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Keyword: education, student learning, test scores, enrollment, PISA, Vietnam

JEL Cassification: H0, I2, O1, P3

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Abstract

Despite being the poorest or second poorest participant, Vietnam performed much better than all other developing countries, and even ahead of wealthier countries such as the U.S. and the U.K., on the 2012 and 2015 PISA assessments. We provide a rigorous investigation of Vietnam's strong performance. After making various parametric and non-parametric corrections for potentially non-representative PISA samples, including bias due to Vietnam's large out-of-school population, Vietnam still remains a large positive outlier conditional on its income. Possible higher motivation of, and coaching given to, Vietnamese students only partly explains Vietnam's performance, and this is also the case for various observed household- and school-level variables. 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' observed characteristics, but instead to Vietnam's greater "productivity" of those characteristics.

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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 strong 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 (note that when quadratic income terms are added they are statistically insignificant). 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. The boxes in Figures 1 and 2 show that Vietnam, and Qatar, are outliers according to two different criteria: Cook's D, which measures influential observations, and the Bonferroni *p*-value for the studentized residual. No

[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).

other countries are outliers by either of these two criteria. Vietnam is also the largest positive outlier when PPP (purchasing power parity) GDP is used.[4] 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 Asian and Southeast Asian participants in the 2012 PISA, Vietnam is still the largest positive outlier.[5]

This paper uses the 2012 and 2015 PISA data to investigate 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 students in Vietnam who participated in the 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; iii) Vietnamese students put more effort into those assessments than other students; or iv) Vietnamese schools implemented coaching to increase their students' scores on the PISA. 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, after reducing Vietnam's PISA scores to account for possibly oversampling better-off students and for Vietnam's low enrollment rate of 15-year-olds, and increasing other countries' PISA scores to compensate for possible higher motivation

[4] Figures B1 and B2 in Appendix B; note Vietnam is not an outlier using the very conservative Bonferroni *p*-value.
[5] See Figures B3 and B4 in Appendix B; these figures do not present outlier statistics due to their small samples.

among, and coaching of, Vietnamese students, Vietnam remains an exceptional performer (the largest positive outlier) on the PISA assessments.

The second finding is the child-, household- and school-level variables in the PISA data explain little of Vietnam's high performance on the 2012 and 2015 PISA assessments relative to its income level. The 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; rather it is 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, offering a rigorous and detailed analysis of the performance of one PISA participant relative to others.[6] Yet the analysis framework used here may be useful for studies of other countries' performance, not only on the PISA but also other skill assessments covering multiple countries.

This paper consists of six sections. The next section describes the PISA data. The following section examines possible mechanisms that could exaggerate Vietnam's performance, after which Section IV uses regression methods to investigate the role of family, teacher and school characteristics in explaining Vietnam's performance. Section V provides Oaxaca-Blinder decompositions of the test score gap between Vietnam and the other PISA countries, focusing on child, household and school characteristics. Conclusions are offered in Section VI.

II. The 2012 and 2015 PISA Assessments

The Programme for International Student Assessment (PISA) is an initiative of the Organization for Economic Cooperation and Development (OECD) to measure the learning of

[6] Asadullah, Perrera, and Xiao (2020) employ an approach similar to that in our Section IV but focus on six Asian countries, and only the 2012 PISA. Waldow and Steiner-Khamsi (2019) investigate the PISA's qualitative aspects.

15-year-old students around the world.[7] PISA was first implemented in the year 2000, and since then has been conducted every three years. While the initial focus was on the OECD countries, in more recent years PISA has included many non-OECD countries. This paper examines the PISA results for 2012 and 2015, when 65 and 72 countries participated, respectively.

The PISA is administered to 15-year-olds who are enrolled in school. It tests students on mathematics, reading and science. Three characteristics of the PISA data are important for the purposes of this paper. First, although countries may care how well they do on the PISA, the students who actually take the test face no consequences for the scores they receive. This may lead some students to exert low levels of effort when taking the test.

Second, in any given school and classroom in which the PISA is administered, students are given several different versions of the test, although all versions have questions in common. This implies that comparing raw scores among students who took different versions of the test could be misleading. Instead, Item Response Theory (IRT) is used to construct comparable scores for students who took different version of these tests. See Das and Zajonc (2010) and Jacob and Rothstein (2016) for useful introductions to IRT methods.

Third, the PISA scoring algorithm partially corrects for low levels of effort. In particular, unanswered questions at the end of the test are not counted in the scoring (OECD 2016b, p.149); they are treated as though the test did not contain those questions. IRT methods easily accommodate for this *de facto* situation where students in effect take different tests. This partially corrects for low effort: the scores of unmotivated students who do not finish the last questions on a test do not count such unanswered questions as incorrect responses.[8] Akyol, Krishna and Wang

[7] The information in this section is from OECD (2014a, 2014b, 2016a, 2016b).

[8] However, unanswered questions in the middle of the test (those followed by answered questions) are counted as incorrect responses. Akyol et al. (2021) note that students taking the PISA assessment rarely run out of time, so the vast majority who leave questions unanswered at the end of the test had time to answer them but chose not to do so.

(2021) estimate that this partial correction for low effort corrects for about half of the difference in PISA test scores that is due to variation in levels of effort, and that methods to correct for the remaining differences in effort have very little effect on countries' rankings.[9]

III. 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.[10] This section investigates four possible mechanisms that could exaggerate Vietnam's performance: i) The 15-year-old Vietnamese PISA participants in 2012 and 2015 were not representative of 15-year-old Vietnamese students in those years; ii) Vietnam's relatively low enrollment rate for 15-year-olds selects higher-performing PISA participants; iii) Vietnamese students exert more effort when participating in the PISA assessments; and iv) Vietnamese schools implemented coaching designed to increase their students' scores on the PISA.

A. Were Vietnam's PISA Participants "Above Average" Students? Vietnam's PISA participants may not have been 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 15 years old in January of 2012) who were enrolled in school in 2012 (OECD, 2014b).[11] Whether the participants in the 2012 PISA in Vietnam are a representative sample of individuals born in 1996 who were students in 2012 can be checked using data from the 2012 Vietnam Household Living

[9] One caveat to this point is that the methods of Akyol, Krishna and Wang (2021) could not be applied to Vietnam because Vietnam implemented the PISA using pencil-and-paper, rather than computer-based, assessments.
[10] See, for example, the comments by Deputy Minister of Education Nguyen Vinh Hien in *Thanh Nien News* (2013).
[11] 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).

Standards Survey (VHLSS), which Vietnam's General Statistical Office conducts every two years. 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 participants in the 2012 PISA.

The first four columns of Table 1 use 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 live in urban areas (50% vs. 26%),[12] are slightly more likely to be in grade 10 (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 live in homes with more 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 was administered in Vietnam in April of 2012, at which time 22% of the children born in 1996 were still in grade 9 (see 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 so had not yet reached the next grade of schooling in September of 2012),[13] 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 almost all provinces students must pass provincial entrance exams to enroll in grade 10. Thus 86% of the students in the PISA sample consist of those who have passed an exam that selects better performing students for upper secondary school, but the VHLSS data indicate that only

[12] Students living in rural areas who attend urban schools would be classified as urban in the PISA and rural in the VHLSS. This may explain part of the urban/rural difference in the two samples, but not other differences, in Table 1.
[13] 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.

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 at that time, and so should be a random sample of students born in 1999) to an average of students who were 15 years old in 2014 and so were 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 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 fathers (8.4 vs. 6.9 years of schooling) and mothers (7.9 vs. 6.4 years), and to live in homes with more air conditioners, cars, computers and televisions. In contrast to 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 those characteristics 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:[14]

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

[14]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.

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

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:

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

where the horizontal bars indicate mean values and $\hat{\boldsymbol{\beta}}_{\text{OLS}}$ is the OLS estimate of $\boldsymbol{\beta}$. This is shown in the top halves of Tables 2 (math) and 3 (reading); the first column depicts $\overline{\mathbf{X}}$ from the 2012 PISA data in Table 1, the fourth column shows the $\hat{\boldsymbol{\beta}}_{\text{OLS}}$ coefficients (from Table B1, Appendix B), and the fifth column shows the product of each variable with its estimated 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 $\overline{\mathbf{X}}$ 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 columns 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. Using the 2012 VHLSS means to predict the PISA scores reduces the math score by about 24 points, to 489.0, and the reading score 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 $\overline{\mathbf{X}}$ 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 no longer in school, and those 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 academically weaker 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 due to 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.[15] Vietnam's lower coverage rate is even more extreme in the 2015 PISA; 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 Vietnam's low coverage rates in the OECD reports, and then

[15] 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.

presents three different methods to adjust for Vietnam's (corrected) lower coverage rate. Even after this correction and these adjustments, Vietnam is still a positive outlier, given its low income, in its performance on the 2012 and 2015 PISA assessments.

Correcting PISA Coverage Rates. The PISA reports incorrectly calculated Vietnam's coverage rates, and correcting them leads to large increases in those rates. As Appendix A explains, Vietnam's census data 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 PISA reports yields the correct PISA coverage rates for 2012 and 2015: 65.9% and 65.6%, respectively. Yet even after making these corrections, 34% of 15-year-olds in Vietnam did not participate in the 2012 and 2015 PISA assessments. They were likely weak students before they left school, since most PISA participants in Vietnam were grade 10 students who, unlike grade 9 students, are a selected group, as explained above. The rest of this subsection applies three different methods to adjust PISA scores to account for variation in countries' coverage rates.

Method 1: Focus on the 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 if non-participating 15-year-olds had participated, they would have scored in the lowest 50% of the distribution of test scores among all 15-year-olds in their respective countries, and then exclude the bottom 50% of 15-year-olds for all countries. In fact, for countries with a lower coverage rate, such as Vietnam, this adjustment underestimates 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).[16] Vietnam ranks 16 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 proposed above, [17] 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 (third and fourth columns of Table 4A).

Next, consider the 2015 PISA assessment. Table 4B shows that Vietnam ranks 24 out of 66 countries in math and 28 out of 66 in reading. These rankings are lower than the 2012 PISA rankings, yet this performance is still very strong given that Vietnam is the second poorest of all participating countries (see Figures 3 and 4). However, when the bottom 50% of 15-year-olds are excluded for all countries, as in the third and fourth columns of Table 4B, the performance of Vietnam's "top 50%" 15-year-olds falls; of the 66 countries it ranks 37 in math and 41 in reading.

Yet these lower rankings are still impressive given Vietnam's low income. First, Vietnam 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, Vietnam is still by far the largest positive outlier for the 2012 PISA when the scores of the "top 50% of all 15-year-olds" are plotted against the log of per capita GDP.[18] Although Vietnam's "top 50%" scores in mathematics and reading are not much higher than their "unadjusted"

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[16] 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.

[17] 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.

[18] While the Bonferroni *p*-values for Vietnam are only marginally significant in Figures 7 and 8, they are still larger than those for any other country, including Qatar.

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

Method 2: Adjustment with Auxiliary Data. A second 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. This is done only for Vietnam, because only one other PISA country has such data; 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 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, respectively).

Assuming that the Young Lives reading and math scores assigns ranks to 15-year-olds that are similar to the PISA rankings, one can adjust the observed PISA test scores to include 15-year-olds who are not in school. This was 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 15-year-olds 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 served two purposes. First, they were 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 was to adjust the proportions in school (for the Young Lives sample) in column (1) of Table B3 so that they have a mean of 1.000; this shows how 15-year-olds in that sample *who are in school* are distributed among the deciles of the distribution of academic performance for *all* 15-year-olds. This is shown in column (2) of Table B3; it 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 of this distribution, and so forth.

The second purpose of these proportions is to generate “inflation factors” for the PISA students assigned to these deciles. These inflation factors, which are shown in column (3) of Table B3 and are the inverses of the proportions in column (2), are applied to the PISA participants assigned to these deciles to calculate 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 have a weight of 1.427 (= 1/7.01); they represent the bottom 10% of the entire population of 15-year-olds.

The last step in the adjustment is to assume that the mean scores of 15-year-olds not in school in each decile of the population equals the mean of the 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 actual means, by decile, in the 2012 PISA, which are in column (5). Overall, 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, shown in columns (6) and (7), show that this this adjustment reduces the 2015 PISA math scores by only 12.4 points and the 2015 PISA reading scores by only 10.9 points. These relatively small changes do not change the overall finding that Vietnam's PISA performance was exceptional.

Method 3: Bounds Analysis, Inferring the Full Distribution Mean from the Truncated Distribution Mean. A third method to correct for Vietnam's relatively low coverage rate builds on the intuition of Method 1 that individuals not in school have lower academic skills by estimating 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 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, had they participated in the PISA, would be lower than those of all children in school. This assumption is illustrated in Figure B6 in Appendix B. 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 extreme. It is very likely that some PISA non-participants would have scored higher on that assessment than some participants. If so, the adjustment described below *underestimates* (and so provides a lower bound for) the true mean for all 15-year-olds. To see the intuition, consider Figure B6. Suppose some 15-year-olds to the right of the truncation point did not participate in the PISA, and some 15-year-olds to the left of that point did participate. This reduces 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 below in Proposition 1 overcorrects, providing 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 $\frac{\tau-\mu}{\sigma}$, let r represent the given school enrollment rate, and denote by $\phi(.)$ and $\Phi(.)$ the normal pdf and the normal cdf, respectively.

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:

$$\mu_{lt} = \bar{T}_b - \lambda_b(\alpha)\frac{\bar{T}_b - T_{min}}{\lambda_b(\alpha)-\alpha} \qquad (3)$$

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

$$\mu_{ut} = \bar{T}_a + \lambda_a(\alpha)\frac{T_{max} - \bar{T}_a}{\lambda_a(\alpha)+\alpha} \qquad (4)$$

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 in Appendix A. Since the assumptions in Proposition 1 that the PISA participants include only either the best or worst-performing children are rather extreme, Equations (3) and

(4) provide, respectively, lower bound and upper bound estimates of the true test score mean. Equation (3) is the result of interest since the mean test score of the PISA participants is almost certainly higher than the mean of PISA non-participants (as shown above for the Young Lives data from Vietnam). We show Equation (4) only for mathematical completeness.

Applying Equation (3) 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 since participants almost certainly score higher than non-participants. 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 equals zero when enrollment 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 if all 15-year-olds in each country were tested is the mid-point between the lower bound in Equation (1) and the upper bound given by the observed mean for the participants, that is the midpoints of the gaps in Figures 9 and 10. These mid-point values are shown in Figures 11-14, which are again plotted against log of per capita GDP. Vietnam still stands out as an outlier, especially in 2012.

C. Were Vietnamese Students More Motivated to Exert Effort on the PISA? A third 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. 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. For example, 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. students under standard conditions. Yet 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, so Vietnamese students' intrinsic motivation may have contributed to their high PISA scores. As explained in Section II, the PISA scoring algorithm partially corrects for low levels of effort by not counting unanswered questions at the end of the test; those questions are treated as though the test did not contain them and so are *not* counted as incorrect answers. Yet the PISA algorithm still counts unanswered questions in the middle of the test (unanswered questions followed by questions that were answered) as incorrect answers; such unanswered questions may reflect low student effort.

Akyol, Krishna and Wang (2021) used the 2015 PISA, which was administered using computers in most (53 of 66) of the participating countries, to further correct for lack of effort. They imputed values for unanswered questions based on students' performance on the questions they did answer. Also, questions on which the students spent very little time (e.g. less than five seconds) but did answer, which can be identified because the computers record time spent on every question, are also treated as questions for which students exerted little effort. The authors provide estimates (see their Table 3) that can be used to adjust upwards scores on the 2015 PISA science test to predict how students would have scored if they had exerted greater effort.

Vietnam did not use computers to administer the PISA in 2015, yet most of the other countries did use computers, and so their scores can be increased to incorporate additional effort. Akyol et al.'s effort adjustments increase in test scores (in addition to the adjustments already made by PISA) by only 4.4 points on the PISA exam.[19] Even though their analysis is for science, rather than math or reading, it seems unlikely that additional effort by Vietnamese students can explain Vietnam's performance on the PISA.

D. Did Vietnamese Students Perform Better Because They Were Coached? About two thirds of PISA test questions are multiple choice. Since is no penalty for incorrect answers, a useful strategy for students is to guess when they are not sure of the correct answers. There is evidence that teachers and schools prepared Vietnamese students to take the 2012 and 2015 PISA tests.[20] Studies in the U.S. and elsewhere have shown that prep sessions for academic tests can greatly increase students' scores. For example, Bangert-Drowns et al. (1983), summarizing earlier studies, found that programs involving coaching sessions of over nine hours duration increased average test scores by 0.39 standard deviations (of the distribution of test scores, which for the PISA would be 39 points). However, those studies are of students whose scores on the tests had important consequences for their academic futures while, as explained in Section II, students' scores on the PISA exams have no consequences for those students.[21]

Brunner et al. (2007) is the only study of the impact of coaching on students' scores on the PISA exam. The authors examined the impact of a coaching program in Germany. The program they examined was relatively modest: about three hours spread over one week (the

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[19] This is the difference between "SENA" and "FIS" in Table 3 of Akyol, Krishna and Wang (2021).

[20] Vietnamese students took a draft version of the PISA exam in 2011 to prepare for the 2012 PISA. Their performance was lower than expected, so Vietnam's Ministry of Education and Training took some steps to increase their performance. This does not violate PISA assessment rules; students can practice, using old exams, to become "accustomed" to PISA exams. In each country, the schools that participate in the PISA are selected several months, and participating students are selected 3-4 weeks, before the exams. In Vietnam, the selected 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 in this footnote is based on emails and discussions with Francesco Avvisati.

[21] 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.

week before a set of questions from the 2000 PISA exam was administered). One weakness of this study is that the schools that participated in coaching and the schools that did not were not randomly assigned, but instead the teachers, in consultation with their school principals, chose the group (coaching or no coaching) they wanted. On the other hand, all results are based on changes over time (a pre-test was given one week before the coaching) in the scores on the questions from the 2000 PISA. The study examined both mathematics and reading performance.

The Brunner et al. study was implemented in the two main types of secondary schools in Germany: *Hauptschulen* (for students who typically do not go to a university after secondary school); and *Gymnasium* (for students who plan to enroll in a university). The authors found that this program slightly reduced math scores in the *Hauptschulen*, by a statistically insignificant 1.5 points, yet it raised math scores in *Gymnasium* by a statistically insignificant 10.4 points.[22] The coaching program raised reading scores in the *Hauptschulen* by a statistically insignificant 5.1 points, while it increased scores in *Gymnasium* by a statistically significant 27.2 points. It is difficult to know whether the PISA coaching in Vietnam had a larger or smaller impact than the coaching in Germany, yet these results (averaged over the two types of schools) suggest modest impacts at best: 4.5 points for math and 16.2 for reading. Other countries, such as Abu Dhabi, Canada and Colombia,[23] have also tried to raise their students' PISA scores, so any correction of Vietnam's PISA scores to account for coaching would also require correction for other countries.

E. Is Vietnam Still an Outlier after Adjusting for Such Potential "Exaggeration"?

None of the four possible sources of exaggeration discussed in this section seem, on their own, to

[22] These figures are from Table 5. The "control" group is schools that had the pre- and post-tests but no coaching, and the "treatment" group had both tests and coaching. These impacts are rescaled to be equivalent to PISA scores.
[23] See Akyol et al. (2021) for what was done in Abu Dhabi and Canada. When presenting an earlier version of this paper in Colombia, Ministry of Education officials told us that Colombia has made similar efforts to increase its students' performance on the PISA, but their efforts were not particularly effective. We suspect that there are more countries who have tried to increase their scores on the PISA through coaching or even changing their curriculum (see Akyol et al., 2021).

explain Vietnam's exceptional performance on the 2012 and 2015 PISA assessments, yet if they are combined is Vietnam still an outlier? This is examined by combining all the "corrections" in the previous four subsections. First, based on Tables 2 and 3, Vietnam's 2012 (2015) PISA math and reading scores are reduced by 23.7 and 20.3 (13.6 and 14.7) points, respectively. Second, based on the corrections derived from the Young Lives data to account for 15-year-olds no longer in school, Vietnam's 2012 (2015) PISA math and reading scores are further reduced by 12.8 and 11.3 (12.4 and 10.9) points, respectively. Third, based on Akyol et al. (2021), the 2012 and 2015 scores on both the reading and math tests of the other countries are increased by those authors' estimates of how they would perform if their students had exerted full effort.[24] Note that this adjustment puts Vietnam at a disadvantage since its score is not adjusted, which essentially assumes that all Vietnamese students exerted full effort. Finally, based on Brunner et al. (2007), the math and reading scores in 2012 (and in 2015) of all countries except Vietnam are raised by 4.5 and 16.2, respectively, to account for coaching in Vietnam. This also puts Vietnam at a disadvantage since it implicitly assumes that no coaching took place in any other country.

The results when these adjustments are made are shown in Figures 15 and 16 for 2012, and Figures 17 and 18 for 2015. Vietnam is still a large positive outlier; indeed, it is the largest positive outlier, although Qatar's negative outlier value is larger in magnitude. For Cook's D criterion, Vietnam is an outlier, and no other country is a significant positive outlier. Yet Vietnam is no longer an outlier in terms of the very conservative Bonferroni criterion. We conclude that, relative to its income, Vietnam is still the largest positive outlier among all the countries in the 2012 PISA, after correcting for all four potential biases that favor Vietnam.

[24] Twelve countries other than Vietnam did not use computer-administered tests, and so were not adjusted by Akyol et al. (2021). We imputed adjustments for them based on the average adjustments in the regions for those 12 nations. For example, the adjustment for Argentina is the average of Brazil, Chile, Colombia, Peru and Uruguay adjustments.

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

The preceding section 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 concerns that: 1. Vietnam's PISA sample was not representative of the 15-year-olds in school; 2. Vietnam 15-year-olds have a low enrollment rate; 3. Vietnam's students may be more motivated; and 4. Vietnam provided coaching to increase its PISA test scores. Thus, there must be some other reason(s) why Vietnamese students outperform those in other nations conditional on per capita GDP. This section uses the PISA data to investigate Vietnam's PISA performance.

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

$$\text{Test Score} = \beta_0 + \beta_{gdp}\times\text{Log(GDP/capita)} + u \qquad (5)$$

In these figures, the gap between any country's performance and its predicted performance given its (log) GDP per capita is given by u in (5). These figures show that Vietnam's u is very high. The regressions that generated these figures have one observation per country. Do student-level regressions using the PISA data yield the same finding?

Before estimating student-level regressions, the finding in Section II that the PISA data may not be representative of 15-year-olds in school in Vietnam suggests that the weights for Vietnam in the PISA data should be adjusted. This can be done by using Vietnam census data. The PISA sample for Vietnam is based on a stratification that divides Vietnam into three regions (north, central and south), each of which is further stratified into urban and rural areas. Finally, within these six areas 15-year-old students are further stratified into those in public schools and those in private schools. To construct weights for the 2012 PISA data, the 2009 census was used to calculate the distribution of 15-year-olds who were enrolled in school in 2009 into the three regions, and into urban and rural areas. Unfortunately, the census has no data on whether the school attended is public or private. Yet given that private school students tend to have wealthier and better educated parents, and the PISA's apparent oversampling of grade 10 students in Vietnam, we further stratified the census data into whether students were enrolled in grade 10, whether students' mothers had upper secondary (or higher) education, and whether the family owned a computer. This yields 48 (3×2×2×2×2) strata of students in both the 2009 census and in the PISA data. We used these to calculate strata-level weights for the PISA data: for each stratum they are the number of students in the census divided by the number of students in the PISA data.

Recall Table 1, which showed the differences in student characteristics as found in the PISA data and in the VHLSS data. Table B.4 in the appendix shows columns (1) and (3) from Table 1, and shows in column (2) the student characteristics when the weights described above are applied to the PISA data. Applying these weights tends to move the means of the students' characteristics in the PISA data closer to those found in the VHLSS data. For example, the proportion in urban areas drops from 50.3% to 26.9% (in the VHLSS it is 25.3%), and the fraction who are in grade 10 drops from 86.1% to 80.2% (75.7% in the VHLSS). These weights will be used for Vietnam in the analysis of the PISA data in this section and in Section V.

Estimates based on regressions of the student-level PISA test score in 2012 on a constant term and the log of per capita GDP are shown in columns (1) and (2) 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 scores in the 2012 PISA are much higher than those predicted by this regression: its averaged u is 128.7 for the math regression (in bold in the fifth row of Table 5), and 112.6 for the reading regression. These are the highest values of all the countries included in the regression, as seen in the “Residual Rank” row in Table 5, just as Vietnam is the largest positive outlier in the country-level regressions shown in Figures 1-4.

A natural question is: Why is Vietnam’s residual so high? In particular, would adding more variables to the regression yield a “better fit” with an (average) residual for Vietnam that is not so high? This question is addressed in the rest of this section, first by adding household and student characteristics, and then adding school characteristics, from the 2012 and 2015 PISA, which contains not only reading and mathematics tests but also student, parent and school data.

The remaining columns in Table 5 explore the relationship between student test scores and national and household level income and wealth. One disadvantage of the regressions in the first two columns of Table 5 is that the log of GDP per capita does not vary over students in the same country; ideally, a wealth or income variable that varies within countries should provide more explanatory power in student-level regressions. Such a variable can be generated from the PISA data by using data from the student questionnaire. This was done by applying principal components analysis to the following household level variables in the student-level data: internet connection, dishwasher, DVD, number of cell phones, number of televisions, number of computers, and number of cars.[25] The first estimated principle component is used as a wealth variable in the analysis of this section. Columns (3) and (4) of Table 5 show that, for the 2012 PISA, when this variable replaces the log of GDP per capita, Vietnam is still the largest outlier in the reading regression, but it is only the second largest outlier in the math regression, after Hong Kong. Henceforth, this paper will use this wealth variable instead of log of GDP per capita because the former varies across students within each country.

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

Before adding other variables to equation (5), the last four columns of Table 5 explore two aspects of the wealth variable. First, columns (3) and (4) use country averages of the wealth variable, for comparability with columns (1) and (2) in that table, which use the log of GDP per capita. In contrast, columns (5) and (6) allow each student to have his or her household-specific value of wealth, instead of the national average. This allows the wealth variable to explain test score differences not only across, but also within, countries. This reduces the wealth variable coefficients somewhat, but they remain highly significant.[26] More interesting is that Vietnam is somewhat less than an outlier. For math it is now the fourth highest outlier, while for reading it is the second highest. This occurs because the predictive power of the wealth variable falls by about one fifth when it varies within countries; its role is stronger when explaining differences between countries than when explaining differences within them. The smaller coefficient reduces the slope in the fitted lines in Figures 1-4, reducing the size of Vietnam's residual and increasing 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, columns (7) and (8) 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. Vietnam is still an outlier, but slightly less of an outlier; it has the sixth highest fixed effect for math and the fourth highest for reading.

The bottom half of Table 5 shows a similar analysis for the 2015 PISA data in. The overall pattern is the same. Vietnam's average residual falls slightly when the average wealth variable is used instead of GDP per capita, and falls slightly more when the wealth variable varies at the student level. But Vietnam is still one of the largest, if not the largest, outlier. This

[26] Adding a quadratic wealth variable had virtually no explanatory power, increasing the R^2 coefficient from 0.1552 to 0.1554 for the math regression and from 0.1404 to 0,1405 for the reading regression.

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 systematic analysis to find characteristics of Vietnamese students, households, and schools that explain Vietnam's outlier status in the 2012 and 2015 PISA assessments. 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, that student's household, the teachers he or she has had, and the school(s) he or she has attended:

$$S_{ic} = \boldsymbol{\beta}'\mathbf{x}_{ic} + \varepsilon_{ic} \qquad (6)$$

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

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

$$S_{ic} = \boldsymbol{\beta}^{\mathbf{o}\prime}\mathbf{x}_{ic}^{o} + \boldsymbol{\beta}^{\mathbf{u}\prime}\mathbf{x}_{ic}^{u} + \varepsilon_{ic} \qquad (7)$$

$$= \boldsymbol{\beta}^{\mathbf{o}\prime}\mathbf{x}_{ic}^{o} + \boldsymbol{\beta}^{\mathbf{u}\prime}\bar{\mathbf{x}}_{c}^{u} + \boldsymbol{\beta}^{\mathbf{u}\prime}\mathbf{x}_{ic}^{u,d} + \varepsilon_{ic}$$

where the superscripts o and u indicate observed and unobserved, respectively. The second line of (7) disaggregates $\mathbf{x}_{ic}^{u}$ into its country specific mean, $\bar{\mathbf{x}}_{c}^{u}$, and the within-country deviation from that mean for student i, $\mathbf{x}_{ic}^{u,d}$, where the superscript d denotes that deviation. Thus the within-country mean of $\mathbf{x}_{ic}^{u,d}$ is zero for all countries.

In a regression with country fixed effects, the fixed effect for country c is $\boldsymbol{\beta}^{\mathbf{u}\prime}\bar{\mathbf{x}}_{c}^{u}$, and the error term is $\boldsymbol{\beta}^{\mathbf{u}\prime}\mathbf{x}_{ic}^{u,d} + \varepsilon_{ic}$. The regressions in columns (7) and (8) of Table 5 have only one observed variable, the wealth indicator. The rest of this section adds other observed variables to (7), which in effect moves those variables out of $\mathbf{x}_{ic}^{u}$ and into $\mathbf{x}_{ic}^{o}$, 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 (2020) to explain differences in the test scores of school age children across Ethiopia, India, 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 key variables that contribute to the $\boldsymbol{\beta}^{\mathbf{u}\prime}\bar{\mathbf{x}}_{c}^{u}$ term in the second line of (5). If the variables added 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 simply be the (within-country) variation in the measurement error, ε_{ic}.

Even if the PISA data lack some key variables that explain Vietnam's success, and more generally explain student learning in all the countries that participate in the PISA, it may be that the country fixed effects, while statistically significant, are greatly reduced and thus at least part of Vietnam's success is 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 scores – after adding the variables available in the PISA data. In contrast, if the key student, household, teacher and school variables that explain Vietnam's success are mostly *not* in the PISA data, then Vietnam will continue to be a large, positive outlier and the reason(s) for its outlier status will reflect factors not measured, or at least not well measured, in the PISA data.

To begin, the effects of adding student and household level variables from the 2012 PISA to the regression are shown in Table 6A. The first two columns are regressions identical to those in columns (7) and (8) of Table 5, except that the sample is the same (smaller) sample used 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 columns (7) and (8) of Table 5; the only difference is that Vietnam's rank (estimated country fixed effect) drops from fourth to fifth for reading, due to Japan becoming a larger outlier (having a larger fixed effect).

The third and fourth columns of Table 6A add four "pre-determined" household characteristics that may explain students' test performance: a girl student dummy variable, an index of the number of siblings at home (0 = none, 1 = brothers only, or sisters only, and 2 = brothers and sisters); and mother's and father's years of schooling. Each of variable has some missing values, reducing the sample to 401,489, compared to 455,971 in columns (7) and (8) of Table 5.[27]

The key question for Table 6A is whether adding these four household-level variables "explains" any 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 these variables reduces the explanatory power of the wealth index by about one third (although it is still highly significant) but has very little impact on the Vietnam fixed effect. Indeed, its fixed effects increase slightly, from 78.2 to 80.6 for math and from 68.3 to 70.7 for reading. Vietnam's realtive outlier status is also largely unchanged; its fixed effect in the math regression remains in sixth place, and for reading it moves from fifth place to second place.

The finding that these four household-level variables do not explain Vietnam's strong performance on the 2012 PISA is not surprising when these variables means' are compared for Vietnam and the 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

[27] 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.

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 directly related to students' education, such as their current grade, 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 to their most promising children), so adding them to the regression may produce biased estimates of these variables' causal impacts. Even so, these variables 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, 2.6 for math) than do students in other PISA countries (0.9 for reading, 1.3 for math), and even biased estimates may reduce Vietnam's outlier status.[28]

The last two columns of Table 6A add these more education-focused child and household variables to the regression; 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 also reduces Vietnam's estimated country fixed effects (from 73.3 to 57.6 for math, and from 65.7 to 51.3 for reading), but this has only a small effect on Vietnam's outlier status: it drops from fifth to eighth highest outlier for math and from fourth to fifth largest for reading. Again, the reason why its relative outlier status changes little is that, for some of the added variables, Vietnamese students have

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

lower average values than do the students in the other PISA countries. For example, Vietnamese students have fewer educational inputs[29] 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, with one exception. The Vietnam fixed effect changes very little when additional household-level variables are added to the regression, and Vietnam is one of the top seven positive outliers (columns 3, 4 and 7). Yet when the more endogenous household variables are added, Vietnam's performance in reading drops to 12th place, making Vietnam's performance less exceptional. Yet there could be considerable biases since the grade 10 and educational input variables are more likely to endogenous, and it is also worth noting that all of the countries that are larger outliers than Vietnam are also much wealthier than Vietnam.

Since the child and household variables in the PISA data explain little of Vietnam's exceptional performance, perhaps that performance is due to better schools and teachers. To examine this, Tables 7A and 7B add school and teacher characteristics to the regressions. As before, the first two columns show, for comparison, regressions that include only the wealth variable, using the same samples as the regressions that include the school and teacher variables.

The third and fourth columns of Tables 7A and 7B show regressions that add not only child and household variables (not shown to reduce clutter) but also school and teacher variables. These variables are: class size; the proportion of teachers who have the required qualifications; computers per student; a variable indicating that 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

[29] 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.

indicator of whether student performance determines teacher pay (2012 only); and an indicator of teacher mentoring. Most of these variables have the expected signs; the key question is whether they "explain" at least part of Vietnam's outlier status, that is 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; its estimated fixed effects are reduced by 28% (from 71.5 to 51.4) for math and 30% (from 63.5 to 44.5) for reading. Most importantly, adding these variables reduces the rank of Vietnam's fixed effect from 5 to 11 for math, and from 5 to 9 for reading. The countries that are larger outliers than Vietnam are much wealthier countries, yet it also seems that school and teacher variables have some power to explain Vietnam's outlier status.

The same analysis using the 2015 PISA data is shown in Table 7B, and the results are similar. Vietnam's relative rank as measured by its country fixed effect falls substantially when school and teacher variables are added, from 6 to 12 for mathematics and from 5 to 18 for reading. Again, although all of the countries that are more of an outlier than Vietnam are much wealthier, Vietnam's outlier status appears to be explained in part by differences in schools and teachers between Vietnam and the other countries that participated in the PISA assessments.

To summarize this section, the observed child and household 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. Yet there is suggestive evidence that school and teacher characteristics can explain in part Vietnam's outlier status. The next section examines this further by implementing Blinder-Oaxaca decompositions to investigate Vietnam's strong performance on the 2012 and 2015 PISA assessments.

V. 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, yielding the following regression equations (omitting the i subscript to reduce clutter):

$$S_{vn} = \boldsymbol{\beta}_{vn}'\mathbf{x}_{vn} + u_{vn} \quad \text{(Vietnam)} \qquad (8)$$

$$S_{o} = \boldsymbol{\beta}_{o}'\mathbf{x}_{o} + u_{o} \quad \text{(Other countries)} \qquad (9)$$

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 equations (8) and (9) gives the following expressions for the average test scores in Vietnam, $\bar{S}_{vn}$, and in the other 62 PISA countries, $\bar{S}_{o}$:

$$\bar{S}_{vn} = \boldsymbol{\beta}_{vn}'\bar{\mathbf{x}}_{vn} \qquad (10)$$

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

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:

$$\bar{S}_{vn} - \bar{S}_{o} = \boldsymbol{\beta}_{vn}'\bar{\mathbf{x}}_{vn} - \boldsymbol{\beta}_{o}'\bar{\mathbf{x}}_{o} \qquad (12)$$

$$= \boldsymbol{\beta}_{vn}'\bar{\mathbf{x}}_{vn} - \boldsymbol{\beta}_{o}'\bar{\mathbf{x}}_{o} + \boldsymbol{\beta}_{o}'\bar{\mathbf{x}}_{vn} - \boldsymbol{\beta}_{o}'\bar{\mathbf{x}}_{vn}$$

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

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 $\boldsymbol{\beta}$ 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 (12) is that the differences in the explanatory variables' means ($\bar{\mathbf{x}}_{vn} - \bar{\mathbf{x}}_o$) are weighted by the coefficient for the other 62 countries ($\boldsymbol{\beta}_o$), and the differences in the coefficients ($\boldsymbol{\beta}_{vn} - \boldsymbol{\beta}_o$) are weighted by the explanatory variables' means for Vietnam. It seems unbalanced that all the weight is put on one group; it may be better to use as weights averages of the $\boldsymbol{\beta}$'s and $\bar{\mathbf{x}}$'s of both groups. This can be done by averaging the two $\boldsymbol{\beta}$ vectors and using that average $\boldsymbol{\beta}$ as the weight for the differences in the means; this yields the following decomposition:

$$\bar{S}_{vn} - \bar{S}_o = \boldsymbol{\beta}_{vn}'\bar{\mathbf{x}}_{vn} - \boldsymbol{\beta}_o'\bar{\mathbf{x}}_o \qquad (13)$$

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

where $\bar{\boldsymbol{\beta}} = (\boldsymbol{\beta}_{vn} + \boldsymbol{\beta}_o)/2$.[30] The first term, $\bar{\boldsymbol{\beta}}'(\bar{\mathbf{x}}_{vn} - \bar{\mathbf{x}}_o)$, weights the differences in the **x** variables by the simple average of the two $\boldsymbol{\beta}$ 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 between $\boldsymbol{\beta}_{vn}$ and $\boldsymbol{\beta}_o$ by splitting that difference into two differences; that between $\boldsymbol{\beta}_{vn}$ and $\bar{\boldsymbol{\beta}}$, weighted by $\bar{\mathbf{x}}_{vn}$, and that between $\bar{\boldsymbol{\beta}}$ and $\boldsymbol{\beta}_o$, weighted by $\bar{\mathbf{x}}_o$. As in equation (12), equation (13) decomposes the difference in the mean test scores between Vietnam and the other countries into that due to Vietnamese students having different characteristics than the other students, and that due to differences in the *impacts* of the various **x** variables, as measured by the difference between $\boldsymbol{\beta}_{vn}$ and $\boldsymbol{\beta}_o$.

[30] This decomposition holds even when $\bar{\boldsymbol{\beta}}$ is replaced by *any* $\boldsymbol{\beta}$ of the same dimension; the arithmetic average is used for its intuitive appeal. Other $\boldsymbol{\beta}$'s have been proposed; see Fortin *et al.* (2011) and Jann (2008) for further discussion.

In addition to decomposing the differences in the mean test scores, $\bar{S}_{vn} - \bar{S}_o$, into 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, the sum of which is the overall component. For example, one variable used below is hours per week that children receive math tutoring, which in the 2012 PISA is much higher in Vietnam (2.6) than the average for the other 62 countries (1.3), as seen in Table 8. This 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 contributes to the second component via the difference in the β_t coefficients; that contribution is $[(\beta_{vn,t} - \bar{\beta}_t)'\bar{x}_{vn,t} + (\bar{\beta}_t - \beta_{o,t})'\bar{x}_{o,t}]$.

However, there are two difficulties in determining the roles played by specific variables in these decompositions. First, categorical variables, such as region or ethnic group, require an omitted (base) category, and different base categories can produce different results for the impacts of the differences in the mean values of the **x** variables across the two groups. Yet this is not a problem here because there is only one categorical variable, a dummy variable for girl students. If dummy for boy students were used this would change the contribution of student gender to the "unexplained" component of the decomposition by the difference in the **β** terms for Vietnam and the other countries for the girl dummy variable. Fortunately, this difference is very small, so the choice of this dummy variable has almost no effect on the decomposition results.

Second, variables without "natural" zero points can yield different results for the impacts of the differences in the values of the **β** terms across the two groups; adding an arbitrary constant to such variables changes the contribution of the difference in the **β** terms because that difference is multiplied by the mean of that variable, which has changed. While almost all of the **x** variables have natural zeros, the wealth index and education input indices were constructed using principal components analysis, and the first principal components that are the indices 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 for Vietnam and for the other PISA countries for both 2012 and 2015. The 2012 means are also shown in the second and fifth columns of Table 9A (and Table 10A). The bottom of Table 9A shows Vietnam's mean math test score, 503.9 (in the third column), which is $\bar{S}_{vn}$, and the mean score for the other 62 countries, 462.8 (sixth column), which is $\bar{S}_o$.[31] The gap between these means is 41.1. Similarly, Table 10A shows that the gap between the two mean reading scores is 30.9. These gaps are lower than the Vietnam mean residuals in Table 5 because those residuals compare Vietnam to a hypothetical "typical" country with the same wealth as Vietnam, while the gaps in Tables 9A and 10A compare Vietnam, with a wealth of only 2.74, to the other 62 countries, with a mean wealth of 5.20.

Returning to Table 9A, the **x** variables with higher means in Vietnam than in the other 62 countries, and which have positive $\bar{\boldsymbol{\beta}}$ coefficients, can potentially explain part of the gap in mean test scores between Vietnam and the other 62 countries in the 2012 PISA, because their contribution 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 Vietnam's mean is lower than that of the other 62 countries and the corresponding $\bar{\boldsymbol{\beta}}$ coefficient is negative. An example of the former is the teacher mentoring variable, which is higher in Vietnam than in the other countries and is estimated to increase students' test scores.

[31] 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.

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

Table 9A provides the Oaxaca-Blinder decomposition for the 2012 PISA math test. The overall gap to explain is 41.1 points. The differences in the **x** variables, which underlie the $\boldsymbol{\beta}_o'(\bar{\mathbf{x}}_{vn} - \bar{\mathbf{x}}_o)$ component of the decomposition, cannot explain the gap. Indeed, summing over all the **x** variables shows that they lead one to expect an even larger gap since their overall contribution is -22.1 (see the bottom row, second to last column in Table 9A), although this sum is not significantly different from zero. This negative overall contribution comes primarily from the difference in wealth between Vietnam and the other PISA countries, which accounts for -18.3 of the overall -22.1 contribution and is significant at the 10% level; the contributions of all other variables in this column are either small or statistically insignificant (and usually both).

Instead, the decomposition in Table 9A indicates that the entire gap between Vietnam and the other PISA countries is due to differences in the $\boldsymbol{\beta}$ 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; the bottom row shows that the overall contribution of the differences in the $\boldsymbol{\beta}$ coefficients is 63.1, which is significant at the 5% level. Yet none of the individual variables makes a statistically significant contribution to this overall effect of the differences in the $\boldsymbol{\beta}$ terms, even though some estimates are very large, such as the 141.2-point estimated contribution of the grade (years in secondary school) variable, which is insignificant due to its large standard error of 92.4.

Table 10A yields similar results for the 2012 reading decomposition. The overall gap to explain is 30.9 points. As with the math score, the differences in the **x** variables explain little, and the sum of these contributions widens the gap by 19.7 points, though this sum is statistically insignificant. As in Table 9A, the wealth variable explains almost the entire gap (-16.4 points), and its contribution is significant at the 5% level. All other variables in the second to last column of Table 10A are either statistically insignificant or much smaller, and most of them are both.

In contrast, as seen in the last column of Table 10A, the **x** variables' "greater efficiency" (over)explains the gap by 50.6 points, which is statistically significant at the 5% level. Yet none of the individual variables explaining this overall contribution is statistically significant, even though again some of them are very large. Thus it is not possible to determine which of these "more efficiently used" variables explain the overall finding of greater efficiency.[32]

Oaxaca-Blinder decompositions for the 2015 PISA data yield similar results, as seen in Tables 9B and 10B. Note that, as seen in Table 8, there are seven fewer variables in the 2015 PISA for this decomposition, but that still leaves 16 variables that can be used.

The decomposition of the difference in the math scores for the 2015 PISA is shown in Table 9B. As in the 2012 PISA, the differences in the **x** variables do not explain the 33.9-point gap in the mean test score between Vietnam and the 65 other participating countries in the 2015 PISA. Indeed, those differences add 30.2 points to the gap, as seen at the bottom of the second to last column in Table 9B, though this estimate is statistically insignificant. As in 2012, most of this widening of the gap is due to Vietnam's lower wealth. Thus, as in 2012, the gap is due to

[32] Applying the Oaxaca-Blinder decomposition could be misleading in that the estimated $\boldsymbol{\beta}$ terms for Vietnam use only within-country variation in the variables, while the estimates of $\boldsymbol{\beta}$ for all other countries use both within- and between-country variation. The decomposition results could change if the latter estimates also used only within-country variation, which can be done by using a country-fixed-effects specification. This was done, and the main results still hold, as seen in Appendix Tables B.5 and B.6. In particular, the contribution of the difference in the **x** variables, $\bar{\boldsymbol{\beta}}'(\bar{\mathbf{x}}_{vn}-\bar{\mathbf{x}}_{o})$, remains very small.

differences in the **β** terms for Vietnam and for the other countries, although the explanatory power of the differences in the individual **β** terms is almost always statistically insignificant.

The decomposition of the difference in the 2015 PISA reading scores is shown in Table 10B; at first the gap to be explained seems small, at only 13.5 points, but the differences in the means of the **x** variables widen the gap, by 33.2, to 46.7 points. Again, the explanation for the gap must focus on the differences in the **β** terms between Vietnam and the other countries and, unfortunately, the contributions of individual variables are almost all statistically insignificant.

To summarize, 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 on the two PISA assessments is from the "unexplained" portion of this decomposition, so this decomposition sheds very little light on the underlying reasons for that performance.

VI. Conclusion

Vietnam's strong performances on the 2012 and 2015 PISA assessments raise the question of why it does so well, and whether other countries can raise their students' learning by applying what works well in Vietnam.[33] This paper applies three types of analyses to the 2012 and 2015 PISA data to explore the reasons behind Vietnam's apparent success. It finds three sets of results.

First, one important, albeit partial, explanation of Vietnam's strong performance on the 2012 and 2015 PISA is that the weakest students are excluded. In particular, only about 66% of

[33] We do not use the 2018 PISA since some "minor violations" (but no "major violations") were found in its implementation; see Annex A4 of OECD (2018). No violations were not found in the 2012 and 2015 PISA assessments.

Vietnamese 15-year-olds participated in the 2012 and 2015 PISA assessments; 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 rates.) Yet applying three different methods to adjust for Vietnam's low coverage (enrollment) rates has little effect on its outlier status. A related point is that the 15-year-old students who participated in the PISA 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 the differences in the two datasets, those scores are still well above what one would predict based on Vietnam's income. Moreover, adjustments to account for possible higher motivation of Vietnamese students on the PISA explain little of Vietnam's outlier status. Finally, adjustments to account of the coaching provided to Vietnam's PISA participants have little effect on Vietnam's outlier status. Even after combining all of these adjustments, 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 "explain" Vietnam's high performance. In general, accounting for household level and school level variables in the PISA data explains at most only one third of Vietnam's high performance on the 2012 and 2015 PISA assessments relative to its income level.

Third, the Oaxaca-Blinder decomposition method was applied to better understand the difference in average test scores between students in Vietnam and students in the other countries who participated in the 2012 and 2015 PISA assessments. This approach is more flexible than the analysis in the previous paragraph since it allows the household and school variable impacts to differ between Vietnam and all other countries that participated in the PISA. The decompositions indicate that *all* of the gap in average test scores between Vietnam and the other countries is due to greater "productivity" of various household and school variables in Vietnam, relative to their "productivity" in other countries. Unfortunately, little more can be said; the contributions of each variable are almost always imprecisely estimated and thus statistically insignificant.

While the analysis in this paper has shed some light on Vietnam's exceptional performance on the 2012 and 2015 PISA assessments, in the end its main contribution is to show 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, possible selection of "better" students (as measured by urban location, parental education and household wealth) into the PISA assessments, higher motivation to perform, or organized coaching. Observable child, household, and school characteristics explain little of the differential performance, and Oaxaca-Blinder decompositions attribute none of the gap in test scores to differences in the levels of these factors; instead, they attribute all of the gap to differences between Vietnam and the PISA participants in the impacts ("productivity") 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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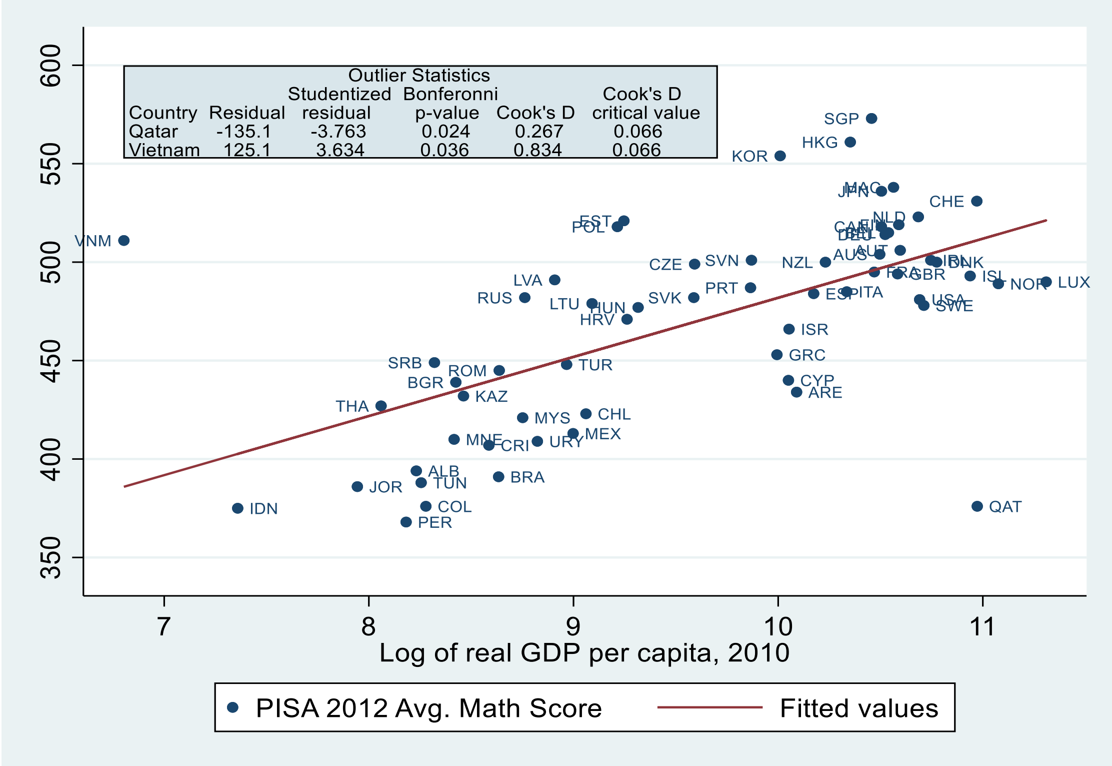
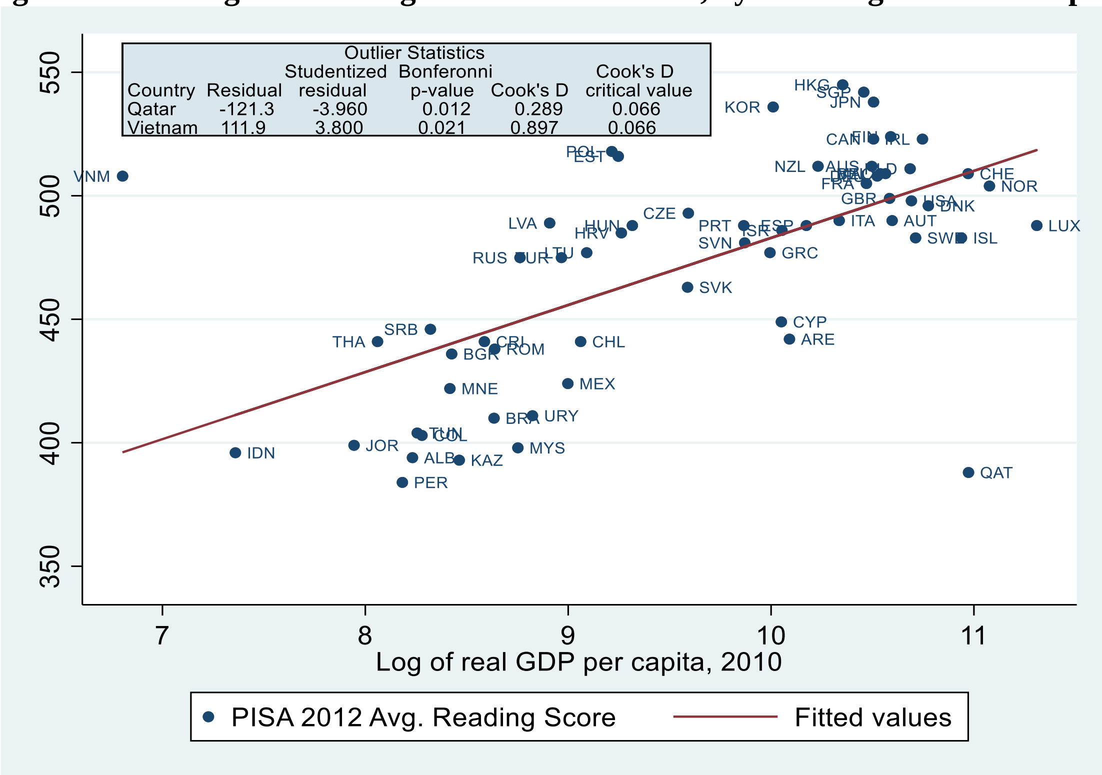
Figure 1. Mean Age 15 Math Scores in 2012 PISA, by 2010 Log Real GDP/capita



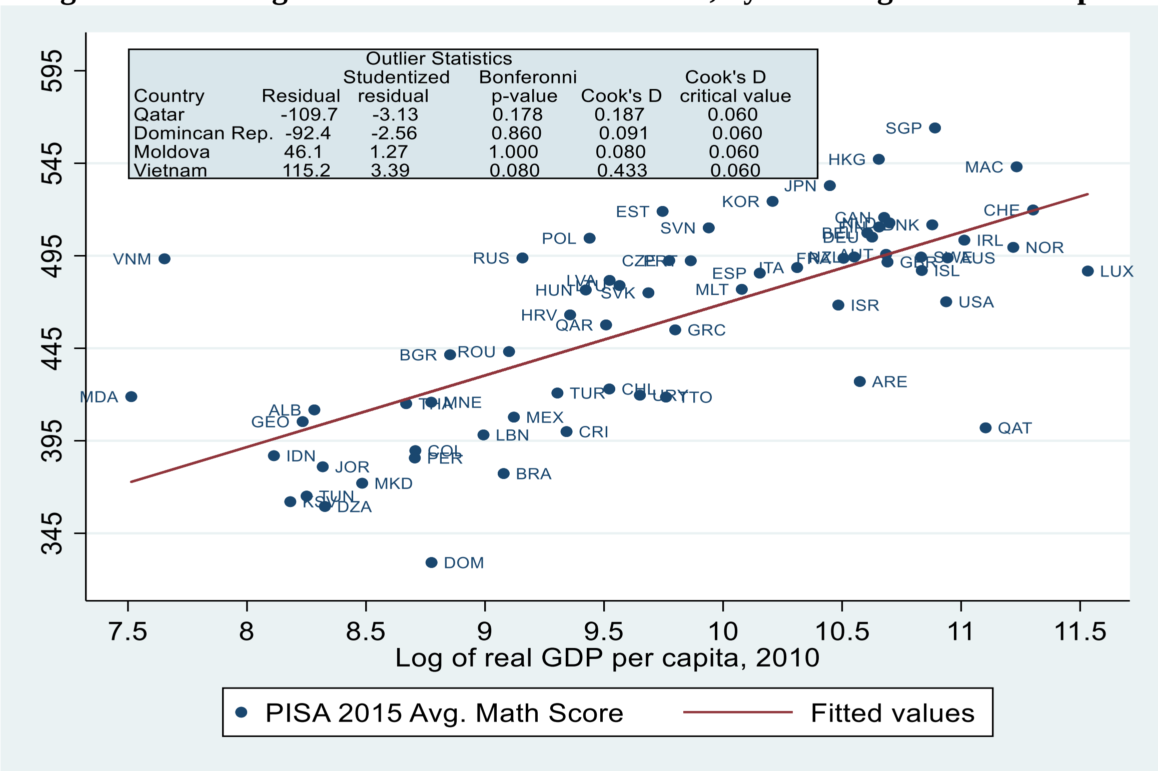
Note: The outlier statistics are shown only for countries that are outliers by one or both of the two criteria.

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



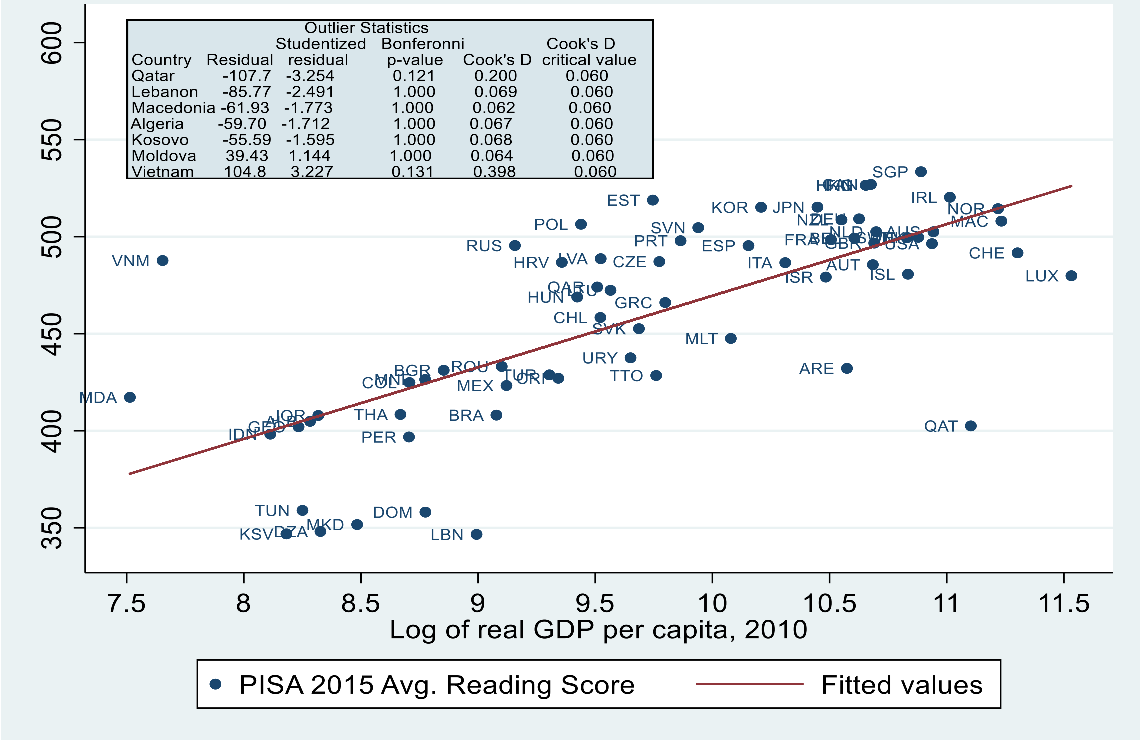
Note: The outlier statistics are shown only for countries that are outliers by one or both of the two criteria.

Figure 3. Mean Age 15 Math Scores in 2015 PISA, by 2010 Log Real GDP/capita



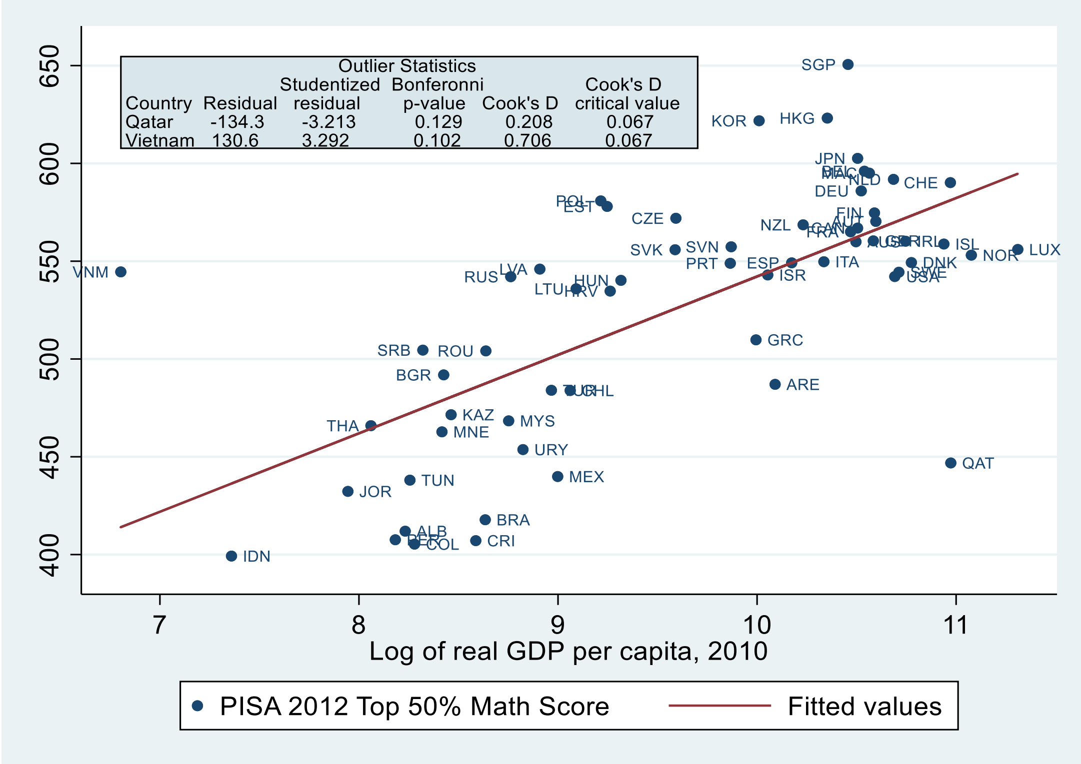
Note: The outlier statistics are shown only for countries that are outliers by one or both of the two criteria.

Figure 4. Mean Age 15 Language Scores in 2015 PISA, by 2010 Log Real GDP/capita



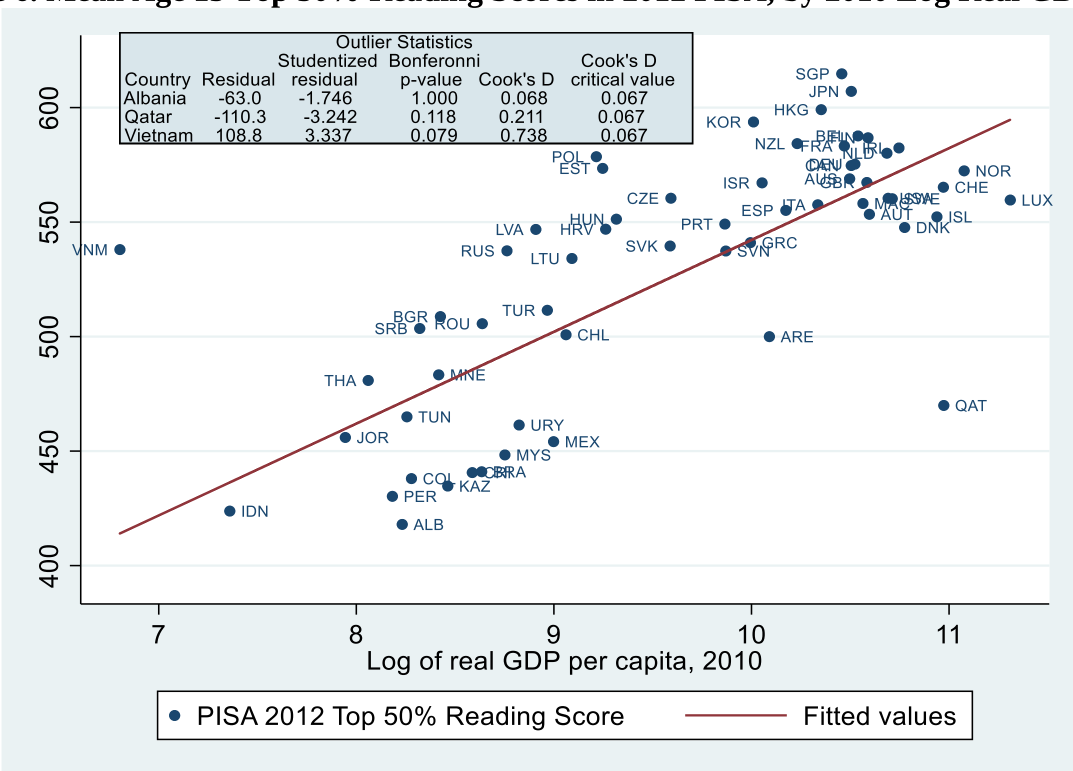
Note: The outlier statistics are shown only for countries that are outliers by one or both of the two criteria.

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



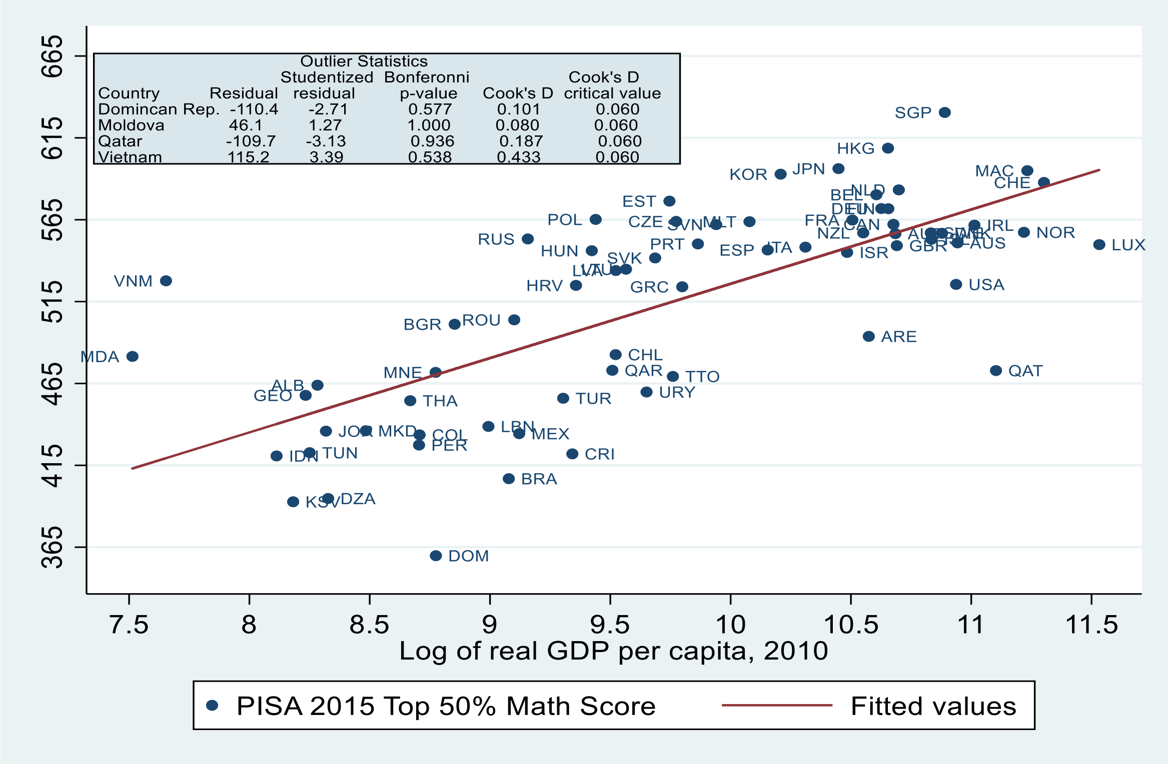
Note: The outlier statistics are shown only for countries that are outliers by one or both of the two criteria.

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



Note: The outlier statistics are shown only for countries that are outliers by one or both of the two criteria.

Figure 7. Mean Age 15 Top 50% Math Scores in 2015 PISA, by 2010 Log Real GDP/capita

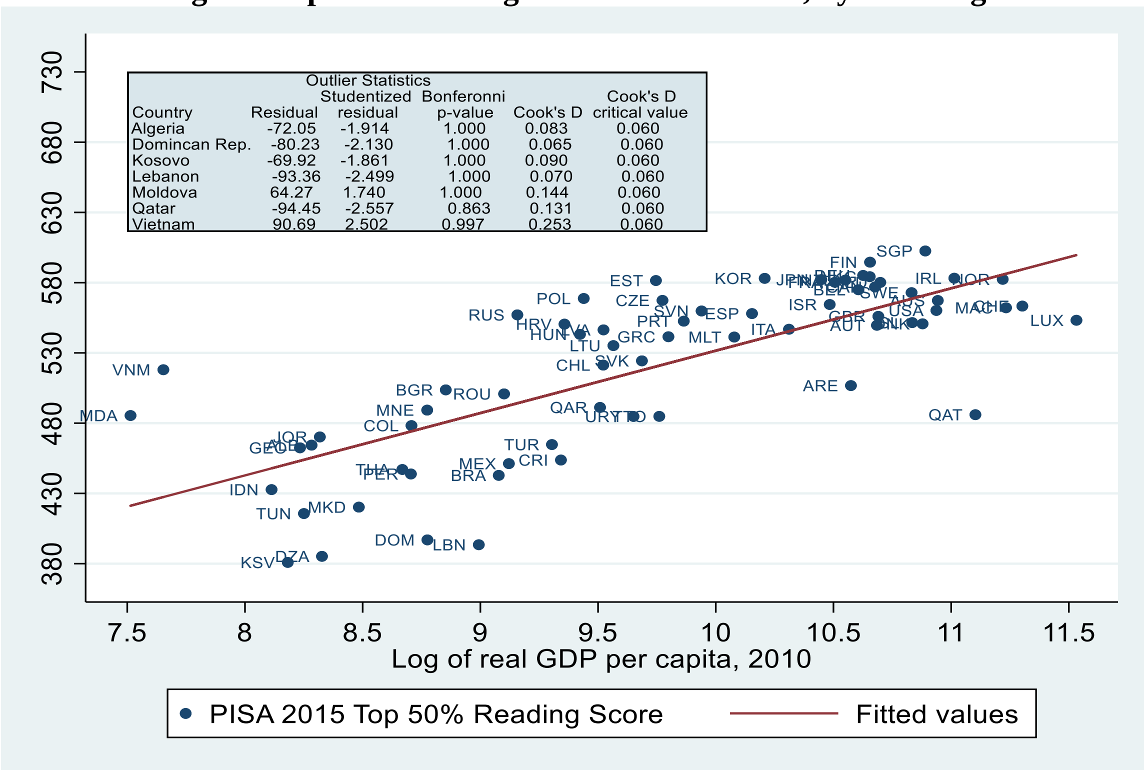


Outlier Statistics

Country	Residual	Studentized residual	Bonferonni p-value	Cook's D	Cook's D critical value
Domincan Rep.	-110.4	-2.71	0.577	0.101	0.060
Moldova	46.1	1.27	1.000	0.080	0.060
Qatar	-109.7	-3.13	0.936	0.187	0.060
Vietnam	115.2	3.39	0.538	0.433	0.060

Note: The outlier statistics are shown only for countries that are outliers by one or both of the two criteria.

Figure 8. Mean Age 15 Top 50% Reading Scores in 2015 PISA, by 2010 Log Real GDP/capita

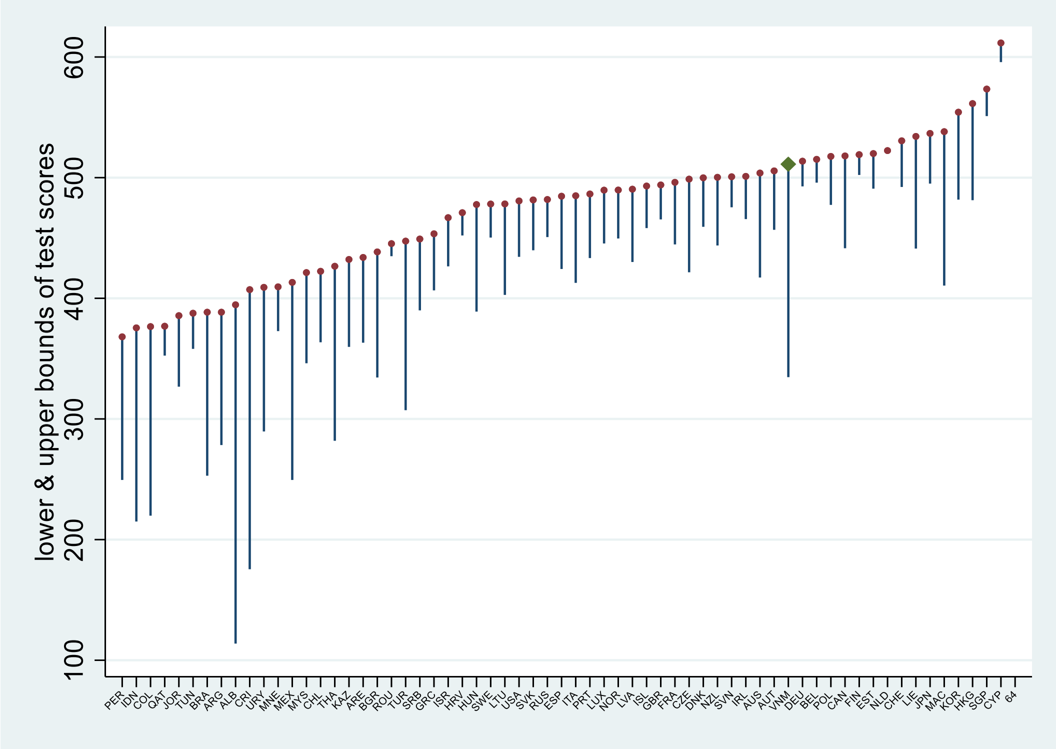


Outlier Statistics

Country	Residual	Studentized residual	Bonferonni p-value	Cook's D	Cook's D critical value
Algeria	-72.05	-1.914	1.000	0.083	0.060
Domincan Rep.	-80.23	-2.130	1.000	0.065	0.060
Kosovo	-69.92	-1.861	1.000	0.090	0.060
Lebanon	-93.36	-2.499	1.000	0.070	0.060
Moldova	64.27	1.740	1.000	0.144	0.060
Qatar	-94.45	-2.557	0.863	0.131	0.060
Vietnam	90.69	2.502	0.997	0.253	0.060

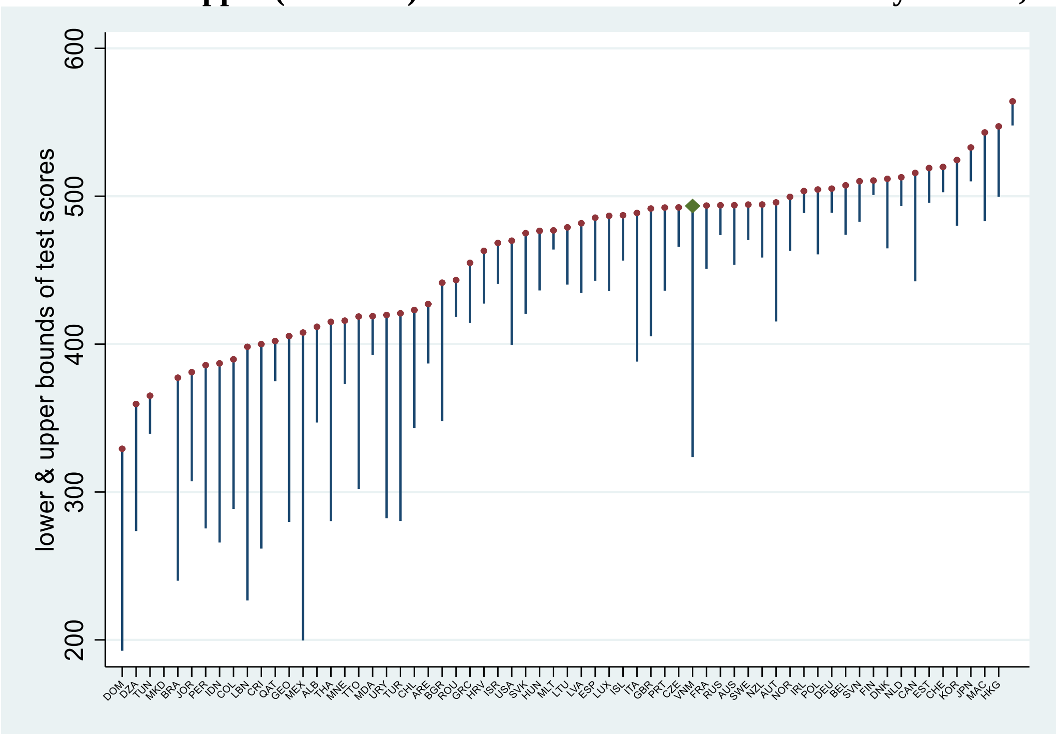
Note: The outlier statistics are shown only for countries that are outliers by one or both of the two criteria.

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



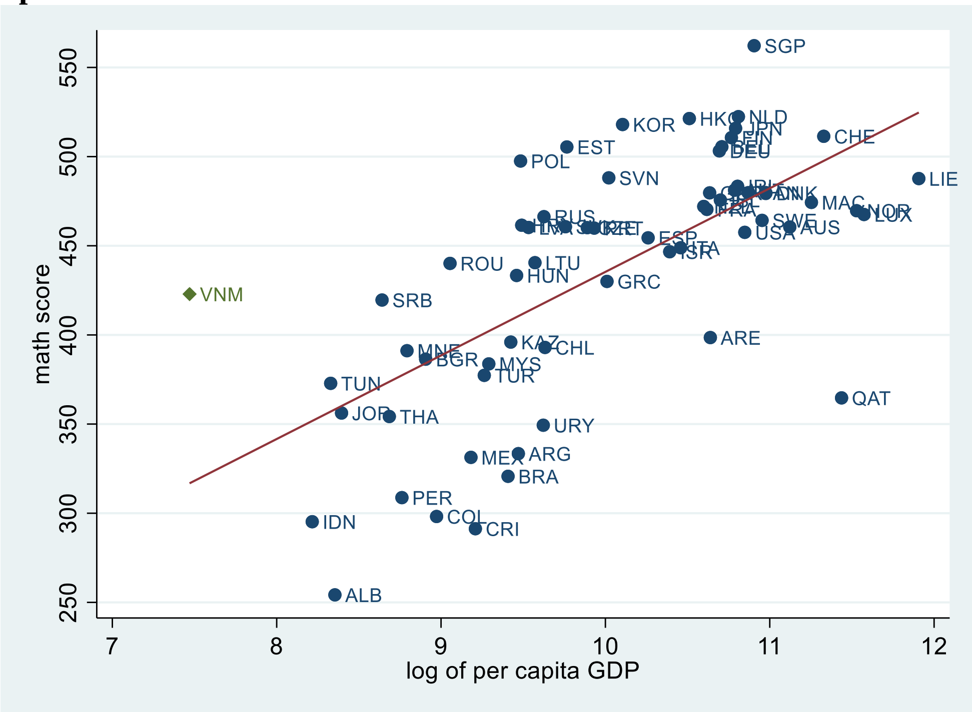
Note: All countries are sorted in an increasing order of the upper bound (observed mean from PISA participants) of test scores. The dots represent the observed mean test scores. Vietnam is indicated by the larger diamond.

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



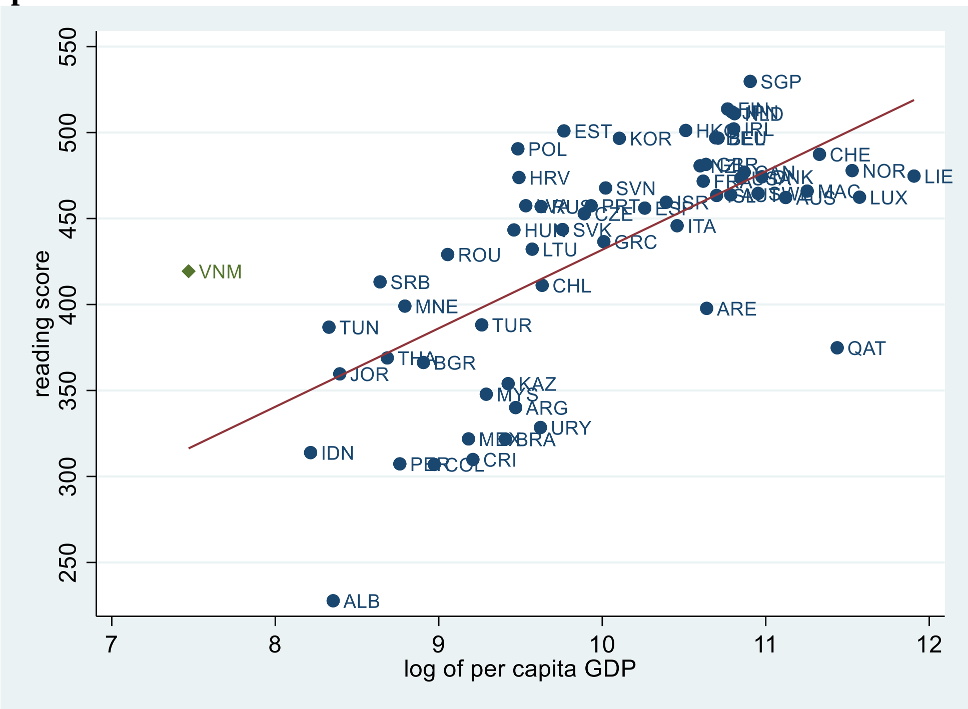
Note: All countries are sorted in an increasing order of the upper bound (observed mean from PISA participants) of test scores. The dots represent the observed mean test scores. Vietnam is indicated by the larger diamond.

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



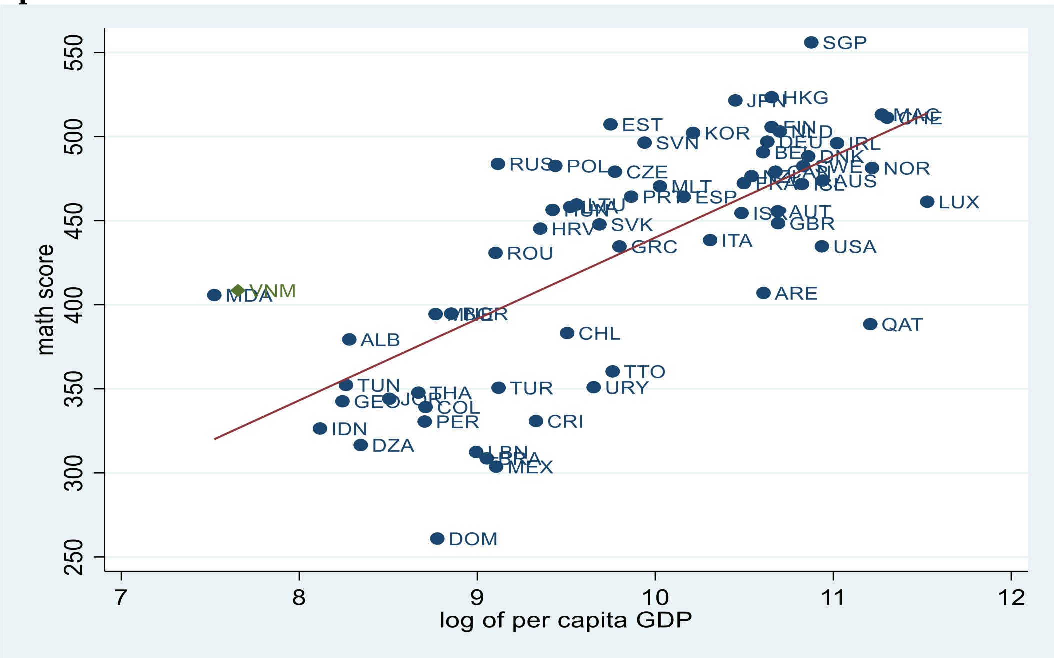
Note: Adjusted test scores for each country are the mid-point value of the observed test scores and the theoretical lower bounds based on Proposition 1.

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



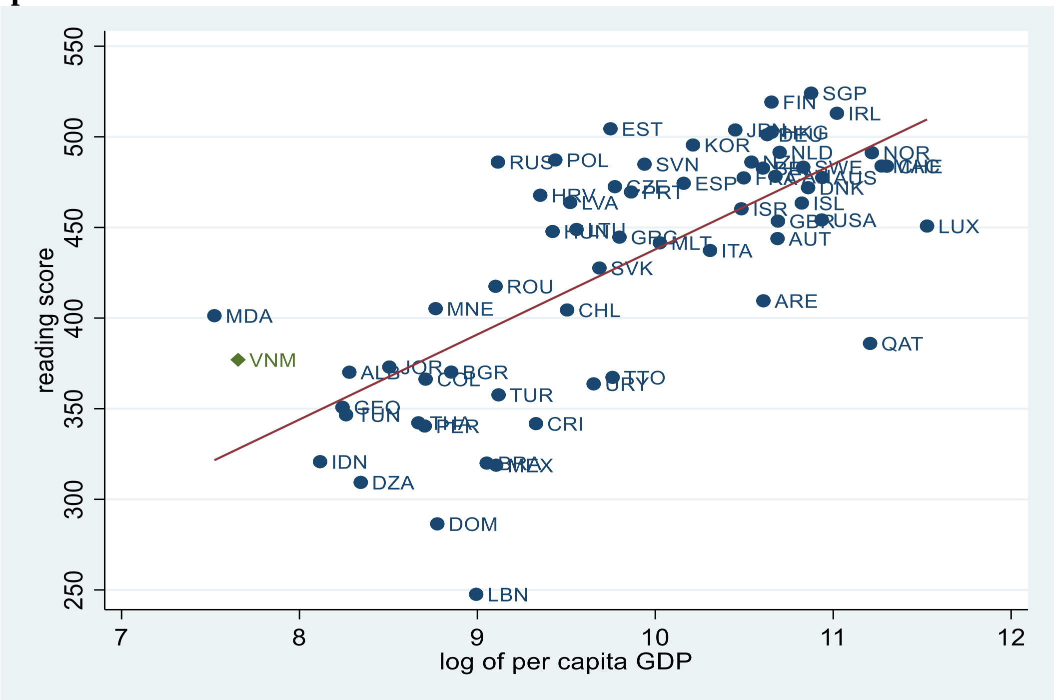
Note: Adjusted test scores for each country are the mid-point value of the observed test scores and the theoretical lower bounds based on Proposition 1.

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



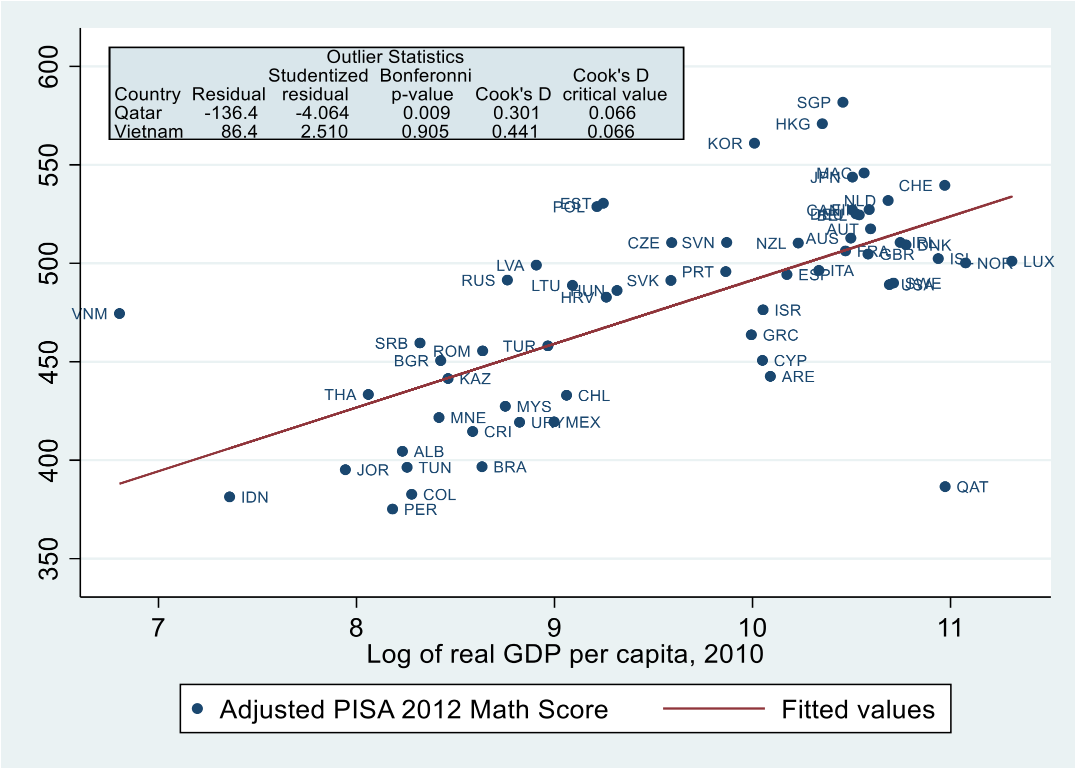
Note: Adjusted test scores for each country are the mid-point value of the observed test scores and the theoretical lower bounds based on Proposition 1.

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



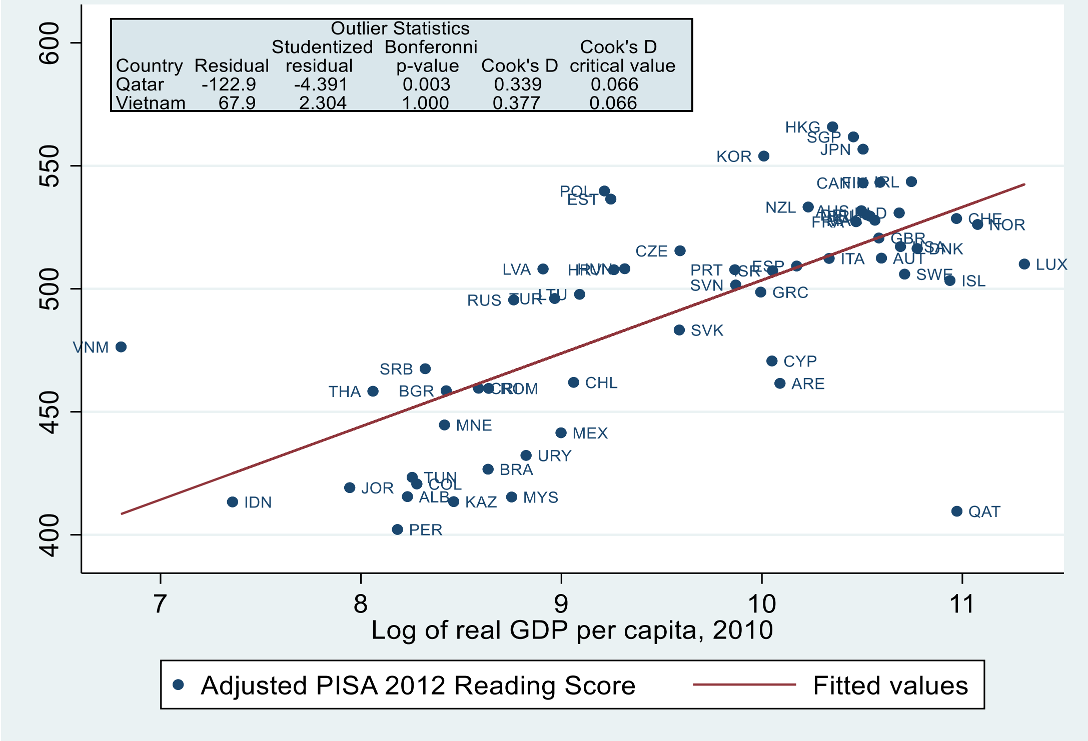
Note: Adjusted test scores for each country are the mid-point value of the observed test scores and the theoretical lower bounds based on Proposition 1.

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



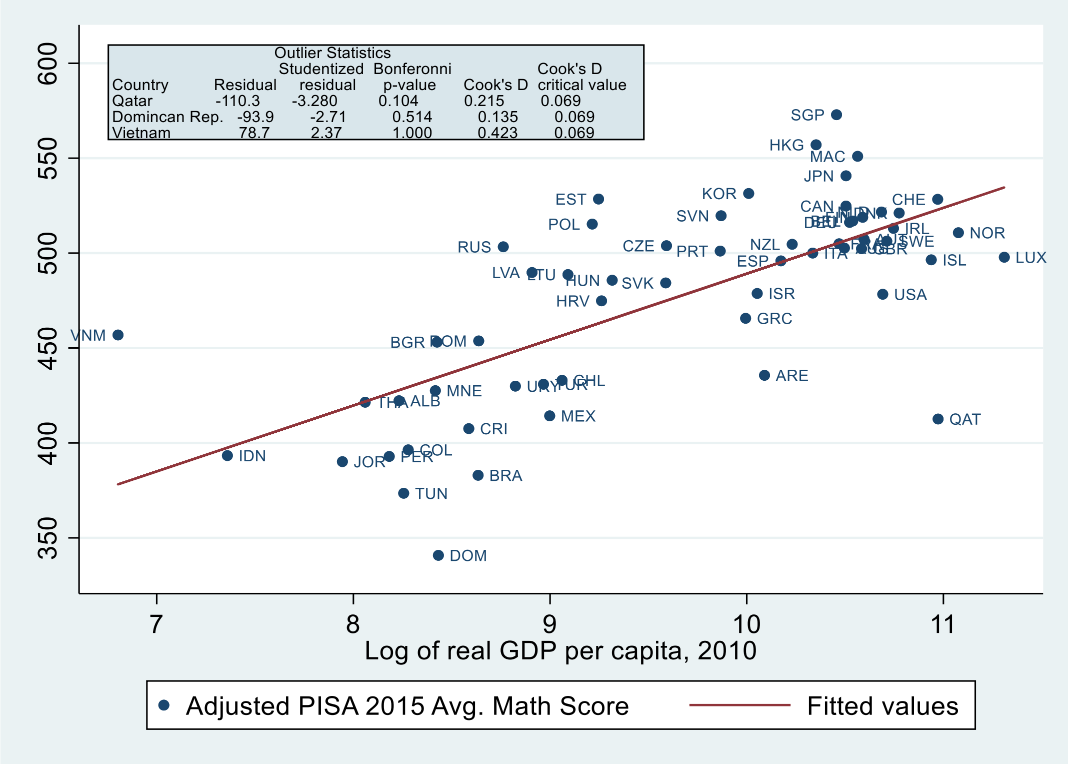
Note: The outlier statistics are shown only for countries that are outliers by one or both of the two criteria.

Figure 16. "Adjusted" Mean Age 15 Reading Scores in 2012 PISA, by 2010 Log Real GDP/capita



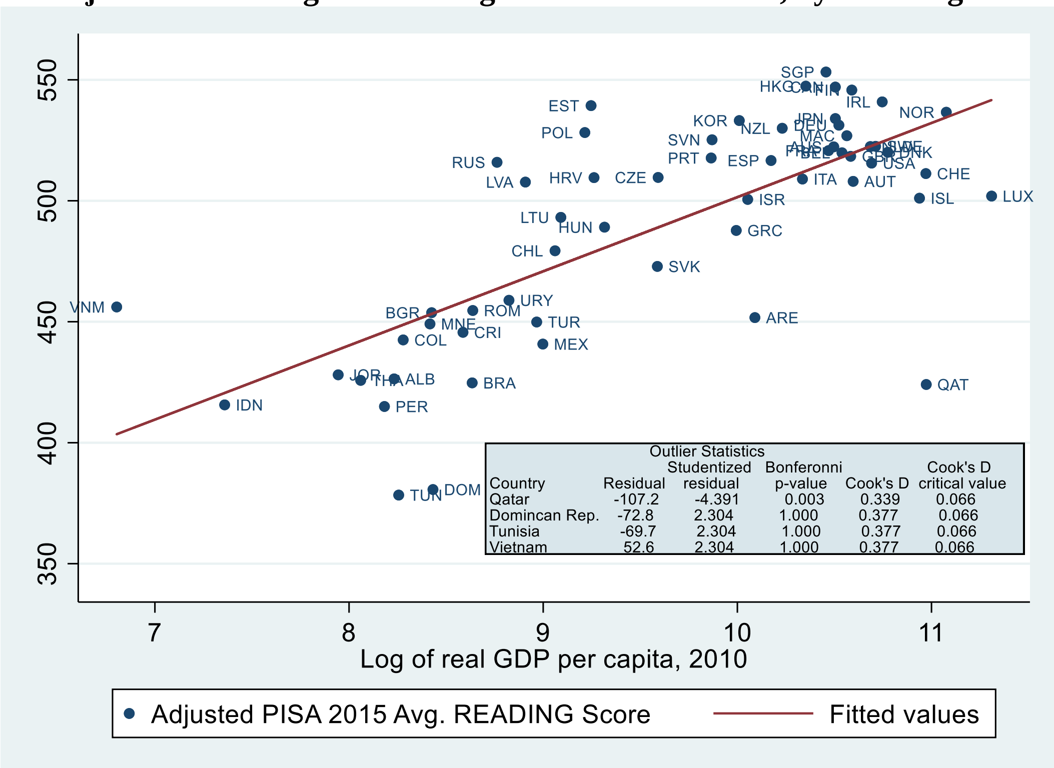
Note: The outlier statistics are shown only for countries that are outliers by one or both of the two criteria.

Figure 17. "Adjusted" Mean Age 15 Math Scores in 2015 PISA, by 2010 Log Real GDP/capita



Note: The outlier statistics are shown only for countries that are outliers by one or both of the two criteria.

Figure 18. "Adjusted" Mean Age 15 Reading Scores in 2015 PISA, by 2010 Log Real GDP/capita



Note: The outlier statistics are shown only for countries that are outliers by one or both of the two criteria.

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		All	Mar.-July	Difference		All	Mar.-July	Difference
	(1)	(2)	(3)	(3) – (1)	(4)	(5)	(6)	(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		Difference in Means	Math Coeff.	Math Coefficient Multiplied by:		
	PISA	VHLSS			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		Difference in Means	Math Coeff.	Math Coefficient Multiplied by:		
	PISA	VHLSS			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		Difference in Means	Reading Coeff.	Reading Coefficient Multiplied by:		
	PISA	VHLSS			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		Difference in Means	Reading Coeff.	Reading Coefficient Multiplied by:		
	PISA	VHLSS			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	31.63***	29.25***						
	(1.56)	(1.44)						
Wealth (national average)			27.84***	25.73***				
			(1.10)	(1.04)				
Wealth (student specific)					20.93***	19.58***	16.26***	15.21***
					(0.57)	(0.55)	(0.53)	(0.46)
Constant	151.41***	182.55***	455.69***	463.91***	459.39***	468.01***	--	--
	(15.4)	(14.19)	(1.18)	(1.12)	(1.09)	(1.02)		
Vietnam residual (average)	**128.7**	**112.6**	**108.8**	**94.2**	**94.4**	**80.2**	**74.7**	**67.9**
Residual rank	**1**	**1**	**2**	**1**	**4**	**2**	**6**	**4**
More highly ranked	**none**	**none**	**HK**	**none**	**HK S. Korea Singap.**	**HK**	**HK S. Korea Macedon. Singap. Taiwan**	**HK S. Korea Singap.**
Observations	473,236	473,236	473,236	473,236	455,971	455,971	455,971	455,971
R-squared	0.108	0.095	0.121	0.106	0.143	0.130	0.345	0.276
B. 2015 PISA Assessment								
Log of per capita GDP	30.91***	32.29***						
	(1.272)	(1.176)						
Wealth (national average)			28.27***	28.97***				
			(1.019)	(0.949)				
Wealth (student specific)					20.78***	21.45***	16.15***	16.22***
					(0.530)	(0.490)	(0.479)	(0.445)
Constant	153.7***	150.4***	447.9***	457.7***	452.7***	462.7***		
	(12.43)	(11.38)	(1.113)	(1.048)	(1.012)	(0.937)		
Vietnam residual (average)	**105.9**	**92.4**	**100.1**	**85.3**	**83.7**	**68.3**	**66.54**	**54.7**
Residual rank	**1**	**1**	**1**	**1**	**3**	**1**	**6**	**4**
More highly ranked	**None**	**none**	**none**	**none**	**HK Singap.**	**none**	**Singap. HK Macao Japan S. Korea**	**HK Singap. S. Korea**
Observations	464,518	464,518	460,701	460,701	428,716	428,716	428,716	428,716
R-squared	0.111	0.117	0.126	0.129	0.149	0.155	0.324	0.257
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***	14.71***	10.04***	9.61***	15.78***	14.54***	4.86***	4.22***
	(0.53)	(0.48)	(0.44)	(0.41)	(0.53)	(0.49)	(0.39)	(0.35)
Girl			-8.41***	33.58***			-17.36***	24.42***
			(0.78)	(0.76)			(0.70)	(0.66)
Sibling index			-1.67***	-2.29***			-1.733***	-2.24***
			(0.53)	(0.55)			(0.50)	(0.50)
Sibling index missing			-19.43***	-15.62***			-16.36***	-12.41***
			(0.80)	(0.85)			(0.75)	(0.76)
Mom years school			2.97***	2.89***			1.41***	1.32***
			(0.14)	(0.14)			(0.13)	(0.12)
Dad years school			3.27***	3.02***			1.87***	1.66***
			(0.13)	(0.13)			(0.12)	(0.12)
Grade							30.80***	32.24***
							(0.89)	(0.86)
Years of preschool							10.26***	9.53***
							(0.68)	(0.68)
Educational input index							6.84***	7.38***
							(0.27)	(0.29)
Attendance (past 2 weeks)							7.09***	7.02***
							(0.36)	(0.36)
Books at home							0.070***	0.061***
							(0.002)	(0.003)
Hours of study							3.02***	2.86***
							(0.09)	(0.09)
Extra math classes (tutored)							-0.28	
							(0.21)	
Extra math variable missing							-2.53***	
							(0.52)	
Extra read. classes (tutored)								-4.06***
								(0.23)
Extra read. variable missing								-2.73***
								(0.56)
Vietnam fixed effect	**70.1**	**62.9**	**72.2**	**65.7**	**73.3**	**65.7**	**57.6**	**51.3**
Fixed effect rank	**6**	**5**	**6**	**2**	**5**	**4**	**8**	**5**
More highly ranked:	**HK**	**HK**	**HK**	**HK**	**HK**	**HK**	**Finland**	**Finland**
	Macao	**Japan**	**Macao**		**S. Korea**	**S. Korea**	**HK**	**HK**
	S. Korea	**S. Korea**	**S. Korea**		**Singap.**	**Singap.**	**Macao**	**Lichten.**
	Singap.	**Singap.**	**Singap.**		**Taiwan**		**S. Korea**	**Macao**
	Taiwan		**Taiwan**				**Singap.**	
							Switz.	
							Taiwan	
Observations	401,489	401,489	401,489	401,489	393,146	393,146	393,146	393,146
R-squared	0.360	0.291	0.394	0.347	0.356	0.288	0.484	0.446

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	16.02***	16.01***	10.23***	10.77***	15.89***	15.87***	6.059***	6.219***
	(0.486)	(0.455)	(0.403)	(0.394)	(0.484)	(0.455)	(0.372)	(0.370)
Girl			-6.225***	23.74***			-11.48***	18.17***
			(0.684)	(0.690)			(0.651)	(0.676)
Mom years school			2.787***	2.603***			1.731***	1.495***
			(0.133)	(0.136)			(0.122)	(0.128)
Dad years school			3.143***	2.993***			2.204***	1.997***
			(0.123)	(0.130)			(0.111)	(0.120)
Grade 10							30.19***	32.71***
							(0.800)	(0.795)
Educational input index							6.942***	7.949***
							(0.290)	(0.302)
Books at home							0.0625***	0.0581***
							(0.002)	(0.002)
Vietnam fixed effect	**66.0**	**53.6**	**73.8**	**62.0**	**68.6**	**55.7**	**61.7**	**47.8**
Fixed effect rank	**6**	**4**	**4**	**3**	**5**	**4**	**7**	**12**
More highly ranked:	**Singap. HK Macao Japan S. Korea**	**HK Singap. S. Korea**	**HK Singap. Macao**	**HK Singap.**	**Singap. HK Macao Japan**	**HK Singap. S. Korea**	**Macao HK Singap. Switz, Estonia**	**Finland HKG Estonia Macao Germany Singap. Ireland Poland Sweden Denmark Portugal**
Observations	389,472	389,472	389,472	389,472	387,092	387,092	387,092	387,092
R-squared	0.334	0.271	0.364	0.309	0.333	0.269	0.422	0.374

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	15.29***	13.76***	4.50***	3.86***
	(0.58)	(0.51)	(0.42)	(0.39)
Class size (student/teacher ratio)			0.08	0.20**
			(0.08)	(0.08)
Ratio qualified teachers			13.03***	11.65***
			(3.28)	(3.19)
Qual. tchr. ratio missing			-1.92	-3.71
			(3.45)	(3.27)
Square root of computers/pupil			-3.07	-1.68
			(3.20)	(2.95)
Stud. perf. used to assess tchrs			1.75	2.21
			(1.86)	(1.81)
Teacher absenteeism			-3.16***	-2.66***
			(0.95)	(0.95)
Parents pressure teachers			11.74***	11.49***
			(1.24)	(1.21)
Principal observes teachers			-3.49*	-0.40
			(1.98)	(1.86)
Inspector observes teachers			-4.71***	-6.32***
			(1.78)	(1.78)
Tchr pay linked to stud perf			-2.40**	-2.33**
			(0.96)	(0.93)
Teacher mentoring index			5.45***	5.27***
			(1.76)	(1.78)
Vietnam fixed effect	**71.5**	**63.5**	**51.4**	**44.5**
Fixed effect rank	**5**	**5**	**11**	**9**
More highly ranked:	**HK S. Korea Singap. Taiwan**	**HK Japan S. Korea Singap.**	**Estonia Finland Germany HK Liecht. Macao S. Korea Singap. Switz. Taiwan**	**Estonia Finland Germany HK Liecht. Macao Poland Switz.**
Observations	340,868	340,868	340,868	340,868
R-squared	0.350	0.284	0.477	0.430

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	15.28***	15.14***	5.654***	5.828***
	(0.537)	(0.492)	(0.401)	(0.401)
Class size (student/teacher ratio)			0.516***	0.624***
			(0.104)	(0.105)
Ratio qualified teachers			11.11***	9.075***
			(3.058)	(2.917)
Qual. tchr. ratio missing			-3.876	-4.045
			(3.762)	(4.301)
Square root of computers/pupil			-1.239	0.00552
			(2.921)	(2.884)
Stud. perf. used to assess tchrs			4.106	1.479
			(2.580)	(2.471)
Teacher absenteeism			-5.084***	-4.261***
			(1.124)	(1.122)
Principal observes teachers			-1.813	0.904
			(2.463)	(2.580)
Inspector observes teachers			-0.826	-2.044
			(1.755)	(1.866)
Teacher mentoring index			0.584	0.343
			(1.163)	(1.152)
Vietnam fixed effect	**63.9**	**50.8**	**46.5**	**32.2**
Fixed effect rank	**6**	**5**	**12**	**18**
More highly ranked:	**Singap. HK Macao Japan Korea**	**HK Singap. S. Korea Germany**	**Macao HK Singap. Switz. Denmark Estonia Finland Germany Poland Netherlands Belgium**	**Finland Estonia Germany Ireland HKG Denmark Poland Macao Switz. Singap. Russia Portugal Latvia Belgium Netherlands Croatia Canada**
Observations	317,006	317,006	317,006	317,006
R-squared	0.313	0.256	0.401	0.355

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	503.9	462.8	501.2	456.6
Reading test score	503.5	472.6	495.1	468.1
Wealth	2.741	5.200	3.21	5.63
Girl	0.535	0.509		
Grade	9.810	9.806	0.89	0.59
Sibling index	1.048	1.086	--	--
Sibling index missing	0.143	0.238	--	--
Mom years schooling	7.984	10.98	8.03	11.45
Dad years schooling	8.351	11.09	8.53	11.54
Years preschool enrollment	1.576	1.488	--	--
Education inputs index (desk, books)	3.978	4.654	4.87	5.48
Books in home	52.00	114.1	69.17	113.15
Days attended in past 2 weeks	9.837	9.622	--	--
Hours of study per week	5.519	5.362	--	--
Extra reading classes (tutoring), hours/week	1.344	0.944	--	--
Extra reading classes variable missing	0.343	0.358	--	--
Extra math classes (tutoring), hours/week	2.567	1.325	--	--
Extra math classes variable missing	0.342	0.358	--	--
Class size	42.82	32.62	40.61	31.08
Proportion of teachers who are qualified	0.800	0.834	0.85	0.80
Proportion qualified teacher missing	0.057	0.188	0.07	0.08
Square root of computers/pupil	0.497	0.623	0.44	0.65
Student performance used to assess teachers	0.995	0.708	0.99	0.88
Teacher absenteeism	0.695	0.779	1.60	1.83
Parents pressure teachers	1.297	0.957	--	--
Principal observes teachers	0.986	0.802	0.99	0.87
Outside Inspector observes teachers	0.888	0.406	0.77	0.57
Teacher pay linked to student performance	1.461	0.704	--	--
Teachers are mentored	0.833	0.684	1.81	1.46
Sample size	4,264	336,604	4,895	312,111

Notes: 1. Averages over countries are weighted by country populations, using adjusted weights for Vietnam. These are the samples used in Tables 7A and 7B.

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 = 503.89– 462.83 = 41.06)

Variable	β_{vn}	$\bar{x}_{vn}$	$\beta_{vn}'\bar{x}_{vn}$	β_o	$\bar{x}_o$	$\beta_o'\bar{x}_o$	$\bar{\beta}$ (= $(\beta_{vn}+\beta_o)/2$)
Wealth	6.475***	2.741	17.75	8.433***	5.200	43.86	7.454
Girl	-20.03***	0.535	-10.72	-17.79***	0.509	-9.06	-18.91
Grade (yrs in secondary)	55.94***	3.810	213.11	18.86***	3.806	71.75	37.40
Sibling index	4.824***	1.048	5.05	-1.496***	1.086	-1.63	1.664
Sibling index missing	-0.717	0.143	-0.10	-17.23***	0.238	-4.10	-8.974
Mom years schooling	0.507	7.984	4.05	1.511***	10.977	16.59	1.009
Dad years schooling	0.953***	8.351	7.96	2.407***	11.088	26.69	1.680
Years in preschool	4.750***	1.576	7.48	14.09***	1.488	20.96	9.421
Education inputs index	4.552***	3.978	18.11	7.829***	4.654	36.44	6.190
Books in home	-0.0016	52.00	-0.08	0.090***	114.10	10.26	0.044
Days attend past 2 wks	11.53***	9.837	113.40	8.003***	9.622	77.01	9.765
Hours study per week	2.991***	5.519	16.51	2.610***	5.362	14.00	2.801
Extra math class, hrs/wk	3.730***	2.567	9.57	-0.663***	1.325	-0.88	1.534
Extra math class missing	7.235***	0.342	2.47	-3.202***	0.358	-1.15	2.017
Class size	0.167*	42.82	7.15	0.149***	32.62	4.85	0.158
Proport. qualified tchrs	11.05***	0.800	8.84	45.80***	0.834	38.18	28.43
Prop. qual. tchr. missing	-14.87***	0.057	-0.85	-31.50***	0.188	-5.92	-23.19
Square root comp/pupil	0.533	0.407	0.22	2.841***	0.623	1.77	1.687
Stud perf. to assess tchrs	16.34	0.995	16.26	-6.268***	0.708	-4.44	5.037
Teacher absenteeism	0.939	0.695	0.65	-7.336***	0.779	-5.71	-3.198
Parents pressure tchrs	19.82***	1.297	25.70	5.765***	0.957	5.52	12.79
Principal observes tchrs	-1.551	0.986	-1.53	-3.506***	0.802	-2.81	-2.529
Inspector observes tchrs	-16.97***	0.888	-15.07	-10.74***	0.406	-4.36	-13.86
Tchr pay link stud. perf.	3.718***	1.461	5.43	-1.339***	0.704	-0.94	1.189
Teachers are mentored	19.44***	0.833	16.18	7.260***	0.684	4.96	13.35
Constant	36.36***	1.000	36.36	130.99***	1.000	130.99	83.68
Column sum:	--	--	503.89	--	--	462.83	--

Table 9B: Math Decomposition, 2015 (diff = 490.5– 456.6 = 33.9)

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
Wealth	5.252***	1.754	9.21	9.875***	4.194	41.41	7.564
Girl	-5.131*	0.528	-2.709	-11.24***	0.509	-5.722	-8.185
Grade 10	47.56***	3.862	183.6	15.47***	3.779	58.44	31.51
Mom years schooling	0.408	7.924	3.23	2.363***	11.45	27.06	1.385
Dad years schooling	1.891***	8.060	15.24	3.093***	11.54	35.70	2.492
Education input index	8.348***	3.907	32.62	7.428***	4.407	32.73	7.888
Books in home	-0.029**	67.81	-1.933	0.091***	113.2	10.31	0.031
Class size	0.812	39.44	32.02	-0.015	31.09	-0.470	0.398
Proport. qualified tchrs	2.224	0.832	1.851	25.19***	0.805	20.27	13.707
Prop. Qual. tchr. missing	-14.53	0.074	-1.077	-12.74***	0.085	-1.079	-13.634
Square root comp/pupil	11.01	0.391	4.305	11.32***	0.649	7.349	11.16
Stud perf. to assess tchrs	-13.65*	0.987	-13.46	-6.383**	0.879	-5.608	-10.02
Teacher absenteeism	-3.521	0.650	-2.287	-8.761***	0.833	-7.294	-6.141
Principal observes tchrs	37.35***	0.997	37.24	3.572	0.875	3.125	20.46
Inspector observes tchrs	1.599	0.756	1.209	-0.637	0.568	-0.361	0.481
Teacher are mentored	31.21***	0.981	30.63	-12.46***	0.857	-10.67	9.378
Constant	160.8***	1.000	160.8	251.4***	1.000	251.4	206.1
Column sum:			490.5			456.6	

Table 10A: Reading Decomposition, 2012 (diff = 503.48– 472.56 = 30.92)

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
Wealth	4.833***	2.741	13.25	8.505***	5.200	44.23	6.669
Girl	22.57***	0.535	12.08	23.75***	0.509	12.90	23.16
Grade (yrs in secondary)	48.04***	3.810	183.00	22.23***	3.806	84.60	35.13
Sibling index	2.764	1.048	2.90	-2.070***	1.086	-2.25	0.347
Sibling index missing	-0.434	0.143	-0.06	-12.39***	0.238	-2.95	-6.411
Mom years schooling	0.871**	7.984	6.95	1.012***	10.977	11.10	0.941
Dad years schooling	0.324	8.351	2.71	2.032***	11.088	22.53	1.178
Years in preschool	2.680	1.576	4.22	11.05***	1.488	16.44	6.864
Education inputs index	5.731***	3.978	22.90	7.518***	4.654	34.99	6.625
Books in home	-0.007	52.00	-0.37	0.077***	114.10	8.78	0.035
Days attend past 2 wks	13.88***	9.837	136.50	7.114***	9.622	68.46	10.50
Hours study per week	2.340***	5.519	12.92	2.517***	5.362	13.49	2.429
Extra reading class hr/wk	-1.798***	1.344	-2.42	-4.881***	0.994	-4.61	-3.340
Extra reading class miss.	-0.201	0.343	-0.07	-3.113***	0.358	-1.12	-1.657
Class size	0.396	42.82	16.95	0.295***	32.62	9.62	0.345
Proport. qualified tchrs	10.63*	0.800	5.50	35.38***	0.834	29.50	23.00
Prop. qual. tchr. missing	-16.37**	0.057	-0.93	-27.05***	0.188	-5.08	-21.71
Square root comp/pupil	1.345	0.407	0.55	3.813	0.623	2.38	2.579
Stud perf. to assess tchrs	4.980	0.995	4.95	-6.334***	0.708	-4.48	-0.677
Teacher absenteeism	2.549	0.695	1.77	-6.743***	0.779	-5.25	-2.097
Parents pressure tchrs	14.90***	1.297	19.32	7.045***	0.957	6.74	10.97
Principal observes tchrs	32.79***	0.986	32.32	-1.359	0.802	-1.09	15.71
Inspector observes tchrs	-19.56***	0.888	-17.37	-12.18***	0.406	-4.95	-15.87
Tchr pay link stud. perf.	5.123	1.461	7.48	-3.207***	0.704	-2.26	0.958
Teachers are mentored	12.92*	0.833	10.76	6.500***	0.684	4.44	9.711
Constant	24.77	1.000	24.77	137.20***	1.000	137.20	80.98
Column sum:	--	--	503.48	--	--	472.56	--

Table 10B: Reading Decomposition, 2015 (diff = 481.6– 468.1 = 13.5)

Variable	β_{vn}	$\bar{x}_{vn}$	$\beta_{vn}'\bar{x}_{vn}$	β_o	$\bar{x}_o$	$\beta_o'\bar{x}_o$	$\bar{\beta}$ (= $(\beta_{vn}+\beta_o)/2$	$\bar{\beta}'$
Wealth	7.132***	1.754	12.51	10.57***	4.194	44.31	8.849	[illegible]
Girl	15.93***	0.528	8.409	18.44***	0.509	9.389	17.185	
Grade 10	53.02***	3.862	204.7	21.16***	3.779	79.95	37.09	
Mom years schooling	0.324	7.924	2.56	2.261***	11.45	25.89	1.292	[illegible]
Dad years schooling	1.801***	8.060	14.51	2.422***	11.54	27.95	2.111	[illegible]
Education input index	6.075***	3.907	23.74	7.982***	4.407	35.17	7.028	[illegible]
Books in home	-0.032***	67.81	-2.190	0.078***	113.2	8.87	0.023	[illegible]
Class size	0.759*	39.44	29.93	0.029	31.09	0.904	0.394	
Proport. qualified tchrs	1.670	0.832	1.390	13.63***	0.805	10.96	7.649	
Prop. Qual. tchr. missing	-20.04*	0.074	-1.485	-6.213	0.085	-0.526	-13.126	
Square root comp/pupil	15.86	0.391	6.198	16.68***	0.649	10.835	16.27	[illegible]
Stud perf. to assess tchrs	-20.83**	0.987	-20.55	-3.835	0.879	-3.369	-12.33	[illegible]
Teacher absenteeism	-0.241	0.650	-0.156	-5.240***	0.833	-4.363	-2.741	
Principal observes tchrs	32.85***	0.997	32.75	2.473	0.875	2.164	17.66	
Inspector observes tchrs	-0.676	0.756	-0.511	-3.148*	0.568	-1.787	-1.912	[illegible]
Teacher are mentored	25.97***	0.981	25.48	-8.747***	0.857	-7.50	8.611	
Constant	144.3***	1.000	144.3	229.23***	1.000	229.2	186.8	
Column sum:			481.6			468.1		[illegible]

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

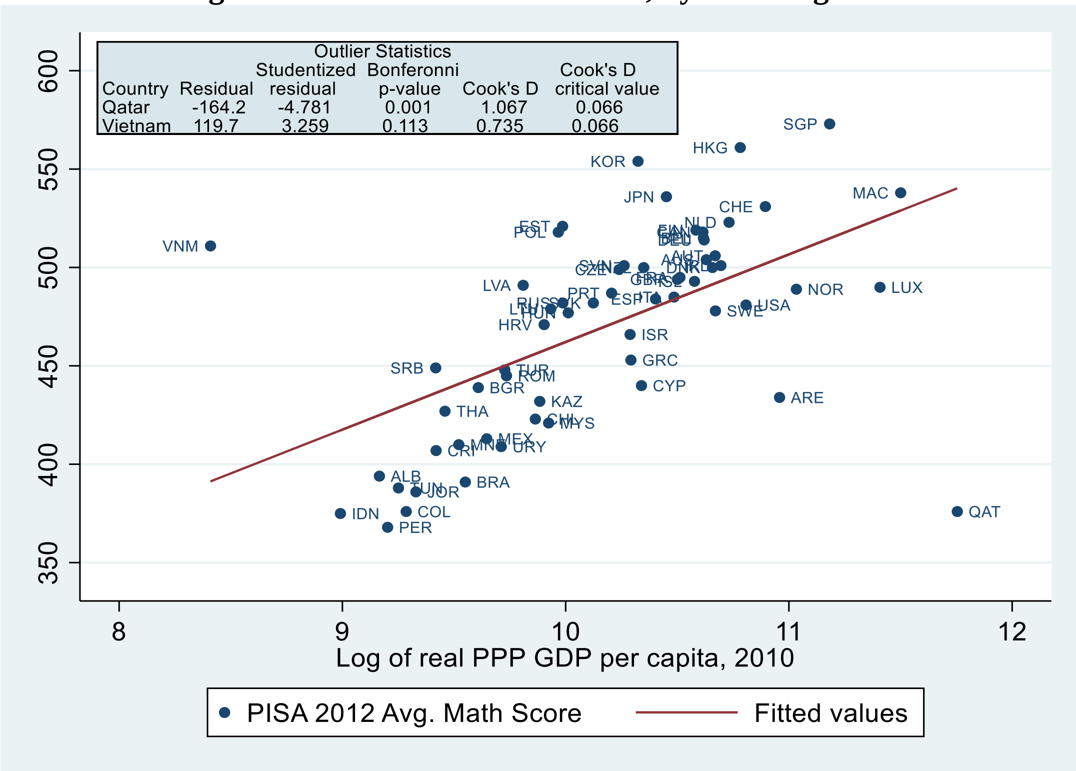
$$\mu_{ut} = \bar{T}_a + \lambda_a(\alpha) \frac{\tau - \bar{T}_a}{\lambda_a(\alpha) + \alpha} \tag{1.13}$$

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)

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

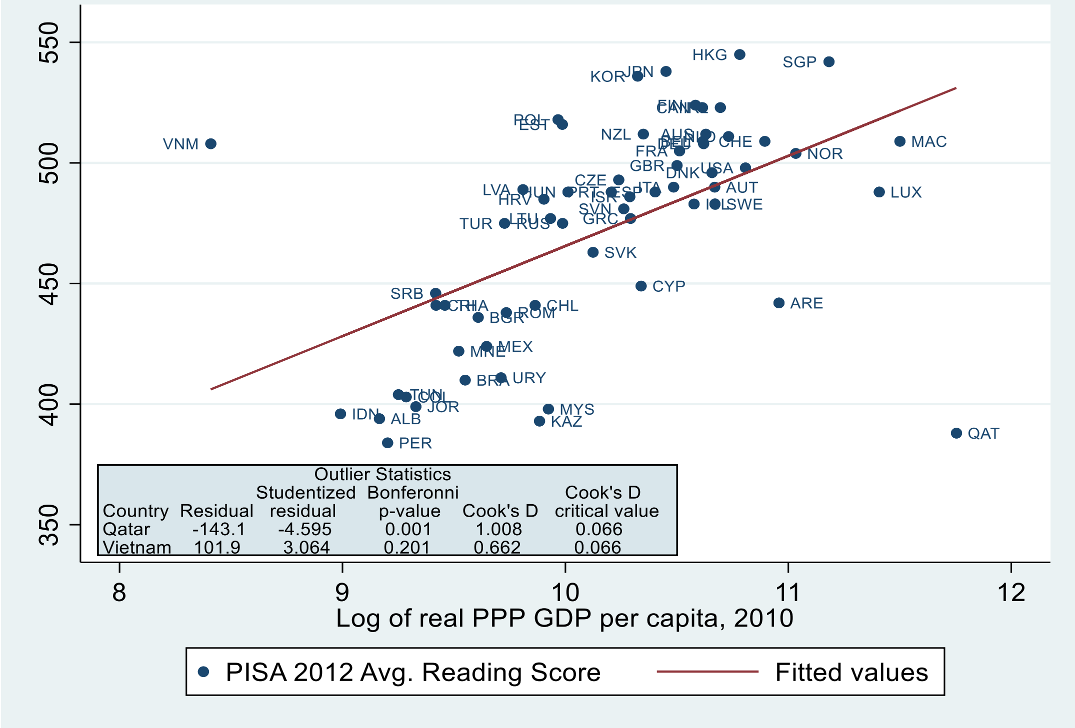
Appendix B: Additional Figures and Tables

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



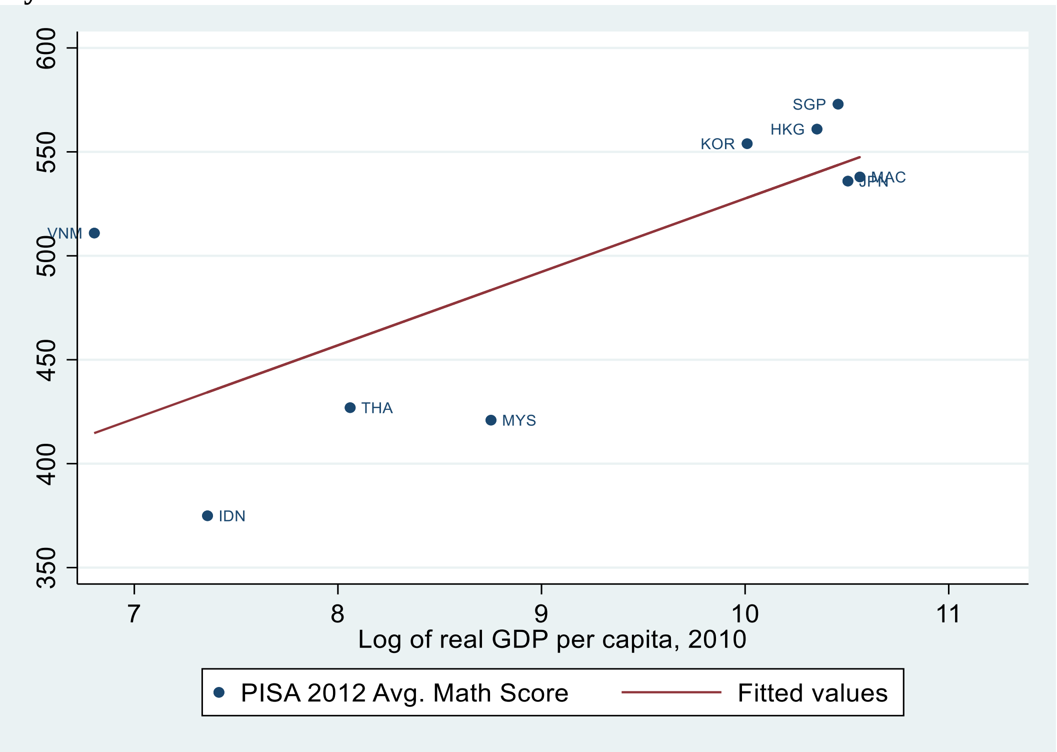
Note: The outlier statistics are shown only for countries that are outliers by one or both of the two criteria.

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



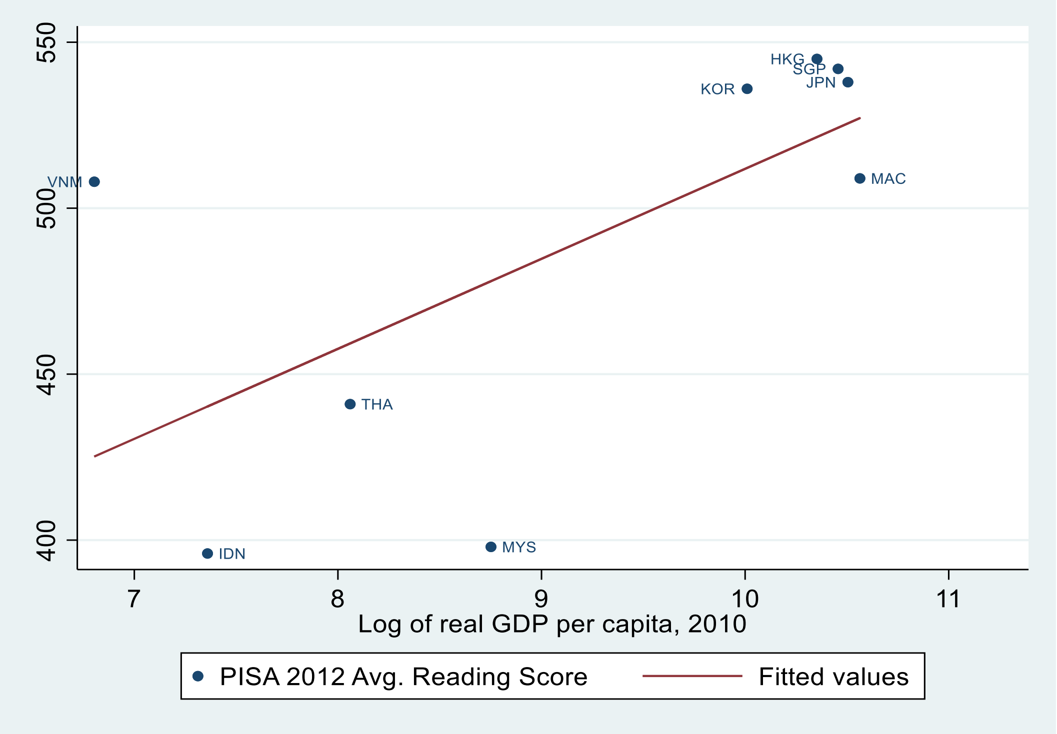
Note: The outlier statistics are shown only for countries that are outliers by one or both of the two criteria.

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



Outlier statistics not shown due to small sample size.

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



Outlier statistics not shown due to small sample size.

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

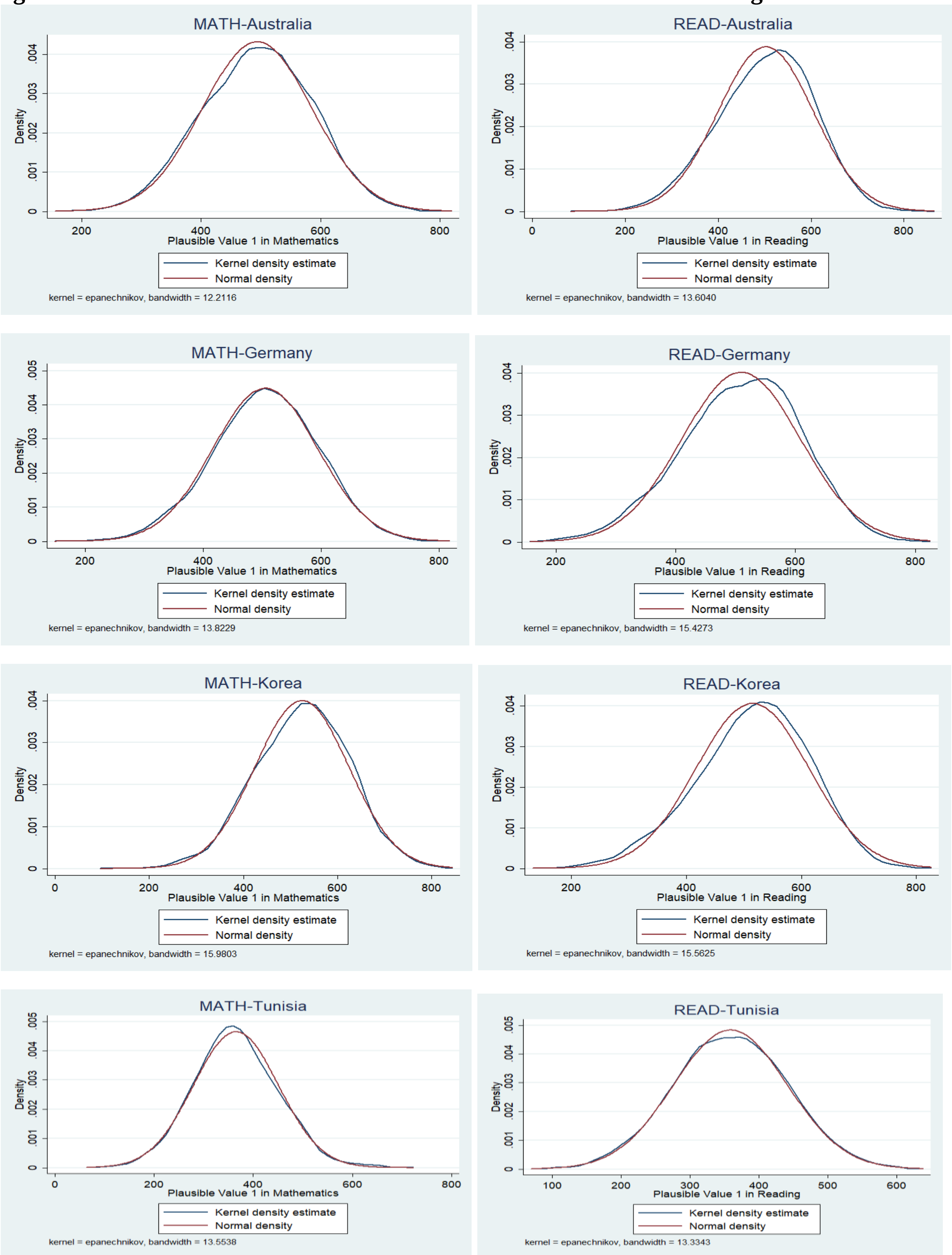


Figure B6. Distribution of Test Scores, Truncated from Below

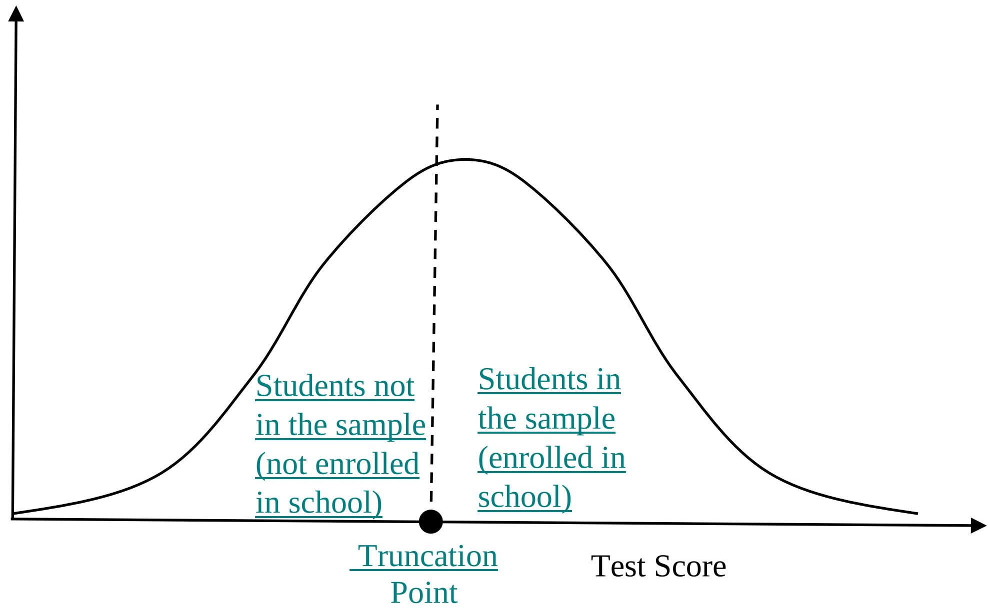


Table B1: Predictors of 2012 PISA Scores in Vietnam

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<0.01, ** p<0.05, * p<0.1

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

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 20 PISA Scores, Decile (all 1 year-olds)**	
				Math	Reading	Math	Reading	Math	Reac
1	0.582	0.701	1.427	358.0	363.4	364.3	370.3	340.8	34
2	0.646	0.776	1.289	409.4	419.2	421.5	432.1	391.2	39
3	0.746	0.897	1.115	442.1	449.6	454.3	461.7	419.9	42
4	0.761	0.915	1.093	463.2	472.1	477.2	484.8	444.1	44
5	0.849	1.022	0.978	483.2	492.6	498.7	502.7	466.3	46
6	0.885	1.065	0.939	507.2	509.4	521.2	520.1	488.0	48
7	0.920	1.106	0.904	530.1	528.2	543.8	539.5	512.7	50
8	0.951	1.144	0.874	555.4	548.1	568.5	558.8	539.6	52
9	0.973	1.171	0.854	586.6	570.8	600.6	583.2	571.5	55
10	1.000	1.203	0.831	648.7	615.9	662.6	630.1	635.6	60
Average	0.831	1.000		498.4	496.9	511.2	508.2	481.0	47

Table B4: Student Characteristics in 2012 (born in 1996) and 2015 (born in 1999): PISA, VHLSS, PISA with 2009 Census Weights

	2012 PISA and 2012 VHLSS			2015 PISA and 2014 & 2016 VHLSS		
	PISA		VHLSS (PISA-eligible only)	PISA		VHLSS (PISA-eligible only)
Variable	PISA weights (1)	Census weights (2)	Mar.-July (3)	PISA weights (4)	Census weights (5)	Mar.-July (6)
Urban	50.3%	26.9%	25.3%	49.6%	27.1%	28.6%
Female	53.8%	52.5%	51.7%	51.4%	49.5%	47.1%
Current grade: 10 or higher	86.1%	80.2%	75.7%	85.5%	79.4%	84.3%
Current grade: 9 or lower	10.3%	16.4%	22.2%	9.0%	14.5%	15.1%
Current grade: unknown/other[a/]	3.6%	3.4%	2.1%	5.5%	6.1%	0.6%
Father's years of schooling	8.95	8.26	7.19	8.4	8.02	6.9
Mother's years of schooling	8.34	7.88	6.93	7.9	7.81	6.4
Owns an air-conditioner	16.0%	9.2%	7.1%	20.7%	12.8%	15.2%
Owns a motorbike	93.1%	91.2%	90.7%	93.9%	93.0%	93.8%
Owns a car	7.3%	6.8%	1.0%	7.9%	4.9%	2.6%
Owns a computer	39.1%	17.9%	25.1%	44.1%	24.2%	28.5%
Number of televisions owned	1.39	1.24	1.00	1.42	1.27	1.05
Sample size	4,771	4,771	236	5,687	5,687	415

[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 B.5: Math Decomposition Using Fixed-Effects Estimates of β_o (diff = 516.54– 462.80 = 53.74)

Variable	β_{vn}	$\bar{x}_{vn}$	$\beta_{vn}'\bar{x}_{vn}$	β_o	$\bar{x}_o$	$\beta_o'\bar{x}_o$	$\bar{\beta}$ (= $(\beta_{vn}+\beta_o)/2$	$\bar{\beta}'(\bar{x}_{vn}$
Wealth	6.764^{***}	4.143	28.02	5.316^{***}	6.101	32.43	6.040	-11.8
Grade 10	85.85^{***}	0.874	75.01	19.34^{***}	0.584	11.29	52.595	15.2
Sibling index	3.152^{*}	1.048	3.30	-2.343^{***}	1.086	-2.54	0.405	-0.0
Sibling index missing	-0.576	0.149	-0.09	-18.19^{***}	0.238	-4.33	-9.383	0.84
Mom years schooling	0.962^{***}	8.313	8.00	1.657^{***}	10.975	18.19	1.310	-3.4
Dad years schooling	1.511^{***}	8.883	13.42	1.991^{***}	11.086	22.07	1.751	-3.8
Years in preschool	6.533^{***}	1.600	10.45	9.972^{***}	1.487	14.83	8.253	0.93
Education inputs index	4.397^{***}	4.680	20.58	6.858^{***}	5.154	35.35	5.628	-2.6
Books in home	0.00887	57.59	0.51	0.0677^{***}	114.07	7.72	0.038	-2.1
Days attend past 2 wks	10.43^{***}	9.849	102.72	7.040^{***}	9.622	67.74	8.735	1.98
Hours study per week	2.920^{***}	5.756	16.81	2.882^{***}	5.362	15.45	2.901	1.14
Extra math class, hrs/wk	3.904^{***}	2.741	10.70	-0.858^{***}	1.325	-1.14	1.523	2.16
Extra math class missing	8.890^{***}	0.336	2.98	-2.590^{***}	0.358	-0.93	3.150	-0.0
Class size	0.0643	44.81	2.88	0.0657^{***}	32.61	2.14	0.065	0.79
Proport. qualified tchrs	18.18^{***}	0.800	14.55	12.62^{***}	0.834	10.53	15.400	-0.5
Prop. qual. tchr. missing	-17.15^{***}	0.069	-1.18	-0.486	0.188	-0.09	-8.818	1.05
Square root comp/pupil	-0.0392	0.417	-0.02	-0.782	0.623	-0.49	-0.411	0.08
Stud perf. to assess tchrs	25.08^{**}	0.992	24.89	1.708^{***}	0.708	1.21	13.394	3.80
Teacher absenteeism	-0.759	0.692	-0.53	-3.475^{***}	0.778	-2.70	-2.117	0.18
Parents pressure tchrs	15.71^{***}	1.311	20.60	11.23^{***}	0.957	10.75	13.470	4.77
Principal observes tchrs	14.12^{**}	0.965	13.63	-2.586^{***}	0.802	-2.07	5.767	0.94
Inspector observes tchrs	-16.73^{***}	0.847	-14.17	-4.317^{***}	0.406	-1.75	-10.524	-4.6
Tchr pay link stud. perf.	2.209	1.487	3.28	-2.397^{***}	0.703	-1.69	-0.094	-0.0
Teachers are mentored	6.766^{**}	0.845	5.72	5.030^{***}	0.684	3.44	5.898	0.95
Constant	154.46^{***}	1.000	154.46	227.4^{***}	1.000	227.39	190.93	0.00
			516.54			462.80		5.55

Table B.6: 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	$\bar{x}_o$	$\beta_o'\bar{x}_o$	$\bar{\beta}$ (= $(\beta_{vn}+\beta_o)/2$	$\bar{\beta}'(\bar{x}_{vn}-$
Wealth	4.748***	4.143	19.67	3.859***	6.101	23.54	4.3035	-8.4
Grade 10	79.18***	0.874	69.18	21.15***	0.584	12.35	50.165	14.5
Sibling index	4.045***	1.048	4.24	-2.214***	1.086	-2.40	0.9155	-0.0
Sibling index missing	-0.428	0.149	-0.06	-12.56***	0.238	-2.99	-6.494	0.58
Mom years schooling	0.721**	8.313	5.99	1.297***	10.975	14.23	1.009	-2.6
Dad years schooling	0.694**	8.883	6.17	1.702***	11.086	18.87	1.198	-2.6
Years in preschool	4.884***	1.600	7.81	10.28***	1.487	15.29	7.582	0.86
Education inputs index	5.657***	4.680	26.47	8.447***	5.154	43.54	7.052	-3.3
Books in home	0.00231	57.59	0.13	0.0572***	114.07	6.52	0.029755	-1.6
Days attend past 2 wks	16.08***	9.849	158.34	7.325***	9.622	70.48	11.7025	2.66
Hours study per week	2.335***	5.756	13.44	3.225***	5.362	17.29	2.78	1.10
Extra reading class hr/wk	-1.547***	2.741	-1.99	-4.460***	1.325	-5.91	-3.0035	-4.2
Extra reading class miss.	0.712	0.336	0.24	-3.047***	0.358	-1.09	-1.1675	0.03
Class size	0.258***	44.81	11.58	0.261***	32.61	8.51	0.2595	3.17
Proport. qualified tchrs	16.22***	0.800	12.98	9.841***	0.834	8.21	13.0305	-0.4
Prop. qual. tchr. missing	-17.21***	0.069	-1.19	-2.079***	0.188	-0.39	-9.6445	1.15
Square root comp/pupil	-4.467	0.417	-1.86	0.639	0.623	0.40	-1.914	0.39
Stud perf. to assess tchrs	1.901	0.992	1.89	2.067***	0.708	1.46	1.984	0.56
Teacher absenteeism	-1.489	0.692	-1.03	-3.003***	0.778	-2.34	-2.246	0.19
Parents pressure tchrs	9.980***	1.311	13.08	11.22***	0.957	10.74	10.6	3.75
Principal observes tchrs	34.74***	0.965	33.53	-0.136	0.802	-0.11	17.302	2.82
Inspector observes tchrs	-18.02***	0.847	-15.26	-6.500***	0.406	-2.64	-12.26	-5.4
Tchr pay link stud. perf.	3.676***	1.487	5.47	-2.740***	0.703	-1.93	0.468	0.37
Teachers are mentored	9.211***	0.845	7.78	5.721***	0.684	3.91	7.466	1.20
Constant	136.21***	1.000	136.21	237.0***	1.000	236.97***	186.59	0.00
			512.82			472.52		4.45