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What Explains Vietnam's Exceptional Performance in Education Relative to Other Countries? Analysis of the 2012, 2015, and 2018 PISA Data

Hai-Anh Dang [a,b,c], Paul Glewwe [d], Jongwook Lee [e,*], Khoa Vu [d]

[a] World Bank, United States
[b] International School, Vietnam National University, Hanoi, Vietnam
[c] London School of Economics and Political Science, United Kingdom
[d] Department of Applied Economics, University of Minnesota, United States
[e] Department of Agricultural Economics and Rural Development, Seoul National University, Republic of Korea

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ABSTRACT

Despite being the poorest or second poorest participant, Vietnam outperformed all other developing countries, and many wealthier countries, on the 2012, 2015, and 2018 PISA assessments. We investigate Vietnam's strong performance, evaluating several possible explanations for this apparent exemplary achievement. After correcting for potentially non-representative PISA samples, including bias from Vietnam's large out-of-school population, Vietnam remains a large positive outlier conditional on its income. Possible higher motivation of, and coaching given to, Vietnamese students can at most only partly explain Vietnam's performance. The child-, household- and school-level variables in the PISA data explain little of Vietnam's strong PISA performance relative to its income level. At most, they explain about 30% of Vietnam's exceptional performance in math and reading. Further research is needed to understand the exceptional performance of Vietnamese students.

1. 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 and MPI, 2016). More recently, its accomplishments in education have been equally impressive. In terms of "quantity", it has a primary school completion rate of 97% and a lower secondary enrollment rate of 95%.[1] More striking is its performance on the 2012 PISA assessment of education "quality"; despite being the poorest participant, it 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 all other developing countries (OECD, 2014a). Its 2012 PISA math and readings scores (at 511 and 508), for example, were over one standard deviation higher than those of Indonesia (375 and 396), a nearby country with GDP per capita 60% higher than that of Vietnam.[3]

A visual depiction of Vietnam's performance on the PISA in 2012 is shown in Figs. 1 and 2, which plot PISA math and reading scores by the log of per capita GDP for all 63 countries (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 Figs. 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 other countries are outliers by these criteria. Vietnam is also the largest positive outlier when: a) purchasing power parity (PPP) GDP is used; b) the 2015 and

* Corresponding author.
E-mail address: jongwooklee@snu.ac.kr (J. Lee).

[1] The lower secondary rate is from Dang and Glewwe (2018); the primary rate is from the 2014 VHLSS (see below).

[2] We consider only countries, so we drop Shanghai (a city in China) and Perm (part of Russia) respectively. We treat Hong Kong, Macao and Taiwan as countries, though the first two are part of China, and Taiwan's status is disputed.

[3] Indonesia, which is similar to Vietnam and was the second poorest participant in the 2012 PISA, has a GDP per capita of $US 3,331 in 2015; the corresponding figure for Vietnam in that year was $US 2,085 (World Bank, 2021).

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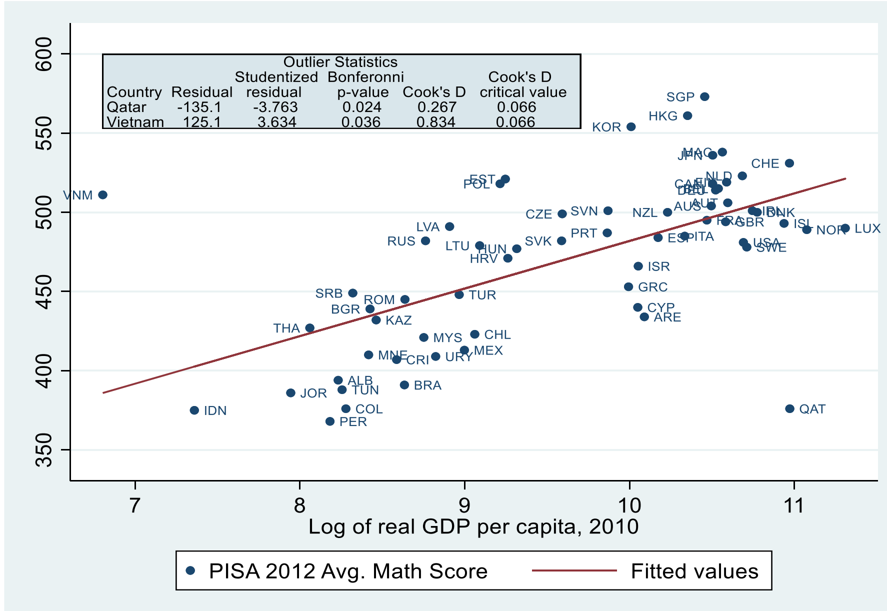

Fig. 1. Mean Age 15 Math Scores in 2012 PISA, by 2010 Log Real GDP/capita
Note: The outlier statistics are shown only for countries that are outliers by one or both of the two criteria.

2018 PISA assessments are considered; and c) the sample is limited to the nine East Asian and Southeast Asian nations in the 2012 PISA.[4]

This paper uses the 2012, 2015, and 2018 PISA data to investigate Vietnam's unusually high performance on these assessments of student learning. It has two objectives. First, it examines whether Vietnam's impressive PISA performance may be exaggerated because: i) the 15-year-old students in Vietnam who participated in the PISA are not representative of 15-year-old students in Vietnam; ii) the enrollment rate of 15-year-olds in Vietnam is much lower than the rates in other PISA countries; iii) Vietnamese students put more effort into those assessments than other students; and iv) Vietnamese schools implemented coaching to increase their students' PISA scores. Second, it uses regression methods to investigate whether child, household, teacher or school characteristics can explain Vietnamese students' high PISA performance.

The first finding is that Vietnam's striking performance on the 2012, 2015, and 2018 PISA assessments is at most only partially reduced by adjustments to reduce the above-mentioned possible sources of upward bias. The second finding is that the child-, household-, teacher- and school-level variables in the PISA data explain little of Vietnam's high performance on the PISA assessments relative to its income level. At most, they explain about 30% of Vietnam's exceptional performance in math and reading on the PISA assessments.

This paper consists of five sections. Section 2 describes the PISA data. The following section examines possible mechanisms that could exaggerate Vietnam's performance, after which Section 4 uses regression methods to investigate whether family, teacher and school characteristics can explain Vietnam's performance. Section 5 summarizes and concludes.

2. The 2012, 2015, and 2018 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 15-year-old students around the world.[5] First implemented in the year 2000, since then it has been conducted every three years. While initially focused on the OECD countries, in recent years PISA has added many non-OECD countries. This paper examines the PISA results for 2012, 2015, and 2018, when 65, 72 and 79 countries participated, respectively.

The PISA administers mathematics, reading and science tests to 15-year-olds who are enrolled in school. Three characteristics of the PISA are important for this paper. First, while countries may care about their PISA scores, the students who participate face no consequences for their performance. This may lead some students to exert little effort when taking the test.

Second, in any classroom where students participate in the PISA, several versions of the test are given, although all versions have questions in common. Thus, comparing raw scores among students who took different versions of the test may be misleading. Instead, we use Item Response Theory (IRT) to generate comparable scores for students who took different versions. See Das and Zajonc (2010) and Jacob and Rothstein (2016) for introductions to IRT methods.

Third, the PISA scoring algorithm partially corrects for low effort. Unanswered questions at the end of the tests are not counted in the scoring (OECD 2016b, p.149); they are treated as though the test did not have those questions.[6] 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 do not treat such unanswered questions as incorrect responses. Akyol, Krishna and Wang (2021) estimate that this algorithm removes about half of the difference in PISA test scores that is due to variation in effort, and that methods to correct for the remaining

[4] See Figures B1 and B2 (PPP GDP), B3-B6 (2015 and 2018) and B7 and B8 (Asian nations) in online Appendix B.

[5] The information in this section is from OECD (2014a, 2014b, 2016a, 2016b, 2019). Note that the number of "countries" given later in this paragraph includes entities that are not countries, which we exclude (see footnote 2).

[6] 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 rarely run out of time; the vast majority who left questions unanswered at the end of the test had time to answer them but chose not to do so.

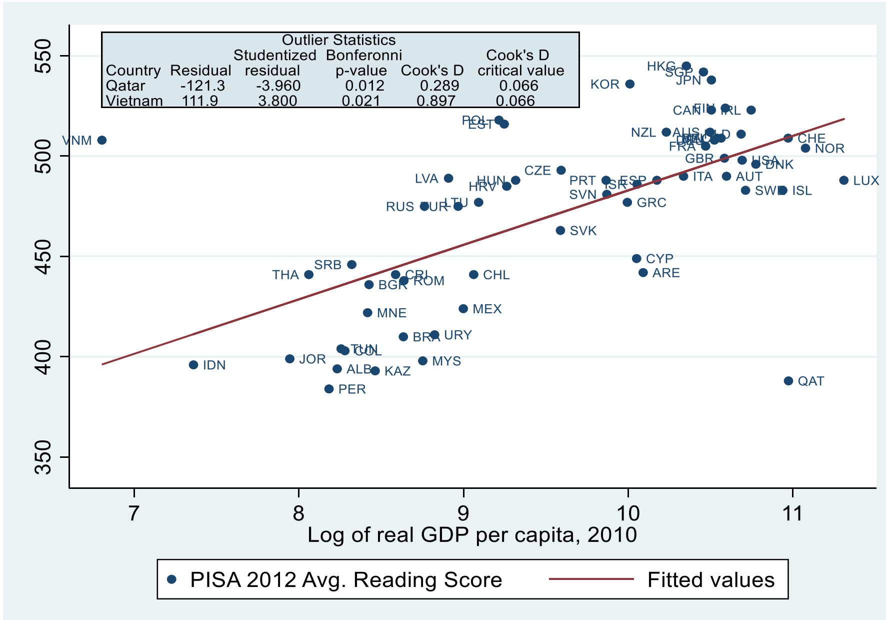

Fig. 2. Mean Age 15 Reading Scores in 2012 PISA, by 2010 Log Real GDP/capita
Note: The outlier statistics are shown only for countries that are outliers by one or both of the two criteria.

effort differences have little effect on countries' rankings.[7]

3. Is Vietnam's Performance on the 2012, 2015, and 2018 PISA Assessments Exaggerated?

Some observers, both Vietnamese and international, of Vietnam's high performance on the 2012, 2015, and, 2018 PISA assessments are surprised that Vietnam could perform so well.[8] This section investigates four possible phenomena that could exaggerate Vietnam's performance: i) The 15-year-old Vietnamese PISA participants in those three years were not representative of the population 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 exerted more effort when participating in the PISA; and iv) Vietnamese schools organized coaching to increase their students' PISA scores.

3.1. Were Vietnam's PISA Participants "Above Average" Students?

Vietnam's PISA participants may not have been representative of the students those assessments were intended to sample. Consider the 2012 PISA. In each 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).[9] Whether Vietnam's 2012 PISA participants 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 Standards Survey (VHLSS), which Vietnam's General Statistical Office conducts every two years. One can compare Vietnamese children in the 2012 VHLSS who were born in 1996 and were students in 2012 with the Vietnamese students who participated in the 2012 PISA.

Table 1 makes this comparison using the 2012 PISA and the 2012 VHLSS data. There are several discrepancies that merit attention. Compared to the 2012 VHLSS data, students who participated in the 2012 PISA are much more likely to live in urban areas (50% vs. 26%),[10] are 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 wealthier homes (with more air conditioners, motorbikes, cars, computers and televisions).

The discrepancy in 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, when 22% of the children born in 1996 were still in grade 9 (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 moved up to the next grade in September of 2012),[11] 76% were in grade 10, and 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. Grades 9 and 10 have an important difference in Vietnam; 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 data have passed an exam that selects better-performing students for upper secondary school, but the VHLSS data indicate that only 76% of students in Vietnam who were eligible to participate in the PISA when it was given in April of 2012 were in grade 10 and thus had passed that exam. Similar patterns are seen in the 2015 PISA and 2018 PISA data (see Tables B1

[7] 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.

[8] See, for example, the comments by Deputy Minister of Education Nguyen Vinh Hien in Dân Trí News (2013).

[9] 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) to 16 years and 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).

[10] 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.

[11] 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.

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

	2012 PISA and 2012 VHLSS			
	PISA	VHLSS (PISA-eligible only)		
Variable	(1)	All (2)	Mar.-July (3)	Difference (3) – (1)
Urban	50.3%	26.0%	25.3%	-24.9***
	(4.2)	(2.3)	(3.2)	(5.2)
Female	53.8%	51.7%	51.7%	-2.1
	(0.8)	(2.6)	(3.5)	(3.6)
Current grade: 10 or higher	86.1%	84.3%	75.7%	-10.4***
	(2.6)	(1.8)	(3.0)	(3.9)
Current grade: 9 or lower	10.3%	14.0%	22.2%	11.9***
	(2.2)	(1.7)	(2.8)	(3.6)
Current grade: unknown/ other[a/]	3.6%	1.7%	2.1%	-1.5
	(1.5)	(0.7)	(1.3)	(2.0)
Father's years of schooling	8.95	7.18	7.19	-1.76***
	(0.17)	(0.22)	(0.32)	(0.37)
Mother's years of schooling	8.34	6.80	6.93	-1.41***
	(0.19)	(0.19)	(0.26)	(0.32)
Owns an air-conditioner	16.0%	7.1%	7.1%	-8.8***
	(2.1)	(1.4)	(2.1)	(3.0)
Owns a motorbike	93.1%	91.0%	90.7%	-2.4
	(0.5)	(1.4)	(2.0)	(2.1)
Owns a car	7.3%	0.7%	1.0%	-6.3***
	(0.8)	(0.3)	(0.7)	(1.1)
Owns a computer	39.1%	24.5%	25.1%	-14.1***
	(2.2)	(2.3)	(3.2)	(3.9)
Number of televisions owned	1.39	1.00	1.00	-0.38***
	(0.03)	(0.02)	(0.03)	(0.04)
Sample size	4,771	455	236	
PISA coverage/eligibility rate	56%	75%	78%	

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".

and B2 in online Appendix B, and see Dang et al. (2021) for further discussion of these results).

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 Vietnam PISA data to predict Vietnamese students' performance on the PISA, assuming that the predictive power of the student-level characteristics is valid for those same characteristics measured in the VHLSS.

More specifically, consider an ordinary least squares (OLS) regression that uses the PISA data for Vietnam to predict student scores on that assessment based on the variables in Table 1:[12]

$$PISAscore_i = \boldsymbol{\beta}'\mathbf{X}_i + u_i \tag{1}$$

where $\mathbf{X}_i$ is a vector, for student i, of the student characteristics shown in Table 1.

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:

$$\overline{\text{PISAscore}} = \widehat{\boldsymbol{\beta}}'_{\text{OLS}}\overline{\mathbf{X}}_{\text{PISA}} \tag{2}$$

where the horizontal bars indicate mean values and $\widehat{\boldsymbol{\beta}}_{\text{OLS}}$ is the OLS estimate of $\boldsymbol{\beta}$. This is shown in 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 $\widehat{\beta}_{\text{OLS}}$ coefficients (from Table B3 in online Appendix B, which shows the regression results for the 2012, 2015, and 2018 PISA data), and the fifth column shows the product of each variable with its estimated coefficient. Summing the fifth column produces the actual 2012 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.

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 Figs. 1 and 2 shows that Vietnam is still an outlier even after allowing for this drop. Similar calculations comparing the 2015 PISA with the 2014 and 2016 VHLSS and the 2018 PISA with the 2018 VHLSS show even smaller effects that do not change Vietnam's outlier status (see Figures B3-B6 and Tables B4-B7 in online Appendix B, and see Dang et al. (2021) for further discussion of these results).

3.2. *Correcting, and Two 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 in school. 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 because they were not 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 65 countries that participated in the 2012 PISA; only Albania (55.2%) and Costa Rica (49.6%) had lower rates.[13] Vietnam's coverage rate is even lower in the 2015 PISA; of the 66 participating countries, its 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 for the 2012 and 2015 PISAs, and then presents two different methods to adjust for Vietnam's (corrected) lower coverage rate. Even after making these corrections and adjustments, Vietnam is still a positive outlier, given its low income, in terms of its performance on the 2012 and 2015 PISA assessments.

[12] 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.

[13] Albania's rate may be wrong; it is much higher for the 2009 and 2015 PISA; we thank Francesco Avvisati for this information.

Table 2
Predicted 2012 PISA Math Scores Based on VHLSS Data, Decomposed by Variable (Using March – July Means of VHLSS data)

Variable	Variable Means		Difference in Means	Math Coeff.	Math Coefficient Multiplied by:		Difference in Means
	PISA	VHLSS			PISA Mean	VHLSS Mean	
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	1.30	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

Table 3
Predicted 2012 PISA Reading Scores Based on VHLSS Data, Decomposed by Variable. (Using March – July Means for the VHLSS data)

Variable	Variable Means		Difference in Means	Reading Coeff.	Reading Coefficient Multiplied by:		Difference in Means
	PISA	VHLSS			PISA Mean	VHLSS Mean	
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

Correcting PISA Coverage Rates. The 2012 and 2015 PISA reports (but not the 2018 report) incorrectly calculated Vietnam's coverage rates. Correcting them leads to large increases in those rates. Vietnam's census data were incorrectly used to calculate the number of 15-year-olds in Vietnam in 2012 and 2015 (see online Appendix A). Correctly applying the census data to the school enrollment data in the PISA reports yields the correct 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, as explained above, are a selected group. The rest of this subsection applies two 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 low coverage rates, such as Vietnam, this adjustment underestimates the performance of the top 50% of 15-year-olds 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%.

Comparisons of the top 50% of 15-year-olds show that Vietnam's performance is still impressive given its low income. First, Vietnam still outperforms almost all other developing countries on the 2012, 2015, and 2018 PISA assessments, 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).[14] Second, 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. The (studentized) size of these outliers, and Vietnam's residual ranking, are shown in rows 7 and 8 of Table 4, while rows 1 and 2 (taken from Figs. 1 and 2) show the same information when no adjustments are made. While the studentized residuals are slightly smaller in rows 7 and 8, Vietnam remains the largest positive outlier. Vietnam also remains the largest positive outlier when the same adjustments are made for the 2015 PISA and the 2018 PISA, as seen by comparing rows 9-12 with rows 3-6 in Table 4.[15]

Method 2. *Adjustment with Auxiliary Data*. A second way to adjust the mean of the test scores for Vietnamese students to account for PISA non-participants is to use the Young Lives data. The Young Lives Study has collected six rounds of data from two cohorts of children in four developing countries – Ethiopia, India, Peru and Vietnam – since 2002; for further details, see www.younglives.org.uk. The younger cohort children in the Young Lives Study were 15 years old in Round 5 of that study. The data from that round, collected in 2016, include math and reading comprehension tests.[16] The Vietnam sample consists of 1,940 15-year-olds, *including both those in shcool and those not in school*; as expected, the latter had lower average math (9.4 out of 21) and reading (10.9 out of 25) scores than the former (15.5 and 14.8, respectively).

Assuming that the Young Lives reading and math scores assign ranks

[14] See Tables B8 and B9 of online Appendix B, which are discussed in detail in Dang et al. (2021).

[15] Figs. B9-B14 in online Appendix B provide a visual depiction of these results for 2012, 2015, and 2018.

[16] These math and reading tests were designed by the Young Lives Study and are not the same as the PISA tests.

Table 4
Outlier Statistics for Vietnam for Other Years and Alternative Assumptions

Alternative Assumption	Year	Subject	Studentized Residual for Vietnam	Residual Rank
1. None	2012	Math	3.63	1
2. None	2012	Reading	3.80	1
3. None	2015	Math	3.39	1
4. None	2015	Reading	3.23	1
5. None	2018	Math	3.13	1
6. None	2018	Reading	3.63	1
7. Top 50% of all 15-year olds	2012	Math	3.29	1
8. Top 50% of all 15-year olds	2012	Reading	3.34	1
9. Top 50% of all 15-year olds	2015	Math	3.39	1
10. Top 50% of all 15-year olds	2015	Reading	2.50	1
11. Top 50% of all 15-year olds	2018	Math	2.41	1
12. Top 50% of all 15-year olds	2018	Reading	2.96	1
13. Set of four other adjustments	2012	Math	2.51	1
14. Set of four other adjustments	2012	Reading	2.30	1
15. Set of four other adjustments	2015	Math	2.37	1
16. Set of four other adjustments	2015	Reading	2.30	2
17. Set of four other adjustments	2018	Math	2.33	1
18. Set of four other adjustments	2018	Reading	2.40	1

Studentized residuals divide the Vietnam residual by the estimated standard deviation of all of the residuals in the regression. The "four other adjustments" are: 1. Adjustments for a possibly unrepresentative sample of 15-year-olds who are in school, based on comparisons with the 2012, 2014 and 2016 VHLSS data; 2. Adjustments for 15-year-olds who are not enrolled in school; 3. Accounting for possibly higher motivation to perform on any test by Vietnamese students; and 4. PISA-specific coaching. See the text for the details of all these adjustments.

to Vietnamese 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 is done only for Vietnam, because only one other PISA country (Peru) has Young Lives data; doing this adjustment only for Vietnam will generate a bias against finding Vietnam to be an outlier.) This adjustment is done as follows. First, the Young Lives sample was sorted into 10 deciles based on the average test scores over the math and reading 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. 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. The PISA data are then divided into corresponding deciles. For example, of all 15-year-olds *in school* in the Young Lives data, 7.01% are in the bottom decile of the distribution of the academic performance of *all* 15-year-olds in the Young Lives data. Thus, the bottom 7.01% (in terms of performance on the PISA) of the 15-year-old PISA participants are assigned to the bottom decile of the hypothetical PISA distribution that includes all 15-year-olds. The last step in the adjustment is to assume that the mean of the scores of 15-year-olds not in school in each decile 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. See Table B10 in online Appendix B for the calculations; Dang et al. (2021) provide a more detailed explanation.

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 and 2018 PISA data reduce the 2015 (2018) PISA math scores by only 12.4 (10.8) points and the 2015 (2018) PISA reading scores by only 10.9 (10.8) points. These relatively small changes do not change the overall finding that Vietnam's PISA performance was exceptional.

3.3. Were Vietnamese Students More Motivated to Exert Effort on the PISA?

A third possible reason for Vietnam's high PISA performance is that Vietnamese students really did outperform those in most other countries, but not due to higher skills; rather, they were highly motivated when taking the PISA tests. There are no studies of the motivation of Vietnamese students when taking international tests, but there are 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 that have no consequences. Gneezy et al. (2019) administered tests based on questions from previous PISA math tests to Chinese and U.S. students. The Chinese students scored much higher than U.S. students under usual conditions. Yet randomly selected U.S. students who were offered financial rewards for high scores performed much better (22-24 points higher), while Chinese students performed no differently. This suggests that Chinese students are highly motivated to exert effort on tests despite no direct benefits.

Vietnam's culture is similar to China's culture, so Vietnamese students' intrinsic motivation may have raised their PISA scores. As Section 2 explained, PISA's scoring algorithm partly adjusts for low effort by ignoring unanswered questions at the end of the test; such questions are treated as though the test did not have them and so are *not* counted as incorrect. Yet the PISA algorithm still counts unanswered questions in the middle of the test (unanswered questions followed by answered questions) as incorrect; such unanswered questions may reflect low effort.

Akyol, Krishna and Wang (2021) used the 2015 PISA, which was administered using computers in most (53 of 66) participating countries, to further correct for low effort. They imputed values for unanswered questions based on students' performance on the questions they did answer. Also, questions on which a student spent very little time (e.g. less than five seconds) but did answer, which can be identified since the computers record time spent on all questions, 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 upward scores on the 2015 PISA science test to predict what students' scores would be if they had exerted more effort.

Vietnam did not use computers for the 2015 PISA, yet most of the other countries did use them, and so their scores can be adjusted to incorporate further effort. Akyol et al.'s adjustments increase PISA test scores (in addition to the adjustments already made by PISA) by only 4.4 points.[17] While their analysis is for science, rather than math or reading, the results of Akyol et al. suggest that additional effort by Vietnamese students cannot explain their PISA performance.

3.4. Did Vietnamese Students Perform Better Because They Were Coached?

About two thirds of PISA test questions are multiple choice. Incorrect answers incur no penalty, so a useful strategy for students is to guess if they do not know the correct answer. There is evidence that Vietnam's teachers and schools prepped their students who took the 2012, 2015,

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

and 2018 PISA tests.[18] Studies in the U.S. and elsewhere have shown that prep sessions for academic tests can greatly raise students' scores. Bangert-Drowns et al. (1983), summarizing earlier studies, found that programs with coaching sessions of over nine hours raised average test scores by 0.39 standard deviations (of the test score distribution, which for the PISA would be 39 points). Yet those studies are of students whose test scores had crucial consequences for their academic futures while, as explained in Section 2, students' scores on the PISA have no consequences for them.[19]

Brunner et al. (2007) is the only study of the impact of coaching on students' scores on the PISA. The authors examined the impact of a German coaching program. The program was relatively modest: about three hours spread over one week (the week before a set of 2000 PISA exam questions was administered). One weakness of this study is that the schools participating in coaching were not randomly assigned; instead the teachers, in consultation with their school principals, chose the group (coaching or no coaching) they preferred. On the other hand, all results are based on changes over time (a pre-test was given one week before the coaching) in the students' scores. The study examined both mathematics and reading performance.

The Brunner et al. study was implemented in Germany's two main types of secondary schools: *Hauptschulen* (for students unlikely to go to a university after secondary school); and *Gymnasium* (for students likely to enroll in a university). The authors found that this program slightly reduced *Hauptschulen* math scores by 1.5 points, yet it raised *Gymnasium* math scores by 10.4 points (both effects are statistically insignificant).[20] The program raised *Hauptschulen* reading scores by a statistically insignificant 5.1 points, while it increased *Gymnasium* scores by a statistically significant 27.2 points. It is hard to know whether Vietnam's PISA coaching had a larger or smaller impact than the German coaching, yet these results (averaged over both types of schools) imply modest impacts at best: 4.5 points for math and 16.2 for reading. Other countries, such as Abu Dhabi, Canada and Colombia,[21] have also tried to raise their PISA scores, so any "coaching correction" of Vietnam's PISA scores would also need to be done for other countries.

3.5. *Is Vietnam Still an Outlier after Adjusting for All Potential "Exaggerations"?*

The four possible sources of exaggeration discussed above do not seem, on their own, to explain Vietnam's exceptional PISA performance, yet if they are combined is Vietnam still an outlier? This is examined by combining all the "corrections" in the previous four subsections. The results after combining these four corrections are summarized in rows 13-18 of Table 4.[22] Vietnam is still a large positive outlier; indeed, relative to its income Vietnam is the largest positive outlier in five out of six cases among all the countries in the 2012, 2015, and 2018 PISA data, after correcting (and in some ways overcorrecting) for all four potential biases that favor Vietnam.

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

Section 3 showed that 15-year-old students in Vietnam scored unusually high on the 2012, 2015, and 2018 PISA assessments given Vietnam's low GDP per capita, even after adjusting for four potential biases that may exaggerate Vietnam's performance on the PISA. Thus, there must be some other reason(s) why Vietnamese students outperform those in the other PISA countries conditional on per capita GDP. This section uses the PISA data to investigate several possible explanations for Vietnam's impressive PISA performance.

4.1. *From Country Level to Student Level Regressions*

Figs. 1 and 2 in Section 2 (and all online Appendix B figures) are based on the following simple linear regression equation:

$$\text{TestScore} = \beta_0 + \beta_{\text{gdp}} \times \text{Log}(\text{GDP} / \text{capita}) + \text{u} \tag{3}$$

In these figures, the gap between any country's actual performance and its predicted performance given its (log) GDP per capita is given by u in equation (3). Figures1 and 2 show that Vietnam's u is positive and very large. The regressions that generated these figures have one observation per country. Do student-level regressions using the PISA data yield the same finding?

Results of 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 Table 5.[23] The coefficient on GDP per capita is positive, as expected. More importantly, Vietnamese students' scores on the 2012 PISA are much higher than those predicted by this regression: their averaged u is 128.7 for the math regression and 112.6 for the reading regression (fifth row of Table 5). These are the highest values for all of the countries in the regression (see the "Residual Rank" row in Table 5), just as Vietnam is the largest positive outlier in the country-level regressions shown in Figs. 1 and 2.

The remaining columns in Table 5 explore the relationship between student test scores in 2012 and national and household level income and wealth. The log of GDP per capita variable in the columns (1) and (2) regressions in Table 5 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 student questionnaire data. This was done by applying principal components analysis to the following household variables in the student-level data: internet connection, dishwasher, DVD, number of cell phones, number of televisions, number of computers, and number of cars. The first estimated principal 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 the country average of this variable replaces the log of GDP per capita, Vietnam is still the largest outlier in the reading regression, but it

[18] Vietnamese students took a draft version of the PISA 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 protocol; students can practice using old exams to become "accustomed" to PISA exams. The schools that participate in the PISA are selected several months, and student paritipants are selected 3-4 weeks, before the exams. In Vietnam, the selected students were told that a strong showing would bring Vietnam honor and received t-shirts identifying them as PISA participants. We thank Francesco Avvisati for this information.

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

[20] 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.

[21] 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 also made efforts to increase its students' performance on the PISA, but their efforts were unsuccessful. It is likely that more countries have tried to increase their PISA scores through coaching or even changing their curriculum (see Akyol et al., 2021).

[22] These results are shown visually in Figures B15-B20 in online Appendix B; see Dang et al. (2021) for details.

[23] Recall that the PISA data may not be representative of 15-year-olds in school in Vietnam. Thus one should adjust the Vietnam weights in the PISA data. This was done using Vietnam census data; see Dang et al. (2021) for details.

Table 5
Regressions of 2012 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
Log of per capita GDP	31.63*** (1.56)	29.25*** (1.44)						
Wealth (national average)			27.84*** (1.10)	25.73*** (1.04)				
Wealth (student specific)					20.93*** (0.57)	19.58*** (0.55)	16.26*** (0.53)	15.21*** (0.46)
Constant	151.41*** (15.4)	182.55*** (14.19)	455.69*** (1.18)	463.91*** (1.12)	459.39*** (1.09)	468.01*** (1.02)	–	–
Vietnam residual (average)	128.7	112.6	108.8	94.2	94.4	80.2	74.7	67.9
Residual or fixed effect rank	1	1	2	1	4	2	6	4
More highly ranked	None	None	HK	None	HK S. Korea Singap.	HK	HK S. Korea Macao Singap. Taiwan	HK S. Korea Singap.
Country fixed effects	No	No	No	No	No	No	Yes	Yes
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

Robust standard errors, clustered at the school level, in parentheses *** p<0.01; ** p<0.05; * p<0.1
Columns (7) and (8) are fixed effects regressions, and the residual is the fixed effect, where all fixed effects have been recentered to have a mean of zero.
HK = Hong Kong.
The wealth variable is generated 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.

is only the second largest outlier in the math regression, after Hong Kong. Thus, when the country average of the wealth variable replaces the log of GDP per capita, the results are very similar.

Columns (5)-(8) of Table 5 explore two aspects of the wealth variable. First, columns (5) and (6) replace the country average wealth variable in columns (3) and (4) with each student's household-specific value of wealth. This allows the wealth variable to explain test score differences not only across, but also within, countries. This reduces the wealth variable coefficients slightly, but they remain highly significant.[24] More interesting is that Vietnam is somewhat less of an outlier. It is now the fourth highest outlier for math, and for reading it is the second highest. This occurs because the predictive power of the wealth variable falls by one fourth when it varies within countries; its role is stronger explaining differences between countries than explaining differences within them. The smaller coefficient reduces the slope in the lines in Figs. 1 and 2, reducing Vietnam's residual and increasing those of the wealthiest top performers (Hong Kong, Singapore and South Korea). Yet Vietnam is still a large outlier, and the only low income outlier.

Second, columns (7) and (8) of Table 5 add country fixed effects, which again reduces the impact of wealth somewhat. This is not surprising since the wealth variable no longer explains differences in (average) test score across countries, instead it explains only differences within countries. The reported residuals in columns (7) and (8) are simply the estimated country fixed effects.[25] 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.[26]

4.2. Do Other Variables in the PISA Data Explain Vietnam's Performance?

The regressions in columns (7) and (8) of Table 5 have only country fixed effects and the wealth indicator as explanatory variables. This subsection adds other variables in the PISA data to these regressions to see whether Vietnam's outlier status can be explained by those variables. Fryer and Levitt (2004) used this approach to examine the gap in test scores between black and white students in the U.S., and Singh (2020) used it to explain test score differences among school age children in Ethiopia, India, Peru and Vietnam. If the PISA data contain the key factors that determine Vietnamese students' success, adding them as regressors will yield a small, statistically insignificant country fixed effect for Vietnam. Even if the PISA data lack some key variables that explain Vietnam's success, and more generally that explain student learning in all countries participating in the PISA, it may be that the country fixed effects, while statistically significant, are greatly reduced and thus most of Vietnam's success would be explained by the PISA data. In contrast, if the key child, household, teacher and school variables underlying Vietnam's success are mostly *not* in the PISA data, then Vietnam will continue to be a large, positive outlier and the reasons why it is an outlier will be factors not measured, or not well measured, in the PISA data.

To begin, Table 6 presents variables in the PISA data that, *a priori*, seem likely to be determinants of student learning. They are divided into: i) basic demographic and household characteristics that are likely to influence student learning, such as parental education and the presence of siblings; ii) educational "inputs" that parents can provide to their children (desks, book, tutoring services) or that students can directly choose (hours of studying); and iii) school and teacher characteristic that are thought to affect student learning. To explain part of the gap, a variable must have significant explanatory power for test score, and there must be a difference between the mean for Vietnam and the mean for the other countries. A quick examination of the basic demographic and household characteristics reveals no variables with a large difference between Vietnam and the other countries that could explain Vietnam's strong performance on the PISA. In contrast, two educational input variables seem promising: hours in tutoring classes (called "extra classes" in Vietnam) are 42% higher for reading and 94% higher for math. Lastly, school and teacher variables that seem auspicious are the

[24] 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.

[25] These fixed effects regressions, and those in Table 6, do not have overall constant terms. Instead, they have country-specific constant terms. Technically, they are the country-specific mean (expected value) test score for a student whose wealth index equals zero (this index is standardized and has both positive and negative values).

[26] Tables B12 and B13 in online Appendix B repeat the regressions in Table 5 for the 2015 and 2018 PISA data. The overall pattern is the same.

Table 6
Means of Regression Variables, for Vietnam and for Other Countries, 2012

Variable (x)	Vietnam	Other PISA Countries
Math test score	503.9	462.8
Reading test score	503.5	472.6
Wealth	2.741	5.200
Demographic and Household Variables		
Girl	0.535	0.509
Has one or more brothers	0.514	0.507
Brothers variable is missing	0.098	0.159
Has one or more sisters	0.466	0.456
Sisters variable is missing	0.107	0.179
Mother's years schooling	7.984	10.98
Father's years schooling	8.351	11.09
Household Education Input Variables		
Years preschool enrollment	1.576	1.488
Grade	9.810	9.806
Education inputs index (desk, books)	3.978	4.654
Books in home	52.00	114.1
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
School and Teacher Variables		
Class size	42.82	32.62
Proportion of teachers who are qualified	0.800	0.834
Proportion qualified teacher missing	0.057	0.188
Square root of computers/pupil	0.497	0.623
Student performance used to assess teachers	0.995	0.708
Teacher absenteeism	0.695	0.779
Parents pressure teachers	1.297	0.957
Principal observes teachers	0.986	0.802
Outside Inspector observes teachers	0.888	0.406
Teacher pay linked to student performance	1.461	0.704
Teachers are mentored	0.833	0.684
Sample size	4,264	336,604

Notes: 1. Averages over countries are weighted by country populations, using adjusted weights
for Vietnam. These are the samples used in Tables 6A and 6B.
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.

use of student performance to assess teachers, parental pressure on teachers, observation of teachers by school principals and outside observers, teacher pay linked to student performance, and mentoring of teachers.

Table 7 summarizes the results from adding these three sets of variables. The first panel reproduces the results from columns (7) and (8) of Table 5, and the second panel shows that those results change only slightly when the sample size falls due to missing data for these additional variables. The third panel shows what happens to the coefficient on the Vietnam fixed effects when all three sets of variables are added. Two results stand out: a) The Vietnam fixed effects decreases, but only by about 30%; and b) Vietnam's ranking (in terms of the size of its fixed effect) falls from 5 to 11 for math and from 5 to 9 for reading. Note, however, that again all the countries that have larger fixed effects are much wealthier than Vietnam.

Finally, the last panel in Table 7 applies the decomposition of Gelbach (2016) to see the contributions of the three sets of variables to reducing in the Vietnam fixed effects seen in the third panel (relative to the second panel). As expected, the basic demographic and household characteristics contribute almost nothing to this reduction. More surprising is that the school and teacher variables also contribute very little to the reduction, despite their apparent potential to do so in Table 6. The main contributions come from the household education input variables, but even their contributions are modest: they "explain" only 22-23% of the Vietnam fixed effect shown in the second panel. The findings for the 2015 and 2018 PISA are similar. Overall, the PISA data explain little of how Vietnamese students outperform those in most other countries.

Table 7
Investigating Which PISA Variables Explain Vietnam's Outlier Status. (2012 PISA)

Variables	Math	Reading
Basic Regression (Full Sample: N = 455,971)		
Coefficient on Vietnam dummy variable	74.7	67.9
Vietnam's Rank	6	4
More highly ranked countries	Hong Kong Macao Singapore South Korea Taiwan	Hong Kong Singapore South Korea
Basic Regression (Sample with No Missing Data on Additional Variables: N = 340,868)		
Coefficient on Vietnam dummy variable	71.5	63.5
Vietnam's Rank	5	5
More highly ranked countries	Hong Kong Singapore South Korea Taiwan	Hong Kong Japan Singapore South Korea
Basic Regression (Full Sample: N = 340,868)		
Coefficient on Vietnam dummy variable	51.0	44.2
Vietnam's Rank	11	9
More highly ranked countries	Estonia Finland Germany Hong Kong Lichtenstein Macao Singapore South Korea Switzerland Taiwan	Estonia Finland Germany Hong Kong Lichtenstein Macao Poland Switzerland
Gelbach decomposition of change in coefficient on Vietnam dummy variables		
Difference in Vietnam dummy variable coefficient between basic and full regressions	20.5	19.3
Decomposition of difference into contributions from:		
Demographic and Household Variables	1.1	0.6
Household Education Input Variables	16.0	14.5
School and Teacher Variables	3.3	4.1

5. Conclusion

Vietnam's strong performance on the 2012, 2015, and 2018 PISA assessments raises the questions of why it does so well, and whether other countries can raise their students' learning by applying "what works" in Vietnam. This paper makes two contributions to understanding Vietnam's PISA performance. First, it examines whether that performance may be exaggerated because: i) the 15-year-old students in Vietnam who participated in the PISA are not representative of 15-year-old students in Vietnam; ii) the enrollment rate of 15-year-olds in Vietnam is much lower than the 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' PISA scores. Second, it investigates whether child, family, teacher or school characteristics can explain Vietnamese students' high PISA performance.

The first finding is that Vietnam's striking performance on the 2012, 2015, and 2018 PISA assessments is at most only partially reduced by adjustments to account for the above-mentioned possible sources of upward bias. The second finding is that the child-, household- teacher- and school-level variables in the PISA data explain little of Vietnam's high performance on the PISA assessments relative to its income level. At most, they explain about 30% of Vietnam's performance in math and reading, and most of this explanatory power is from household provision of educational inputs, rather than policy levers such as school and teacher characteristics.

Our analysis points to the potential contributions of unobserved characteristics to explain Vietnam's exceptional performance on the PISA. Several authors suggest a role for Confucian norms, especially a strong work ethic and a high value on education (Jerrim, 2015; Asadullah et al., 2020). Consistent with this, De Philippis and Rossi (2021) recently analyzed cross-country performance on the PISA and found that unobserved parental characteristics are at least as important as commonly used indicators of parents' socioeconomic status for explaining that performance, and are "a key driver of the high performance of East Asian countries". Another possibility is that Vietnam's success reflects several (ongoing) education reforms, which are seen as crucial for promoting higher-order thinking skills, creativity, and independent learning, and may explain other high-performing PISA participants, such as China (Shanghai) and Singapore (Tan, 2011). Others contend that a mix of "traditional values" and modern teaching practices may explain this performance, citing the example of Singapore (Deng and Gopinathan, 2016).

Unfortunately, there is little quantitative evidence on whether these unobserved factors explain Vietnamese students' performance on the PISA. Thus, our findings also serve as a call for more research to be done, and more data to be collected, on these (as yet) unobserved factors, which we believe will open up rich and promising directions for future research.

CRediT authorship contribution statement

Hai-Anh Dang: Methodology, Resources, Validation, Writing – review & editing. **Paul Glewwe:** Conceptualization, Funding acquisition, Methodology, Resources, Supervision, Validation, Writing – original draft. **Jongwook Lee:** Data curation, Formal analysis, Project administration, Software, Writing – review & editing, Validation. **Khoa Vu:** Data curation, Formal analysis, Project administration, Software, Visualization.

Data availability

The PISA data are available to any researcher at no charge from https://www.oecd.org/pisa/data/.

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Supplementary materials

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