HOOVER EDUCATION SUCCESS INITIATIVE

A Global Perspective on US Learning Losses

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Abstract

Recent international and national assessments point to the substantial learning losses that resulted from school disruptions during the pandemic. The United States, which entered the pandemic with achievement near the OECD average, had average pandemic learning losses and emerged from it at roughly the same international ranking as before. At the same time, there was substantial heterogeneity in achievement losses across states and across individuals, leading to disproportionate economic impacts on some individuals and states. The learning losses from the pandemic foretell substantial economic costs related to the lower skills of those in the COVID-19 cohort. Unlike the other economic costs of the pandemic, those from learning losses are future costs that are yet to accrue and that can be ameliorated by public action—but the time for feasibly addressing them is quickly running out.

OVERVIEW

As concerns about the health aspects of the COVID-19 pandemic have receded, more of the public discussion has turned to the learning losses that resulted from school closures and erratic reopenings. We now have both national and international data that permit more rigorous discussions of the losses, their sources, and their costs. Although these data will be analyzed for years to come, we can begin to assess the pandemic's impact on education in terms of the economic costs for individuals and the nation. Unfortunately, policy responses to the learning losses do not appear to be commensurate with the magnitude of their future economic impact.

Recent international assessments conducted by the Program for International Student Assessment (PISA) and the National Assessment of Educational Progress (NAEP) provide data on student performance that brackets the pandemic. By harmonizing these assessments, it is possible to place both the United States as a whole and the individual states in the world achievement distribution. It is also possible to translate the learning losses resulting from school disruptions during the pandemic into economic implications.

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Most, but not all, nations saw the achievement of their students fall below that before the pandemic. These declines proved to be very uneven globally. Because higher-performing countries tended to suffer greater losses than lower-performing ones, there was some compression in the variations across countries. The United States continued to rank closer to lower-income countries than to more developed countries that are its direct economic competitors.

Within the United States, there was also significant heterogeneity at the state level. Some states clearly came through the pandemic substantially better than others. Although they were still not competitive with those in top-performing countries, the students in top-performing states became more competitive with students from abroad, whereas other states moved down in the international rankings.

From the available evidence, it is difficult to identify the specific responses to the pandemic that led to better outcomes. Countries clearly responded to the challenges in very different ways, from essentially no school closures (Sweden) to multiple years of closures (Uganda and Indonesia). Yet, simple statistics such as the length of school closures or overall health policies cannot explain much of the variance in outcomes. And, like many other countries, the United States saw widely varying responses implemented by the states and local districts.

We begin by situating the United States as a whole in the world distribution of educational achievement. To do so, we rely on the 2022 edition of PISA that provides comparisons of math skills for fifteen-year-olds in eighty-one countries.[1] The United States ranks thirty-fourth among the participating countries and territories, thus reinforcing the challenges facing US students both before and after the pandemic.

We then compare the 2022 scores to those for the similar cohort tested in 2018—the pre-COVID cohort—to obtain an estimate of the overall impact of the pandemic on learning. Although these comparisons are subject both to influences other than the pandemic and to nonschool factors, they provide a direct estimate of losses in human capital. There were very wide differences in the changes in scores occurring during these four years, with math scores in thirteen countries actually improving over the period. The United States was not one of those countries with improving scores but saw losses in the mid-range for the world.

The United States is, however, a large and very diverse country. States and localities show large differences in school performance and endured widely different learning losses. Using performance on the NAEP, it is possible to put each of the states into the world distribution of math performance. The best-performing state (Massachusetts) would rank sixteenth in the world, placing student performance just ahead of the average student in Austria and just behind the average student in the United Kingdom. The next-highest-performing state was Utah, ranking twenty-first in the combined state and national rankings for the participating countries, placing it ahead of Finland but behind Slovenia. At the other end, thirteen states had students whose math achievement fell behind the average student in Turkey.

These declines in learning imply a future labor force that is less well prepared than it would have been without the pandemic. If not corrected, the learning losses may bring significant

economic losses both for individuals who were in school during the pandemic and for the nation. Throughout the pandemic, continuous consideration was given to the economic impact of business closures and business-cycle losses. Yet, the economic consequences of learning losses will dwarf these other economic costs if substantial changes are not made in the schools. Importantly, unlike the business-cycle costs, the losses in human capital can still be addressed, although the time to do so feasibly is running out as the affected cohort exits from the schools.

Based on the available research on lifetime earnings associated with more skills, the average student in school during the pandemic will lose 5 to 6 percent of lifetime earnings. Because a lower-skilled workforce leads to lower economic growth, the nation will lose some $31 trillion (in present value terms) during the twenty-first century. This aggregate economic loss is higher than the US GDP for one year and dwarfs the total economic losses from either the slowdown of the economy during the pandemic or from the 2008 recession.

It is also possible to assess how the economic costs of the pandemic were spread across the United States. Students from different states can expect to lose widely different proportions of their future earnings. Whereas the students from Utah, who on average suffered the lowest learning losses in the nation, can expect 2 percent lower lifetime earnings, this economic loss climbs to 9 percent for the students in Delaware and Oklahoma.

State economic growth, like national economic growth, is directly related to the skills of the state labor force. In percentage terms, the state losses mirror the losses to individuals. The lowest average loss is found in the state of Utah, which will lose slightly more than one-half percent of future state GDP compared to an aggregate loss in Delaware and Oklahoma of almost 3 percent of future state GDP.

A different perspective on the economic losses comes from calculating the dollar value of losses. This calculation differs from the prior estimated losses because two factors come into play: not only the degree of learning loss of the average student in each state must be considered but also the total loss must take into account the size of each state. Thus, California is estimated to lose far more in total GDP than all the other states, even though its average learning loss was less than that in thirty-nine states. The present value of total loss in California is estimated to be $1.3 trillion. In fact, five states show losses greater than $500 billion, but of those, only Pennsylvania also had learning losses above average for the nation.

Finally, we provide a few observations about recovery from the learning losses. History suggests that these losses are likely to be permanent unless the schools become better than they were before the pandemic. Since the end of the pandemic, states and localities have made varying attempts to ameliorate the losses from the pandemic, including prominently extending school days and school years, providing varying amounts of tutoring, and establishing both voluntary and involuntary summer school. To date, however, these efforts have not on average been very successful in addressing the pandemic losses. In fact, some schools have struggled just to return to their prepandemic level of operations, and a portion of the school population has even disappeared.[2]

The federal government provided $190 billion in extra school funding to deal with the problems of the pandemic. Much of this money was directed at individual districts, although a relatively small portion of these funds was directed specifically at student learning loss.[3] The actions to date have been generally insufficient to deal with the magnitude of learning loss. Although some local programs have achieved a high level of effectiveness, it has been difficult to identify the elements of successful programs. Thus, these programs remain isolated without significant duplication and scaling.

Unfortunately, any ability to deal with the learning losses is largely limited to the time that the affected students are enrolled in K–12 schools. More than seventeen million students have already completed their K–12 schooling without having been substantially brought up to the learning levels of the school seen before the pandemic. Thus, for most of this segment of the population, the learning losses are likely to be permanent, and the implications for future earnings losses are locked in.

The pandemic magnified already existing reasons to want to improve our schools. The timing of dealing with the losses means that long-term reforms to the K–12 system, however valuable and warranted, will not address the pandemic losses already incurred. Thus, there needs to be an emphasis on immediate improvements that build on the existing system.

THE WORLD RESULTS

The Organisation for Economic Co-operation and Development (OECD) has through the PISA assessments tested fifteen-year-olds in math, reading, and science every three years since 2000. The latest testing was moved back one year to 2022 because of the pandemic. That move allows us to bracket the pandemic with testing in 2018 and then again in 2022.

BACKGROUND ON PISA 2022

Although varying numbers of countries have participated over time in the PISA testing, eighty-one countries and economies participated in the 2022 assessments (OECD 2023a). These countries included all those in OECD except Luxembourg and forty-four non-OECD countries or economies. Some special regions such as Macao and Hong Kong are included along with those with partial country coverage such as Baku (Azerbaijan) and the Palestinian Authority; thus, the rankings are not strictly "country rankings."

The testing program, like the schools themselves, faced challenges during 2022. The OECD has strong requirements for sampling and testing in each country, and a number of countries—including the United States—did not meet the cutoffs for school and student participation. Thirteen countries failed to meet one or more of the sampling criteria during the 2022 assessment (OECD 2023b).[4]

For the United States, sampling problems occurred in both the exclusion of selected students within the participating schools and the overall school response rates. The PISA standard

calls for 95 percent or more of the targeted students to participate, but 6.1 percent were excluded in 2022—a significantly greater rate than for 2018.[5] Additionally, the school response rates of 51 percent before replacement and 63 percent after replacement of initially sampled schools with alternative schools fell below the goals of 85 percent for each.[6]

As with the other countries failing to meet the sampling standards, the US results are reported for the tested students. After analysis, OECD (2023b) reached this conclusion for the US data: "Based on the available information, it is not possible to exclude the possibility of bias, nor to determine its most likely direction." We thus take the sampled scores at face value, with the caveat that some of the following analysis might be affected by obtained sampling.

AGGREGATE PERFORMANCE LEVELS IN 2022

At the end of the pandemic, the United States was not doing well in an absolute sense. Figure 1 displays the country ranking in mathematics for the eighty-one participants in PISA 2022.[7] The United States falls slightly below the OECD mean score and is competing with Malta and the Slovak Republic. This places the US a full three-quarters of a standard deviation behind students in Singapore and half of a standard deviation behind Macao and Taiwan.

This level of performance is disturbing because it has significant economic implications. At the individual level, skills are rewarded in the labor market. In fact, the United States rewards skills more than most OECD countries. The relative returns on math skills across countries, shown in figure 2, indicate that an individual who is at the eighty-fourth percentile of the achievement distribution will on average earn 25 percent higher lifetime income than the median worker at the fiftieth percentile.[8] The high return to skills reflects the fact that the United States has a very dynamic economy, and people with higher skills are rewarded for being generally more able to adjust to change.[9]

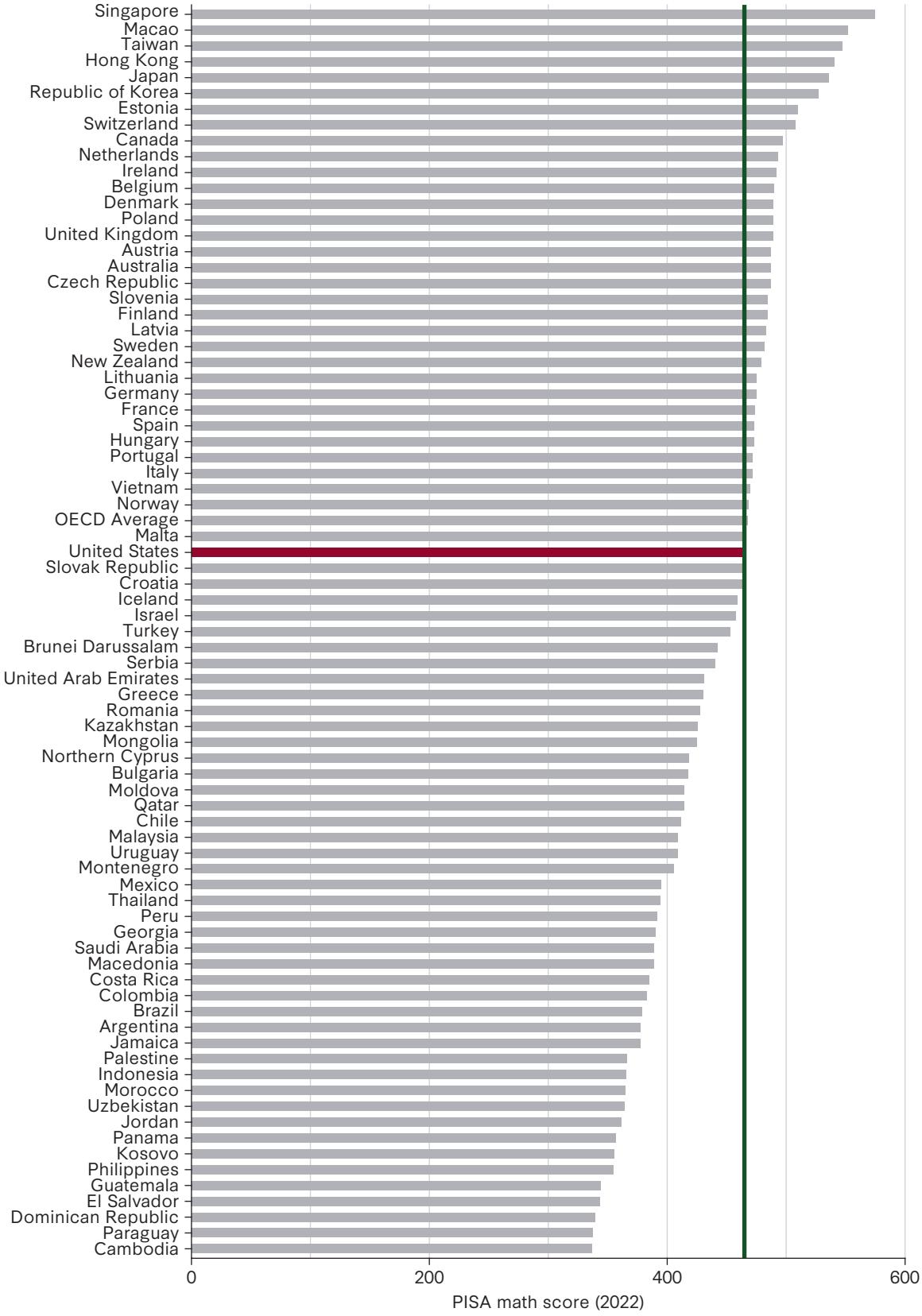
The rewards for skills also come into play in terms of the overall national economy. Countries with a more skilled workforce also tend to grow faster, as seen in figure 3. This plot of country average scores against long-term annual growth rates shows the close relationship between the two.[10]

It is economic growth that leads to improvements in a nation's economic well-being. The historic relationship of skills to growth imply that huge economic gains will come from improving US schools. We emphasize this in the aggregate and show the impact of learning losses that results from the lower skills of the future labor force because of the pandemic.

INTERNATIONAL LEARNING LOSSES WITH THE PANDEMIC

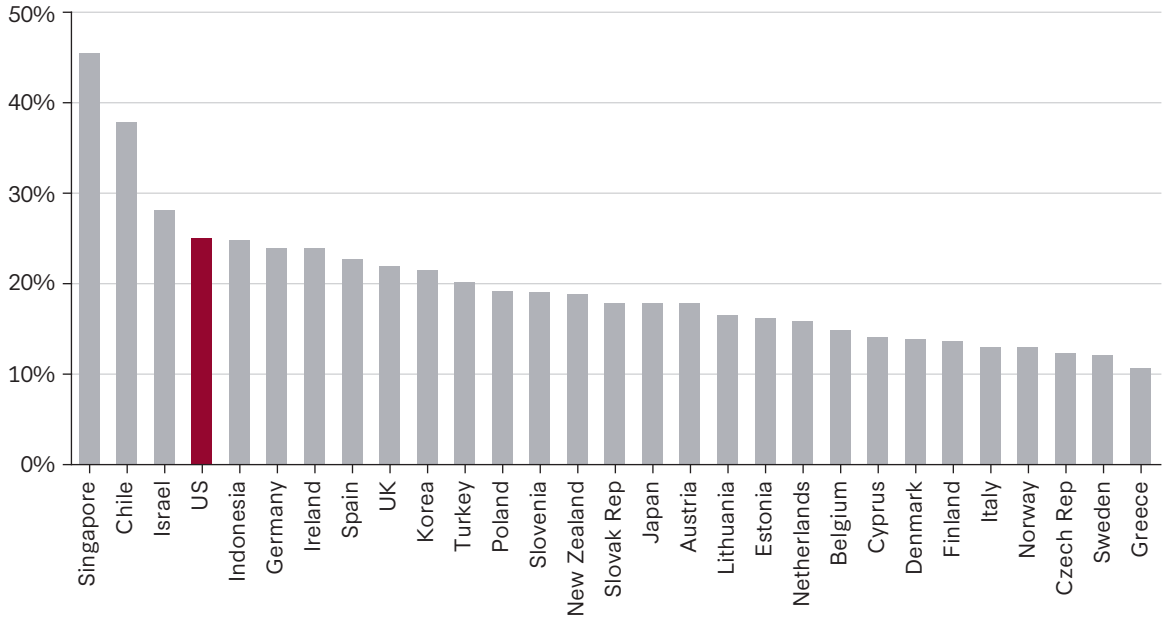
The pandemic was a worldwide phenomenon that had varying impacts across countries and, as seen in the next section, within the United States. The distribution of country performance in figure 1 incorporates the change in performance over the pandemic. It is useful to look directly at the changes because their pattern gives some hints about the source of the changes.

FIGURE 1 PISA math scores 2022



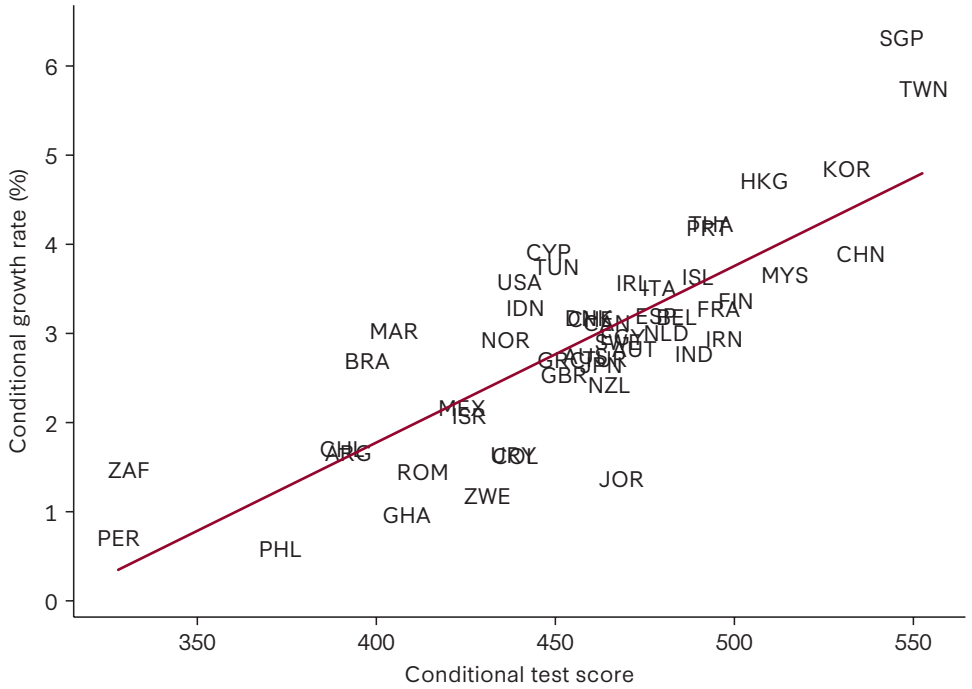
Source: OECD (2023a).

FIGURE 2 Returns to math skills for OECD countries



Source: Adapted from Hanushek, Schwerdt, et al. (2017).

FIGURE 3 Knowledge capital and economic growth, 1960–2000



Note: See the text for a discussion of this relationship.

Source: Hanushek and Woessmann (2015).

Thirteen of the countries with scores available for 2018 and 2022 showed gains in the math assessment over the pandemic (figure 4). This finding underscores a key element of interpretation: when we focus on the differences in scores between the two cohorts of fifteen-year-olds, these scores do not just reflect the impact of schools on student outcomes. They also are determined by nonschool factors such as family and peer inputs. Further, because they are different cohorts of students, they may have entered the pandemic at a different level, perhaps reflecting earlier changes in the schools. Given the disruption of the pandemic, it is doubtful that the average student enrolled in school during it did better than he or she would have if there had been no pandemic. Thus, although we interpret the changes in scores between cohorts as an estimate of how much less learning was accomplished by the average student during the cohort, it must be recognized that this is a rough estimate. At the same time, there is no reason to expect this estimate to be biased either positively or negatively.

The United States did not do well during the pandemic. Among the countries with lower 2022 math scores, the US ranked thirty-first in losses. This loss is slightly less than seen for all OECD countries.

The losses tended to be larger in countries with higher achievement before the pandemic (figure 5). This finding may reflect the fact that the lower rate of learning in schools for low-achieving countries meant that school closures had relatively less impact on overall achievement. But the fact that Taiwan, Japan, Singapore, and South Korea all showed gains over the pandemic suggests that families there stepped in to offset any potential losses from school closures and the pandemic.

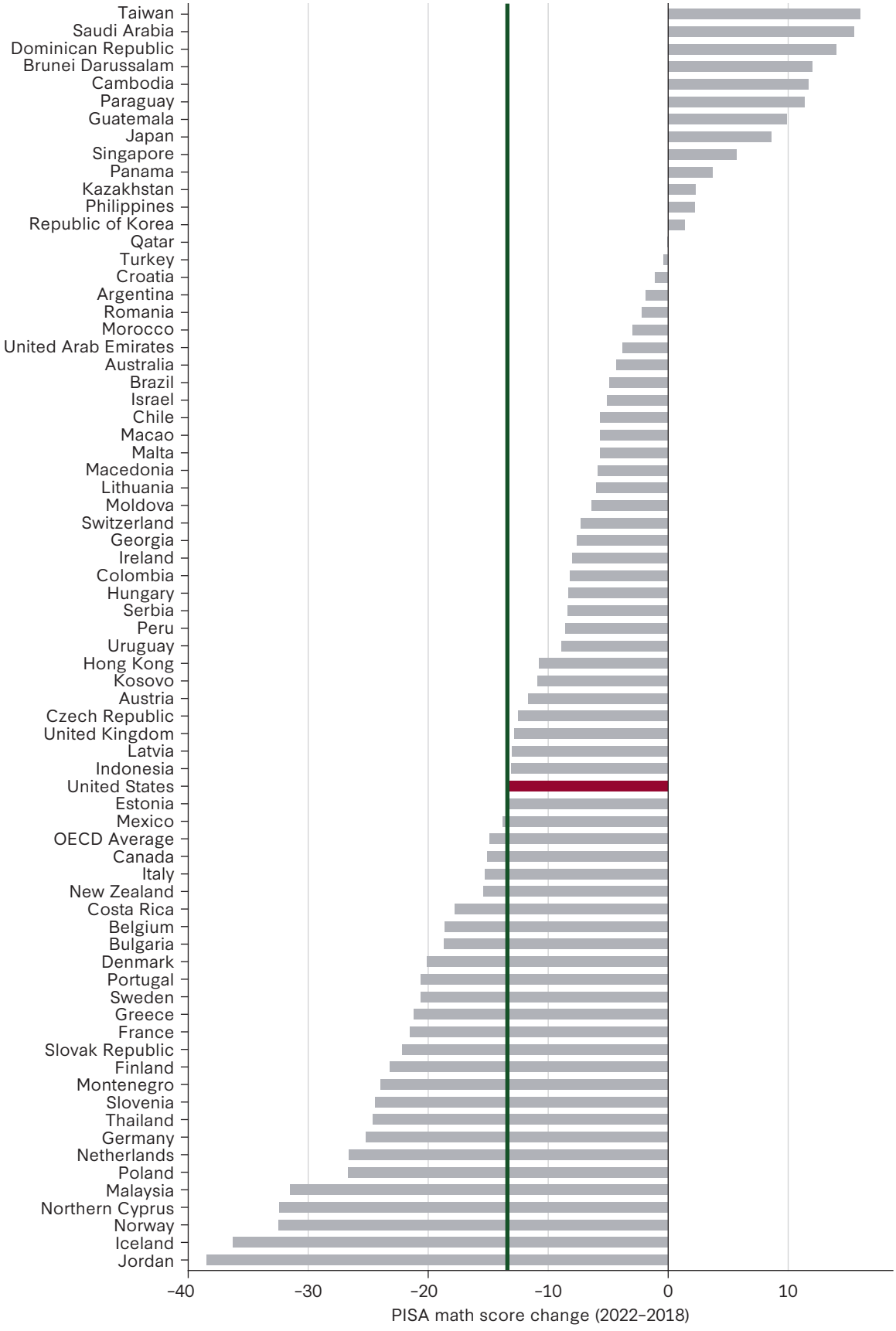
There have been several alternative efforts to collect data on the responses of different countries to the pandemic in terms of school policies.[11] Our preliminary investigation of these reports indicates some inconsistencies in their data, particularly regarding closure times. Some of the inconsistencies relate to time periods of observations, the details of coding, and the like. We have thus made only limited efforts to understand why the differences in losses might have happened. Instead, as described later, we focus on the extent of learning losses, their implications, and future policies to ameliorate them.

HETEROGENEITY IN THE UNITED STATES

Just as seen internationally, American states had very heterogeneous performance, both in absolute terms and in response to the pandemic. This varying performance has obvious implications for the long-run economic costs that students from different states absorb.

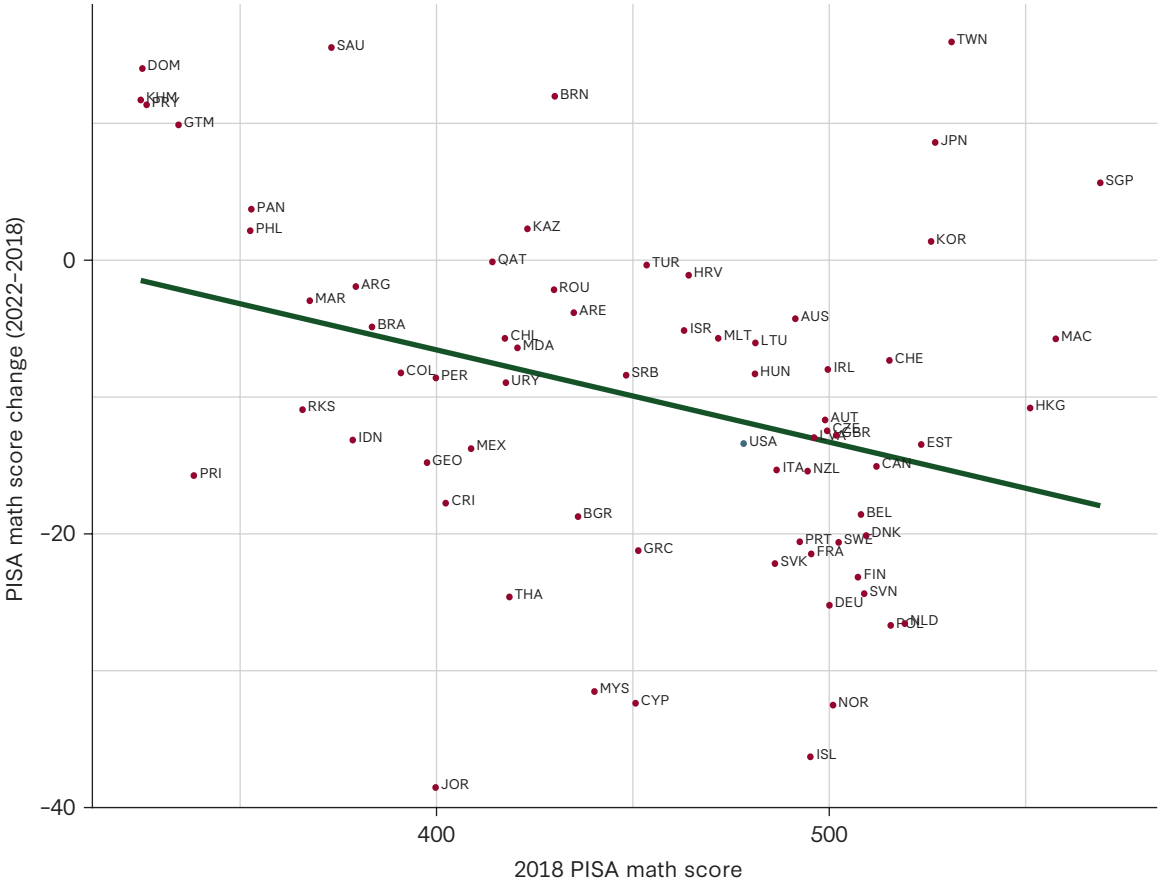
The range of performance across states is perhaps best seen by placing the individual states into the world distribution of achievement as seen in PISA 2022. The NAEP testing of mathematics in 2019 and 2022 for eighth-graders provides assessments that can be related directly to the PISA scores, which makes it possible to judge where individual states fall in the international distribution.[12] Overall, the learning losses highlighted by the PISA score changes are very similar to those found in the NAEP test.[13]

FIGURE 4 Change in math PISA scores, 2018–22



Source: OECD (2023a).

FIGURE 5 Change in PISA math scores relative to prepandemic scores



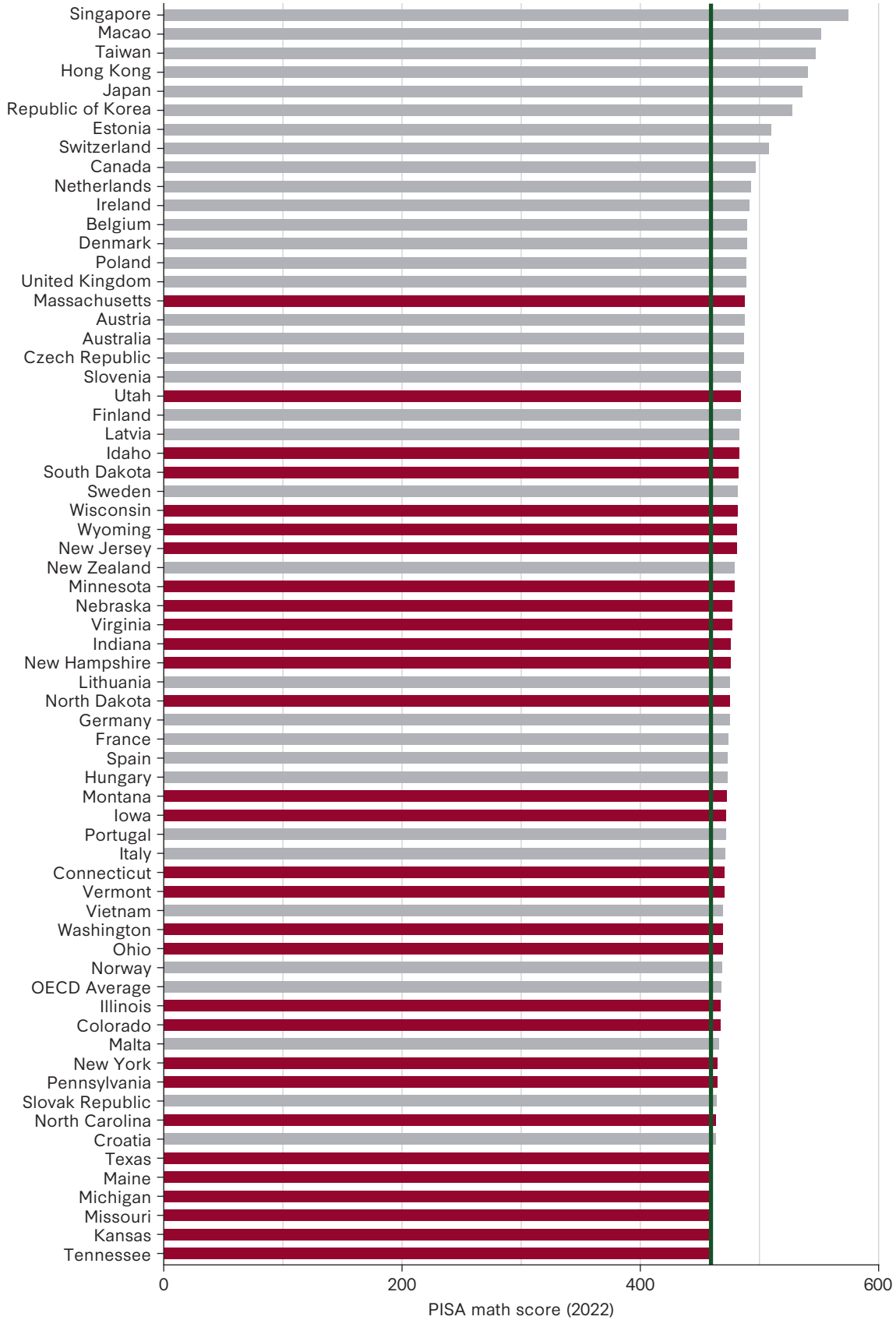
Source: Author calculations from OECD (2023a).

Superimposing the state distribution on the international distribution shows that the highest-achieving state—Massachusetts—would place sixteenth in the world distribution (figure 6 for states and countries above the median; figure 7 for those below the median). Utah would place twenty-first. A total of thirty states placed in the top half of the participating countries and states. The majority of states are bunched just above or just below the median, but that position does not have them competing with the most economically vibrant countries. The lowest-ranking state (New Mexico) is competing with Romania and Kazakhstan.

The simple summary of this set of comparisons is that even the best-performing American states did not do well when compared to what is possible. The large number of countries where the average student performed better than the average student in the best states raises concerns about the economic future of our country.[14]

As with the range of outcomes during the pandemic that were seen internationally, the states differed dramatically in how they dealt with closures and learning losses. Utah lost very little during the pandemic (again, as measured by score comparisons for those eighth-graders

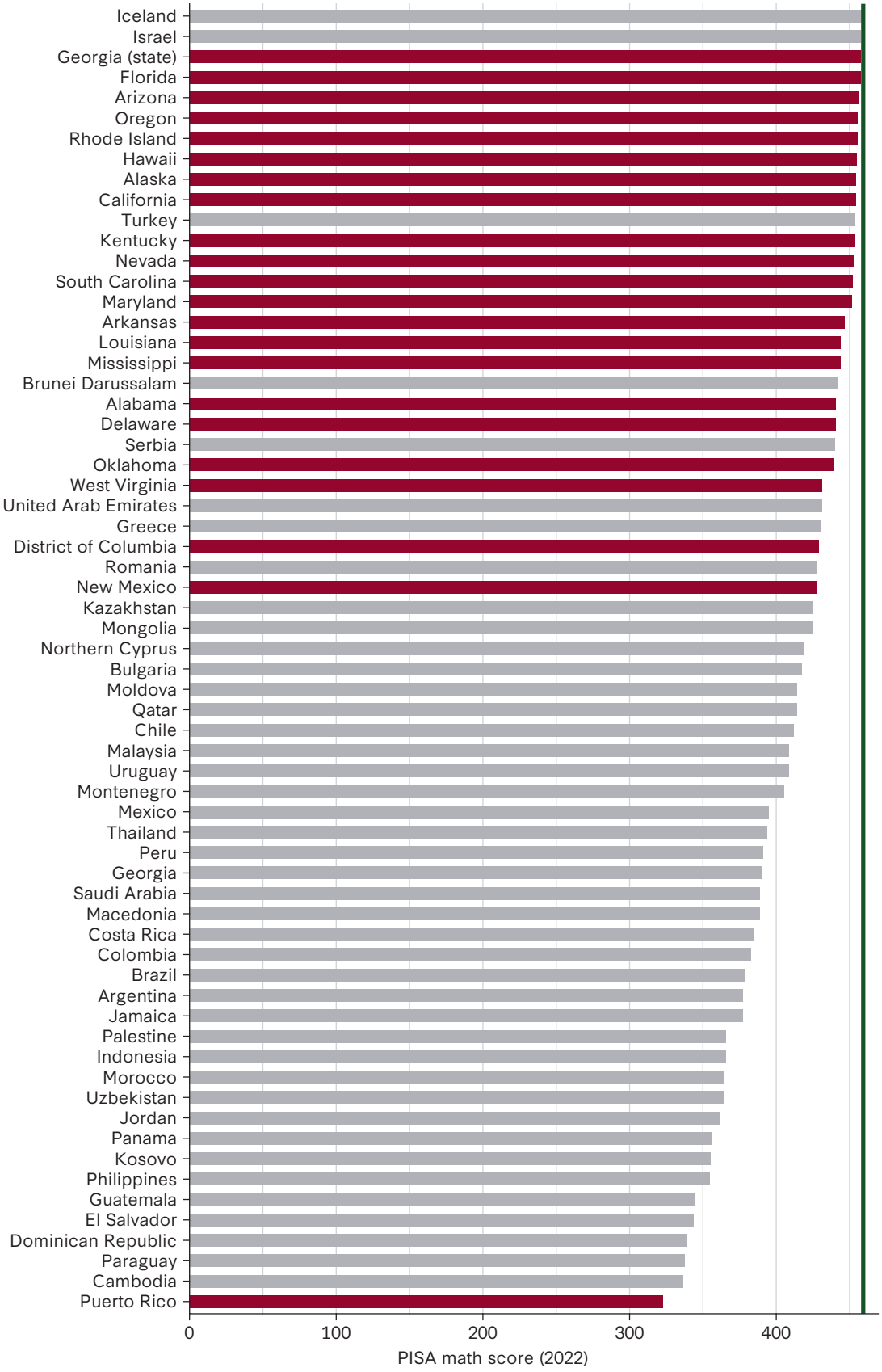
FIGURE 6 Math achievement in 2022 for US states and for countries above the international median



Note: State scores on NAEP 2022 are transformed onto the PISA 2022 scale.

Source: Author calculations from OECD (2023a) and NAEP (2024).

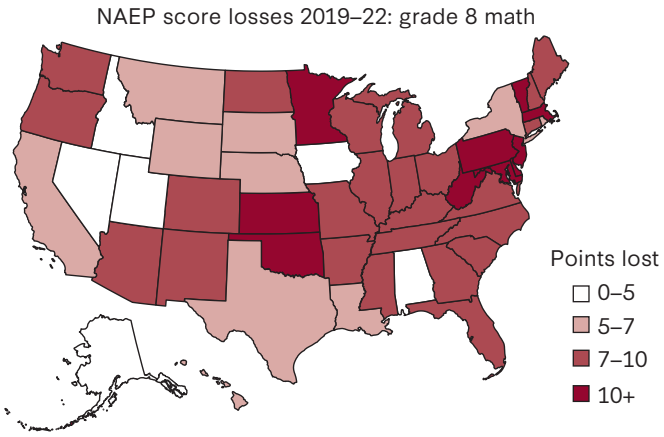
FIGURE 7 Math achievement in 2022 for US states and for countries below the international median



Note: State scores on NAEP 2022 are transformed onto the PISA 2022 scale.

Source: Author calculations from OECD (2023a) and NAEP (2024).

FIGURE 8 NAEP score declines by state, 2019–22



Source: Author calculations from NAEP (2024).

preceding the pandemic in 2019 with those in 2022). But, as seen in figure 8, Oklahoma and Delaware at the other end of the spectrum suffered huge losses.

ECONOMIC COSTS OF THE PANDEMIC

Of course, the scores both on the NAEP assessments and on the PISA assessment are measured in arbitrarily set scale scores that have no natural meaning. Saying that a state lost two points or twelve points on the NAEP scale provides little indication of the severity of any lowered achievement. It is possible to move to common technical rankings in terms of standard deviations of the distribution, but this again provides little intuition about the severity of the losses. To provide a more precise and understandable measure of these losses, we address the economic implications of these losses.

As discussed earlier, the significance of the skills measured by the standardized PISA and NAEP tests is readily apparent in the economic realm. Students who know more tend to earn more, and countries with more skilled labor forces grow faster. These relationships were seen graphically in figures 2 and 3, but it is hard to see from these graphs just how important skills are. Knowing that there is a positive relationship does not say whether any differences are truly meaningful.

AVERAGE IMPACT OF THE PANDEMIC FOR INDIVIDUALS

We begin with the losses suffered during the pandemic in terms of the lifetime earnings expected by the average student. This is readily calculated from the relationship presented in figure 2 and shows the dramatic impact on the COVID cohort.

The average student in the United States will have 5–6 percent lower lifetime earnings compared to expected earnings had there been no pandemic. These losses have important lifelong

consequences. First, the losses will persist throughout individuals' lifetimes unless something is done to make up for them. In simplest terms, if schools were doing the best that they could before the pandemic, a return to that pace of learning will not erase the deficits suffered during the pandemic.[15] Second, this cohort can expect lower lifetime earnings than the cohort finishing school immediately before the pandemic and the cohort starting school immediately after the pandemic.

IMPACT OF THE PANDEMIC ON THE UNITED STATES

The COVID cohort implies that the labor force of the future will have less-skilled workers. As such, the previous description of the relationship of skills to growth implies that the learning losses will have a lasting impact on the economy.

We can estimate this impact by comparing the lower growth as the COVID cohort works through the system with the growth that would be expected without a pandemic.[16] This simulation allows for members of the COVID cohort to move into the labor force steadily as they graduate, staying in the labor force for forty years, and then retiring. Thus, the quality of the labor force dips for a period as this cohort moves fully into the labor force and then returns to the pre-COVID quality level as this cohort fully retires. Using the historic growth relationship portrayed in figure 3, we estimate future growth in GDP through the remainder of the twenty-first century. We then calculate the present value of GDP with and without a pandemic (using a 3 percent discount rate), so that the differences in future GDP are all placed in terms of current value.[17]

The impact of the lower-quality future labor force on the economy is dramatic. The present value of the losses amounts to $31 trillion (in 2020 dollars). Although numbers of this magnitude are difficult to understand, table 1 puts them into perspective.[18] This loss on average amounts to a 3 percent lower GDP throughout the remainder of the century. The present value of the economic impact of learning losses amounts to one and one-half times the GDP for the United States at the start of the pandemic in 2020.

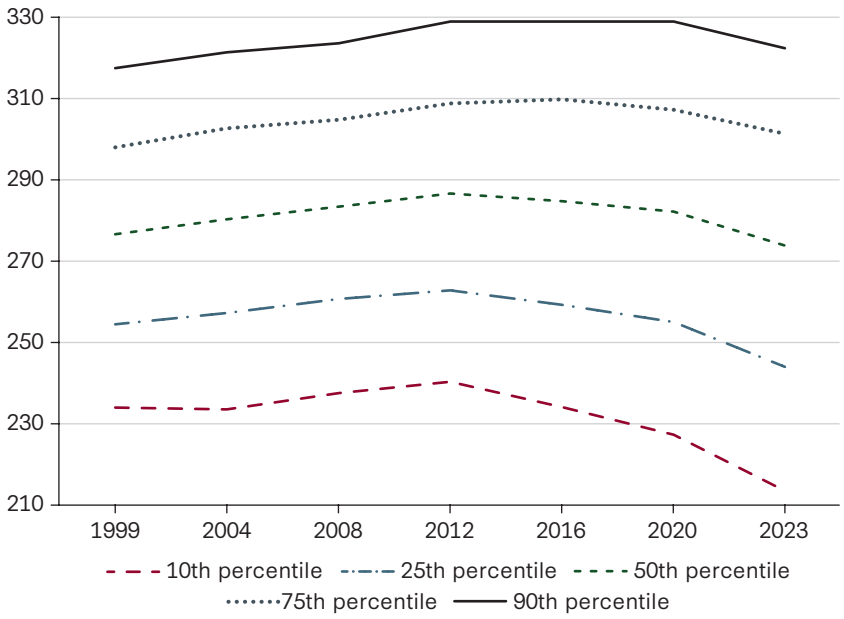
The lopsided attention to the business-cycle losses from the 2008 recession and from the pandemic is startling once we see the comparable pandemic learning loss figures. The economic losses from the loss of human capital are fully six times the total losses from the 2008 recession, which was labeled the largest recession since the Great Depression. They are seventeen times the economic losses during the pandemic slowdown, including those incurred by plant and business closures, COVID-related unemployment, and the like.

TABLE 1 COMPARISONS OF AGGREGATE ECONOMIC COSTS OF PANDEMIC

Pv of learning losses (billion USD)	Compared to discounted GDP	Compared to GDP in 2020	Cumulative business cycle	
			2008	COVID
$30,711	3.1%	147%	$4,983	$1,760

Source: Author calculations.

FIGURE 9 Changes in NAEP scores by achievement percentiles, NAEP age 13 math



Source: Author calculations from NAEP (2024).

HETEROGENEOUS INDIVIDUAL ECONOMIC LOSSES

The school disruptions and closures had a very uneven impact on students, implying that the average losses do not tell the entire story. Clearly, some families were better able to offset the school closures—by providing direct help in learning, purchasing learning aids and supplements, and so on—than others. The PISA 2022 scores show both an increase in the variation of scores for US students and an expansion of the score distribution. The differential impact seen in NAEP scores can be seen in figure 9. Using the simple estimates of score declines between 2019 and 2022 on the long-term NAEP, we see noticeably larger declines at the bottom of the score distribution than at the top.

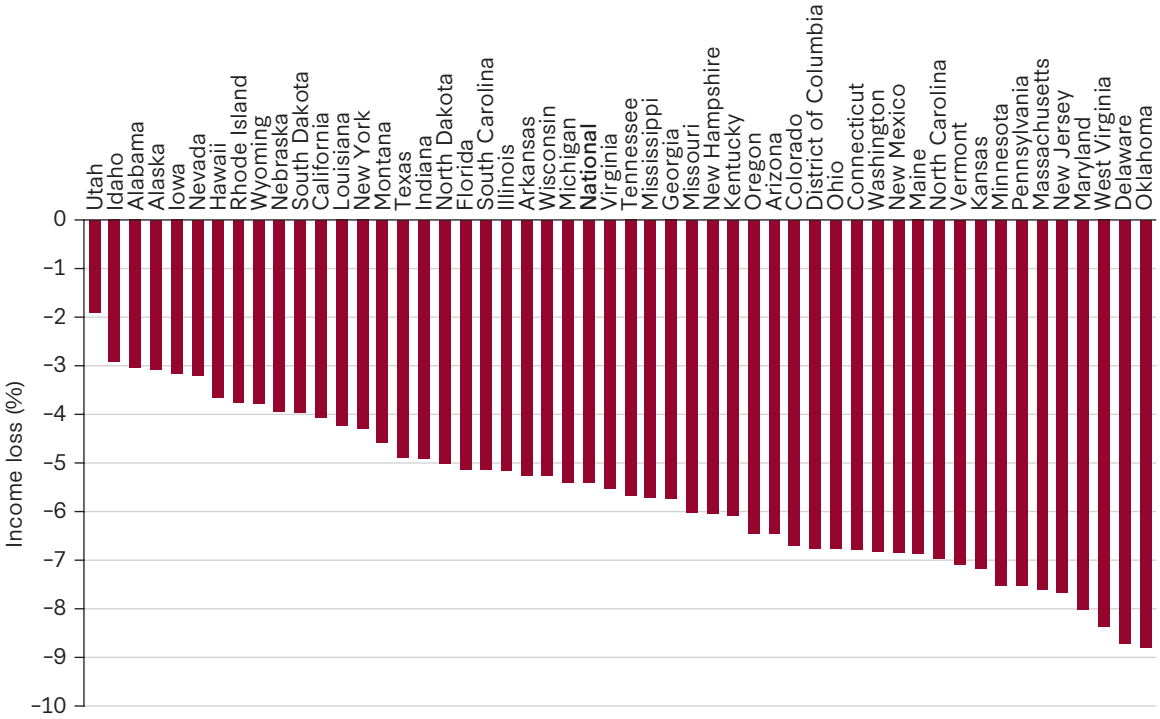
The 5–6 percent loss in average lifetime earnings masks a highly skewed distribution of impacts. In terms of individual expected earnings, these score differentials imply a 4 percent loss for those at the top of the score distribution and a 9 percent loss for those at the bottom. The full explanation of the causes of the differential losses is not available, but there is evidence that hybrid and remote instruction related to closures contributed to the distribution of losses (Goldhaber et al. 2023).

HETEROGENEOUS STATE ECONOMIC LOSSES

An alternative perspective on the heterogeneous losses comes from the differences in outcomes seen across the states. The differential losses shown in figure 8 translate into very different expected economic outcomes.

At the individual level, students in Utah, which navigated the pandemic better than other states, would on average lose 2 percent of their lifetime income (figure 10). In contrast,

FIGURE 10 Average individual economic losses by state



Source: Hanushek (2023).

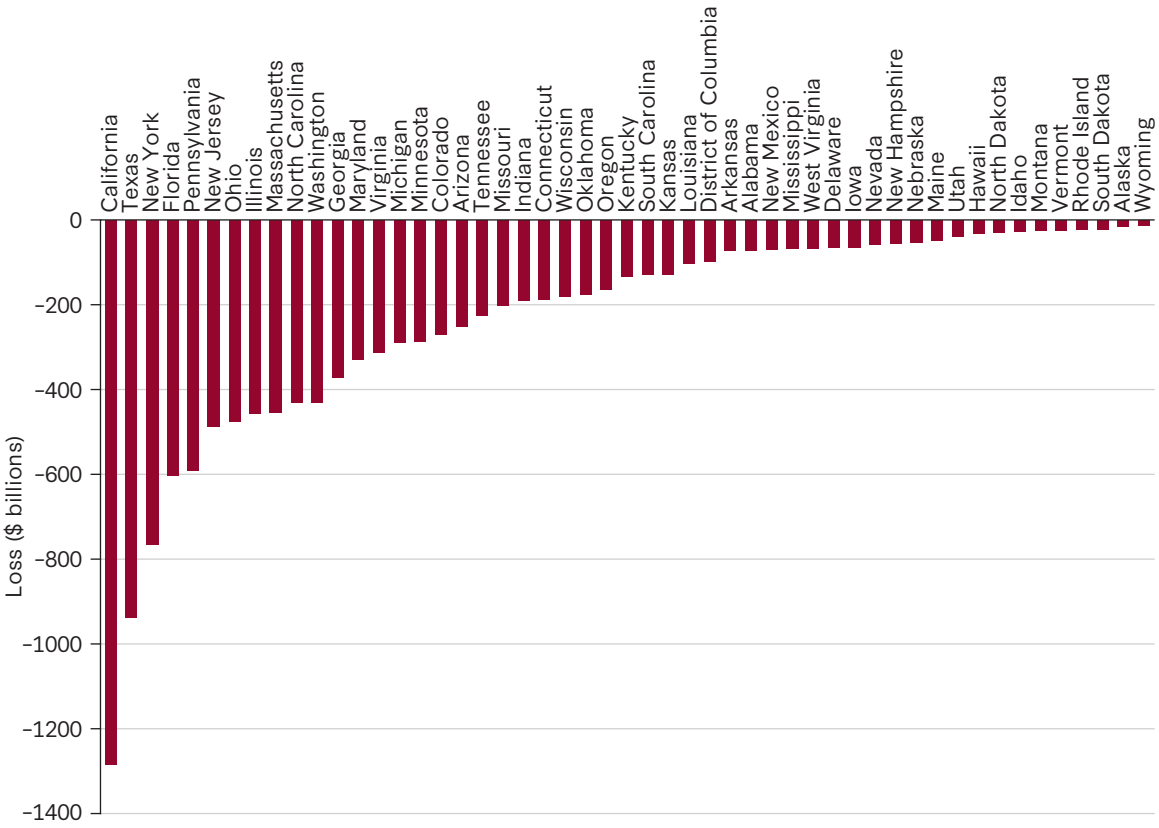
students in Delaware and Oklahoma can expect to lose 9 percent of their lifetime income. These dramatic differences underscore the direct linkage between learning loss and the expected incomes of students.

As previously seen at the national level, there is also a direct linkage between skills of the state population and state GDP growth (Hanushek, Ruhose, and Woessmann 2017a, 2017b). In percentage terms, the losses in state GDP follow exactly the same pattern as seen for individual earnings. Utah can expect future GDP that is 0.6 percent lower than that without the pandemic, whereas Oklahoma and Delaware can expect a 2.9 percent lower GDP.

But the picture changes when considering the total dollar value of losses because they reflect not only the magnitude of the learning losses but also the size of the state economies. The lowest losses come in Wyoming and Alaska, which have low learning losses and relatively small economies, thus limiting the present value of economic loss to around $15 billion (figure 11). In contrast, California's learning losses were only slightly more than Wyoming's but the total economic loss is $1.3 trillion, a differential reflecting the size of the economies.

In addition to California, the economies of Texas, New York, Florida, and Pennsylvania each have losses greater than $500 billion. Again, these losses reflect both the magnitude of learning losses and the size of the economies. Each of these large-loss states except Pennsylvania actually suffered less-than-average learning losses as measured by NAEP scores.

FIGURE 11 Present value of aggregate state losses in GDP



Source: Hanushek (2023).

DEALING WITH LEARNING LOSSES

The comparisons of the economic costs of the pandemic with those from business-cycle unemployment, business closures, and the like were made to indicate the gravity of the situation. There is, however, a fundamental difference between these two cost streams. The recessionary costs have already occurred and cannot be erased. The costs associated with the learning losses are future costs, and they can be eliminated with appropriate remedial measures. However, the opportunity to alleviate the costs for the COVID cohort is quickly disappearing because the chance to aid this cohort becomes difficult if not impossible as it ages out of the schools.

Considerable analysis and discussion have been directed at assessing why some countries and some American states had larger learning losses than others.[19] High-level explanations of losses largely focus on the extent of school closures. But these studies provide little guidance on remedial efforts to deal with the existing losses.

Substantial historical research suggests that these losses will be permanent unless something is done to make the schools better than they were before the pandemic.[20] That underscores

the urgency of the situation. We have few systematic ways to remediate students of the pandemic once they leave the K–12 schools. This means that long-term plans, no matter how useful for future school improvement, cannot deal with the learning losses of the pandemic cohort of students.

From the start of the pandemic in March 2020 through 2023, about seventeen million students left the K–12 system with, according to the most recent data, significant learning deficits.[21] This group on average has little chance of recovering.

The federal government appropriated $190 billion to K–12 schools to compensate for the disruptions and challenges of the pandemic. These funds, which mostly went directly to schools, will disappear soon, but little of this money has been directed at remediating the learning losses. The most widely used approaches have been tutoring programs or providing additional learning time through expanded school days, summer school, or other ways to add time. Only a minority of schools have offered the high-dosage tutoring that is often held to be the best alternative.[22] Initial investigations suggest highly variable outcomes where they have been attempted.[23]

One alternative that has received limited attention is using the current teacher corps more effectively. A substantial body of evidence has emphasized the effectiveness of teachers in raising student achievement. This importance of teachers is the clearest way to interpret the evidence of the superiority of in-class instruction to hybrid instruction and to fully remote instruction (Jack et al. 2023). Moreover, there is evidence that effective teachers will take on more demanding classroom tasks if given incentives to do so (Morgan et al. 2023).

If the more effective teachers could through varying incentives be induced to teach a greater proportion of the students, the average effectiveness of the schools could be improved immediately (Hanushek 2022; Raymond 2023). Of course, this would require restructuring school operations and as such will likely meet with considerable opposition.

ACKNOWLEDGMENTS

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NOTES

1. These data provide the most recent worldwide picture. Earlier world estimates can be found in Patrinos, Vegas, and Carter-Rau (2022).

2. Dee (2023) observes, "More than a third of the loss in public school enrollment cannot be explained by corresponding gains in private school and homeschool enrollment and by demographic change."

3. The federal funds were disbursed in three waves. The first wave went largely for health and safety uses that included buildings, capital expenditures, and equipment. The second wave was directed more to professional development and to maintaining personnel in the schools, but throughout this period, limited

amounts were directed at ameliorating learning losses (see Stadler 2023). The third wave included direct financial assistance to most Americans; forgivable loans to small businesses and employees; and additional resources for health care providers and and state and local governments.

4. The countries falling below the sampling requirements were Canada, Ireland, New Zealand, the United Kingdom, and Scotland, where more than minimal bias was most likely introduced; and Australia, Denmark, Hong Kong (China), Jamaica, Latvia, the Netherlands, Panama, and the United States, where the possibility of more than minimal bias could not be excluded (OECD 2023b).

5. The top three reasons for exclusion in the United States were intellectual disability, functional disability, and language.

6. The sampling identified a primary set of sampled schools and another set of schools that could replace primary schools that did not participate. The United States had the lowest participation rate after replacement of the seven countries that failed to reach the 85 percent goal after replacement.

7. Each assessment focuses on one of the subjects (mathematics, science, or reading) by having assessment items heavily weighted toward it and by aligning survey items with it. In 2022, mathematics was the focus area. Moreover, math receives most of our attention because it is more readily compared across countries and it has been directly linked to economic outcomes.

8. These estimates rely on data from the OECD Program on International Assessment of Adult Competencies (PIAAC). In different waves beginning in 2011, a random sample of adults ages sixteen to sixty-five was surveyed about demographics and employment and, importantly, was given a bank of achievement tests, including math and reading assessments. The estimates in figure 2 come from a separate regression in each country of log income on potential experience and experience squared, years of schooling, and the math test score in standard deviation units (see Hanushek, Schwerdt, et al. 2017).

9. For background on the value of skills, see Nelson and Phelps (1966), Welch (1970), and Schultz (1975).

10. This figure plots the relationship of test scores to average growth rates in GDP per capita over the period 1960–2000. The regression analysis that is behind this also includes the initial 1960 level of GDP per capita and the average school attainment of the adult population. The details of these calculations along with a discussion of causation can be found in Hanushek and Woessmann (2015).

11. See, among others, UNESCO (2022), Angrist et al. (2022), and Jakubowski, Gajderowicz, and Patrinos (2023). Data are available at https://www.bsg.ox.ac.uk/research/covid-19-government-response-tracker.

12. For this, we rely on the Main NAEP assessments of eighth-grade math in 2022. We put the NAEP scores on the same scale as the PISA scores by transforming the mean and standard deviation of NAEP data to that of PISA. This is an exact equating if the distributions are normal and are measuring the same skills. Of course, the NAEP and PISA tests are given at different ages and grades and are constructed with different philosophies, possibly introducing some errors in the equating.

13. The change in math scores with PISA amounted to –0.13 standard deviations for fifteen-year-olds between 2018–22; the change for the NAEP math scores was –0.23 standard deviations for thirteen-year-olds between 2020–23 on LTT NAEP and –0.20 for eighth graders between 2019–22 on Main NAEP.

14. For the implications of current skills for future economic well-being, see Hanushek, Peterson, and Woessmann (2013).

15. See the discussion on the pace of learning in Raymond (2023). Discussion of historical periods of school closures can be found in Hanushek and Woessmann (2020).

16. A detailed description of these calculations can be found in Hanushek and Woessmann (2020).

17. Present value can be thought of as calculating what amount needs to be deposited in a bank account today to completely offset the future losses in GDP, assuming that the bank account accrues 3 percent interest on any annual balances.

18. Aggregate changes use the scores on the LTT NAEP from 2020–23.

19. See, for example, Donnelly and Patrinos (2022); Jakubowski, Gajderowicz, and Patrinos (2023); Psacharopoulos et al. (2021); Jack and Oster (2023); and Jack et al. (2023).

20. See the summary of international studies in Hanushek and Woessmann (2020), Werner and Woessmann (2021), and Cygan-Rehm (2022).

21. These calculations include students in grades nine through twelve in spring 2020 from public (15.3 million) and private (1.4 million) schools, along with home-schooled (0.3 million) students (US Department of Education 2022). There is no consistent information on the differential learning losses across sectors. There is some partial evidence suggesting that charter and private schools responded more quickly than traditional public schools. The responses of home schooling are less clear. although school closures have less meaning for this population.

22. Data for the 2023–24 school year show different kinds of tutoring offered by tutors with varying backgrounds or training; see https://nces.ed.gov/surveys/spp/results.asp.

23. Guryan et al. (2023) report very strong impacts of high-dosage tutoring on Chicago high school students, but there is little evidence of its general adoption in either Chicago public schools or in other schools.

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