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Abrigo, Michael Ralph M.; Francisco, Kris A.; Santos, Kevin Carl P.

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SCHOOL CLOSURES, SHELTER USE, AND LEARNING OUTCOMES IN THE PHILIPPINES: EVIDENCE FROM 2019 TIMSS

Michael R. M. Abrigo, Kris A. Francisco, and Kevin Carl P. Santos

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Michael R. M. Abrigo and Kris A. Francisco are research fellows at the Philippine Institute for Development Studies, Philippines. Kevin Carl P. Santos is an associate professor at the College of Education, University of the Philippines-Diliman, Philippines.

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Please contact the authors for information about this paper.

Email: mabrigo@pids.gov.ph

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Asian Development Bank Institute Kasumigaseki Building, 8th Floor 3-2-5 Kasumigaseki, Chiyoda-ku Tokyo 100-6008, Japan

Tel: +81-3-3593-5500 Fax: +81-3-3593-5571 URL: www.adbi.org E-mail: info@adbi.org

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Abstract

In many parts of the world, schools are often used as temporary shelters before, during, and after disasters that may prolong calamity-induced school closures. In this study, we combined student assessment data from the Philippine round of the 2019 Trends in International Mathematics and Science Study with school administrative records and area-level typhoon warnings to assess the impact of short school closures on learning outcomes. Results show that one school closure day induced by school-as-shelter use reduces student achievement by 12% to 14% of a standard deviation, equivalent to roughly half to a full year's worth of learning. This is likely driven by a decline in student interest, rather than by a contraction in the breadth of topics covered in class or by poorer teaching quality. These findings highlight potential hidden disasters from seemingly benign but frequent hazards.

Keywords: school closure, learning loss, student achievement, TIMSS

JEL Classification: H52, I20, Q54

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1. INTRODUCTION

In many places around the world, schools are often used as temporary shelters before, during, and immediately after calamities. The ubiquity and strategic location of schools, with their many rooms and amenities, make them natural candidates for this purpose. On the one hand, this may arrest further economic losses from disasters by providing safe shelters for vulnerable populations during calamities. But the secondary use of schools as shelters may encroach on their primary function as dedicated formal learning spaces for children. This may have important immediate implications for human capital acquisition and therefore later future productivity.

Previous studies on the impact of natural disasters on school closures, school attendance, and learning outcomes were largely based on acute but generally infrequent shocks, such as pandemics, super typhoons, and volcanic eruptions (c.f. Marin, Schwarz and Sabarwal, 2024). The impact of benign but more commonly occurring hazards, on the other hand, remains poorly understood (Cadag et al. 2017). Exceptions include Zivin, Shiang, and Neidell (2018), who documented that short-run changes in temperature negatively affected mathematics performance among a panel of children in the United States, and Miller and Hui (2022), who found that even short school closures due to wildfires in California worsened children's academic performance.

We contribute to this strand of the literature by assessing the impact of short school closures cumulated over a school year on the learning outcomes of Grade 4 students in the Philippine round of the 2019 Trends in International Mathematics and Science Study (TIMSS). By combining student-level assessment data with administrative records on school closures and area-level typhoon warnings from official weather bulletins, we can assess how policy choices aimed at mitigating immediate economic losses from disasters may have unintended consequences for other domains, in this case on children's learning outcomes.

The Philippines is one of the most typhoon-prone countries in the world with about 20 typhoons entering its territory annually, of which about nine make landfall and five are likely to be destructive (Lapidez et al. 2015). The economic losses from such typhoons are quite massive, with Typhoons Ondoy and Pepeng, which hit in 2009, for example, costing the country about 2.7% of its gross domestic product (GDP), and with other less destructive typhoons reducing economic activity by about 1% to 2% (Strobl 2019).

While Philippine public policy officially discourages the use of schools as temporary shelters during such calamities, they are nonetheless often the de facto evacuation centers, potentially due to their ubiquity across the country and the facilities they may offer (David et al. 2018). In 2020, around 95% of barangays (villages) had access to a school either within or outside their boundaries but within 2 kilometers from the village government center. Public community centers, such as multipurpose halls, covered courts, etc., are less prevalent, especially in less affluent areas.

Our analysis reveals that school closures induced by school-as-shelter use led to substantial learning loss. We find that one school closure day is associated with around a 0.12 to 0.14 standard deviation (SD) decline in mathematics and science achievement. This is roughly equivalent to as much as a whole year's worth of schooling. Back-of-the-envelope calculations point to a potential annual foregone USD4 billion public education financing in the Philippines because of this learning

setback. Furthermore, a one-off nationwide school closure day may reduce the country's long-term GDP by about USD1 billion per year.

The results appear to be largely driven by a decline in student interest, rather than by a reduction in curricular topics covered in class or a deterioration in teaching quality. This may be related to previous evidence suggesting increased psychological distress from traumatic events, such as displacement because of calamities (Adams et al. 2023; Pfefferbaum et al. 2016; Wang et al. 2019). This underscores the multifaceted nature of learning and the need for multipronged interventions to arrest learning losses from disasters.

The rest of the study is organized as follows. In the next section, we provide a short overview of school-as-shelter use and school closures in the Philippines. This is followed in Sections 3 and 4 by discussions on the data and methods that we employed. We present the results in Section 5. Finally, we conclude with a summary and some implications for policy.

2. SHELTER USE AND SCHOOL CLOSURES IN THE PHILIPPINES

The Philippine government, as a national policy, discourages the use of schools as temporary shelters during calamities. However, dedicated structures for evacuation or temporary shelter are not always available in local communities. Indeed, many of the evacuation centers are not originally designed to be used as such, including multipurpose halls, public school buildings, and covered basketball courts (Cajucom et al. 2019).

Administrative records from the Department of Education show that the propensity of public elementary schools to be used as shelters varies across the country's municipalities. While only 5% of public elementary schools across the country were ever used as evacuation centers during this period, the rates vary wildly across locations, reaching as high as two-thirds of all schools in a municipality. Schools in the Eastern Seaboard of the country appear to be the ones most used as temporary shelters, which coincides with the usual path and first landfall location of typhoons coming from the Pacific Ocean.

The number of public elementary schools used as shelters seems to follow the progression of the Philippine monsoon season, which starts in early June, and appears to correlate with the strength of the particular typhoon passing the Philippines. The December 2017 peak shown in Figure 1 (Panel A) coincides with the back-to-back tropical cyclones Kai-tak and Tembin that passed through the southern Philippine islands.

Schools used as shelters are more likely to experience school closures (Panel B) and, if closed, remain closed relatively longer (Panel C). While these may be partly conditioned by the degree of exposure to natural hazards, these observations remain true even when comparing schools from the same municipality, which are arguably exposed more similarly.

3. DATA

We used Grade 4 student-level science and mathematics assessment data in the 2019 Trends in International Mathematics and Science Study (TIMSS) in the Philippines. The 2019 TIMSS is the seventh cycle of the international large-scale assessment, and the third time that the Philippines participated in TIMSS.

The TIMSS student assessment is based on a comprehensive test framework co-developed with participating countries that focuses on both subject content and student thinking processes. The 2019 TIMSS for Grade 4 covers three content domains in mathematics (number, measurement and geometry, and data) and in science (life science, physical science, and earth science) and includes approximately 350 test items in total. In addition to the student assessment, TIMSS also collects contextual variables from students, parents, teachers, and school heads that provide information on students' home and school learning environments.¹

Many items in TIMSS are analyzed using item response theory (IRT) models. Blocks of contextual questions, such as on the availability of learning resources, experience of bullying, and subject matter confidence, are usually summarized as indices based on the partial credit IRT model. Student assessment scores in mathematics and science are also provided in IRT scales. Unlike other indices in TIMSS, however, five imputed plausible values are provided for each student in each assessment subject to account for uncertainty associated with measuring latent variables. Reported TIMSS scores are scaled relative to the distribution of scores in the first TIMSS in 1995, centered at 500 points with a standard deviation of 100 points.

We combined responses in TIMSS with information on school closures collected from public schools by DepEd, and tropical cyclone warnings (TCWs) from weather bulletins provided by the Philippine Atmospheric, Geophysical, and Astronomical Services Administration (PAGASA). The tropical cyclone warnings were converted into typhoon school days by cross-referencing days with area-level tropical cyclone warnings with DepEd's official school calendar for public schools. Classes in elementary schools in the Philippines that are covered by any tropical cyclone warning are automatically cancelled. Local government chief executives may also declare class suspensions for localized extreme weather disturbances that are not covered by TCWs. We aggregated these variables as sums by school year and school.

The Philippine public basic education school calendar begins in early June, coinciding with the start of the southwest monsoon season, and lasts until early April of the following year, before the peak of the summer season. The Philippine round of the 2019 TIMSS was collected in March 2019, toward the end of the school calendar. However, information on school closures from DepEd is only available for public elementary schools for the prior school year, 2017–2018, and the school year 2019–2020, skipping the 2019 TIMSS school year 2018–2019. We used school closures from the school year 2017–2018 in our main analysis, and the 2019–2020 school closures in our falsification test.

¹ See Martin, von Davier and Mullis (2020) for a detailed description of the TIMSS 2019 methods and procedures.

Figure 1: Shelter Use and School Closure Among Public Elementary Schools, 2017–2018



A. Number of schools used as shelter











The 2019 TIMSS implemented a two-stage random sampling design. In the first stage, schools were randomly selected. From each of these schools, one Grade 4 class section was randomly selected to take the student assessment. From the 180 randomly selected schools that participated in TIMSS 2019, we excluded 23 private schools, which did not report school closures to DepEd, and one public school, which had problematic school closure information. This resulted in 156 public schools left for analysis, of which nine had been used as shelters in the school year 2017–2018. The final database included almost 5,000 Grade 4 public school students whose TIMSS scores in mathematics and science averaged 287 and 236 points, respectively, which were both slightly lower than the national average of 297 and 249 points.

Table 1 presents summary statistics for key variables included in our analyses. Schoollevel information, such as school closures and the responses of school heads, are merged with responses by students and weighted appropriately to reflect studentweighted statistics.

| | School Used as Shelter | | | Balance | | |
|--|------------------------|--------------|-------|---------|-------|-------|
| | No (N= | No (N=4,660) | | =297) | Std. | Var. |
| | Mean | S.D. | Mean | S.D. | Diff. | Ratio |
| A. School closure and typhoon days | | | | | | |
| With school day closure (=1) | 0.20 | 0.40 | 0.78 | 0.42 | 1.42 | 1.11 |
| School days closed | 1.04 | 2.55 | 5.95 | 4.47 | 1.35 | 3.07 |
| Typhoon school days, 2017 | 2.96 | 1.94 | 3.82 | 1.91 | 0.45 | 0.97 |
| Typhoon school days, 2018 | 2.63 | 1.79 | 3.40 | 1.69 | 0.44 | 0.89 |
| B. Student characteristics | | | | | | |
| Female (=1) | 0.48 | 0.50 | 0.52 | 0.50 | 0.08 | 1.00 |
| Age (years) | 10.15 | 0.75 | 10.10 | 0.71 | -0.07 | 0.89 |
| Home resources for learning | 7.93 | 1.57 | 8.15 | 1.51 | 0.14 | 0.92 |
| Sense of school belonging | 9.49 | 1.98 | 9.45 | 1.96 | -0.02 | 0.98 |
| School bullying | 7.66 | 1.37 | 7.58 | 1.64 | -0.05 | 1.42 |
| Disorderly behavior during class | 9.30 | 1.54 | 9.32 | 1.70 | 0.01 | 1.22 |
| Student confidence in mathematics | 9.01 | 1.12 | 9.08 | 1.23 | 0.05 | 1.20 |
| Student confidence in science | 8.73 | 1.13 | 8.82 | 1.31 | 0.08 | 1.34 |
| C. School head characteristics | | | | | | |
| Years as principal | 9.04 | 5.81 | 6.14 | 3.64 | -0.60 | 0.39 |
| Years as principal in current school | 2.81 | 3.02 | 1.78 | 1.52 | -0.43 | 0.25 |
| With graduate degree (=1) | 0.80 | 0.40 | 0.78 | 0.41 | -0.03 | 1.04 |
| With leadership training certificate (=1) | 0.78 | 0.42 | 0.87 | 0.33 | 0.26 | 0.63 |
| With leadership training graduate degree (=1) | 0.81 | 0.39 | 0.91 | 0.29 | 0.29 | 0.54 |
| D. School characteristics | | | | | | |
| Resource shortage, mathematics | 8.71 | 1.11 | 8.72 | 0.81 | 0.01 | 0.52 |
| Resource shortage, science | 8.82 | 1.18 | 8.72 | 0.77 | -0.10 | 0.43 |
| School emphasis on academic success | 9.47 | 1.26 | 10.29 | 1.83 | 0.52 | 2.10 |
| Students have literacy and numeracy skills | 10.98 | 1.67 | 11.52 | 2.00 | 0.29 | 1.42 |
| Students are generally more affluent (=1) | 0.10 | 0.29 | 0.22 | 0.41 | 0.34 | 1.98 |
| Students are generally more disadvantaged (=1) | 0.46 | 0.50 | 0.50 | 0.50 | 0.08 | 1.01 |

Table 1: Selected Child and School Characteristics: TIMSS 2019 Public School Sample

Note: The sample includes Grade 4 public school students in the 2019 Philippine TIMSS. Out of 181 schools originally included in the 2019 Philippine TIMSS, 23 private schools, which have no school closure data, and one public school, which has problematic school closure data, were excluded. From the remaining 156 public schools, nine schools had been used as shelters in 2018–2019. Std. Diff. = Standardized difference; Var. Ratio = Variance ratio.

Panel A of Table 1 confirms our earlier observation that public schools used as shelters are more likely to experience school closures. This may be partly explained by greater exposure to natural hazards, in this case longer typhoon school days. But even among schools that have had school closures, public schools used as shelters have had two more closed school days on average than schools that were not used as shelters.

Student characteristics appear to be similar by school-as-shelter use (Table 1, Panel B). There is no marked difference in the distribution of students by sex, age, proxies for home and school learning environment, and even in confidence in the tested subjects. The availability of school resources for mathematics and science also appears to be balanced between the two groups of students (Panel D).

The characteristics of school heads are more varied, however. Heads of schools that were used as shelters typically had fewer years of experience as principals in the TIMSS sample school that they were managing and in total, although they were more likely to have had formal leadership training (Panel C). These school heads were also more likely to report that their school emphasized academic success, that their students had literacy and numeracy skills, and that their students generally came from more affluent homes (Panel D).

4. ESTIMATION

We are interested in estimating the impact of school closures on student learning outcomes. In an ideal scenario, school closures are randomly assigned and are uncorrelated with other covariates that also affect student outcomes. This may not be realistic as the decision to suspend classes may vary with attributes, such as the leadership style of school principals or exposure to natural hazards, that may also influence student outcomes. A naïve comparison of average outcomes by school closure days would generally be biased as a result.

In order to address this endogeneity issue, we use the number of days a school had been used as a shelter to instrument for the number of school closure days in a two-stage least squares framework. This technique critically relies on two assumptions. First, the instrument, i.e., school-as-shelter days, should be relevant in explaining the endogenous variable, i.e., school closure days. Second, the instrument should have no direct effect on the outcomes of interest, and it should only influence the outcomes indirectly through the endogenous variable.

The first assumption may be directly tested. As we have shown in Table 1, schools used as shelters have more school closure days. But Table 1 also suggests that the use of schools as shelters is correlated with exposure to natural hazards and school head characteristics, which have been documented to be correlated with schooling outcomes. This violates our second assumption. Had these variables not been measured and considered in our model, the estimates from the instrumental variable (IV) model are expected to have been biased with a generally unknown direction and magnitude. Since these covariates are observed, we can include them in our IV model to remove the bias that they could introduce if they were excluded.

The second assumption is not testable. While we may include additional covariates to remove bias from potential confounding, there may be other unobserved variables that we cannot control for in our IV model. We performed several robustness checks to assess the sensitivity of our IV estimates to such unobserved confounding. First, we estimated additional IV models that include previously excluded covariates that may influence learning outcomes. We also performed a placebo test using school closure

information from the school year 2019–2020, i.e., the school year after TIMSS 2019. We believe that school closures that are yet to happen should have no influence on student achievements in the 2019 TIMSS, and that any estimated impact from this exercise reflects the potential bias from violating the second assumption. Finally, we also estimated IV models using student achievement in a national assessment taken by Grade 4 students in October 2018 as an additional robustness check.

As we noted in the previous section, the 2019 TIMSS provides five plausible values per subject tested for each student assessed. These values are imputed based on random draws from the IRT model that incorporates students' responses in the assessment, their background characteristics, and the psychometric characteristics of the assessment items. Following the guidance by Rubin (1987) and Beaton and Gonzalez (1995), we estimated separate IV models for each of the five sets of plausible values and averaged the resulting point estimates, covariance matrices, and test statistics.

5. RESULTS AND DISCUSSION

5.1 School Closures and Learning Outcomes

Table 2 presents the main results of our IV model estimation. Separate estimates are provided for mathematics and science. We progressively add covariates in the model to capture the sensitivity of our estimates to potential unobserved confounding. In all the models, we control for the number of typhoon school days to ensure that each IV model compares schools with similar exposure to typhoon hazards. In the full model, we include student, school, and school head attributes in addition to typhoon school days as covariates. Observations are clustered at the school level and weighted following the TIMSS sampling design. Since TIMSS achievement scores are normalized to have a (baseline) standard deviation of 100 points, we can readily interpret the IV estimates as standardized effect sizes (in %).

The results in Table 2 suggest that school closures induced by school-as-shelter use have a sizeable negative impact on learning outcomes. An additional school closure day reduces students' learning achievement as measured in the 2019 TIMSS by as much as 12.4 points in mathematics and by 13.9 points in science based on the full model. It is worth noting that the point estimates are negative but much muted in the more basic models, suggesting the importance of controlling for covariates that are correlated with both learning outcomes and the chosen instrument.

Previous evidence from the literature shows that natural disasters may affect the education outcomes of boys and girls differently (e.g., Bjorkman-Nyqvist 2013; Takasaki 2017). We explored this in our analysis by reestimating the IV models separately for boys and girls. The results presented in Table 3 show that the impact of school closures on learning outcomes appears to be similar for boys and girls in our study sample.

The impact of school closures that we presented is on the extreme negative end relative to the distribution of effect sizes in education reported in other recent studies. Evans and Yuan (2022), for example, provide percentiles of standardized effect sizes on learning and access based on education interventions in low- and middle-income countries. They reported median standardized effect sizes on mathematics achievement of 0.05 for quasi-experimental studies and 0.07 for randomized control trials (RCTs). Our IV estimates are lower than their reported tenth percentile of –0.05 for RCTs and –0.09 for quasi-experimental studies.

It is instructive to compare our results with estimated learning losses from the extended school closures during the COVID-19 pandemic. The Philippines has one of the most protracted pandemic-induced school closures around the world, lasting two and a half years. During the pandemic, content delivery in public elementary schools had shifted primarily to the use of learning modules, which focused on the most essential learning competencies (Orbeta, 2022).

Again, our estimates appear to be rather extreme. Jakubowski et al. (2023) estimated that reading literacy declined by 9% of a standard deviation among Grade 4 students in 2021 for every ten weeks, i.e., about a 0.18 percentage point SD decline per day, of at least partial school closure during the COVID-19 pandemic. Using the learning achievement results of 15-year-old students in 2022, Jakubowski et al. (2024) documented learning losses of as much as a 4% SD decline in mathematics and science scores for every ten weeks, i.e., a 0.08 percentage point SD decline per day, of school closure. Their results are based on pooled multiyear international large-scale student assessments, i.e., PIRLS for those aged 10 and PISA for those aged 15, before and during the COVID-19 pandemic.

| | (1) | (2) | (3) | (4) |
|-----------------------------|--------|---------|-----------|-----------|
| A. Mathematics | | | | |
| School closure days | -3.85 | -8.85** | -10.49*** | -12.42*** |
| | (5.63) | (6.03) | (5.91) | (6.83) |
| Underidentification test, F | 3 | 4 | 3 | 4 |
| Weak identification test, F | 10 | 12 | 15 | 13 |
| Adjusted R-sq. | -0.01 | -0.04 | 0.13 | 0.11 |
| Observations | 4,957 | 4,920 | 4,298 | 4,185 |
| B. Science | | | | |
| School closure days | -3.45 | -9.20* | -11.48*** | -13.89*** |
| | (6.58) | (6.92) | (6.58) | (7.55) |
| Underidentification test, F | 3 | 4 | 3 | 4 |
| Weak identification test, F | 10 | 12 | 15 | 14 |
| Adjusted R-sq. | 0.00 | -0.03 | 0.16 | 0.15 |
| Observations | 4,957 | 4,920 | 4,202 | 4,096 |
| Included covariates: | | | | |
| Typhoon school days | Yes | Yes | Yes | Yes |
| Student attributes | | | Yes | Yes |
| School head attributes | | | | Yes |
| School attributes | | Yes | Yes | Yes |

Table 2: School Closure Days and TIMSS 2019 Score

Note: *, **, and *** signify statistical significance at the 10%, 5%, and 1% alpha levels, respectively. Values in parentheses are heteroskedasticity-robust standard errors clustered at the school level. The sample includes Grade 4 public school students in the 2019 Philippine TIMSS. See Table 1 for the full list of covariates included in the estimation. The under- and weak identification F statistics refer to the Kleibergen-Paap rank LM and rank Wald statistics, respectively. Due to the reported weak instruments, inference on the point estimates is based on the Anderson-Rubin weak identification-robust Wald test.

| | Male | | | | F | emale | | |
|-----------------------------|--------|--------|----------|----------|--------|----------|-----------|-----------|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| A. Mathematics | - | • | | | - | | | |
| School closure days | -3.41 | -7.37* | -10.22** | -12.64** | -5.03 | -10.80** | -11.34*** | -12.54*** |
| | (5.78) | (6.17) | (6.94) | (8.07) | (5.95) | (6.22) | (5.39) | (5.91) |
| Underidentification test, F | 3 | 4 | 3 | 4 | 3 | 3 | 3 | 4 |
| Weak identification test, F | 9 | 11 | 13 | 12 | 11 | 14 | 17 | 16 |
| Adjusted R-sq. | 0.00 | -0.02 | 0.12 | 0.10 | -0.02 | -0.06 | 0.08 | 0.07 |
| Observations | 2,566 | 2,547 | 2,196 | 2,140 | 2,391 | 2,373 | 2,102 | 2,045 |
| B. Science | - | • | | | - | | | |
| School closure days | -3.72 | -8.51* | -10.20** | -13.34** | -3.67 | -10.22* | -12.94*** | -14.29*** |
| | (6.58) | (7.08) | (7.14) | (8.31) | (6.93) | (7.00) | (6.27) | (6.82) |
| Underidentification test, F | 3 | 4 | 3 | 4 | 3 | 3 | 3 | 3 |
| Weak identification test, F | 9 | 11 | 14 | 12 | 11 | 14 | 18 | 17 |
| Adjusted R-sq. | -0.01 | -0.03 | 0.19 | 0.17 | -0.01 | -0.04 | 0.12 | 0.12 |
| Observations | 2,566 | 2,547 | 2,137 | 2,086 | 2,391 | 2,373 | 2,065 | 2,010 |
| Included covariates: | - | • | | | - | | | |
| Typhoon school days | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Student attributes | | | Yes | Yes | | | Yes | Yes |
| School head attributes | | | | Yes | | | | Yes |
| School attributes | | Yes | Yes | Yes | | Yes | Yes | Yes |

Table 3: School Closure Days and TIMSS 2019 Score by Sex

Note: *, **, and *** signify statistical significance at the 10%, 5%, and 1% alpha levels, respectively. Values in parentheses are heteroskedasticity-robust standard errors clustered at the school level. The sample includes Grade 4 public school students in the 2019 Philippine TIMSS. See Table 1 for the full list of covariates included in the estimation. The under- and weak identification F statistics refer to the Kleibergen-Paap rank LM and rank Wald statistics, respectively. Due to the reported weak instruments, inference on the point estimates is based on the Anderson-Rubin weak identification-robust Wald test.

5.2 Robustness and Falsification Tests

In order to assess the sensitivity of our results to unobserved confounding, we estimated similar IV models, but using a more extensive list of covariates. Starting from the full model in Table 2, we sequentially added explanatory variables that may be correlated with school-as-shelter days that may also influence learning achievement. We present the results in Table 4.

First, we added fixed effects for the broad region and for schools in the Eastern Seaboard. These fixed effects should be able to capture the contribution of common conditions within the region and in the Eastern Seaboard to learning outcomes. For instance, schools in the Eastern Seaboard are usually those most affected by typhoons from the Pacific and may have developed specific coping mechanisms over the years. Further, schools within broad regions (National Capital Region, the rest of Luzon, Visayas, and Mindanao) may share more similarities, e.g., culture, environment, weather patterns, etc., than schools across regions.

Next, we controlled for longer lags of typhoon school days to account for the potential effect of persistent exposure to extreme weather events. We also had another model where we weighed typhoon school days by typhoon-specific intensity as measured by the minimum wind speed for a particular tropical cyclone warning.

| | Baseline | With Broad Region and Eastern Seaboard Fixed Effects | With Lagged Typhoon School Days | With Intensity- weighted Typhoon School Days | With Language Homogeneity Index |
|-----------------------------|-----------|--|---------------------------------------|--|--|
| | (1) | (2) | (3) | (4) | (5) |
| A. Mathematics | | | | | |
| School closure days | -12.42*** | -11.66*** | -10.01*** | -11.97*** | -12.58*** |
| | (6.83) | (4.84) | (5.12) | (6.68) | (7.27) |
| Underidentification test, F | 4 | 4 | 4 | 4 | 4 |
| Weak identification test, F | 13 | 22 | 15 | 13 | 13 |
| Adjusted R-sq. | 0.11 | 0.20 | 0.19 | 0.12 | 0.13 |
| Observations | 4,185 | 4,185 | 4,185 | 4,185 | 4,148 |
| B. Science | | | | | |
| School closure days | -13.89*** | -12.77*** | -11.23*** | -13.46*** | -14.07*** |
| | (7.55) | (5.61) | (5.90) | (7.39) | (8.08) |
| Underidentification test, F | 4 | 4 | 3 | 4 | 4 |
| Weak identification test, F | 14 | 23 | 16 | 13 | 13 |
| Adjusted R-sq. | 0.15 | 0.23 | 0.21 | 0.16 | 0.16 |
| Observations | 4,096 | 4,096 | 4,096 | 4,096 | 4,059 |
| Included covariates: | | | | | |
| Typhoon school days | Yes | Yes | Yes | Yes | Yes |
| Student attributes | Yes | Yes | Yes | Yes | Yes |
| School head attributes | Yes | Yes | Yes | Yes | Yes |
| School attributes | Yes | Yes | Yes | Yes | Yes |

Table 4: School Closure Days and TIMSS 2019 Score: Alternative Specifications

Note: *, **, and *** signify statistical significance at the 10%, 5%, and 1% alpha levels, respectively. Values in parentheses are heteroskedasticity-robust standard errors clustered at the school level. The sample includes Grade 4 public school students in the 2019 Philippine TIMSS. See Table 1 for the full list of covariates included in the estimation. The under- and weak identification F statistics refer to the Kleibergen-Paap rank LM and rank Wald statistics, respectively. Due to the reported weak instruments, inference on the point estimates is based on the Anderson-Rubin weak identification-robust Wald test.

Finally, we controlled for language homogeneity to proxy the ease of implementing mother tongue-based multilingual education (MTB-MLE), which uses local languages instead of exclusively English or Filipino as the medium of instruction. A language homogeneity index was calculated as the sum of the squared shares of each mother tongue by population in each municipality. The Philippines has adopted MTB-MLE but has experienced several implementation issues (Orbeta et al. 2021). Having a more homogeneous mix of students by language use is expected to result in better implementation of MTB-MLE (e.g., Gupta 1997).

The IV estimates presented in Table 4 appear to be robust to the inclusion of the additional covariates in these alternative specifications.

We also performed a falsification test by using information on school closures for the school year 2019–2020, i.e., the school year immediately after the 2019 TIMSS was administered. Since the school closures happened after the 2019 TIMSS assessment, we did not expect these to affect the assessment outcomes. A significant coefficient would suggest that our chosen IV may be picking up effects of characteristics other than school closure days.

The results of our falsification test shown in Table 5 suggest that such is not the case. The IV estimates are all smaller in absolute magnitude than our main estimates in Table 2, and are all statistically insignificant. Except for the most basic model for mathematics, all estimates are positive, which suggests that our main estimates could even be attenuated. As a final robustness check, we also performed a similar IV analysis using school-level averages of the Early Language Literacy and Numeracy Assessment (ELLNA) conducted in October 2018. ELLNA is a nationally representative student assessment that gauges students' learning achievements acquired from Kindergarten to Grade 3. It is administered to a random sample of Grade 4 students and covers topics in literacy in three languages (Filipino, English, and a mother tongue) and in numeracy.

In our estimation, we standardized the scores relative to the national average to ease interpretation. The basic IV model controls for typhoon school days and includes school division fixed effects. We also estimated a more elaborate model wherein we also controlled for student-teacher ratio, student-classroom ratio, and student dropout rate, among other things. Similarly to our main analysis, we used school closure days from the school year 2017–2018.

The results presented in Table 6 show that a single school closure day induced by school-as-shelter use reduced language literacy scores by as much as 0.11 SD and numeracy scores by about 0.15 SD. It is noteworthy that these estimates are very similar to our earlier results using student-level TIMSS assessment data.

| | (1) | (2) | (3) | (4) |
|-----------------------------|--------|--------|--------|--------|
| A. Mathematics | | | | · |
| School closure days | -0.09 | 1.69 | 1.44 | 1.69 |
| | (7.71) | (5.86) | (4.18) | (6.89) |
| Underidentification test, F | 2 | 2 | 3 | 1 |
| Weak identification test, F | 2 | 2 | 3 | 1 |
| Adjusted R-sq. | 0.01 | 0.06 | 0.24 | 0.24 |
| Observations | 4,863 | 4,826 | 4,211 | 4,098 |
| B. Science | | | | |
| School closure days | 3.02 | 4.47 | 4.45 | 6.83 |
| | (8.64) | (6.65) | (5.18) | (9.31) |
| Underidentification test, F | 2 | 2 | 3 | 1 |
| Weak identification test, F | 2 | 2 | 3 | 1 |
| Adjusted R-sq. | 0.02 | 0.04 | 0.24 | 0.17 |
| Observations | 4,863 | 4,826 | 4,121 | 4,015 |
| Included covariates: | | | | |
| Typhoon school days | Yes | Yes | Yes | Yes |
| Student attributes | | | Yes | Yes |
| School head attributes | | | | Yes |
| School attributes | | Yes | Yes | Yes |

Table 5: School Closure Days and TIMSS 2019 Score: Falsification Test

Note: *, **, and *** signify statistical significance at the 10%, 5%, and 1% alpha levels, respectively. Values in parentheses are heteroskedasticity-robust standard errors clustered at the school level. The sample includes Grade 4 public school students in the 2019 Philippine TIMSS. See Table 1 for the full list of covariates included in the estimation. The under- and weak identification F statistics refer to the Kleibergen-Paap rank LM and rank Wald statistics, respectively. Due to the reported weak instruments, inference on the point estimates is based on the Anderson-Rubin weak identification-robust Wald test.

5.3 Potential Mechanisms

What could possibly drive learning losses from school closures? Previous studies have highlighted shifts in the opportunity cost of time, especially for boys, in the aftermath of natural disasters. Children are withdrawn from schooling to take up employment, acting

as household self-insurance (e.g., Khan and Hussain 2023; Takasaki 2017). Along the same lines, households may choose to recalibrate family expenses away from longer-term investments, such as children's education (Deuchert and Felfe 2015), toward more immediate concerns, such as for food consumption and reconstruction.

We looked at other potential mechanisms that may explain the observed learning losses.

First, we assessed whether school closures lead to curricular topics not being taught. We conjecture that school closures reduce school instructional days, which directly impacts the breadth and depth of topics covered in class. In its teacher module, the 2019 TIMSS directly asks teachers the extent to which the topics included in the TIMSS assessment have been taught in class. The responses are summarized as separate indices under broader headings.

Second, we checked whether school closures result in a worse teaching quality. In relation to the above conjecture, teachers may choose to sacrifice exposition quality to be able to cover the breadth of the prescribed curriculum. In the 2019 TIMSS, the student questionnaire asks students to rate the level of teachers' instructional quality (e.g., "My teacher is easy to understand") separately for science and mathematics. These are also summarized as indices.

Finally, we looked at students' enthusiasm for science and mathematics, which has been shown to correlate well with the assessment outcomes (Yin and Fishbein 2020). The 2019 TIMSS asks students to rate several statements on the degree to which they like science or mathematics (e.g., "I like any schoolwork that involves numbers," "I like to do science experiments"), which are also transformed by TIMSS into separate indices.

| | Filipino | English | Mother Tongue | Numeracy |
|-------------------------------------|----------------------|----------|---------------|----------|
| | (1) | (2) | (3) | (4) |
| A. With typhoon school days and se | chool division fixed | effects | | |
| School closure days | -0.09** | -0.09*** | -0.12** | -0.15* |
| | (0.06) | (0.05) | (0.07) | (0.06) |
| Underidentification test, F | 10 | 10 | 10 | 10 |
| Weak identification test, F | 2 | 2 | 2 | 2 |
| Adjusted R-sq. | -0.15 | -0.21 | -0.18 | -0.17 |
| Observations | 3,064 | 3,064 | 3,064 | 3,064 |
| B. With additional school character | istics as covariates | | | |
| School closure days | -0.07** | -0.08*** | -0.11** | -0.14* |
| | (0.05) | (0.05) | (0.07) | (0.06) |
| Underidentification test, F | 11 | 11 | 11 | 11 |
| Weak identification test, F | 2 | 2 | 2 | 2 |
| Adjusted R-sq. | -0.14 | -0.20 | -0.17 | -0.17 |
| Observations | 3,038 | 3,038 | 3,038 | 3,038 |

Table 6: School Closure Days and 2018 ELLNA Standardized Score

Note: *, **, and *** signify statistical significance at the 10%, 5%, and 1% alpha levels, respectively. Values in parentheses are heteroskedasticity-robust standard errors clustered at the school divisions level. The sample includes standardized school-average scores of Grade 4 public school students in the 2018 ELLNA. The under- and weak identification F statistics refer to the Kleibergen-Paap rank LM and rank Wald statistics, respectively. Due to the reported weak instruments, inference on the point estimates is based on the Anderson-Rubin weak identification-robust Wald test.

| | Mathematics | | | Science | | |
|---------------------------------------|--------------|-----------------------------|--------|-----------------|---------------------|------------------|
| | Numbers | Measurement and Geometry | Data | Life Science | Physical Science | Earth Science |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| A. Controlling for typhoon school day | S | | | | | |
| School closure days | 0.00 | -0.10 | -5.29 | 1.26 | -0.59 | -3.30 |
| | (0.28) | (1.50) | (9.30) | (1.28) | (2.02) | (5.60) |
| Underidentification test, F | 2 | 2 | 2 | 2 | 2 | 2 |
| Weak identification test, F | 3 | 3 | 3 | 3 | 3 | 3 |
| Adjusted R-sq. | 0.00 | -0.01 | -0.12 | -0.12 | -0.01 | -0.04 |
| Observations | 156 | 156 | 156 | 153 | 153 | 154 |
| B. With additional teacher and schoo | l covariates | | | | | |
| School closure days | -0.35 | 0.04 | -4.49 | 1.46 | 0.19 | -3.62 |
| | (0.34) | (2.11) | (9.87) | (1.18) | (2.15) | (6.38) |
| Underidentification test, F | 2 | 2 | 2 | 2 | 2 | 2 |
| Weak identification test, F | 3 | 3 | 3 | 3 | 3 | 3 |
| Adjusted R-sq. | 0.01 | 0.05 | -0.12 | 0.12 | 0.11 | -0.05 |
| Observations | 150 | 150 | 150 | 147 | 147 | 148 |
| Memorandum items: | | | | | | |
| Unconditional mean | 99.14 | 92.57 | 77.11 | 95.06 | 89.58 | 74.13 |
| Unconditional S.D. | 5.68 | 14.51 | 35.68 | 12.76 | 14.81 | 28.91 |

Table 7: School Closure Days and Share of Students (%) Taught by Topic

Note: *, **, and *** signify statistical significance at the 10%, 5%, and 1% alpha levels, respectively. Values in parentheses are heteroskedasticity-robust standard errors. The sample includes Grade 4 public school teachers in the 2019 Philippine TIMSS. See Table 1 for the full list of covariates included in the estimation. The under- and weak identification F statistics refer to the Kleibergen-Paap rank LM and rank Wald statistics, respectively. Due to the reported weak instruments, inference on the point estimates is based on the Anderson-Rubin weak identification-robust Wald test.

| | Mathematics | | Scie | ence |
|-----------------------------|-------------|--------|--------|--------|
| | (1) | (2) | (3) | (4) |
| School closure days | 0.04 | 0.01 | 0.00 | -0.03 |
| | (0.05) | (0.03) | (0.05) | (0.05) |
| Underidentification test, F | 3 | 4 | 3 | 4 |
| Weak identification test, F | 10 | 13 | 11 | 14 |
| Adjusted R-sq. | 0.00 | 0.31 | 0.00 | 0.29 |
| Observations | 4,772 | 4,150 | 4,726 | 4,084 |
| Included covariates: | | | | |
| Typhoon school days | Yes | Yes | Yes | Yes |
| Student attributes | | Yes | | Yes |
| School head attributes | | Yes | | Yes |
| School attributes | | Yes | | Yes |
| Memorandum items: | | | - | |
| Unconditional mean | | 8.73 | | 8.84 |
| Unconditional S.D. | | 2.03 | | 1.95 |

Table 8: School Closure Days and Instructional Clarity

Note: *, **, and *** signify statistical significance at the 10%, 5%, and 1% alpha levels, respectively. Values in parentheses are heteroskedasticity-robust standard errors clustered at the school level. The sample includes Grade 4 public school students in the 2019 Philippine TIMSS. See Table 1 for the full list of covariates included in the estimation. The under- and weak identification F statistics refer to the Kleibergen-Paap rank LM and rank Wald statistics, respectively. Due to the reported weak instruments, inference on the point estimates is based on the Anderson-Rubin weak identification-robust Wald test.

There appears to be no statistically discernible impact of school closure days on curricular topics covered in class (Table 7) or on the instructional quality of teachers (Table 8). However, we find some indication that school closures dampen student interest, particularly in mathematics (Table 9). Using rough back-of-the-envelope calculations, we estimated how much such reduced student interest contributed to our estimated learning loss.

| | Mathe | ematics | Scie | ence |
|-----------------------------|--------|----------|--------|--------|
| | (1) | (2) | (3) | (4) |
| School closure days | -0.02 | -0.07*** | 0.02 | -0.05 |
| | (0.04) | (0.04) | (0.05) | (0.05) |
| Underidentification test, F | 3 | 4 | 3 | 4 |
| Weak identification test, F | 11 | 14 | 11 | 14 |
| Adjusted R-sq. | 0.00 | 0.36 | 0.00 | 0.38 |
| Observations | 4,818 | 4,169 | 4,744 | 4,084 |
| Included covariates: | | | | |
| Typhoon school days | Yes | Yes | Yes | Yes |
| Student attributes | | Yes | | Yes |
| School head attributes | | Yes | | Yes |
| School attributes | | Yes | | Yes |
| Memorandum items: | | | | |
| Unconditional mean | | 9.72 | | 9.20 |
| Unconditional S.D. | | 1.53 | | 1.79 |

| Table 9: School Closure Da | ys and Student Enthusiasm |
|----------------------------|---------------------------|
|----------------------------|---------------------------|

Note: *, **, and *** signify statistical significance at the 10%, 5%, and 1% alpha levels, respectively. Values in parentheses are heteroskedasticity-robust standard errors clustered at the school level. The sample includes Grade 4 public school students in the 2019 Philippine TIMSS. See Table 1 for the full list of covariates included in the estimation. The under- and weak identification F statistics refer to the Kleibergen-Paap rank LM and rank Wald statistics, respectively. Due to the reported weak instruments, inference on the point estimates is based on the Anderson-Rubin weak identification-robust Wald test.

We first ran a simple linear regression of mathematics scores on students' enthusiasm index, which shows that a unit increase in the index is associated with about a 26-point increase in mathematics achievement. With a five-school-closure-day difference among schools by school-as-shelter use (Table 1) and the -0.07 estimate in Table 9, we estimate a difference in the student enthusiasm index of around -0.35 points. Combined with our simple linear regression estimate, we can say that roughly nine points or about three quarters of the learning loss from school closures is through this channel. Including additional controls in the descriptive regression above leads to a lower but still significant six-point decline or about half of the estimated learning loss from school closures.

5.4 Cost Implications

The practical implications of our results could be catastrophic. With an average learning gain of one tenth to a quarter SD from one year of schooling (Avvisati and Givord 2023), a single day of school closure induced by school shelter use can practically halve or even wipe out a whole year's worth of mathematics and science learning.

In turn, this leads to substantial foregone public education financing. Using DepEd's USD12 billion budget in 2023 as a hypothetical reference, with about 5% of students enrolled in public schools that have been used as shelters and the average school closure of about six days among schools ever used as shelters (Table 1), as much as a third of the government's education budget or USD4 billion-worth of education financing per year could be rendered ineffective because of school closures.

Following Jakubowski, Gajderowicz, and Patrinos (2023, 2024), we also calculated the potential long-term economic loss from school closures. We similarly assumed that the drop in TIMSS score among G4 students leads to a proportional drop in PISA scores among 15-year-old students. This allowed us to link PISA-based estimates to calculate implications for long-term economic welfare. Using the 1.74 coefficient estimated by Hanushek and Woessmann (2010), a one-off nationwide school closure day in the Philippines translates to about a 0.2 percentage point drop in its long-term annual GDP. With the Philippines' 2023 GDP, this is roughly equivalent to a foregone USD1 billion for every day of nationwide school closure.

6. CONCLUSIONS

We combined student-level assessment data with official school closure and typhoon warning information to assess the impact of school closures on children's learning outcomes. We leveraged on school-level differences in school-as-shelter days to provide causal estimates of the impact of school closure on mathematics and science achievement.

Short school closures induced by school-as-shelter use result in large learning losses. The mathematics and science achievement of Grade 4 students in the Philippines declined by 12 to 14 % of a standard deviation on average for each day of school closure, or roughly equal to about half to a whole year's worth of learning. These effects are larger than reported comparable per day learning losses from school closures during the COVID-19 pandemic and closely approximate the cumulative effects for countries with the longest pandemic-induced school closures. Our estimates are robust to alternative model specifications and the student achievement data employed.

Further probing shows that the significant learning loss from school closures may be driven primarily by a drop in student interest, and not necessarily by teachers skipping topics in class or educators teaching ineffectively. This resonates with previous results documenting increased psychological distress among displaced children after disasters, which highlights the need for post-disaster psychosocial interventions for children. However, such interventions may be outside of the purview of education sector managers as may be traditionally imagined and would require the engagement of the broader community.

Why are learning losses from short school closures so big? This may be related to differences in responses implemented to address learning losses from school closures. During the COVID-19 pandemic, public school students in the Philippines were provided with physical learning modules based on key learning competencies that they could study while sheltering in place. Additional support was provided through recorded lessons broadcasted over mass media and through direct interactions with teachers using mobile communication. This was not available prior to the pandemic. Instead, teachers provided learners with additional homework or sometimes held catch-up classes since these interventions were not mandatory. These are conjectures that need to be validated, which we reserve for future examination.

REFERENCES

- Adams, G. G., L. MacMillan, T. Smith, A. Sharp, and R. Casagrande. 2023. Metaanalysis on the Health Effects Resulting from Evacuation or Relocation. *Disaster Medicine and Public Health Preparedness* 17: e538.
- Avvisati, F., and P. Givord. 2023. The Learning Gain Over One School Year among 15-year-olds: An International Comparison Based on PISA. *Labour Economics* 84: 102365.
- Beaton, A. E., and E. J. Gonzalez. 1995. *NAEP Primer*. MA, USA: The Center for the Study of Testing, Evaluation and Education Policy, Boston College.
- Bjorkman-Nyqvist, M. 2013. Income Shocks and Gender Gaps in Education: Evidence from Uganda. *Journal of Development Economics* 105: 237–253.
- Cadag, J. R. D., M. Petal, E. Luna, J. C. Gaillard, L. Pambid, and G. V. Santos. 2017. Hidden Disasters: Recurrent Flooding Impacts on Educational Continuity in the Philippines. *International Journal of Disaster Risk Reduction* 25: 72–81.
- Cajucom, E. P. et al. 2019. Evaluation of the Spatial Distribution of Evacuation Centers in Metro Manila, Philippines. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences* 42: 79–85.
- David, C. C. et al. 2018. School Hazard Vulnerability and Student :earning. International Journal of Educational Research 92(1): 20–29.
- Deuchert, E., and C. Felfe. 2015. The Tempest: Short- and Long-term Consequences of a Natural Disaster for Children's Development. *European Economic Review* 80: 280–294.
- Evans, D. K., and F. Yuan. 2022. How Big Are Effect Sizes in International Education Studies? *Educational Evaluation and Policy Analysis* 44(3): 532–540.
- Gupta, A. F. 1997. When Mother-tongue Is Not Preferred. *Journal of Multilingual and Multicultural Development* 18(6): 496–506.
- Hanushek, E. A., and L. Woessmann. 2010. *The High Cost of Low Educational Performance: The Long-run Impact of Improving PISA Outcomes*. Paris, France: OECD.
- Jakubowski, M., T. Gajderowicz, and H. A. Patrinos. 2023. Global Learning Loss in Student Achievement: First Estimates Using Comparable Reading Scores. *Economics Letters* 232: 111313.
- Jakubowski, M., T. Gajderowicz, and H. A. Patrinos. 2024. COVID-19, School Closures, and New Student Learning Outcomes: New Global Evidence from PISA. IZA Discussion Paper Series, No. 16731. Bonn, Germany: Institute of Labor Economics.
- Khan, Q., and K. Hussain. 2023. Gone with the Flood: Natural Disasters and Children's Schooling in Pakistan. *The B.E. Journal of Economic Analysis & Policy* 23(1): 271–283.
- Lapidez, J. P. et al. 2015. Identification of Storm Surge Vulnerable Areas in the Philippines Through the Simulation of Typhoon Haiyan-induced Storm Surge Levels Over Historical Storm Tracks. *Natural Hazards and Earth System Sciences* 15(7): 1473–1481.

- Marin, S. V., L. Schwarz, and S. Sabarwal. 2024. Impacts of Extreme Weather Events on Education Outcomes: A Review of Evidence. *The World Bank Research Observer* Ikae001.
- Martin, M. O., M. von Davier, and I. V. S. Mullis. (Eds.). 2020. *Methods and Procedures: TIMSS 2019 Technical Report*. Boston College, TIMSS & PIRLS International Study Center website (accessed 6 June 2024 from https://timssandpirls.bc.edu/timss2019/methods/).
- Miller, R. K. and I. Hui. 2022. Impact of Short School Closures (1–5 Days) on Overall Academic Performance of Schools in California. *Scientific Reports* 12: 2079.
- Orbeta, A. C., Jr. 2022. Basic Education During the COVID-19 Pandemic: What Do Enrollment by Learning Modality and Household Characteristics Tell Us? In *The Philippines Response to the COVID-19 Pandemic: Learning from Experiences and Emerging Stronger from Future Shocks*, edited by C.M. Reyes. Quezon City, Philippines: Philippine Institute for Development Studies.
- Orbeta, A. C., Jr., K. A. Francisco, J. D. Monje, and E. M. Capones. 2021.
 "Starting Where the Children Are": Process Evaluation of the Mother Tonguebased Multi-lingual Education Program Implementation. *PIDS Research Paper Series*, No. 2021-02. Quezon City, Philippines: Philippine Institute for Development Studies.
- Pfefferbaum, B., A. K. Jacobs, R. L. Van Horn, and J. B. Houston. 2016. Effects of Displacement in Children Exposed to Disasters. *Current Psychiatry Reports* 18(8): 71.
- Rubin, D. B. 1897. *Multiple Imputation of Nonresponse in Surveys*. New York: John Wiley & Sons.
- Strobl, E. 2019. The Impact of Typhoons on Economic Activity in the Philippines: Evidence from Nightlight Intensity. Asian Development Bank Economics Working Paper Series No. 589. Mandaluyong City, Philippines: Asian Development Bank.
- Takasaki, Y. 2017. Do Natural Disasters Decrease the Gender Gap in Schooling? *World Development* 94(1): 75–89.
- Wang, Z. et al. 2019. The Prevalence of Posttraumatic Stress Disorder among Survivors After a Typhoon or Hurricane: A Systematic Review and Metaanalysis. *Disaster Medicine and Public Health Preparedness* 13(5–6): 1065–1073.
- Yin, L., and B. Fishbein. 2020. Creating and Interpreting the TIMSS 2019 Context Questionnaire Scales. In *Methods and Procedures: TIMSS 2019 Technical Report*, edited by M. O. Martin, von Davier, M., and Mullis, I. V. S. Boston College, TIMSS & PIRLS International Study Center website (accessed 6 June 2024 from https://timssandpirls.bc.edu/timss2019/methods/chapter-16.html).
- Zivin, J. G., S. M. Shiang, and M. Neidell. 2018. Temperature and Human Capital in the Short and Long Run. *Journal of the Association of Environmental and Resource Economists* 5(1): 77–105.