r*. Define α as $\frac{\tau-\mu}{\sigma}$ and $\lambda_b(\alpha)$ as $\frac{\phi(\alpha)}{1-\Phi(\alpha)}$, using Theorem 19.2 in Greene (2018), we have

$$\mu_{lt} = \bar{T}_b - \sigma\,\lambda_b(\alpha) \tag{1.1}$$

Let *r* represent the given school enrollment rate, we also have

$$P(T > \tau) = r \tag{1.2}$$

Since *T* follows a normal distribution, subtracting the two sides of Equation (1.2) from unity yields

$$\Phi\left(\frac{\tau-\mu}{\sigma}\right) \equiv \Phi(\alpha) = 1 - r \tag{1.3}$$

This leads to the following results

$$\alpha = \Phi^{-1}(1-r) \tag{1.4}$$

and

$$\mu_{lt} = \tau - \sigma\alpha \tag{1.5}$$

Combining Equations (1.1) and (1.5), we can solve for σ as

$$\sigma = \frac{\bar{T}_b-\tau}{\lambda_b(\alpha)-\alpha} \tag{1.6}$$

Plugging this result into Equation (1.1), we have the stated result

$$\mu_{lt} = \bar{T}_b - \lambda_b(\alpha)\frac{\bar{T}_b-\tau}{\lambda_b(\alpha)-\alpha} \tag{1.7}$$

Note that the truncation point τ can be empirically estimated with the minimal observed test score in the data T_{min}, which results in the following estimating equation for Equation (1.7)

$$\mu_{lt} = \bar{T}_b - \lambda_b(\alpha)\frac{\bar{T}_b-T_{min}}{\lambda_b(\alpha)-\alpha} \tag{1.8}$$

For equation (2) in Proposition 1, define $\lambda_a(\alpha)$ instead as $\frac{\phi(\alpha)}{\Phi(\alpha)}$, also using Theorem 19.2 in Greene (2018), Equation (1.1) still holds for the case of the truncation from above. However, since we now assume that the PISA students are all worse-performing children, we need to rewrite Equation (1.2) to reflect this assumption as follows

$$P(T \leq \tau) = r \tag{1.9}$$

Again, making use of the assumption that T follows a normal distribution, after some similar straightforward manipulations for Equation (1.9) as with the proof for Proposition 1.1, we have

$$\alpha = \Phi^{-1}(r) \tag{1.10}$$

and

$$\mu_{ut} = \bar{T}_a + \sigma\, \lambda_a(\alpha) \tag{1.11}$$

Combining Equations (1.1) and (1.11), we can solve for σ in this case as

$$\sigma = \frac{\tau - \bar{T}_a}{\lambda_a(\alpha) + \alpha} \tag{1.12}$$

Plugging this result into Equation (1.1), we have the stated result

$$\mu_{ut} = \bar{T}_a + \lambda_a(\alpha) \frac{\tau - \bar{T}_a}{\lambda_a(\alpha) + \alpha} \tag{1.13}$$

Note that the truncation point τ can be empirically estimated with the maximal observed test score in the data T_{max}, which results in the following estimating equation for Equation (1.13)

$$\mu_{ut} = \bar{T}_a + \lambda_a(\alpha) \frac{T_{max} - \bar{T}_a}{\lambda_a(\alpha) + \alpha} \tag{1.14}$$

A3. Procedure to Adjust PISA Test Scores with Young Lives Data

The adjustments to the PISA scores using the Young Lives data were done as follows. First, the Young Lives sample was sorted into 10 deciles based on the average test scores over the math and reading comprehension tests, where Decile 1 has the 10% of the Young Lives sample with the lowest scores, Decile 2 has the 10% with the next lowest test scores, and so forth, up to Decile 10, which has the 10% of the sample with the highest scores. For all 10 deciles, the proportion of Young Lives students who were still in school was calculated, which ranged from 0.582 for Decile 1 to 1.000 for Decile 10. These proportions are shown in column (1) of Table B3 in Appendix B. These proportions serve two purposes. First, they are used to assign students in the Vietnam PISA sample to deciles (ranked by student performance) of the distribution of *all* 15-year-olds, including those not in school. An initial step is to adjust the proportions in school (for the Young Lives sample) in column (1) so that they have a mean of 1.000; this shows how 15-year-olds in that sample *who are in school* are distributed across the deciles of the distribution of academic performance for *all* 15-year-olds. Thus column (2) in Table B3 shows that, of all 15-year-olds in school, 7.01% are in the bottom decile of the distribution of the academic performance of *all* 15-year-olds, 7.76% are in the second decile of that distribution, and so forth, and finally 12.03% are in the top decile; note that these percentages sum to 100%. Then the bottom 7.01% (in terms of academic performance on the PISA) of the 15-year-old PISA participants are assigned to the bottom decile of this "all 15-year-olds" distribution, the next 7.76% are assigned to the second decile, and so forth.

The second purpose of the proportions in column (1) is to generate "inflation factors" for the PISA students assigned to these deciles. These inflation factors, which are shown in column (3) and are the inverses of the proportions in column (2), are applied to the PISA participants assigned to these deciles to approximate the distribution of test scores that would have been generated if the entire population of 15-year-olds in Vietnam had participated in the PISA. For example, the 7.01% of the PISA participants assigned to the first decile are given a weight of 1.427 (= 1/7.01) so that they represent the bottom 10% of the entire population of 15-year-olds. This is last step in the adjustment, which is to assume that the mean scores of 15-year-olds not in school in each decile of the population are equal to the mean scores of the 15-year-olds in the respective deciles who are in school, and thus participated in the PISA. The means for the latter (which by this assumption are also assigned to the former) for the 2012 PISA are shown in column (4) of Table B3, separately for mathematics and reading. They can be compared to the actually means, by decile, in the 2012 PISA, which are shown in column (5). The overall results show that this adjustment decreases the 2012 PISA scores for math by only 12.8 points and the 2012 PISA scores for reading by only 11.3 points. The same adjustments for the 2015 PISA are shown in columns (6) and (7); they show that this this adjustment decreases the 2015 PISA scores for math by only 12.4 points and the 2015 PISA scores for reading by only 10.9 points.

Appendix B: Additional Tables and Figures

Figure B1. Mean Age 15 Math Scores in 2012 PISA, by 2010 Log Real PPP GDP/capita

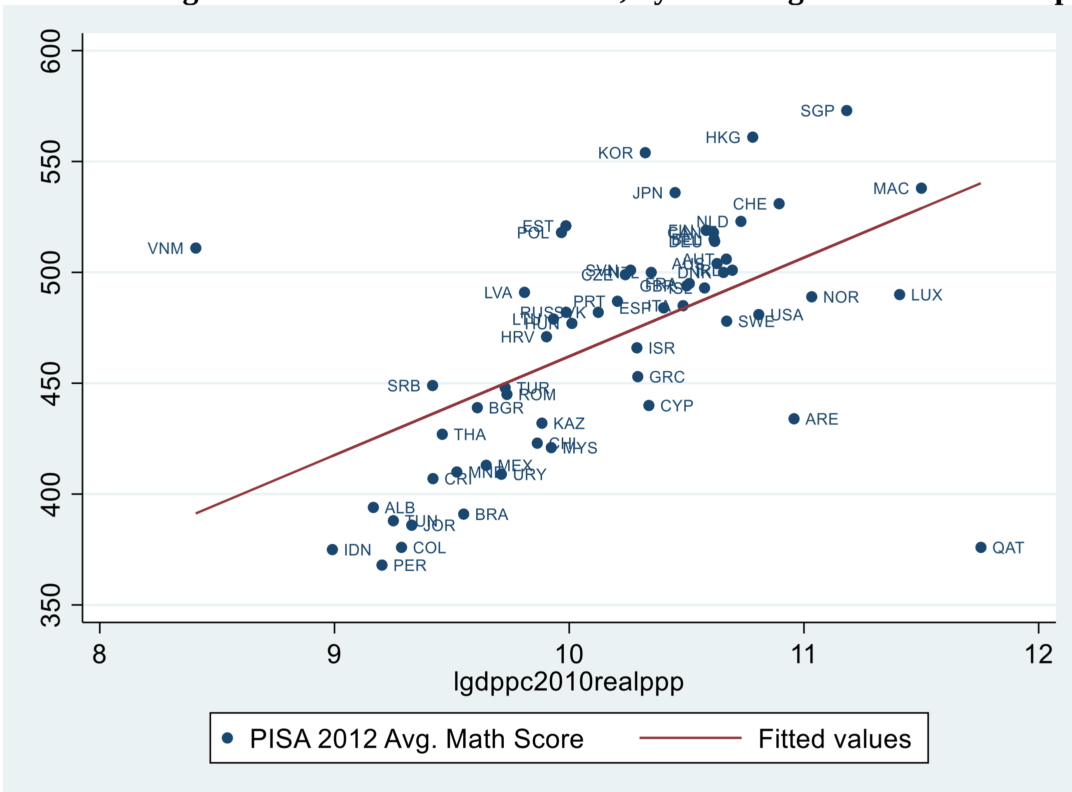


Figure B2. Mean Age 15 Reading Scores in 2012 PISA, by 2010 Log Real PPP GDP/capita

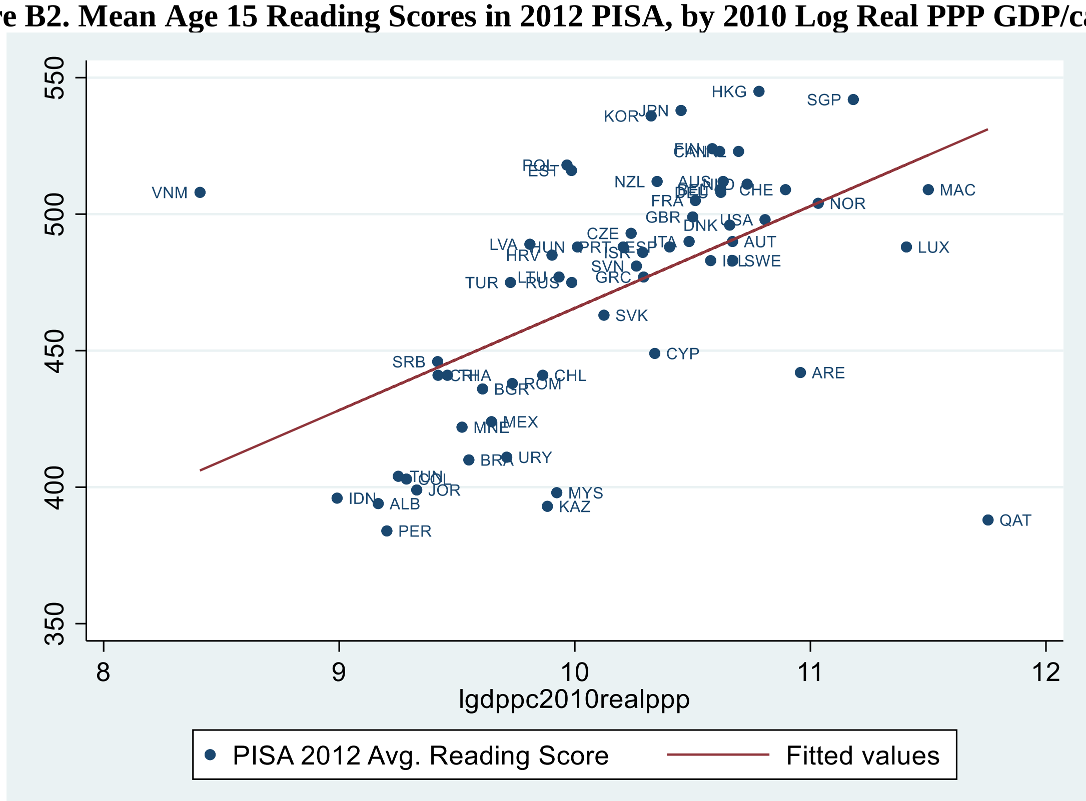


Figure B3. Mean Age 15 Math Scores in 2012 PISA, by 2010 Log Real GDP/capita, East Asia Only

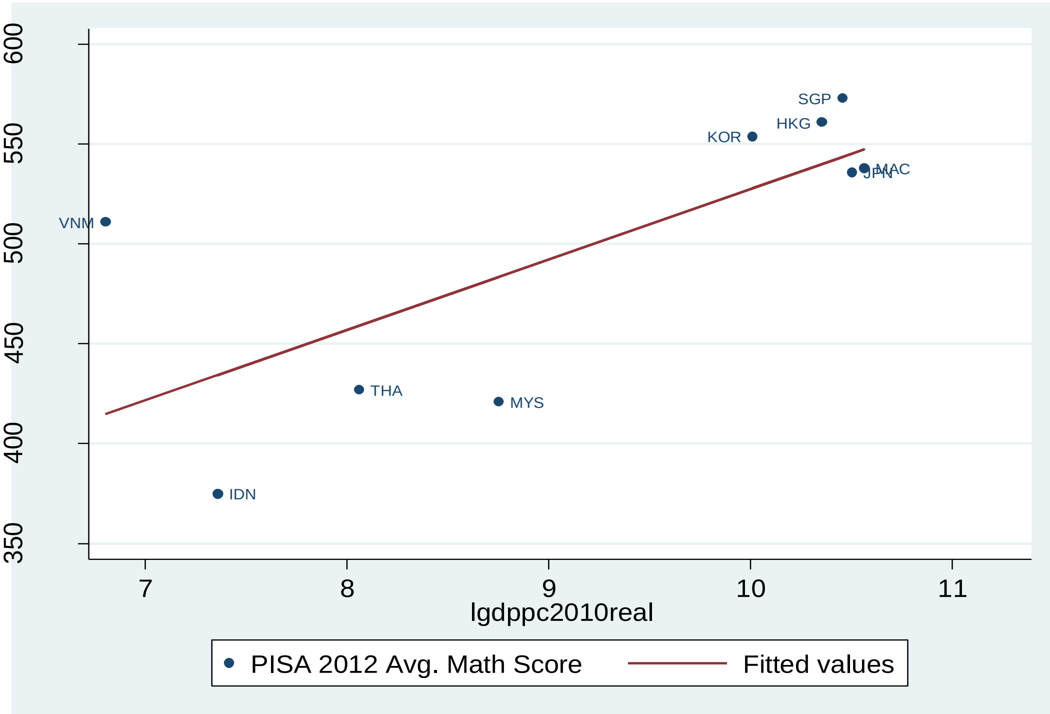


Figure B4. Mean Age 15 Reading Scores in 2012 PISA, by 2010 Log Real GDP/capita, East Asia Only

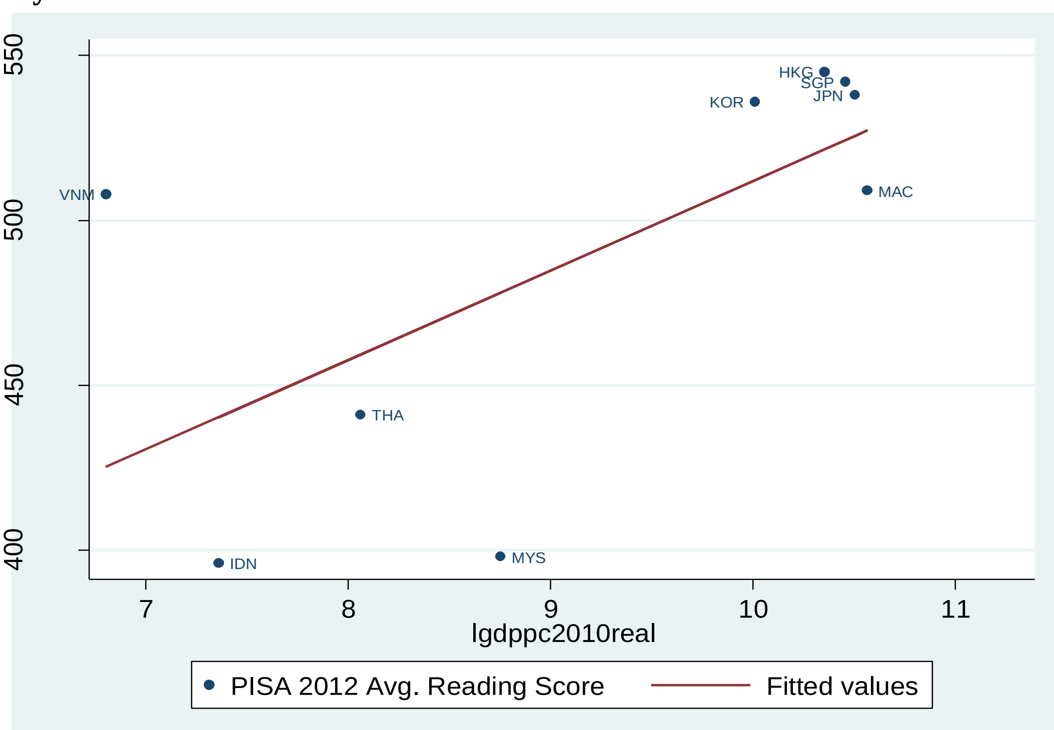


Figure B5. Distributions of 2015 PISA Scores for Four Countries with High Enrollment Rates

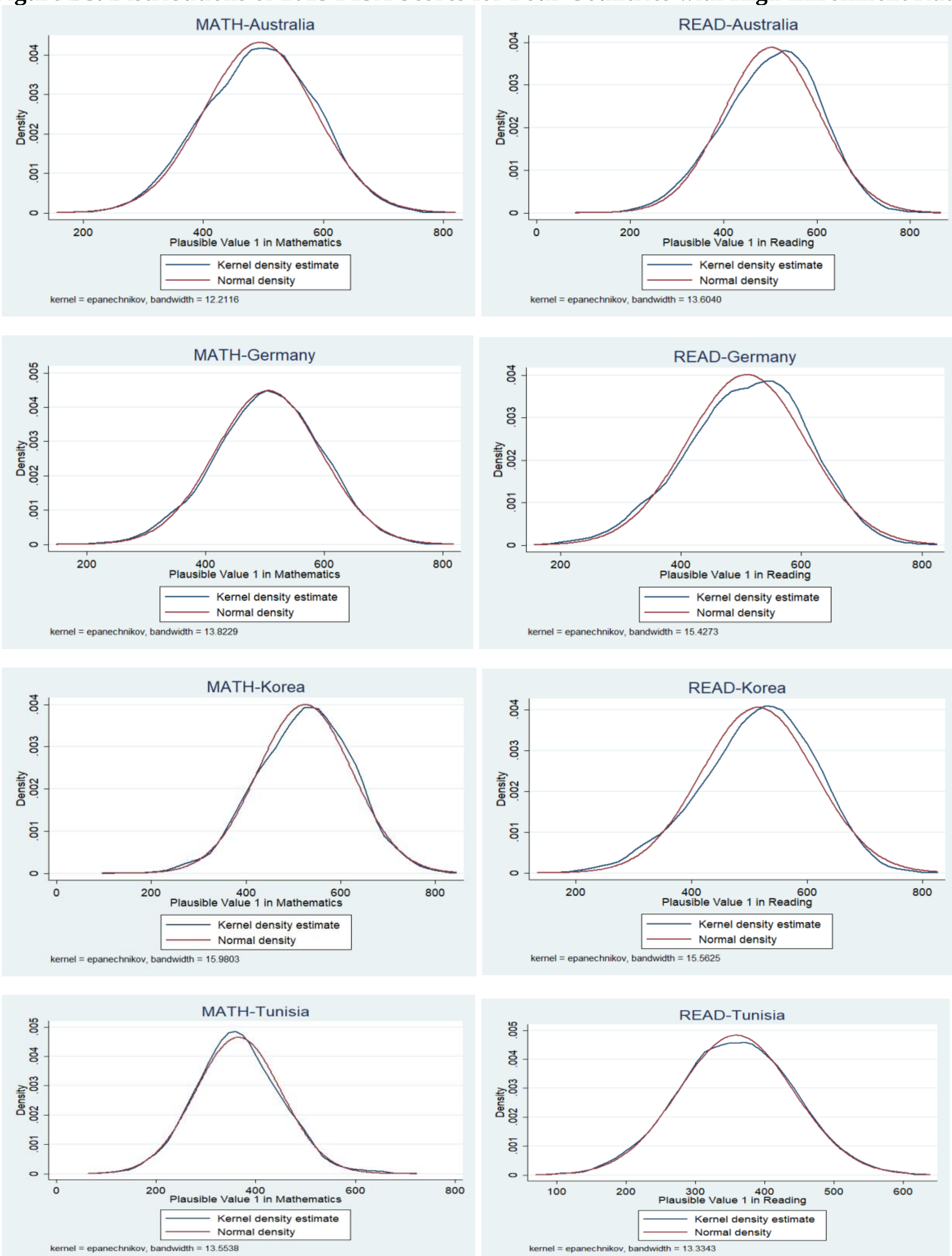


Figure B6. Distribution of Test Scores, Truncated from Below

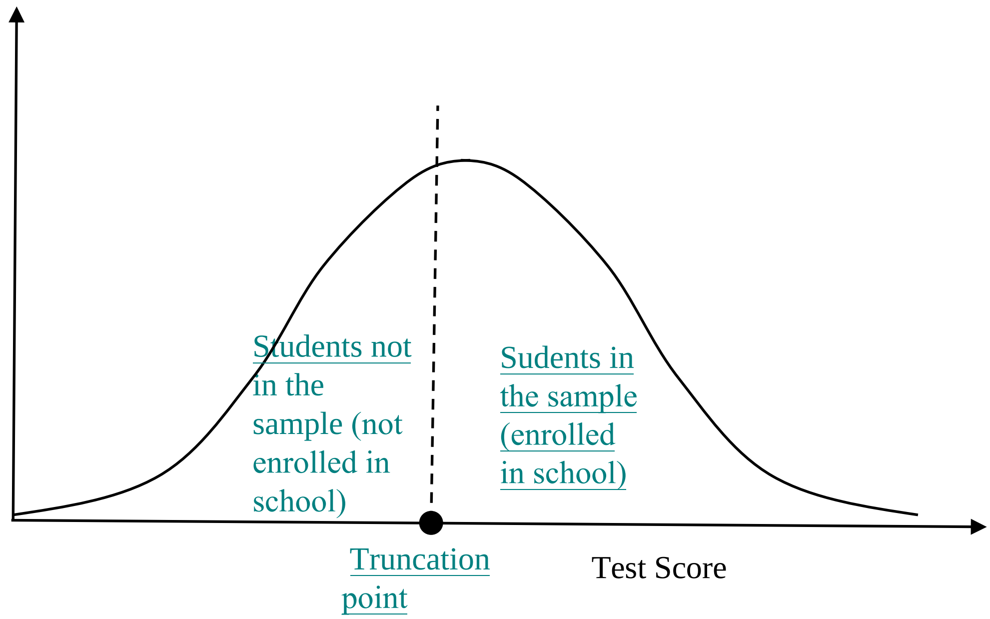


Table B1: Predictors of 2012 PISA Scores in Vietnam

Variables	Math	Reading
Rural	-18.04***	-11.56**
	(6.775)	(5.699)
Female	-16.58***	24.61***
	(2.317)	(2.009)
Grade 10	105.8***	95.14***
	(6.809)	(6.077)
Father years of schooling	2.231***	1.536***
	(0.495)	(0.395)
Mother years of schooling	1.879***	1.661***
	(0.489)	(0.422)
Owns an air conditioner	5.456	-0.626
	(6.279)	(4.450)
Owns a car	-6.723	-3.442
	(4.645)	(3.892)
Owns a computer	17.35***	10.86***
	(3.511)	(2.810)
Number of televisions owned	0.526	2.977
	(2.425)	(2.187)
Constant	396.7***	385.2***
	(8.881)	(8.545)
Observations	4771	4771
R-squared	0.310	0.341

Robust standard errors, clustered at the school level, in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table B2: Predictors of 2015 PISA Scores in Vietnam

Variable	Math	Reading
Rural	-18.86***	-9.822
	(4.98)	(5.908)
Female	15.97***	-8.461***
	(2.05)	(2.272)
Grade 10	69.85***	74.61***
	(7.19)	(6.07)
Mother years of schooling	0.893**	1.460***
	(0.408)	(0.541)
Father years of schooling	1.646***	2.041***
	(0.328)	(0.373)
Owns an air conditioner	-0.712	-2.685
	(4.126)	(4.971)
Owns a motorbike	15.83***	6.451
	(5.01)	(5.974)
Owns a car	5.202	-1.249
	(4.758)	(5.950)
Own a computer	16.61***	23.39***
	(2.611)	(3.34)
Number of televisions owned	7.284***	6.734**
	(2.141)	(2.601)
Constant	376.9***	386.4***
	(9.31)	(10.41)
Observations	5687	5687
R^2	0.274	0.207

Robust standard errors, clustered at the school level, in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table B3. Adjusted PISA 2012 and 2015 Test Scores Using Young Lives Attrition Data

Test Score Decile	(1) Proportion in School in Young Lives Data	(2) Proportions Divided by 0.831 ((1) ÷ 0.831)	(3) Inflation Factor for PISA Sample (1/(2))	(4) Adjusted 2012 PISA Scores, by Decile (all 15-year-olds)		(5) Original 2012 PISA Scores, by Decile (in school only)		(6) Adjusted 2015 PISA Scores, by Decile (all 15-year-olds)		(7) Original 2015 PISA Scores, by Decile (in school only)	
				Math	Reading	Math	Reading	Math	Reading	Math	Reading
1	0.582	0.701	1.427	358.0	363.4	364.3	370.3	340.8	349.0	352.2	359.6
2	0.646	0.776	1.289	409.4	419.2	421.5	432.1	391.2	396.1	405.2	409.9
3	0.746	0.897	1.115	442.1	449.6	454.3	461.7	419.9	424.8	434.6	438.7
4	0.761	0.915	1.093	463.2	472.1	477.2	484.8	444.1	447.2	458.9	460.1
5	0.849	1.022	0.978	483.2	492.6	498.7	502.7	466.3	467.0	479.8	478.8
6	0.885	1.065	0.939	507.2	509.4	521.2	520.1	488.0	485.7	502.5	497.4
7	0.920	1.106	0.904	530.1	528.2	543.8	539.5	512.7	506.1	525.7	516.3
8	0.951	1.144	0.874	555.4	548.1	568.5	558.8	539.6	527.9	550.9	537.4
9	0.973	1.171	0.854	586.6	570.8	600.6	583.2	571.5	556.1	580.7	564.5
10	1.000	1.203	0.831	648.7	615.9	662.6	630.1	635.6	608.7	643.6	614.8
Average	0.831	1.000		498.4	496.9	511.2	508.2	481.0	476.9	493.4	487.8

Table B.4: Math Decomposition Using Fixed-Effects Estimates of βo (diff = 516.54– 462.80 = 53.74)

Variable	β_{vn}	$\bar{x}_{vn}$	$\beta_{vn}'\bar{x}_{vn}$	β_o	$\bar{x}_o$	$\beta_o'\bar{x}_o$	$\bar{\beta}$ (= $(\beta_{vn}+\beta_o)/2$	$\bar{\beta}'(\bar{x}_{vn}-\bar{x}_o)$	$(\beta_{vn} - \bar{\beta})'\bar{x}_{vn} + (\bar{\beta} - \beta_o)'\bar{x}_o$
Wealth	6.764***	4.143	28.02	5.316***	6.101	32.43	6.040	-11.83	7.42
Grade 10	85.85***	0.874	75.01	19.34***	0.584	11.29	52.595	15.25	48.49
Sibling index	3.152*	1.048	3.30	-2.343***	1.086	-2.54	0.405	-0.02	5.86
Sibling index missing	-0.576	0.149	-0.09	-18.19***	0.238	-4.33	-9.383	0.84	3.41
Mom years schooling	0.962***	8.313	8.00	1.657***	10.975	18.19	1.310	-3.49	-6.70
Dad years schooling	1.511***	8.883	13.42	1.991***	11.086	22.07	1.751	-3.86	-4.79
Years in preschool	6.533***	1.600	10.45	9.972***	1.487	14.83	8.253	0.93	-5.31
Education inputs index	4.397***	4.680	20.58	6.858***	5.154	35.35	5.628	-2.67	-12.10
Books in home	0.00887	57.59	0.51	0.0677***	114.07	7.72	0.038	-2.16	-5.05
Days attend past 2 wks	10.43***	9.849	102.72	7.040***	9.622	67.74	8.735	1.98	33.00
Hours study per week	2.920***	5.756	16.81	2.882***	5.362	15.45	2.901	1.14	0.21
Extra math class, hrs/wk	3.904***	2.741	10.70	-0.858***	1.325	-1.14	1.523	2.16	9.68
Extra math class missing	8.890***	0.336	2.98	-2.590***	0.358	-0.93	3.150	-0.07	3.98
Class size	0.0643	44.81	2.88	0.0657***	32.61	2.14	0.065	0.79	-0.05
Proport. qualified tchrs	18.18***	0.800	14.55	12.62***	0.834	10.53	15.400	-0.52	4.54
Prop. qual. tchr. missing	-17.15***	0.069	-1.18	-0.486	0.188	-0.09	-8.818	1.05	-2.14
Square root comp/pupil	-0.0392	0.417	-0.02	-0.782	0.623	-0.49	-0.411	0.08	0.39
Stud perf. to assess tchrs	25.08**	0.992	24.89	1.708***	0.708	1.21	13.394	3.80	19.87
Teacher absenteeism	-0.759	0.692	-0.53	-3.475***	0.778	-2.70	-2.117	0.18	2.00
Parents pressure tchrs	15.71***	1.311	20.60	11.23***	0.957	10.75	13.470	4.77	5.08
Principal observes tchrs	14.12**	0.965	13.63	-2.586***	0.802	-2.07	5.767	0.94	14.76
Inspector observes tchrs	-16.73***	0.847	-14.17	-4.317***	0.406	-1.75	-10.524	-4.64	-7.78
Tchr pay link stud. perf.	2.209	1.487	3.28	-2.397***	0.703	-1.69	-0.094	-0.07	5.04
Teachers are mentored	6.766**	0.845	5.72	5.030***	0.684	3.44	5.898	0.95	1.33
Constant	154.46***	1.000	154.46	227.4***	1.000	227.39	190.93	0.00	-72.93
			516.54			462.80		5.55	48.21

Table B.5: Reading Decomposition Using Fixed-Effects Estimates of β_o (diff = 512.82– 472.52 = 40.30)

Variable	β_{vn}	$\bar{x}_{vn}$	$\beta_{vn}'\bar{x}_{vn}$	β_o	$\bar{x}_o$	$\beta_o'\bar{x}_o$	$\bar{\beta}$ (= (β_{vn}+β_o)/2	$\bar{\beta}'(\bar{x}_{vn}-\bar{x}_o)$	$(\beta_{vn} - \bar{\beta})'\bar{x}_{vn} + (\bar{\beta} - \beta_o)'\bar{x}_o$
Wealth	4.748***	4.143	19.67	3.859***	6.101	23.54	4.3035	-8.43	4.55
Grade 10	79.18***	0.874	69.18	21.15***	0.584	12.35	50.165	14.55	42.30
Sibling index	4.045***	1.048	4.24	-2.214***	1.086	-2.40	0.9155	-0.03	6.68
Sibling index missing	-0.428	0.149	-0.06	-12.56***	0.238	-2.99	-6.494	0.58	2.35
Mom years schooling	0.721**	8.313	5.99	1.297***	10.975	14.23	1.009	-2.69	-5.55
Dad years schooling	0.694**	8.883	6.17	1.702***	11.086	18.87	1.198	-2.64	-10.06
Years in preschool	4.884***	1.600	7.81	10.28***	1.487	15.29	7.582	0.86	-8.33
Education inputs index	5.657***	4.680	26.47	8.447***	5.154	43.54	7.052	-3.34	-13.72
Books in home	0.00231	57.59	0.13	0.0572***	114.07	6.52	0.029755	-1.68	-4.71
Days attend past 2 wks	16.08***	9.849	158.34	7.325***	9.622	70.48	11.7025	2.66	85.23
Hours study per week	2.335***	5.756	13.44	3.225***	5.362	17.29	2.78	1.10	-4.95
Extra reading class hr/wk	-1.547***	2.741	-1.99	-4.460***	1.325	-5.91	-3.0035	-4.25	5.92
Extra reading class miss.	0.712	0.336	0.24	-3.047***	0.358	-1.09	-1.1675	0.03	1.30
Class size	0.258***	44.81	11.58	0.261***	32.61	8.51	0.2595	3.17	-0.12
Proport. qualified tchrs	16.22***	0.800	12.98	9.841***	0.834	8.21	13.0305	-0.44	5.21
Prop. qual. tchr. missing	-17.21***	0.069	-1.19	-2.079***	0.188	-0.39	-9.6445	1.15	-1.94
Square root comp/pupil	-4.467	0.417	-1.86	0.639	0.623	0.40	-1.914	0.39	-2.66
Stud perf. to assess tchrs	1.901	0.992	1.89	2.067***	0.708	1.46	1.984	0.56	-0.14
Teacher absenteeism	-1.489	0.692	-1.03	-3.003***	0.778	-2.34	-2.246	0.19	1.11
Parents pressure tchrs	9.980***	1.311	13.08	11.22***	0.957	10.74	10.6	3.75	-1.41
Principal observes tchrs	34.74***	0.965	33.53	-0.136	0.802	-0.11	17.302	2.82	30.81
Inspector observes tchrs	-18.02***	0.847	-15.26	-6.500***	0.406	-2.64	-12.26	-5.41	-7.22
Tchr pay link stud. perf.	3.676***	1.487	5.47	-2.740***	0.703	-1.93	0.468	0.37	7.03
Teachers are mentored	9.211***	0.845	7.78	5.721***	0.684	3.91	7.466	1.20	2.67
Constant	136.21***	1.000	136.21	237.0***	1.000	236.97***	186.59	0.00	-100.76
			512.82			472.52		4.45	38.04