From Population Growth to Demographic Scarcity: Emerging Challenges to Global Primary Education Provision in the Twenty-First Century*

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Abstract

This paper characterizes evolving demographic pressures on primary education systems around the world and offers select evidence on commonality and variability in system adaptation. We illustrate, first, that global demographic pressures are highly disequalizing: persistent expansionary pressures burden some of the world's least-resourced educational systems, while such pressures are reversing in wealthier countries with higher educational expenditures. Second, we present a global, compensatory response to disequalizing demographic pressures in the form of a converging tendency in child-teacher ratios. Third, in select regions experiencing demographic decline, we demonstrate distinct patterns in primary school size, linked to consolidation and other policy choices made by governments as child populations plateau and decline. Finally, at the leading edge of demographic decline, we demonstrate that educational system consolidation can introduce new salience to geospatial hierarchies and the political economy of allocative decisions. In Korea, policy decentralization and popular resistance stymied a trend in which non-metropolitan areas that experienced student declines bore the brunt of primary school closures and teacher losses, while metropolitan areas saw increases in schools and teachers despite student declines. These examples illustrate critical factors shaping global educational inequalities and highlight the need for new research to illuminate past and future population-education dynamics.

Keywords: Demographic transition, school enrollments, pupil-to-teacher ratio, depopulation

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1 Introduction

Global population trends are changing the nature of what might be termed the "demographic challenge" to primary educational systems. The traditional demographic challenge, which continues in some countries, is that of population expansion. As observed in the 2022 *United Nations World Population Prospects* (Gaigbe-Togbe et al. 2022, 10), "[e]xpanding educational opportunities and ensuring quality education for all can be particularly challenging for low- and lower-middle income countries with growing cohorts of children and youth," and the least developed countries are among the world's most rapidly growing. In high-fertility countries with large proportions of children and youth, spending per capita on the human capital of young people is typically less than half as much as in countries with older population age structures (Sánchez et al. 2023, 1).

In contrast, an emerging regime of sparse and declining child cohorts—demographic scarcity associated with some combination of age structure effects, fertility decline, or urbanization and hollowing out of rural communities—eases demographic pressures on educational expenditures (Sánchez et al. 2023). At the same time, demographic scarcity poses the challenge of designing systems that can serve dispersed, sparse school-age populations, as noted in a recent OECD report:

> Population decline . . . will lead to a decline in the number of students in rural areas, raising additional challenges for the attraction of teachers and principals in these locations, and exacerbating the costs of educational provision (OECD and European Commission 2021, 73).

Moreover, even countries[1] with ample resources face difficulties in educational planning amidst demographic contractions. Once the number of teachers and schools increases, it becomes challenging to reduce them, which places a financial burden on local governments and school districts (Adams 2024; Lee 2022; Tieken and Auldridge-Reveles 2019).

To the best of our knowledge, neither implications of global school-age population change for educational systems nor educational system responses have been a significant focus of scholarly

[1] In this paper, we use the term "country" and, occasionally, "economy" as shorthand to refer to countries and other societal entities that function as large-scale, unified policy jurisdictions.

attention.[2] In this paper, we make the case for closer scrutiny of the educational implications of recent and incipient demographic trends. We demonstrate, first, that global demographic trends in recent decades have left some of the world's poorest countries facing continued expansionary pressures from growing numbers of children, while much wealthier countries with higher primary educational expenditures are generally at the forefront of demographic decline. Second, we show that, despite this disequalizing global pressure, global educational systems have adapted over time to narrow gaps in student-teacher (or, as a proxy, child-teacher) ratios. Third, we illustrate variety in system response to depopulation among systems for which demographic pressures are easing, and underscore the lack of scholarly attention to assessing the impacts of system responses. And finally, focusing on the case of a country at the forefront of depopulation, we illustrate that demographic decline calls for new attention to geospatial inequalities and the political economy of school closures.[3] We argue that the evolution of demographic pressures on educational systems and policy adaptations to demographic shifts are critical elements of global educational stratification, across and within countries.

2 Data and Methods

Data. We construct a novel population and education dataset by combining multiple sources of data. First, we use the World Development Indicators from the World Bank and UN World Population Prospects spanning the years 1960 to 2021 to examine global trends in the school-age population and educational system responses, focusing on primary education (United Nations 2024; World Bank Indicators 2023). We use population aged 6 to 12 as a proxy for the primary-age population, and we use the number of primary school teachers—one of the only long-term indicators linked to school resource availability at the national level—as a global measure of shifts in primary school resources, reflecting system responses. To capture the overall economic resource availability in each country, we also include GDP per capita as well as government

[2] Research has traced recent and pending global demographic shifts (Bloom and Luca 2016; Crimmins and Zhang 2019; Settersten and Angel 2011) and their implications for the structure of labor markets (Korenman and Neumark 1997), economic growth (Bloom, Canning, and Sevilla 2001; Mason et al. 2009), and intergenerational inequality (Dolls et al. 2019; Prettner 2013; Weizsäcker 1996).

[3] Our paper also complements school- and class-size effects literatures that have sought to identify separately the impacts of school enrollment size and class enrollment size on student outcomes (Barrett et al. 2019; Filges, Sonne-Schmidt, and Nielsen 2018; Leithwood and Jantzi 2009).

spending on primary education per student. We focus our analysis on variations over time in child population and educational resources by seven World Bank analytical regional groupings.[4] We complement the regional discussions with country-specific details in Appendix A.

Second, given the lack of availability of international datasets with information on both the number of schools and teachers across countries,[5] we gather official statistics on the number of schools, teachers, and students from economies in East Asia and Western Europe, two regions that have been experiencing downward child population pressures. Specifically, we gather data from mainland China, Japan, South Korea, Taiwan, Austria, Germany, France, the Netherlands, and Switzerland. The Chinese data is sourced from the Chinese National Bureau of Statistics (2023) and spans the years from 1949 to 2021. Korean Educational Statistics Service (2023) data spans the years from 1965 to 2021. Statistics of Japan (2023) data spans the years from 1948 to 2021. Taiwanese Ministry of Education (2023) data spans the years from 1976 to 2021. Our source for German data is German Federal Statistical Office (2023a, 2023b) and this source covers the years from 1992 to 2021. Statistics Austria (2023) data covers 1923 to 2020, French Directorate of Evaluation, Forecasting and Performance Monitoring (2023) and French Ministry of National Education and Youth (2019) data covers 1984 to 2022, Statistics Netherlands (2023a, 2023b) data covers 2003 to 2017, and Federal Statistical Office Switzerland (2023a, 2023b) and Historical Statistics of Switzerland (HSSO) (2023) data cover 1864 to 2020. We present additional details about data sources in Appendix B.

Third, we collect subnational data for South Korea from the Korean Educational Statistics Service (2023). South Korea has seen one of the fastest rates of reduction in child population in recent decades. We group subnational Korean administrative units into metropolitan and non-metropolitan areas. Metropolitan areas include the capital area and metropolitan cities. Non-metropolitan areas encompass all other areas.

[4] While this classification may not fully capture within-group heterogeneity, we adopt it because it includes all economies and effectively reflects broad regional trends and differences.

[5] It is worth noting that, to the best of our knowledge, there is no publicly available comprehensive dataset that provides information on the number of schools at the country level. In contrast, the number of students and teachers, for different geographies, is available from multiple sources such as the World Bank Open Data, UNESCO Institute for Statistics, OECD Data, and Eurostat (Teacher Task Force 2021).

Methods. Combining the data, we present levels and compute percentage changes in the number of schools, teachers, students, and children over time. To measure changes in per-individual education resource availability, we calculate child-teacher and pupil-teacher ratios, as well as child-school and pupil-school ratios when possible. To quantify relative changes in the number of children compared to relative changes in the number of teachers, we construct a *population–teacher growth rate ratio*, defined as the percentage change in the number of teachers divided by the percentage change in the school-age population over the same period (a measure similar to elasticity). A ratio of 1 indicates that changes in teacher numbers are keeping pace with population changes, whereas negative values imply that teachers and students are moving in opposite directions; the absolute value reflects the magnitude of the difference in growth or decline. To allow for consistent decadal cross-national comparisons in locations with limited data gaps, we interpolate and extrapolate missing data, by assuming a constant rate of growth between two points in time between which there is missing data. Additionally, to capture the average level of economic resources for primary education in the past two decades, we average available data points on per primary pupil expenditure between 2000 and 2020, in constant purchasing-power-adjusted 2021 international dollars units. We present additional details of data sources and construction of measures in Appendix C.[6]

Results

Global: Population Analyzing sixty years of global country-level primary-school-age child population data, we identify three groups of world regions: regions where the school age population has been increasing steadily (Sub-Saharan Africa, SSA, and Middle East and North Africa, MEA), regions where school age populations have recently peaked and are beginning to trend downward (Latin America and the Caribbean, LAC, North America, NAC, and South Asia, SAS), and regions that are in longer-term decline (Europe and Central Asia, ECA, and East Asia and Pacific, EAS). Taken together, these regional trajectories reveal a global inverted-U pattern in the evolution of the school-age child population—rising, plateauing, and declining

[6] We also construct a public website that details the data preparation process, provides code, and releases our dataset.

thereafter—with clear clustering of regions along different stages of this demographic transition.

These patterns are illustrated in Figure 1 panel (a), which presents panels for the three regional groups and shows trends in the child population between 1960 and 2020, expressed as percentage differences relative to the reference year of 2020.[7] In Appendix A.1, we provide additional details on country-specific child population changes and information on patterns of changes in the number of primary school students, which is similar to patterns of child population changes.

The SSA and the MEA regions have seen steady growth of child population that accumulated to six-decadal increases of 443 percent and 263 percent, respectively. At the country level, with the exception of Malta, Mauritius, and Seychelles, all countries in the SSA and MEA regions experienced increases in child population between 1980 and 2020.

In contrast, LAC, NAC, and SAS experienced initial growth and plateauing in recent decades: overall school-age population grew by 81 percent, 17 percent, and 163 percent, respectively between 1960 and 2020, but growth rates between 2000 and 2020 have plateaued to -6 percent, 4 percent, and 8 percent, respectively. Country-specific results from the LAC, NAC, and SAS regions show that while most countries experienced increases in child population between 1980 and 2020, between 2000 and 2020, the majority of countries in these regions experienced child population reductions.

While the five aforementioned regions saw school-age population growth overall across the six decades, the child population in EAS has decreased by 19 percent from its peak in 1980; in ECA, child population peaked in 1970, and has fallen by 16 percent by 2020 from its peak. At the country level, the vast majority of ECA countries, with the exception of several Central Asian countries, experienced child population reductions between 1980 and 2020. Results from EAS show child population reductions between 1980 and 2020 as well as between 2000 and 2020 for most East Asian economies, but population increases for smaller island economies in the Pacific along with Australia.

Panel (b) of Figure 1 illustrates how demographic shifts over the past two decades are associ-

[7] For consistency across regions, the reference year for the percentage changes in all figures is 2020. However, in the text, the calculated percentage changes follow the conventional approach, where the reference year is the earlier year. For variations across time in child population *levels* by region, see Appendix Figure A.1.

ated with two measures for economic and educational resources: per primary pupil expenditure and GDP per capita. Each point represents a country, with marker size proportional to population and shape denoting regional groupings. The x-axis shows the percentage change in the primary school-age population between 2000 and 2020, while the y-axes measure corresponding average levels of per primary pupil expenditure and GDP per capita on a natural logarithmic scale in constant purchasing-power-adjusted 2021 international dollar units (see Appendix A.1 for actual values and the names of countries).

The black solid line shows a population-weighted quadratic fit, revealing a clear downward-sloping relationship: countries experiencing rapid growth in their school-age population in recent decades tend to have lower levels of per pupil expenditure and GDP per capita. Specifically, regions (SSA and MEA) with increasing child population spend on average about $1,680 per pupil and have a GDP per capita of $13,240. Plateauing regions (LAC, NAC, and SAS) spend around $3,030 per pupil and have a GDP per capita of $22,540—roughly twice per-pupil spending and about 1.7 times higher than the GDP per capita of rising regions. Declining regions (ECA and EAS) spend roughly $6,690 per pupil and have a GDP per capita of $32,000, which is four times the spending per student and more than double the income level observed in rising regions.

This pattern indicates that demographic expansion has been concentrated in regions where educational resources are most constrained, creating persistent pressures on already limited school resources. By contrast, high-income and higher-performing regions—with stable or declining school-age populations—face easing demographic pressures, enabling them to sustain or even increase resources per student.

The opposing regional child population trends have led to dramatic shifts in the distribution of primary-school-age children across the world over the past six decades, with implications for shifting school resource pressures. The joint share of SSA and MEA regions in the global child population increased by 2.5 times from 12 percent to 30 percent between 1960 and 2020. In contrast, the joint EAS and ECA share of the global child population shrank by half, decreasing from 55 percent in 1960 to 32 percent in 2020. Jointly, the LAC, NAC, and SAS regions' share of the global child population has been relatively stable, increasing from 33 percent in 1960 to

38 percent in 2020. These shifts in relative shares have happened in a setting where the overall number of primary-school-age children globally has increased by 93 percent, from 494 million in 1960 to 954 million in 2020. The total increase is due to an increase of 229 million in SSA and MEA, 36 million in EAS and ECA, and 195 million in LAC, NAC, and SAS. Given the joint patterns of population changes and economic resource levels, an increasing number and increasing share of global primary-age child population live in countries with relatively low levels of overall economic resources and resources for primary education.

Global: Population and Teachers We turn to the educational response to global school age population change, with attention to the implications of demographic context for educational resources.[8] In this section, we complement child population data with data on the number of primary school teachers, which is one of the only indicators linked to school resource availability and quality that exists over time at the national level. A large body of research identifies class size as a key determinant of educational quality, with findings of non-negative effects of smaller class sizes (Barrett et al. 2019; Filges, Sonne-Schmidt, and Nielsen 2018).[9] Our empirical analysis examines global co-movements between the child population and primary teachers. Given population dynamics, maintaining *status quo* levels of teacher availability requires active policy adjustments in teacher cohort sizes.

To allow for global comparisons, we present the child-teacher ratio. Panel (a) of Figure 2 presents the child-teacher ratios across regions in 1980, 2000, and 2020, and panel (b) presents bi-decade percentage changes in the number of primary teachers plotted against percentage changes in the child population. In the main text, we highlight regional-level statistics; country-

[8] In this paper, we use the term "educational response" in a broad, descriptive sense. It does not imply a strict causal relationship; rather, we document how long-term changes in the school-age population create demographic pressures to which education systems and school resources adjust. We acknowledge that many factors—policy choices, economic conditions, and other mediating or confounding factors—may influence these relationships. Our aim is to present long-term patterns in which the direction of influence is plausibly from population change to educational adjustments, while avoiding any strong claim that population change directly and exclusively causes changes in school inputs.

[9] Specifically, studies exploiting cohort size variation find zero to positive effects of smaller classes on primary student achievement (Cho, Glewwe, and Whitler 2012; Hoxby 2000). Using random assignment of students to smaller and larger classes, Krueger (1999, 2003) finds significant gains in test scores and a 6% rate of return from reducing class size from 22 to 15 students. Angrist and Lavy (1999) report similar results in Israel, though not for more recent cohorts (Angrist et al. 2019). Case and Deaton (1999), analyzing large disparities in class size between black and white schools in South Africa, find that "poorly resourced schools, defined as those with high pupil-teacher ratios" discouraged enrollment and attainment, and lowered test scores among black students.

specific results, which largely follow these regional patterns, are provided in Appendix A.2.[10] Despite the diverging tripartite patterns of child population changes examined in the prior section, the child-teacher ratios have consistently decreased across regions between 1980 and 2020, with all regions of the world trending toward NAC, where the child-teacher ratio has been the lowest.

In Sub-Saharan Africa (SSA), the children–teacher ratio rose from 55 in 1980 to 61 in 2000 before falling to 43 in 2020. More specifically, the population–teacher growth rate ratio was 0.85 between 1980 and 2000, as teacher growth (60%) slightly lagged behind school-age population growth (76%). From 2000 to 2020, however, the ratio increased to 2.06, with teacher growth (138%) more than doubling school-age population growth (67%). The Middle East and North Africa (MEA) also experienced rapid child population growth, yet its children–teacher ratio declined steadily from 41 in 1980 to 30 in 2000 and 26 in 2020, a 35 percent overall reduction. Reflecting this expansion in educational capacity, the population-teacher growth rate ratios in the pre- and post-2000 decades were 1.99 and 1.77, respectively, as teacher growth of 121 and 39 percent far outpaced school-age population growth of 61 and 22 percent. While there have been concerns about teacher supply and quality during periods of rapid enrollment expansion, these regions have nonetheless succeeded in substantially increasing the number of teachers despite demographic countercurrents (Adedeji, Olaniyan, et al. 2011; Mulkeen 2009; Teacher Task Force 2021).

In regions where school-age populations have largely plateaued, the number of teachers continued to expand despite demographic stagnation. In Latin America and the Caribbean (LAC), the children–teacher ratio fell by 18 percent, from 34 in 1980 to 28 in 2020. During the pre-millennial decades, primary teacher growth (48%) more than doubled child population growth (22%). After 2000, the number of teachers still grew by 9 percent while the child population declined by 6 percent. Over the full 1980–2020 period, LAC's primary teacher workforce expanded by 61 percent compared with only a 14 percent increase in the child population, yielding a population–teacher growth rate ratio of 4.36—the highest among the

[10] Appendix Figure A.5 provides the same information as in panel (b) of Figure 2, but with country name abbreviations. Figures A.5 and 2 include countries where we have data in both the pre- and post-millennial decades. Appendix Figure A.6 visualizes regional aggregates changes, Appendix Figure A.7 presents changes for all countries where we have data in either or both the pre- and post-millennial decades, and Appendix Table A.2 presents country-specific results.

seven world regions. South Asia (SAS) recorded the largest decline in the children–teacher ratio, which was cut in half from 77 in 1980 to 42 in 2020. Across the two subperiods, teacher growth remained strong (80% and 63%), but the growth rate ratio rose sharply from 1.66 to 8.25 as child population growth slowed dramatically, from 48 percent to just 8 percent. Overall, between 1980 and 2020, the number of primary teachers increased by 194 percent while the number of children grew by 59 percent. Throughout these decades, North America (NAC) maintained the world's lowest children–teacher ratio, which inched up slightly from 16 in 1980 to 18 in 2020, reflecting less than 5 percent change in both the school-age population and the number of teachers in recent decades.

In both East Asia and Pacific (EAS) and Europe and Central Asia (ECA), child populations have declined while the number of primary teachers has continued to grow, resulting in substantial reductions in children–teacher ratios—42 percent (from 71 to 41) in EAS and 28 percent (from 66 to 47) in ECA between 1980 and 2020. Throughout both regions and across both decades, the population–teacher growth rate ratios have remained below -1, indicating that the number of primary teachers increased at a faster rate than the school-age population declined. In EAS, for example, the number of primary teachers rose by about 20 percent in both the pre- and post-2000 periods, while the child population fell by 6 percent and 13 percent, respectively. In ECA, primary teacher growth was 13 percent and 7 percent over the same two periods, compared with child population declines of 7 percent and 6 percent. Overall, from 1980 to 2020, the number of primary teachers increased by 42 percent in EAS as the child population decreased by 19 percent, and increased by 22 percent in ECA as the child population fell by 12 percent.

Overall, a cross-region comparison shows a striking pattern of global convergence. Between 1980 and 2020, all regions except for NAC experienced between one-quarter to one-half reductions in the child-teacher ratio. In 1980, NAC had between two to five times as many primary teachers per child population as other regions. By 2020, relative to NAC's ratio, the child-teacher ratio is only about 10-50 percent larger in EAS, ECA, LAC, and MEA, and only less than three times larger in SAS and SSA.

The cross-country efforts to increase the number of primary teachers per student, despite

vastly different population challenges, indicate a global consensus on the importance of primary teacher availability for education. Going forward, SSA and MEA countries are likely to face greater challenges in maintaining their current rates of child-teacher ratio reduction toward NAC levels as their child populations continue to rise. Concurrently, for other regions, it can become more difficult to maintain the number of primary teachers as the number of children continues to fall.

Western Europe and East Asia: Population, Teachers, and Schools In this section, we focus on East Asia (a part of EAS) and Western Europe (a part of ECA), two sub-regions that are at the forefront of low fertility and declining school age cohorts.[11] Available governmental statistics from these economies permit the investigation of how both the number of schools as well as teachers have responded to changes in the number of primary school students. While much prior research highlights the importance of teacher availability for student learning, school size is another key dimension of educational quality. Existing work documents trade-offs between the broader resources offered by larger schools and the more individualized attention available in smaller ones (Barrett et al. 2019; Leithwood and Jantzi 2009).[12] The number of schools and teachers available to primary students jointly determines the school enrollment size and class size, which are foundational dimensions of a child's school learning experience. In the context of a decreasing child population, inaction leads to reduced school enrollment sizes and class sizes, which may benefit student outcomes to some extent but could come at the cost of increasingly higher per-child cost of primary education.

Figure 3 presents changes in the number of primary schools, teachers, and students in East Asian and Western European economies. Due to high enrollment rates, changes in the number of students and primary age population show similar patterns in Western Europe and East Asia. We provide additional results based on the child population ages 6–12 in the Appendix.[13] In

[11] In 2020, fertility rates in China (1.3), South Korea (0.8), and Taiwan (1.0) are 48 to 89 percent of the fertility rates in Austria (1.4), France (1.8), Germany (1.5), Netherlands (1.5), and Switzerland (1.5) (National Development Council 2021; The World Bank Group 2021).

[12] Although evidence is limited, studies exploiting within-child and within-school variations in grade or enrollment sizes find that smaller enrollments can improve attendance and test scores (Gershenson and Langbein 2015; Kuziemko 2006). In some contexts, smaller schools may also enjoy more resources per pupil—for instance, a national school cash grant program in Zambia provided equal grants per school regardless of enrollment (Das et al. 2013).

[13] For additional details on percentage changes in schools, teachers, students, and children between 1960-2020, see

congruence with our regional child population discussions, one general trend is the persistent decline in the number of students in recent decades. Interestingly, these declines have been more pronounced in East Asia compared to Western Europe. For instance, compared to 1980, primary school student numbers in South Korea, Taiwan, and Japan all decreased by approximately 50 percent, while mainland China experienced a 27 percent reduction. Meanwhile, the number of primary school students declined by 13 percent and 11 percent in Austria and France. Switzerland, which has the highest share of children with migration backgrounds, has seen a 20 percent increase in the number of primary school students.

A key reason for the relative differences in primary school student changes is that the share of children with migration backgrounds is much larger in Western Europe. In 2018, the shares of PISA test takers who reported having a migration background in East Asia economies were all below 1 percent. Corresponding shares were above 13 percent in Western European economies, with Switzerland having the highest share at 34 percent (OECD 2020).[14] Additionally, UNDESA statistics, which estimate the number of children who are first-generation migrants, show that in 2020, the share of international migrants account for at most 2 percent of population below age 15 in East Asia and at least 5 percent in Western Europe.[15]

In terms of teachers, following our prior finding that the number of teachers in EAS and ECA regions has increased, the number of primary teachers in mainland China, South Korea, and Taiwan grew by 17–59 percent since 1980, with only Japan experiencing a 10 percent reduction. But in all the East Asian economies, the number of teachers has increased relative to the declining number of primary students. Consequently, the pupil-teacher ratios have steadily

Appendix Table A.4. For additional details on children and pupil to teacher as well as children and pupil-school ratios by decade, see Appendix Table A.5.

[14] According to OECD OECD (2020), the shares for Japan (0.6%), Korea (0.2%), Beijing-Shanghai-Jiangsu-Zhejiang of China (0.2%), and Taipei (0.7%) are below 1 percent, but the share reported for Austria (22.7%), France (14.3%), Germany (22.3%), Netherlands (13.8%), and Switzerland (33.9%) are between 14 and 34 percent. Furthermore, between 2000 and 2018, the percentages of PISA test takers reporting having a migration background in Austria, France, Germany, and Switzerland have increased by 105 percent, 30 percent, 46 percent, and 64 percent, respectively.

[15] Based on UNPD United Nations Population Division (2021) estimates, in 2020, the share of international migrants below age 15 accounts for 8.2, 4.6, 8.0, 5.6 and 10.0 percent of the population below age 15 in Austria, France, Germany, the Netherlands, and Switzerland. These are substantially higher than the share of migrants below age 15 in 1990, which were 5.3, 2.8, 3.0, 4.2, and 8.9 percent for the economies respectively. In contrast, the share of migrants below age 15 accounts for 0.07, 1.4, and 2.3 percent of the population below age 15 in China, Japan, and Korea, dramatically lower than in Europe. Interestingly, these numbers have been rising in these three East Asian economies, in 1990, the percentages were even lower at 0.02, 0.8, and 0.1 in China, Japan, and Korea, respectively.

declined and converged to between 12 and 17 by 2020. This is in sharp contrast to the large gaps in the pupil-teacher ratio across economies that existed in 1980, when the ratio in South Korea was 48, Taiwan 32, mainland China 27, and Japan 25. Western European economies also experienced similar increases in the number of teachers, with Austria, France, and Switzerland gaining 35 percent, 10 percent, and 117 percent more primary teachers between 1980 and 2020, Germany gaining 31 percent since 1990, and the Netherlands gaining a 4 percent increase since 2000. These have led to primary pupil-teacher ratios that are generally lower than those in East Asia, converging to between 9 and 17 by 2020.

While Western Europe and East Asia have increased the number of teachers, the number of primary schools has followed different trends over time. In Western Europe, Austria and France saw 13 percent and 26 percent reductions in primary schools since 1980; Austria, Germany, France, and the Netherlands all experienced between 10 percent to 15 percent reductions in primary schools between 2000 and 2020. In East Asia, mainland China and Japan closed 83 percent and 22 percent of their primary schools since 1980, respectively.[16] In contrast, Taiwan has seen an 8 percent increase in the number of primary schools during the same time frame. Korea shows stark changes over time: the number of schools decreased by 19 percent from 1981-2000 but increased by 16 percent between 2000 and 2020.

While the pupil-teacher ratios have all been trending downward and converging, there is greater diversity in the levels and trends of pupil-school ratios. Overall, the pupil-school ratios are substantially lower in Western Europe than in East Asia. In Japan, South Korea, and Taiwan, due to much faster reductions in students relative to changes in the number of schools, there have been substantial reductions in pupil-school ratios. The ratios approximately halved in South Korea and Taiwan from around 900 to around 450 between 1980 and 2020, and the ratio decreased from 474 to 323 in Japan during the same time frame. Due to the massive scale of primary school closures in mainland China (Wu 2020; Xie and Wu 2013), the pupil-school ratio

[16] Since the 1980s, China has closed a massive number of schools as large-scale migration from the countryside to cities accelerated. The process intensified in 2001, when the State Council issued the decree Decisions on Basic Education Reform and Development, which required local governments to restructure the geographic distribution of rural schools in order to achieve economies of scale and improve school quality (Wu 2020; Xie and Wu 2013). These closures profoundly affected rural households. With village schools gone, children often had to travel long distances to urban schools without bus services, while boarding schools were poorly equipped and unsuitable for young children, raising parents' concerns about their well-being (Fan and Guo 2009).

has risen sharply in China, increasing from 159 to 679 between 1980 and 2020. In Europe, due to the reductions in primary schools and relatively limited decreases in the number of primary students, the pupil-school ratios have held relatively constant with some experiencing slight increases.

Overall, in East Asia and Western Europe, our findings indicate that responses to demographic decline in education system—measured as changes in the number of teachers and changes in the number of schools—have been heterogeneous, save for one common feature: an emerging small-class norm. As of 2020, Western Europe and East Asia present three emerging response models: a model of growing schools with small classes (e.g., mainland China), a model of declining medium-size schools with small classes (e.g., Japan, South Korea, and Taiwan), and the European model of small schools with small classes. The China model stands out, which may be attributable in part to reliance on primary boarding schools to centralize resources in some remote areas. UNICEF (2025, 113) reports that in 2023, over 8.1 percent of all students in primary schools were boarders, with boarding more common in poorer rural areas and central and western China. These patterns show different response paradigms exhibited by different economies that are at the forefront of declining school-age populations. As economies experience primary-age population reductions, deciding on the appropriate number of teachers to maintain to support the dwindling child population, and choosing whether to downsize, relocate, or consolidate schools will remain a critical problem for policy makers (Hannum, Liu, and Wang 2021; Hannum and Wang 2022; Kim 2024; Tieken and Auldridge-Reveles 2019). Such difficult allocation decisions are on the horizon in economies shifting toward lower fertility and primary-age population reductions. Research on the efficacy and equity implications of emerging primary system responses is sorely needed to inform such decisions.

Korea: Population, Teachers, and Schools in Metropolitan and non-Metropolitan Areas

International comparisons from prior sections shed light on patterns of aggregate variation across countries, but there can also be variation in population dynamics and changes in school and teacher availability within countries. While each country faces unique regional challenges, as a country that has experienced substantial overall school-age population decline as well as substantial urbanization, South Korea provides a useful and possibly illustrative case study of

how within-country population dynamics interact with shifting resources.

South Korea has experienced extremely rapid fertility decline. Between 1960 and 1983, total fertility rates in Korea fell from 6 births per woman to replacement level at 2.1; as of the last data point in the series, 2023, Korea reported an all-time low total fertility rate of 0.7 births per woman (World Bank 2025).[17] Korea's demographic transition unfolded alongside profound social and economic transformation. Over the mid-to-latter 20th century, South Korea transitioned from a largely agrarian, low-income society to a highly industrialized, high-income economy (Collins 1990). During this period, the country also underwent democratization, which gave local communities a stronger voice in shaping social policies, including those related to education (Kim 2003).

These shifts have been accompanied by dramatic spatial changes. Beginning in the 1960s, massive rural-to-urban migration fueled the growth of metropolitan areas, with Seoul and its surrounding region absorbing a large share of the country's population and economic activity. The urban share of the population rose from about 40 percent in the 1970s to more than 80 percent by the early 2000s (World Bank Indicators 2023). This combination of ultralow fertility, rapid urbanization, and regional depopulation has generated new geospatial challenges for educational planning. Rural areas, in particular, have faced declining student numbers and shrinking institutional capacity, while metropolitan regions have absorbed growing concentrations of both population and resources.

To examine these dynamics, we assemble sub-national data spanning 1970–2020 and document changes in the numbers of students, teachers, and schools, as well as pupil–teacher and pupil–school ratios, distinguishing metropolitan and non-metropolitan areas in Figure 4 (province-level details are provided in Appendix Figure A.8 and Table A.6). Over this fifty-year period, South Korea experienced a sharp contraction in primary enrollment, but the timing and magnitude of decline differed by region. In non-metropolitan areas, student numbers fell by 18–34 percent per decade, while metropolitan enrollment remained stable through the 1980s and 1990s before declining by about 18 percent per decade after 2000. Trends in school resources diverged accordingly. The number of metropolitan teachers increased by 229 percent

[17] While some uptick is apparent in the most recent reported estimates, fertility remains at an ultra-low level (Rashid 2025).

and metropolitan schools by 142 percent between 1970 and 2020, whereas non-metropolitan teachers increased by only 4 percent and non-metropolitan schools declined by 36 percent. As a result, the metropolitan share of national primary enrollment rose from 44 percent to 69 percent, while their shares of teachers and schools increased from 22 to 52 percent and from 37 to 65 percent, respectively. These demographic and resource changes produced large reductions in class size and school size nationwide. The pupil–teacher ratio fell from 68 to 15 in metropolitan areas and from 51 to 12 in non-metropolitan areas, and the pupil–school ratio declined from about 1,900 to 600 in metropolitan areas and from 690 to 280 in non-metropolitan areas.

Despite continued enrollment decline, school-system responses in non-metropolitan areas changed markedly around 2000, shifting from contraction to stabilization. Between 1980 and 2000, non-metropolitan primary teachers fell by 21 percent and schools by 40 percent. Between 2000 and 2020, however, the number of primary schools remained essentially constant and the number of teachers increased by 24 percent, offsetting most of the previous decline. Jeonnam Province illustrates the intensity of these shifts. From 1980 to 2000, it lost 70 percent of students, 52 percent of schools, and 40 percent of teachers, but from 2000 to 2020 its teacher count rose 2 percent and its number of schools declined only 7 percent, even as enrollment fell by a further 44 percent.

This inflection reflected a significant policy and political shift. During the 1990s, a wave of rural school consolidations—intensified by the Asian financial crisis—provoked widespread opposition as parents, teachers, and civic groups argued that closures undermined both educational access and the social fabric of rural communities (Korean Ministry of Education 2016). In response, the Ministry of Education introduced the Cultivating Small and Beautiful Schools initiative to support small schools and devolved authority for school closures to local education offices, thereby strengthening community capacity to resist. Although the central government later reclaimed some authority and renewed calls for consolidation, strong local mobilization and the revised governance framework sharply constrained implementation, effectively halting large-scale rural school closures after 2000 despite continued population decline (Lee, Kim, and Ma 2010). As a consequence, the share of small schools with fewer than 60 students has risen markedly, from 15 percent in 2011 to 25 percent in 2023, and is projected to reach 34

percent by 2030 (KEDI 2024; Park and Lee 2015). This rapid increase has created mounting challenges for educational finance and quality (Kwon et al. 2021). With enrollment falling below sustainable levels, schools struggle to secure sufficient funding and staff, leading to multi-grade classrooms where students from different grades are taught together and where access to specialized teachers, extracurricular programs, and diverse peer interactions is limited (Lee 2010). These pressures underscore the tension between preserving community schools and maintaining equitable, high-quality educational opportunities in the face of ongoing demographic decline.

South Korea's experience reveals four distinct phases of policy response. In metropolitan areas before 2000, student numbers remained stable while teachers and schools expanded rapidly. After 2000, metropolitan enrollment declined but expansion of teachers and schools continued. In non-metropolitan areas before 2000, falling enrollment was accompanied by sharp reductions in teachers and schools. Since 2000, non-metropolitan areas have continued to experience declining enrollment but have seen school numbers stabilize and teacher counts rise. These developments underscore the difficulty of aligning educational infrastructure with demographic realities and highlight how geospatial hierarchies can make rural populations particularly vulnerable to institutional loss. They further demonstrate that local political resistance can significantly reshape or delay central government plans for educational provision, a consideration likely to grow in importance as more countries confront sustained declines in child population.

Discussion

This paper has sought to describe the changing demographic context of primary school provision globally, with attention to the implications of an emerging trend of school-age demographic scarcity. Our framework, data, and analysis contribute in two key ways to the demography literature. First, the paper contributes to the study of population dynamics by providing the first systematic accounting of global school-age child population dynamics and revealing a global inverted-U pattern with regional clusters of countries experiencing increasing, plateauing, and decreasing child population counts in recent decades. This development has generated and will continue to generate dramatic shifts in the global spatial distribution of children. Second, we contribute to educational demography by providing the first mapping between child population

dynamics and shifts in societal resources for children as captured by the number of primary school teachers and schools. Our mapping is multi-tiered, with a global, cross-national time series analysis complemented by regional and subnational analyses of data from economies at the leading edge of the inverted-U that are experiencing dramatic child population reductions. Additionally, to conduct our analysis, we develop a simple and robust child population and primary school resources data collection, imputation, and analysis framework with shared data, statistical procedures, and code that are scalable for additional global explorations across more child school resource variables and further geographical explorations of within region and economy heterogeneities.

Our analysis highlights the need for more research on the patterns, implications, and educational resource responses to shifts in global child population dynamics. Three main observations emerge from our analysis. First, across countries and regions, demographic pressures have been changing globally in ways that carry potentially disequalizing implications for educational quality. In the period under study, growing child cohorts remained a daunting challenge in countries in Sub-Saharan Africa. There, ever-increasing cohorts of school-aged children placed pressures to expand capacity on the world region with the highest rates of educational exclusion (UNESCO Institute for Statistics 2019). UNESCO estimates indicate that Sub-Saharan Africa is the world region with the highest primary out-of-school rate by far, at 19.9 percent, and the absolute size of the primary out-of-school population is growing even as the rate declines (UNESCO GEM Report Team and UNESCO Institute for Statistics 2022, 4). At the other demographic extreme, Europe and East Asia are experiencing sharp drops in school-aged populations. This trend reverses expansionary pressures in educational systems that include some of the world's most high-performing on comparative tests (OECD 2023), and, in principle, could allow for higher quality educational experiences via shifts toward smaller pupil-teacher ratios in these educationally-advantaged settings. However, this trend also places pressure on primary education systems to potentially close schools in areas with dwindling populations. Overall, the tripartite global child population patterns we have documented are leading toward a polarized world with an increasingly smaller number of well-resourced primary-age children in some countries and an increasingly larger number of less well-resourced primary-age children in other

countries. Additional studies documenting the shifting patterns of global child population and education inequalities, and how these developments will impact current and future patterns of global development, growth, and inequality, are needed.

Second, within countries, new considerations around spatial inequalities and school system design are emerging in the context of depopulation and demographic scarcity. As we have shown in this paper, in Korea, schools in metropolitan areas have grown and those in non-metropolitan areas have declined sharply, even though the number of students in both kinds of areas has been declining. Rural children in poorer parts of the countries such as China and Korea have been highly susceptible to the policy response of consolidation and boarding at schools (Hannum and Wang 2022; Kwon et al. 2021). These school systems have struggled to provide adequate access and maintain education quality for students who are increasingly dispersed across sparsely populated areas (Fan and Guo 2009; Lee 2010). A recent OECD report highlights that rural schools in OECD countries are facing smaller schools and class sizes as a result of declining student numbers, and suggests that preparing rural schools for the future will require rethinking of traditional approaches to education provision in ways that go beyond relocating rural students to larger, more distant schools (OECD 2021).[18] Research that investigates how child demographic shifts ameliorate or exacerbate existing patterns of educational resource inequalities across children within and across communities is needed.

Finally, studying the diverse response strategies of countries at the forefront of school-age demographic decline is important, as growing numbers of countries will face the same phenomenon. We have shown that country responses to demographic decline are heterogeneous across systems. While reduced pupil-teacher ratios are relatively common as expansionary pressures have eased over the long term, school systems differ dramatically in the degree to which they are changing the number of schools in relation to population decline. For example, while China has undertaken large-scale school closures, Korea has largely maintained its existing school network. Going beyond existing studies that focus on the impacts of enrollment size and class size separately (Barrett et al. 2019; Filges, Sonne-Schmidt, and Nielsen 2018; Leithwood

[18] Further complicating the geospatial considerations, in some countries, immigration into certain parts of the country may buffer the effects of low fertility on population structures, and in many countries internal migration may change the spatial distribution of school-age children substantially at subnational levels.

and Jantzi 2009), an important research direction is to investigate the short and long run effects of different regimes of school enrollment sizes and class enrollment sizes—which are determined by the number of schools and teachers relative to child population—on student outcomes as well as on community welfare.

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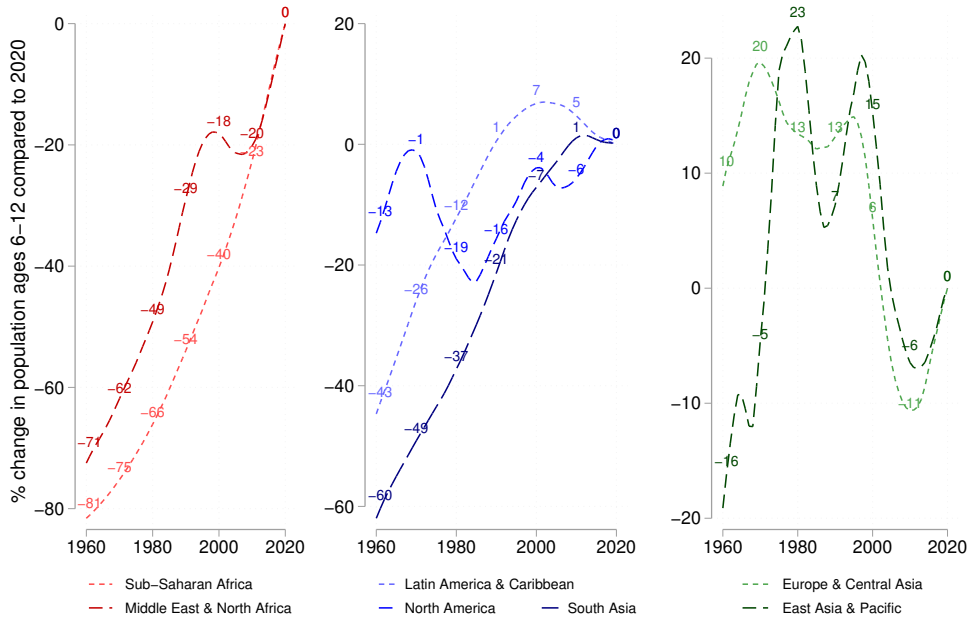
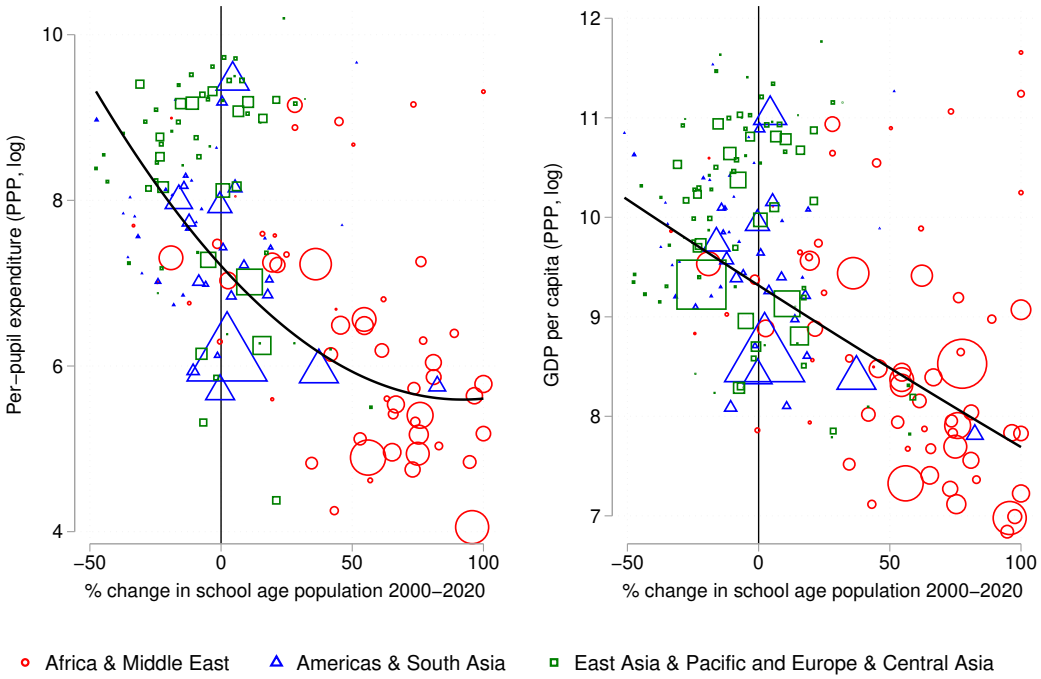
Fig. 1. Percentage change in the primary school-age population

(a) Percentage change in the primary school-age population by region, 1980–2020



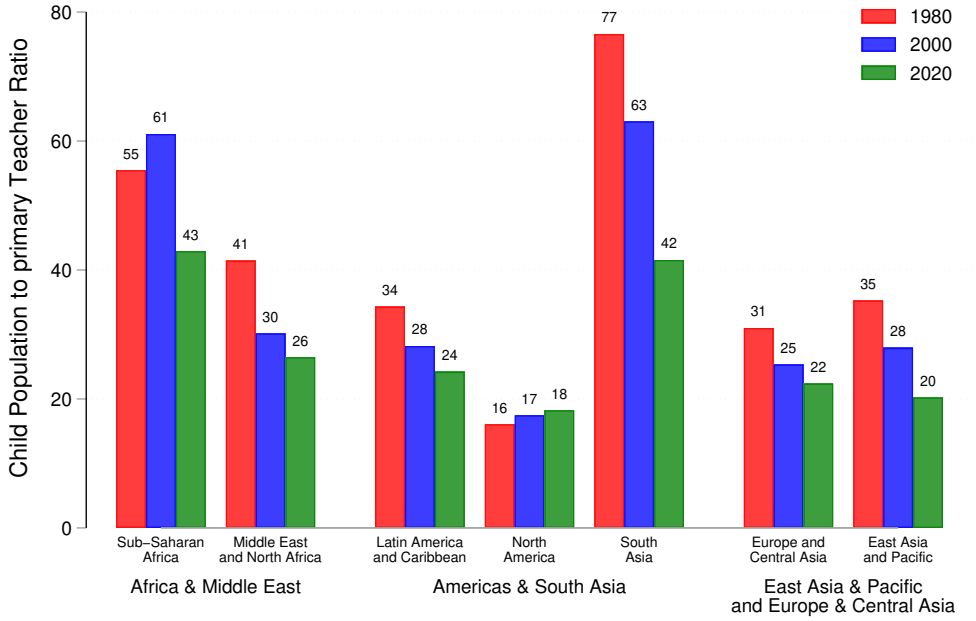
(b) Percentage change in the primary school-age population and economic resources, 2000–2020



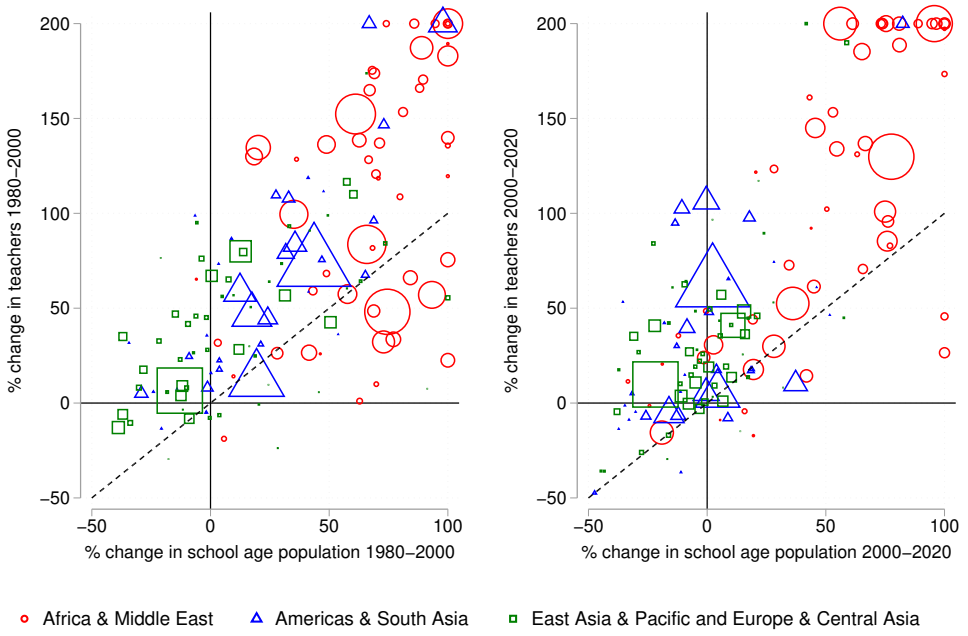
Note: Data come from the World Bank World Development Indicators and UN World Population Prospects. We treat the child population ages 6 to 12 as the school age population. To facilitate comparisons of trends across countries, in panel (a) for each region, the value shown along the y-axis is the percentage change in school age population with year 2020 as the base year, which is computed as: $\%\text{ChgBase2020} = \left(\text{Pop}_{y,\text{region}} - \text{Pop}_{2020,\text{region}}\right) / \left(\text{Pop}_{2020,\text{region}}\right) \times 100$. Percentage change by year 2020 with respect to base year y is equal to $\%\text{ChgBaseY} = 100 \times (-\%\text{ChgBase2020} / (\%\text{ChgBase2020} + 100))$. In panel (b), per-pupil expenditure is calculated as government expenditure on primary education per student (as a percent of GDP) multiplied by GDP per capita, PPP (constant 2021 international $). The y-axis is shown on a logarithmic scale to accommodate the wide cross-country variation. Approximate actual values corresponding to log points are as follows: $4 \approx 55$, $6 \approx 400$, $7 \approx 1{,}100$, $8 \approx 3{,}000$, $10 \approx 22{,}000$, and $12 \approx 163{,}000$. Both per-pupil expenditure and GDP per capita represent averages between 2000 and 2020, based on available observations. The size of plot symbols represents the population size of countries. The black solid line represents a population-weighted quadratic fit.

Fig. 2. Changes in child population and teachers, 1980-2020

(a) Child population to primary teacher ratio, 1980-2020



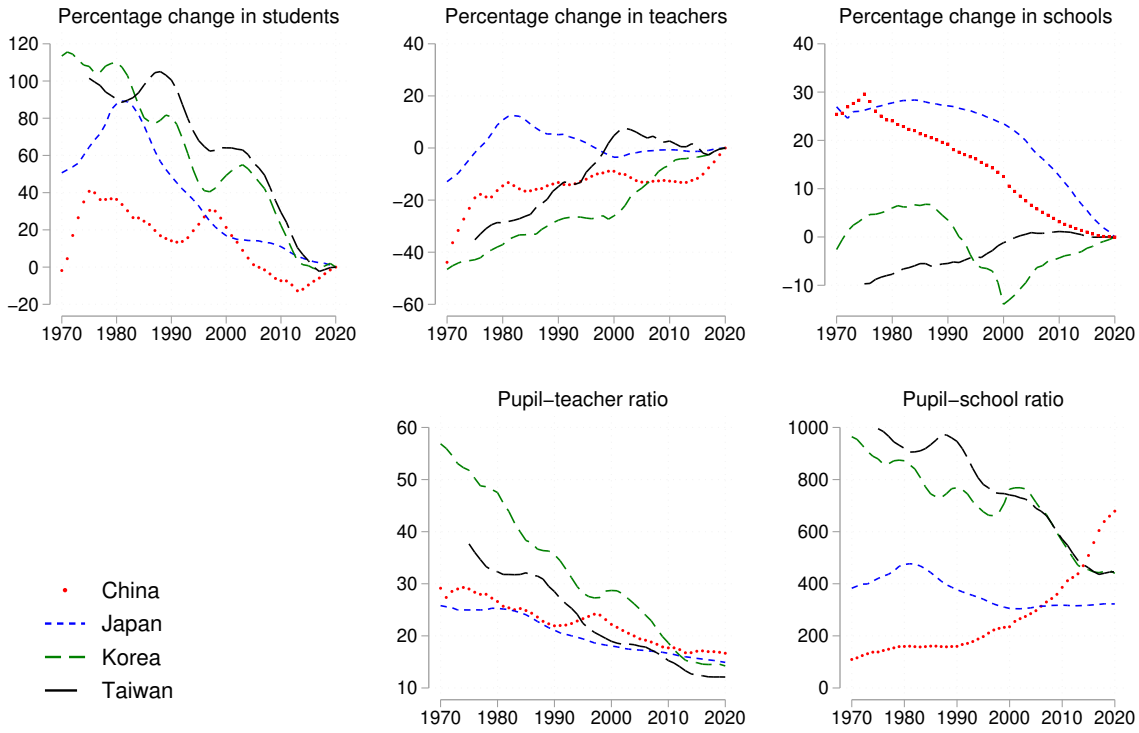
(b) Percentage change in the primary school-age population and teacher counts, 1980-2020



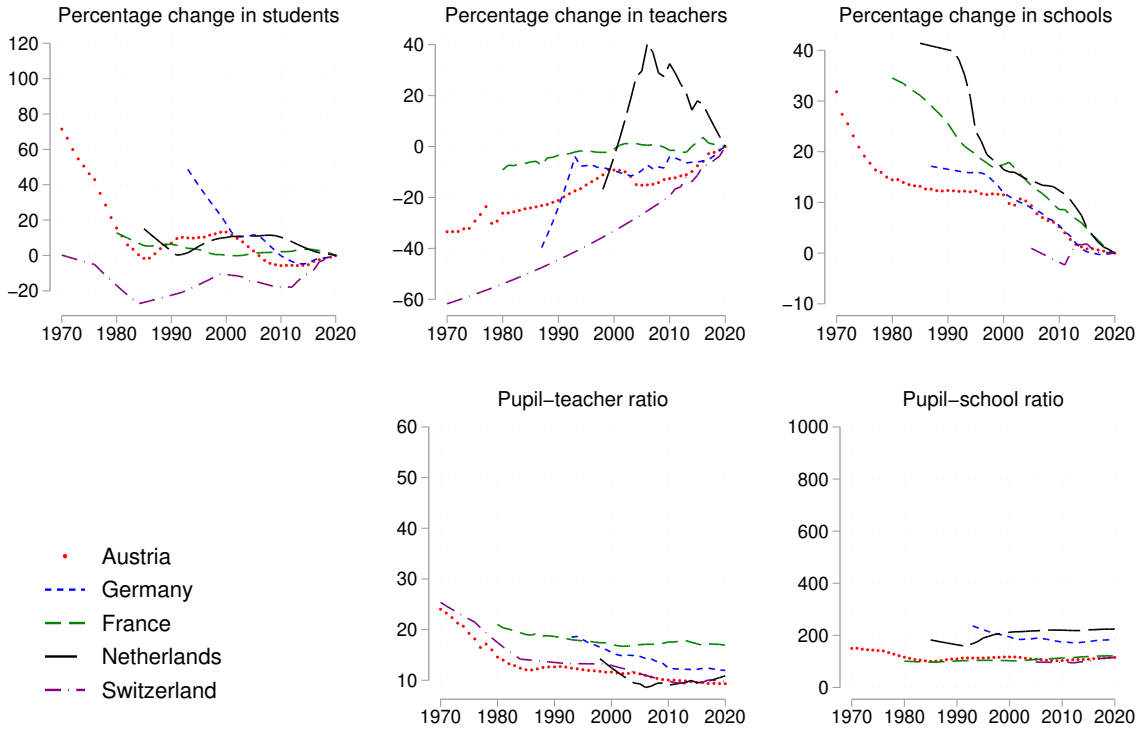
Note: Data come from the World Bank World Development Indicators and UN World Population Prospects. For simplicity, we treat the child population ages 6 to 12 as the school age population. Panel (a) presents child population to primary teacher ratio (i.e., population 6–12 over the number of primary teachers). In panel (b), countries are included when both the primary pupil-to-teacher ratio and the primary school age population data are available for beginning and end years in both figures for computing changes. The size of plot symbols represents the population size of countries. Countries above the 45-degree line experience a reduction in the children-to-teacher ratio, and countries below the 45-degree line experience an increase.

Fig. 3. Primary education in East Asia and Western Europe: demographic contraction, schools, and teachers between 1970 and 2020

(a) East Asia

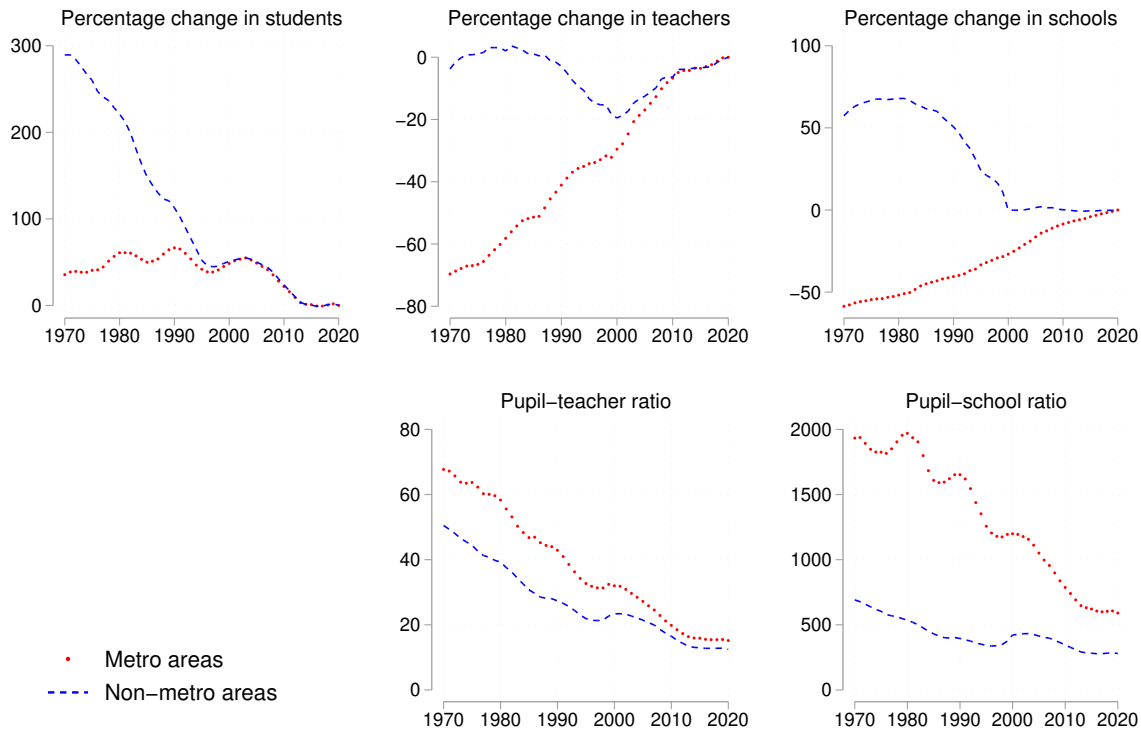


(b) Western Europe



Note: Data come from the corresponding economy's official websites. For details on data sources, see Appendix B. To facilitate comparisons of trends across economies, the value shown along the y-axis for the top three figures of each panel (a) and (b) is the percentage change in each corresponding variable as of 2020, which is computed as: $\frac{\text{Outcome}_{\text{year,area}} - \text{Outcome}_{\text{2020,area}}}{\text{Outcome}_{\text{2020,area}}} \times 100$. Due to the scale difference between China and other economies, we rescaled the percentage change in schools in China by 1/20. A twenty percent change in schools in China is represented by a one percent change in the figure.

Fig. 4. Primary education in Korea: demographic contraction, schools, and teachers in metropolitan and non-metropolitan areas between 1971 and 2020



Note: Data come from the Korean Educational Statistics Service (KESS). Both private and public schools are included. The metropolitan areas include the capital area (Seoul, Incheon, Gyeong-gi), metropolitan cities (Busan, Daegu, Daejeon, Ulsan, Gwangju), and Sejong. Non-Metropolitan areas refer to all other areas excluding Metropolitan areas (Gangwon, Chungbuk, Chungnam, Jeonbuk, Jeonnam, Gyeongbuk, Gyeongnam, Jeju). To facilitate comparisons of trends across areas, for each area, the value shown along the y-axis for the top three figures is the percentage change in each corresponding variable as of 2020, which is computed as: $\frac{\text{Outcome}_{\text{year,area}} - \text{Outcome}_{\text{2020,area}}}{\text{Outcome}_{\text{2020,area}}} \times 100$.

ONLINE APPENDIX

From Population Growth to Demographic Scarcity: Emerging Challenges to Global Primary Education Provision in the Twenty-First Century

Emily Hannum, Jeonghyeok Kim, and Fan Wang

A Additional Results

In this online appendix section, we provide additional visualization and details on changes in global child population patterns (Section A.1), how primary school resources in the form of primary teachers have changed globally (Section A.2), shifts in population, teachers and schools in Western Europe and East Asia (Section A.3, and shifts in these patterns within South Korea (Section A.4).

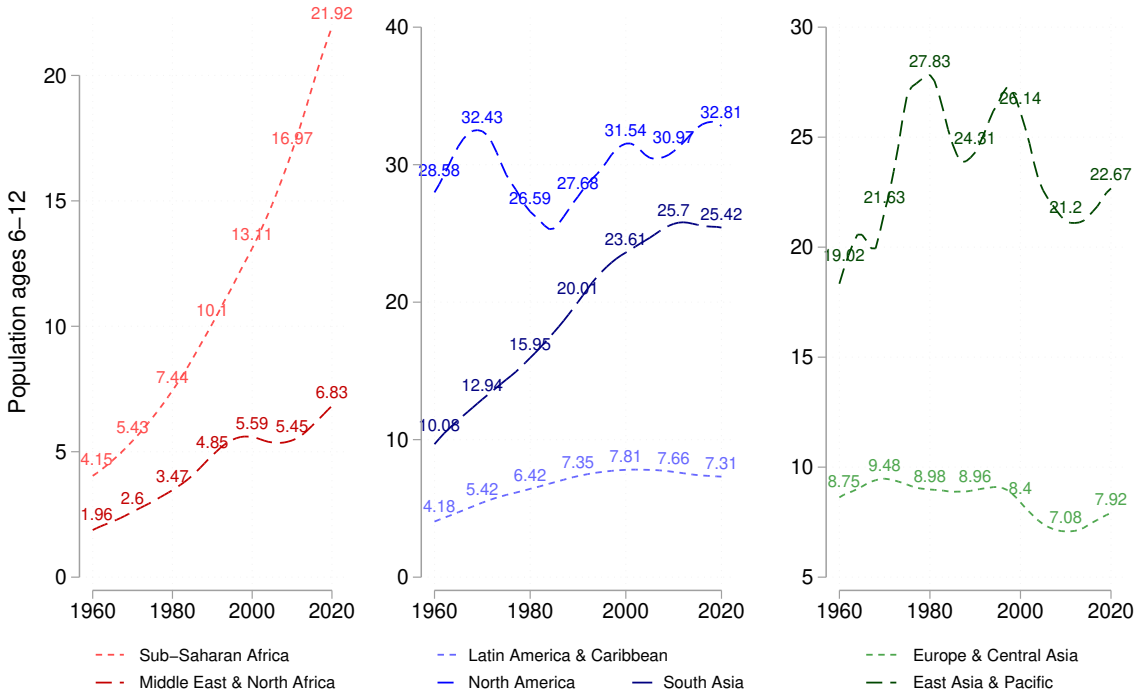
A.1 Global: Child population

In Appendix Figure A.1, we provide changes in population levels from 1960 and 2020 for the three groups regions we identified as exhibiting increasing, plateauing, and falling child population. Appendix Figure A.2 presents an analogous figure to Figure 1 (a), but using a broader definition of the school-age population (ages 0–14). The patterns appear very similar, though fluctuations are more smoothed with the broader definition, which may attenuate short-term population trends. Appendix Figure A.3 provides an analogous figure to Figure 1(b), but labeled with country names, while Appendix Figure A.4 shows the same figure with actual values instead of a logarithmic scale.

In Appendix Table A.1, we present the number of school-age children (ages 6 to 12) at both regional and country levels, along with their percentage changes for the periods 1980-2000, 2000-2020, and 1980-2020. These information complement Figure 1 from the main text where we showed percentage changes in child population for these regions. Country-specific results on child population changes reflect of regional aggregate findings presented in the main text.

To complement our results here which are focused on the number of children between 6-12, on our website, we also present levels and changes in the number of primary school students globally—Table: Global primary school students.

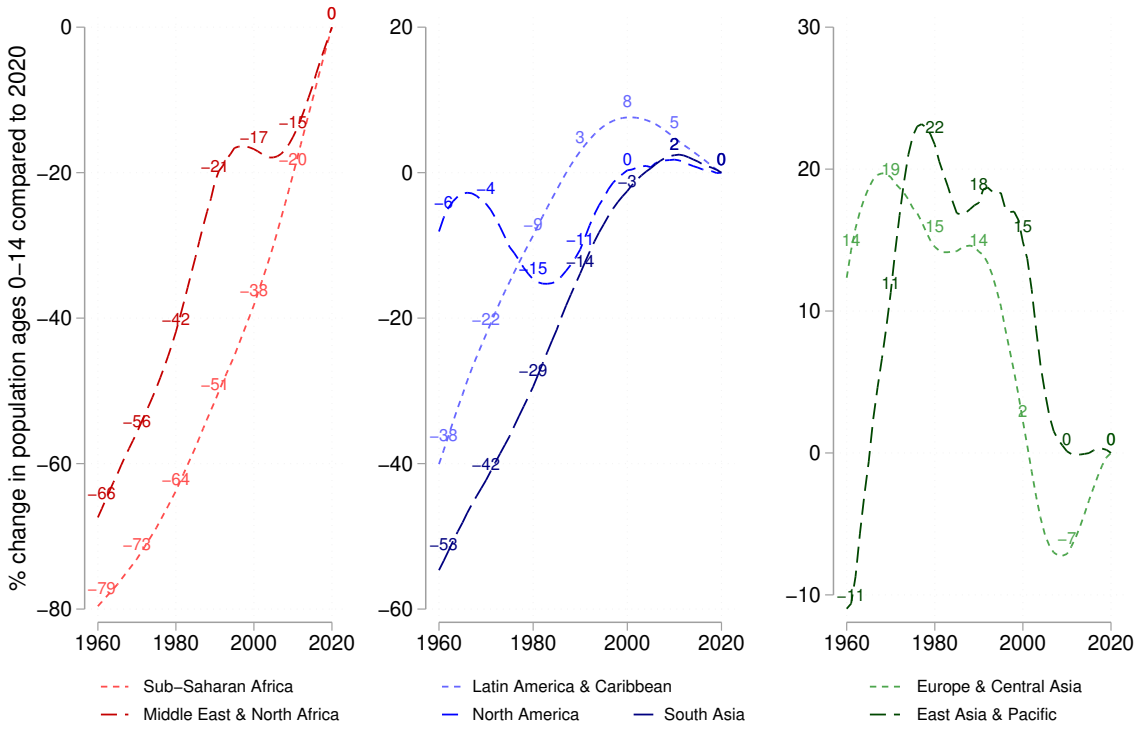
Fig. A.1. 1961-2020 school-age population by region



Unit: 1 million for North America, 10 million for others

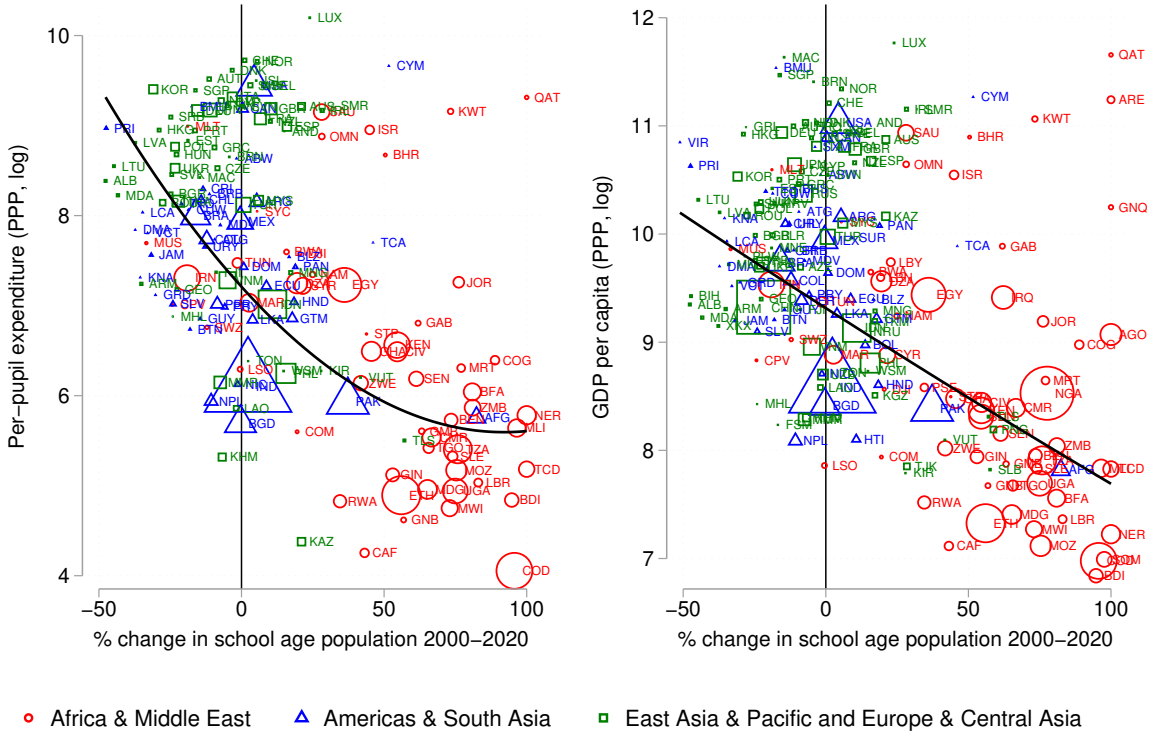
Note: Data come from the World Bank World Development Indicators and UN World Population Prospects. For uniformity of comparisons, we treat the child population ages 6 to 12 as the school age population. To facilitate comparisons of trends across countries, for each region, the unit of the value shown along the y-axis varies by region. The y-axis unit is 10 million for the Euro Area and North America, but 100 million for all other regions.

Fig. A.2. 1961-2020 School Age Population % Change by Region



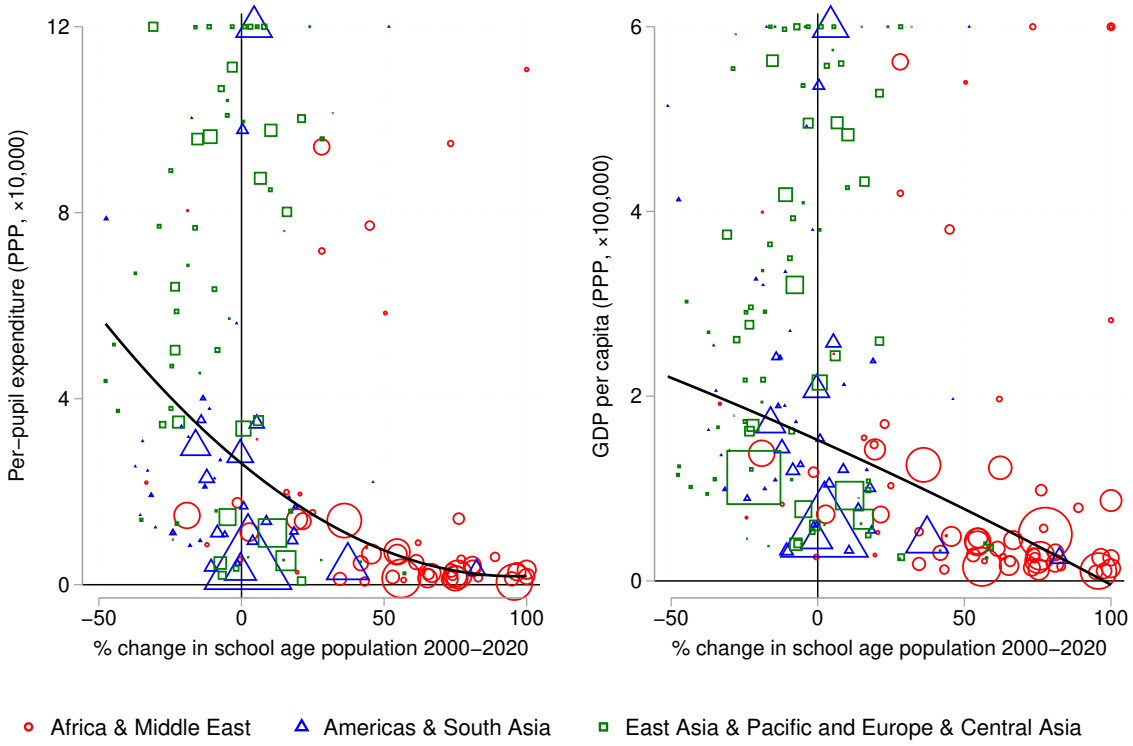
Note: Data come from the World Bank World Development Indicators. We treat the child population ages 0 to 14 as the school-age population, instead of 6-12 (baseline). To facilitate comparisons of trends across countries, for each region, the value shown along the y-axis is the percentage change in school age population with year 2020 as the base year, which is computed as: $\%\text{ChgBase2020} = \left(\text{Pop}_{\text{y,region}} - \text{Pop}_{\text{2020,region}}\right) / \left(\text{Pop}_{\text{2020,region}}\right) \times 100$. Percentage change by year 2020 with respect to base year y is equal to $\%\text{ChgBaseY} = 100 \times (-\%\text{ChgBase2020} / (\%\text{ChgBase2020} + 100))$.

Fig. A.3. Percentage change in the primary school-age population and economic resources with country name, 2000–2020



Note: Data come from the World Bank World Development Indicators and UN World Population Prospects. We treat the child population ages 6 to 12 as the school age population. In the figure, we also display the three-letter country codes. Per-pupil expenditure is calculated as government expenditure on primary education per student (as a percent of GDP) multiplied by GDP per capita, PPP (constant 2021 international $). The y-axis is shown on a logarithmic scale to accommodate the wide cross-country variation. Approximate actual values corresponding to log points are as follows: 4 ≈ 55, 6 ≈ 400, 7 ≈ 1,100, 8 ≈ 3,000, 10 ≈ 22,000, and 12 ≈ 163,000. Both per-pupil expenditure and GDP per capita represent averages between 2000 and 2020, based on available observations. The size of plot symbols represents the population size of countries. The black solid line represents a population-weighted quadratic fit.

Fig. A.4. Percentage change in the primary school-age population and economic resources, actual numbers 2000–2020



Note: The data sources are the World Bank World Development Indicators and UN World Population Prospects. We treat the child population ages 6 to 12 as the school age population. Per-pupil expenditure is calculated as government expenditure on primary education per student (as a percent of GDP) multiplied by GDP per capita, PPP (constant 2021 international $). The y-axis is shown on a logarithmic scale to accommodate the wide cross-country variation. Approximate actual values corresponding to log points are as follows: $4 \approx 55$, $6 \approx 400$, $7 \approx 1{,}100$, $8 \approx 3{,}000$, $10 \approx 22{,}000$, and $12 \approx 163{,}000$. Both per-pupil expenditure and GDP per capita represent averages between 2000 and 2020, based on available observations. The size of plot symbols represents the population size of countries. The black solid line represents a population-weighted quadratic fit.

Table A.1: Global youth population

Country by region	Age 6-12 population (1000s)				Age 6-12 pop. changes (%)			Avg per pupil expenditure ($)
	1960	1980	2000	2020	2000/1980	2020/2000	2020/1980	2000-2020
Global regions								
Sub-Saharan Africa	40,374	74,355	131,057	219,239	76%	67%	195%	543
Middle East & North Africa	18,789	34,688	55,862	68,265	61%	22%	97%	4,713
Latin America & Caribbean	40,466	64,203	78,074	73,120	22%	-6%	14%	2,858
North America	27,982	26,587	31,537	32,812	19%	4%	23%	10,825
South Asia	96,711	159,507	236,122	254,248	48%	8%	59%	785
Europe & Central Asia	86,242	89,849	84,002	79,211	-7%	-6%	-12%	8,549
East Asia & Pacific	183,369	278,316	261,403	226,704	-6%	-13%	-19%	3,663
Sub-Saharan Africa (SSA)								
Angola	847	1,516	3,141	6,593	107%	110%	335%	
Benin	405	744	1,411	2,448	90%	74%	229%	305
Botswana	96	181	302	350	67%	16%	93%	1,992
Burkina Faso	771	1,279	2,378	4,302	86%	81%	236%	421
Burundi	532	832	1,399	2,725	68%	95%	227%	123
Cabo Verde	35	67	91	69	36%	-24%	3%	1,107
Cameroon	835	1,598	2,944	4,906	84%	67%	207%	254
Central African Republic	292	451	766	1,097	70%	43%	143%	70
Chad	525	885	1,723	3,561	95%	107%	302%	178
Comoros	33	68	116	139	71%	19%	104%	270
Congo, Dem. Rep.	2,714	4,995	9,656	18,897	93%	96%	278%	58
Congo, Rep.	190	361	588	1,111	63%	89%	208%	598
Côte d'Ivoire	624	1,595	3,507	5,422	120%	55%	240%	655
Equatorial Guinea	45	51	130	290	154%	124%	468%	
Eritrea	166	299	440	621	47%	41%	107%	
Eswatini	70	120	216	190	80%	-12%	58%	835
Ethiopia	3,752	6,581	13,643	21,286	107%	56%	223%	134
Gabon	68	125	235	381	88%	62%	205%	903
Gambia	63	127	298	486	134%	63%	281%	272
Ghana	1,282	2,363	3,727	5,425	58%	46%	130%	660
Guinea	587	902	1,634	2,500	81%	53%	177%	167
Guinea-Bissau	84	157	238	373	51%	57%	137%	101
Kenya	1,497	3,551	6,225	9,620	75%	55%	171%	722
Lesotho	145	250	372	371	49%	0%	48%	539
Liberia	190	352	534	977	51%	83%	177%	154
Madagascar	974	1,785	3,161	5,223	77%	65%	193%	142
Malawi	621	1,161	2,247	3,887	93%	73%	235%	119
Mali	888	1,353	2,296	4,514	70%	97%	234%	282
Mauritania	142	291	507	898	74%	77%	208%	548
Mauritius	135	143	151	100	6%	-33%	-30%	2,196
Mozambique	1,130	2,160	3,514	6,163	63%	75%	185%	176
Namibia	106	199	357	446	80%	25%	124%	1,542
Niger	693	1,167	2,195	4,973	88%	127%	326%	325
Nigeria	7,597	13,377	23,347	41,463	75%	78%	210%	
Rwanda	622	1,019	1,702	2,289	67%	35%	125%	123
Senegal	605	1,122	1,921	3,098	71%	61%	176%	486
Seychelles	7	12	11	11	-6%	5%	-1%	3,128
Sierra Leone	348	576	824	1,434	43%	74%	149%	206
Somalia	541	1,103	1,659	3,278	50%	98%	197%	
South Sudan	503	820	1,131	2,241	38%	98%	173%	
Sudan	1,621	3,455	5,537	8,554	60%	54%	148%	
São Tomé and Príncipe	8	19	28	40	46%	44%	110%	800
Tanzania	1,829	3,784	6,542	11,506	73%	76%	204%	223
Togo	308	569	962	1,593	69%	66%	180%	225
Uganda	1,508	2,716	5,131	8,978	89%	75%	231%	140
Zambia	603	1,222	2,062	3,733	69%	81%	206%	318
Zimbabwe	764	1,466	2,182	3,095	49%	42%	111%	464
Middle East & North Africa (MEA)								
Algeria	2,197	3,804	5,141	6,144	35%	20%	62%	1,320
Bahrain	28	54	92	138	68%	50%	153%	5,843
Djibouti	16	64	132	159	107%	20%	150%	1,951

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Table A.1: Global youth population

	Age 6-12 population (1000s)				Age 6-12 pop. changes (%)			Avg per pupil expenditure ($)
Country by region	1960	1980	2000	2020	2000/1980	2020/2000	2020/1980	2000-2020
Egypt	4,784	7,746	12,481	16,981	61%	36%	119%	1,380
Iran	3,844	7,212	11,962	9,679	66%	-19%	34%	1,490
Iraq	1,278	2,794	4,719	7,657	69%	62%	174%	
Israel	322	551	779	1,130	42%	45%	105%	7,664
Jordan	159	482	969	1,708	101%	76%	254%	1,422
Kuwait	44	253	261	452	3%	73%	79%	9,489
Lebanon	329	516	662	789	28%	19%	53%	
Libya	266	684	801	983	17%	23%	44%	
Malta	56	36	40	32	10%	-19%	-11%	8,047
Morocco	2,164	3,800	4,566	4,689	20%	3%	23%	1,114
Oman	88	191	401	514	110%	28%	169%	7,178
Qatar	7	34	70	199	104%	185%	480%	11,080
Saudi Arabia	423	1,072	2,858	3,661	166%	28%	241%	9,417
Syrian Arab Republic	878	1,870	3,167	3,847	69%	21%	106%	1,290
Tunisia	771	1,216	1,439	1,418	18%	-1%	17%	1,697
United Arab Emirates	21	105	307	755	191%	146%	616%	
West Bank and Gaza	212	309	669	901	116%	35%	191%	
Yemen	900	1,892	4,347	6,429	130%	48%	240%	
Latin America & Caribbean (LAC)								
Antigua and Barbuda	10	9	10	9	3%	-9%	-6%	2,289
Argentina	2,905	3,731	4,900	5,162	31%	5%	38%	3,426
Aruba	11	8	10	10	20%	-2%	18%	5,561
Bahamas, The	20	40	43	38	9%	-11%	-3%	
Barbados	38	36	28	24	-24%	-11%	-33%	3,645
Belize	17	26	44	52	67%	17%	95%	1,882
Bolivia	630	1,026	1,493	1,700	46%	14%	66%	
Brazil	13,733	20,592	24,185	20,295	17%	-16%	-1%	2,863
British Virgin Islands	2	2	3	3	41%	28%	81%	
Cayman Islands	1	2	4	5	48%	52%	124%	15,726
Chile	1,437	1,791	2,009	1,725	12%	-14%	-4%	3,479
Colombia	3,091	4,764	5,914	5,194	24%	-12%	9%	2,232
Costa Rica	259	394	579	501	47%	-13%	27%	3,902
Cuba	1,143	1,640	1,163	863	-29%	-26%	-47%	
Curaçao	24	23	19	15	-19%	-19%	-34%	3,178
Dominica	11	15	10	6	-34%	-37%	-59%	2,545
Dominican Republic	656	1,112	1,419	1,430	28%	1%	29%	1,685
Ecuador	869	1,548	2,058	2,237	33%	9%	45%	1,241
El Salvador	541	878	1,039	789	18%	-24%	-10%	1,090
Grenada	18	18	17	12	-2%	-30%	-31%	1,234
Guatemala	800	1,333	2,307	2,718	73%	18%	104%	932
Guyana	116	153	128	109	-17%	-14%	-29%	948
Haiti	670	1,000	1,536	1,700	54%	11%	70%	
Honduras	410	750	1,267	1,500	69%	18%	100%	1,142
Jamaica	280	399	413	283	4%	-32%	-29%	1,925
Mexico	7,307	14,082	15,832	15,763	12%	0%	12%	2,761
Nicaragua	360	664	948	935	43%	-1%	41%	458
Panama	214	368	446	530	21%	19%	44%	1,733
Paraguay	379	559	926	871	65%	-6%	56%	1,079
Peru	1,881	3,288	4,331	3,963	32%	-8%	21%	1,090
Puerto Rico	454	470	428	225	-9%	-47%	-52%	7,872
Sint Maarten (Dutch part)	0	2	4	4	102%	-4%	94%	
St. Kitts and Nevis	11	7	6	4	-14%	-35%	-45%	1,500
St. Lucia	18	24	24	16	0%	-35%	-35%	3,090
St. Martin (French part)	1	2	4	3	158%	-28%	87%	
St. Vincent	18	21	17	11	-21%	-33%	-47%	2,432
Suriname	49	72	71	78	-2%	9%	7%	
Trinidad and Tobago	161	170	168	133	-1%	-21%	-22%	3,202
Turks and Caicos Islands	1	2	2	3	54%	46%	125%	2,210
Uruguay	312	360	373	326	4%	-13%	-10%	2,033
Venezuela	1,602	2,803	3,883	3,867	39%	0%	38%	
Virgin Islands (U.S.)	6	17	14	7	-15%	-51%	-59%	
North America (NAC)								

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Table A.1: Global youth population

Country by region	Age 6-12 population (1000s)				Age 6-12 pop. changes (%)			Avg per pupil expenditure ($)
	1960	1980	2000	2020	2000/1980	2020/2000	2020/1980	2000-2020
Bermuda	6	6	6	5	-6%	-17%	-23%	10,039
Canada	2,726	2,608	2,903	2,914	11%	0%	12%	9,778
United States	25,251	23,974	28,628	29,894	19%	4%	25%	12,659
South Asia (SAS)								
Afghanistan	1,575	2,536	4,190	7,643	65%	82%	201%	316
Bangladesh	8,807	16,819	22,809	22,728	36%	0%	35%	297
Bhutan	40	78	110	90	41%	-18%	16%	843
India	75,123	119,643	171,857	175,798	44%	2%	47%	447
Maldives	13	32	57	53	78%	-7%	65%	2,682
Nepal	1,785	2,736	4,565	4,079	67%	-11%	49%	368
Pakistan	7,646	15,216	30,116	41,345	98%	37%	172%	377
Sri Lanka	1,722	2,449	2,418	2,512	-1%	4%	3%	937
Europe & Central Asia (ECA)								
Albania	277	456	458	240	1%	-48%	-47%	4,383
Andorra	1	4	5	5	16%	15%	34%	7,607
Armenia	289	418	438	284	5%	-35%	-32%	1,397
Austria	692	765	668	592	-13%	-11%	-23%	13,492
Azerbaijan	646	1,008	1,295	1,180	28%	-9%	17%	
Belarus	1,145	1,013	960	781	-5%	-19%	-23%	
Belgium	985	963	871	941	-9%	8%	-2%	12,684
Bosnia and Herzegovina	554	544	406	214	-25%	-47%	-61%	
Bulgaria	988	908	642	483	-29%	-25%	-47%	3,794
Croatia	544	446	345	283	-23%	-18%	-36%	
Cyprus	98	81	101	96	25%	-5%	19%	10,100
Czechia	1,210	1,070	871	798	-19%	-8%	-25%	4,934
Denmark	536	513	461	446	-10%	-3%	-13%	14,887
Estonia	133	150	129	105	-14%	-19%	-30%	6,869
Faroe Islands	5	6	5	5	-5%	-6%	-12%	
Finland	653	440	456	434	4%	-5%	-1%	9,952
France	NA	5,948	5,242	5,589	-12%	7%	-6%	8,695
Georgia	511	594	485	375	-18%	-23%	-37%	1,313
Germany	NA	NA	6,205	5,248	NA%	-15%	NA%	9,584
Gibraltar	3	3	3	3	-18%	22%	0%	
Greece	1,017	1,052	823	745	-22%	-9%	-29%	6,356
Greenland	6	7	7	5	7%	-28%	-23%	
Hungary	1,232	1,052	850	656	-19%	-23%	-38%	5,777
Iceland	27	29	32	33	10%	5%	15%	13,177
Ireland	405	485	386	495	-21%	28%	2%	9,366
Isle of Man	5	6	7	6	6%	-1%	4%	
Italy	5,763	6,238	3,933	3,805	-37%	-3%	-39%	11,137
Kazakhstan	1,504	2,241	2,157	2,611	-4%	21%	17%	80
Kosovo	175	281	323	201	15%	-38%	-28%	
Kyrgyz Republic	356	643	856	1,003	33%	17%	56%	
Latvia	218	242	225	141	-7%	-37%	-42%	6,457
Liechtenstein	2	3	3	3	0%	-7%	-7%	
Lithuania	337	382	360	199	-6%	-45%	-48%	5,165
Luxembourg	30	33	38	48	17%	24%	45%	26,851
Moldova	485	485	509	288	5%	-43%	-41%	3,738
Monaco	1	2	2	2	24%	2%	27%	
Montenegro	78	74	66	54	-11%	-19%	-28%	
Netherlands	NA	NA	1,415	1,315	NA%	-7%	NA%	10,670
North Macedonia	254	264	233	154	-11%	-34%	-42%	
Norway	427	454	426	450	-6%	6%	-1%	16,537
Poland	4,660	3,763	3,730	2,861	-1%	-23%	-24%	6,409
Portugal	1,193	1,193	789	661	-34%	-16%	-45%	7,626
Romania	2,433	2,916	2,036	1,473	-30%	-28%	-49%	3,442
Russian Federation	17,007	13,479	13,546	12,488	0%	-8%	-7%	
San Marino	2	2	2	2	-21%	32%	4%	10,142
Serbia	894	736	613	461	-17%	-25%	-37%	8,905
Slovak Republic	612	567	537	406	-5%	-24%	-28%	4,540
Slovenia	211	197	155	156	-21%	1%	-21%	9,962

Continued on next page

Table A.1: Global youth population

	Age 6-12 population (1000s)				Age 6-12 pop. changes (%)			Avg per pupil expenditure ($)
Country by region	1960	1980	2000	2020	2000/1980	2020/2000	2020/1980	2000-2020
Spain	3,779	4,606	2,905	3,368	-37%	16%	-27%	7,951
Sweden	794	786	846	873	8%	3%	11%	12,549
Switzerland	581	611	601	607	-2%	1%	-1%	16,545
Tajikistan	344	743	1,243	1,596	67%	28%	115%	
Turkmenistan	264	510	833	976	63%	17%	91%	
Türkiye	5,104	8,132	9,106	9,168	12%	1%	13%	3,358
Ukraine	5,368	4,955	4,603	3,531	-7%	-23%	-29%	5,045
United Kingdom	5,576	5,845	5,322	5,871	-9%	10%	0%	9,506
Uzbekistan	1,301	2,819	4,438	4,395	57%	-1%	56%	
East Asia & Pacific (EAS)								
American Samoa	4	6	10	7	75%	-30%	22%	
Australia	1,421	1,844	1,886	2,283	2%	21%	24%	9,834
Brunei Darussalam	15	31	47	45	49%	-4%	43%	5,723
Cambodia	1,015	1,136	2,537	2,365	123%	-7%	108%	193
China	120,004	183,190	159,513	124,763	-13%	-22%	-32%	
Fiji	79	110	133	121	20%	-9%	10%	1,589
French Polynesia	15	29	37	30	28%	-20%	3%	
Guam	12	17	22	19	27%	-14%	10%	
Hong Kong SAR, China	549	593	585	416	-1%	-29%	-30%	7,710
Indonesia	14,122	27,166	30,612	33,938	13%	11%	25%	1,113
Japan	14,665	13,862	8,481	7,551	-39%	-11%	-46%	9,636
Kiribati	9	11	16	20	46%	28%	86%	579
Korea, Dem. People's Rep.	1,700	3,341	2,839	2,286	-15%	-19%	-32%	
Korea, Rep.	NA	6,466	4,638	3,203	-28%	-31%	-50%	12,124
Lao PDR	378	623	1,081	1,061	74%	-2%	70%	351
Macao SAR, China	36	37	53	45	42%	-15%	21%	4,432
Malaysia	1,545	2,275	3,645	3,862	60%	6%	70%	3,458
Marshall Islands	3	6	9	7	45%	-24%	10%	972
Micronesia	8	16	20	17	28%	-17%	7%	
Mongolia	146	330	428	502	30%	17%	52%	1,583
Myanmar	3,685	5,846	6,651	6,155	14%	-7%	5%	468
Nauru	1	1	2	2	91%	14%	118%	
New Caledonia	13	27	31	30	15%	-4%	10%	
New Zealand	349	425	423	466	0%	10%	10%	8,494
Northern Mariana Islands	2	3	7	6	126%	-22%	76%	
Palau	2	2	2	2	-4%	-28%	-31%	
Papua New Guinea	362	599	978	1,552	63%	59%	159%	
Philippines	5,748	9,453	14,232	16,450	51%	16%	74%	524
Samoa	23	35	33	38	-8%	15%	6%	482
Singapore	320	309	368	308	19%	-16%	0%	11,990
Solomon Islands	27	50	83	131	66%	58%	161%	
Taiwan	NA	2,657	2,264	1,404	-15%	-38%	-47%	
Thailand	5,014	8,363	7,322	5,705	-12%	-22%	-32%	3,335
Timor-Leste	80	108	137	216	26%	57%	99%	245
Tonga	13	20	18	18	-12%	2%	-10%	592
Tuvalu	1	1	2	2	48%	-6%	39%	
Vanuatu	12	23	37	52	58%	42%	123%	484
Vietnam	5,520	9,304	12,222	11,625	31%	-5%	25%	1,454

Note: Data come from the World Bank World Development Indicators. Global regions are aggregated into the seven world bank analytical groupings—Sub-Saharan Africa (SSA), Middle East and North Africa (MEA), Latin America and the Caribbean (LAC), North America (NAC), South Asia (SAS), Europe and Central Asia (ECA), and East Asia and Pacific (EAS). Percentage changes in the table are computed as: $\frac{\text{Outcome}_{\text{year}+\tau,\text{country}} - \text{Outcome}_{\text{year,country}}}{\text{Outcome}_{\text{year,country}}} \times 100$. Per-pupil expenditure is calculated as government expenditure on primary education per student (as a percent of GDP) multiplied by GDP per capita, PPP (constant 2021 international $). Per-pupil expenditure represents averages between 2000 and 2020, based on available observations. Per-pupil expenditure data for the Middle East & North Africa are not available, so regional averages are calculated using only the available observations. For population figures, we use the regional values reported by the World Bank.

A.2 Global: Population and Teachers

We provide additional details on region- and country-specific results related to the joint pace of changes in child population and the number of teachers. Panel (b) of Figure 2, Appendix Figures A.5, A.6, and A.7 provide visualizations of the changing relative patterns of school age population and teachers across regions, countries, and the pre- and post-millennial decades.

Specifically, Panel (b) of Figure 2 and Appendix Figure A.5, we provide visualizations with and without labels for country names for "balanced" countries—where we have data in both the pre- and post-millennial decades. In Appendix A.7, we show all countries where we have data in either or both the pre- and post-millennial decades. In Figure A.6, we show results based on regional aggregates. In these figures, the x-axis shows the change in child population (age 6 to 12), and the y-axis shows changes in the number of primary school teachers. We mark out the 45 degree line, countries and regions to the top left of the line experiencing reductions in the population to teacher ratio.

In addition to the visualizations, Appendix Table A.2 presents child to teacher ratio, percentage changes in the number of children and teachers, and growth rate ratio of the number of teachers with respect to the number of children at both regional and country levels.[A.1]

In the sections below, we summarize some country-specific findings in each region. The discussions here confirm the findings from the aggregate regional discussions presented in the main text.

SSA and MEA From 1980 to 2020, SSA and MEA countries—marked with red circles across the figures—experienced generally larger increases in both school-age population and teachers than other regions. Overall, SSA countries saw accelerating growth in the number of teachers that initially failed to keep pace with rapid school-age population increases; In MEA countries, growth in teachers doubled the relatively slower population growth throughout the decades. We discussed the regional patterns in the main text. Here, we provide additional details on country-specific results.

Nigeria and Egypt, as the largest countries in SSA and MEA exemplify their regional patterns. In the pre and post-2000 bi-decades, Nigeria saw child population growth of 75% and 78% and population-teacher growth rate ratios of 0.65 and 1.67 as the growth rate of teachers accelerated. Egypt experienced child population growth of 61% and 36% and population-teacher growth rate ratios of 2.49 and 1.46, as teacher growth far outpaced child population increases.

SAS, LNC, and NAC Across the figures, SAS, LNC, and NAC countries are marked as blue triangles. In the first two decades, countries in these regions largely take up space in the top right quadrant and over the 45-degree line, with concurrent increases in teachers and students. In the second set of decades, population stagnation in these regions is apparent from the shift of the blue triangles toward a concentration around zero population growth, but nearly all blue triangles remain over the 45-degree line, indicating a fall in population-to-teacher ratio as the number of primary teachers continued to grow despite population stagnation.

At the economy level, India and Brazil, the largest countries in the SAS and LNC regions respectively, also experienced a faster pace of teacher growth. In the pre- and post-2000 bi-decades, India saw child population growth of 44% and 2% and consistent teacher growth of 73% and 62%, respectively. Brazil experienced child population growth of 17% and -16% and

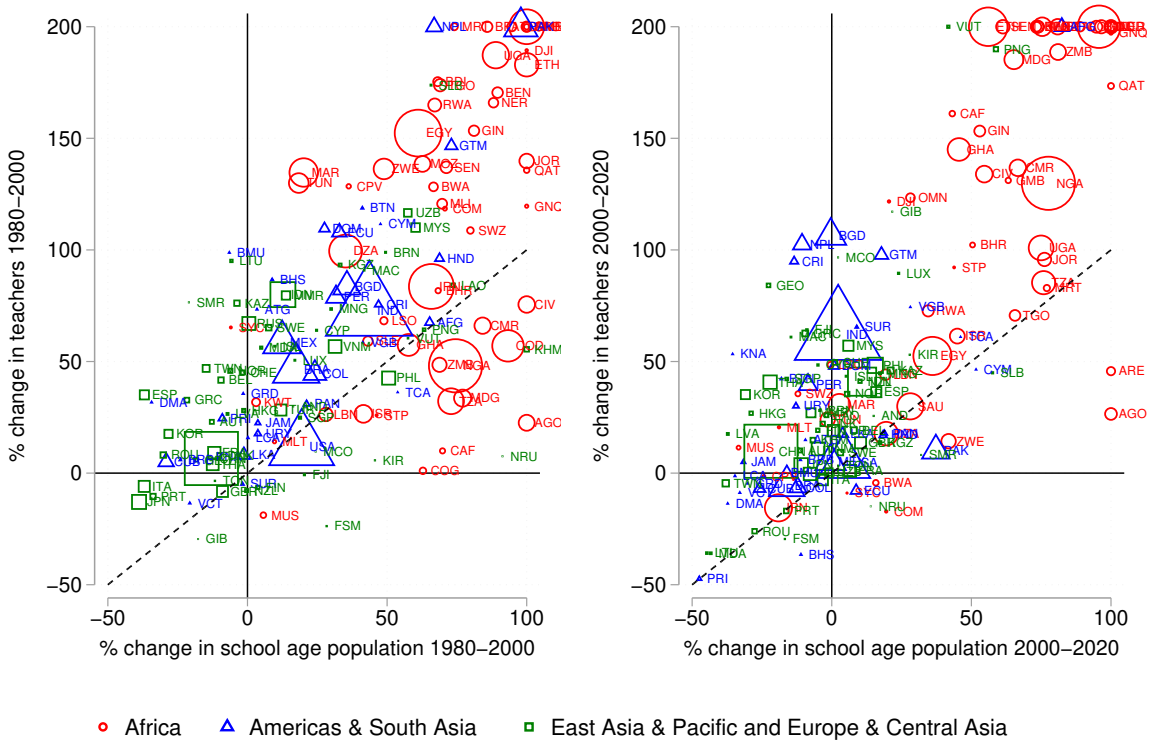
[A.1] Teacher information is more limited. For example, teacher data for Canada is available from 1983 to 2000. Therefore, in the table, we are unable to calculate the percentage changes and growth rate ratio, and these fields are left blank.

teacher growth of 47% and -6%, as the number of teachers first outgrew the population earlier and fell more slowly than the population drop more recently.

EAS and ECA Across the figures, EAS and ECA countries are marked as green rectangles. Across the decades, countries in these regions lie on both the left and right hand sides of the y-axis of zero percent population change, with a larger proportional share experiencing child population reduction. The dispersion of population shifts decreased significantly after 2000 as more countries experienced child population reductions. Similar to SAS, LNC, and NAC regions, across the decades, nearly all EAS and ECA lie over the 45-degree line as the growth of teachers either outpaced the growth rate of child population or dropped less rapidly than the fall in child population.

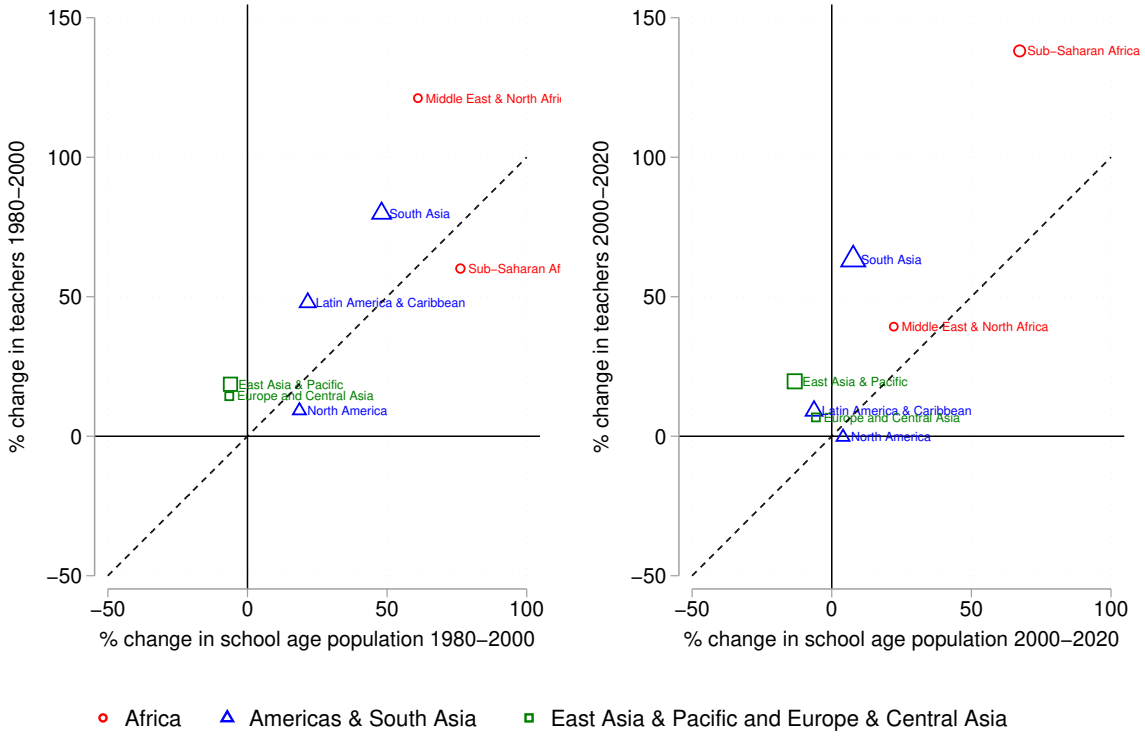
China and Russia, the largest countries in EAS and ECA regions respectively, both experienced child population declines paired with a continued rise in the number of primary teachers. In the two bi-decades, China saw child population reductions of 13% and 22% and but persistent teacher growth of 7% and 10%, respectively. Russia, similarly, experienced child population reductions of 0% and 8% and teacher growth of 67% and -0%.

Fig. A.5. Percentage change in the primary school-age population and teacher counts with country name, 1980-2020



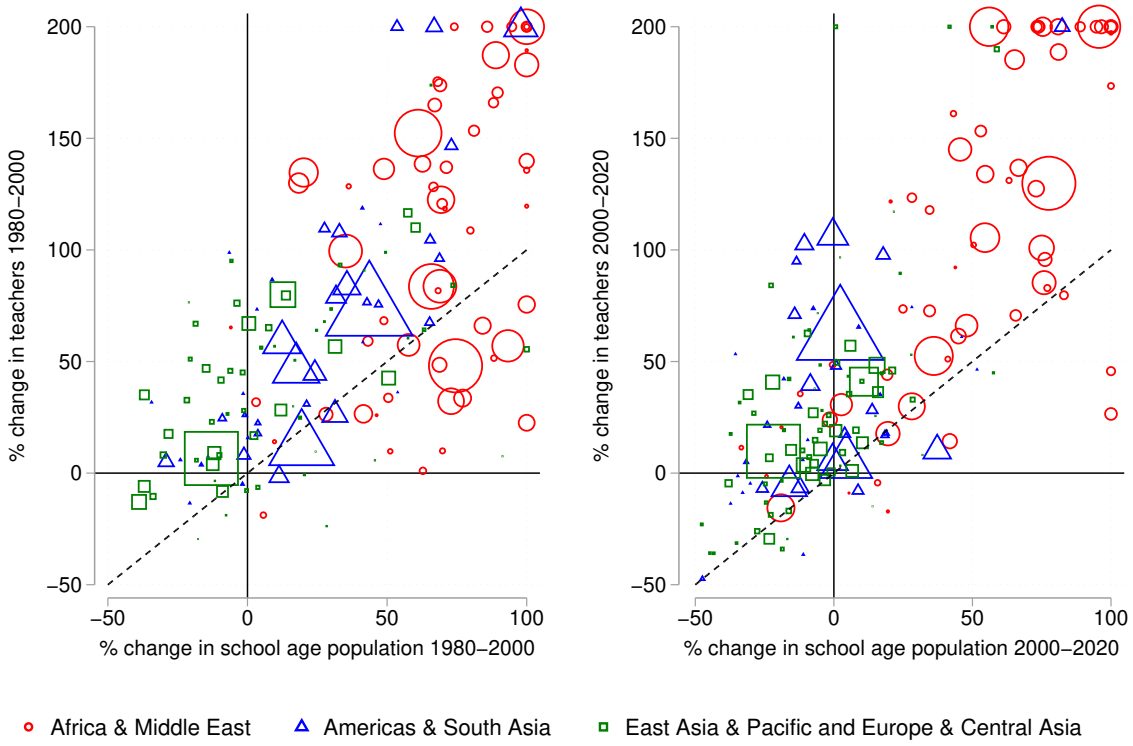
Note: The data sources are the World Bank World Development Indicators and UN World Population Prospects. For uniformity of comparisons, we treat the child population ages 6 to 12 as the school age population. Countries are included when both primary teacher and primary school age population data are available for beginning and end years in both figures for computing changes. 134 countries are included among 211 countries. See Appendix B for a full list of countries. Countries above the 45 degree line experience a reduction in the children to teacher ratio, and countries below the 45 degree line experience an increase.

Fig. A.6. Percentage change in the primary school-age population and teacher counts by sub-region, 1980-2020



Note: The data sources are the World Bank World Development Indicators and UN World Population Prospects. For uniformity of comparisons, we treat the child population ages 6 to 12 as the school age population. Regions above the 45 degree line experience a reduction in the children to teacher ratio, and regions below the 45 degree line experience an increase.

Fig. A.7. Percentage change in the primary school-age population and teacher counts, 1980-2020: unbalanced



Note: The data sources are the World Bank World Development Indicators and UN World Population Prospects. For uniformity of comparisons, we treat the child population ages 6 to 12 as the school age population. Countries are included when both primary teachers and primary school age population data are available for beginning and end years in both figures for computing changes. 134 countries are included among 211 countries. See Appendix B for a full list of countries. Countries above the 45 degree line experience a reduction in the children to teacher ratio, and countries below the 45 degree line experience an increase.

Table A.2: Global changes in youth (Age 6-12) and primary teachers

	Youth to teacher			2000 to 2020			1980 to 2020		
	Ratios			% change		Rate ratio	% change		Rate ratio
Country by region	1980	2000	2020	Youth	Teachers	Δ%T/Δ%Y	Youth	Teachers	Δ%T/Δ%Y
Global regions									
Sub-Saharan Africa	55	61	43	67%	138%	2.05	195%	281%	1.44
Middle East & North Africa	41	30	26	22%	39%	1.77	97%	208%	2.15
Latin America & Caribbean	34	28	24	-6%	9%	-1.43	14%	61%	4.42
North America	16	17	18	4%	0%	-0.08	23%	9%	0.38
South Asia	77	63	42	8%	63%	8.25	59%	194%	3.26
Europe & Central Asia	31	25	22	-6%	7%	-1.18	-12%	22%	-1.87
East Asia & Pacific	35	28	20	-13%	20%	-1.48	-19%	42%	-2.26
Sub-Saharan Africa (SSA)									
Angola	46	78	130	110%	27%	0.24	335%	55%	0.16
Benin	114	80	43	74%	222%	3.02	229%	771%	3.37
Botswana	34	25	30	16%	-4%	-0.27	93%	118%	1.27
Burkina Faso	367	136	49	81%	401%	4.95	236%	2,402%	10.16
Burundi	180	110	53	95%	306%	3.23	227%	1,019%	4.48
Cabo Verde	48	29	22	-24%	-1%	0.06	3%	125%	39.81
Cameroon	63	70	49	67%	137%	2.05	207%	293%	1.42
Central African Republic	112	174	95	43%	161%	3.73	143%	187%	1.31
Chad	237	129	78	107%	242%	2.27	302%	1,119%	3.70
Comoros	59	46	66	19%	-17%	-0.88	104%	81%	0.78
Congo, Dem. Rep.	50	62	29	96%	318%	3.32	278%	556%	2.00
Congo, Rep.	53	85	34	89%	379%	4.26	208%	384%	1.85
Côte d'Ivoire	65	81	54	55%	134%	2.45	240%	311%	1.29
Equatorial Guinea	66	77	58	124%	197%	1.59	468%	553%	1.18
Eritrea		71	66	41%	51%	1.24	107%		
Eswatini	37	32	21	-12%	36%	-2.93	58%	183%	3.15
Ethiopia	214	157	40	56%	519%	9.27	223%	1,652%	7.39
Gabon	36	45		62%			205%		
Gambia	93	64	45	63%	131%	2.07	281%	683%	2.43
Ghana	49	49	29	46%	145%	3.18	130%	286%	2.21
Guinea	132	94	57	53%	153%	2.89	177%	542%	3.06
Guinea-Bissau	51	70		57%			137%		
Kenya		43	32	55%	106%	1.93	171%		
Lesotho	49	43	29	0%	49%	-105.97	48%	150%	3.11
Liberia		41	42	83%	80%	0.96	177%		
Madagascar	52	69	40	65%	185%	2.84	193%	281%	1.46
Malawi		56	42	73%	127%	1.75	235%		
Mali	192	148	71	97%	309%	3.20	234%	802%	3.44
Mauritania	156	64	62	77%	83%	1.08	208%	676%	3.25
Mauritius	22	29	17	-33%	11%	-0.34	-30%	-10%	0.32
Mozambique	130	88	49	75%	214%	2.84	185%	649%	3.50
Namibia		29	21	25%	74%	2.95	124%		
Niger	218	154	76	127%	361%	2.85	326%	1,125%	3.45
Nigeria	44	52	40	78%	130%	1.67	210%	240%	1.15
Rwanda	102	64	50	35%	73%	2.10	125%	358%	2.87
Senegal	122	88	47	61%	205%	3.35	176%	624%	3.54
Seychelles	28	16	18	5%	-9%	-1.63	-1%	51%	-62.64
Sierra Leone	64	57	31	74%	224%	3.02	149%	415%	2.79
Somalia	127	143		98%			197%		
South Sudan			89	98%			173%		
Sudan				54%			148%		
São Tomé and Príncipe	33	38	29	44%	92%	2.10	110%	142%	1.29
Tanzania	48	62	59	76%	85%	1.12	204%	145%	0.71
Togo	64	39	38	66%	71%	1.08	180%	367%	2.04
Uganda	71	46	40	75%	101%	1.35	231%	477%	2.07
Zambia	57	65	41	81%	189%	2.33	206%	329%	1.60
Zimbabwe	52	33	41	42%	14%	0.34	111%	170%	1.53
Middle East & North Africa (MEA)									
Algeria	44	30	31	20%	18%	0.91	62%	135%	2.19
Bahrain	22	20	15	50%	102%	2.03	153%	268%	1.75
Djibouti	177	127	69	20%	122%	5.94	150%	542%	3.61

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Table A.2: Global changes in youth (Age 6-12) and primary teachers

	Youth to teacher			2000 to 2020			1980 to 2020		
	Ratios			% change		Rate ratio	% change		Rate ratio
Country by region	1980	2000	2020	Youth	Teachers	Δ%T/Δ%Y	Youth	Teachers	Δ%T/Δ%Y
Egypt	57	36	32	36%	53%	1.46	119%	285%	2.39
Iran	42	38	36	-19%	-16%	0.81	34%	55%	1.61
Iraq	30	28		62%			174%		
Israel	14	16	14	45%	61%	1.37	105%	104%	0.99
Jordan	35	29	26	76%	96%	1.26	254%	369%	1.45
Kuwait	33	26	13	73%	235%	3.21	79%	342%	4.34
Lebanon	23	23	19	19%	44%	2.29	53%	82%	1.55
Libya	21			23%			44%		
Malta	23	22	15	-19%	21%	-1.09	-11%	38%	-3.40
Morocco	70	36	28	3%	31%	11.34	23%	207%	8.84
Oman	53	32	18	28%	123%	4.38	169%	684%	4.05
Qatar	17	15	15	185%	173%	0.94	480%	545%	1.13
Saudi Arabia	23	15	15	28%	30%	1.06	241%	443%	1.84
Syrian Arab Republic	37	28		21%			106%		
Tunisia	46	24	19	-1%	24%	-16.59	17%	185%	11.12
United Arab Emirates	21	18	31	146%	46%	0.31	616%	398%	0.65
West Bank and Gaza		62	38	35%	118%	3.41	191%		
Yemen		42	37	48%	66%	1.38	240%		
Latin America & Caribbean (LAC)									
Antigua and Barbuda	23	14	11	-9%	15%	-1.58	-6%	99%	-15.65
Argentina	19	20		5%			38%		
Aruba		20		-2%			18%		
Bahamas, The	32	19	27	-11%	-36%	3.31	-3%	19%	-5.86
Barbados	28	20	17	-11%	6%	-0.53	-33%	12%	-0.38
Belize		23	20	17%	35%	2.11	95%		
Bolivia		25	22	14%	28%	2.04	66%		
Brazil	37	30	26	-16%	-6%	0.36	-1%	38%	-26.43
British Virgin Islands	17	15	11	28%	74%	2.64	81%	177%	2.18
Cayman Islands	22	15	16	52%	46%	0.90	124%	210%	1.69
Chile		36	18	-14%	71%	-5.02	-4%		
Colombia	35	30	28	-12%	-6%	0.52	9%	36%	3.94
Costa Rica	31	26	12	-13%	95%	-7.04	27%	242%	8.92
Cuba	19	13	10	-26%	-7%	0.27	-47%	-2%	0.05
Curaçao				-19%			-34%		
Dominica	33	16	12	-37%	-14%	0.37	-59%	14%	-0.23
Dominican Republic	53	32	22	1%	48%	60.39	29%	210%	7.35
Ecuador	39	25	29	9%	-8%	-0.90	45%	92%	2.06
El Salvador		49	30	-24%	22%	-0.89	-10%		
Grenada	30	22	16	-30%	-5%	0.15	-31%	29%	-0.94
Guatemala	56	39	23	18%	98%	5.49	104%	388%	3.74
Guyana	38	31		-14%			-29%		
Haiti	74	30		11%			70%		
Honduras	46	39	40	18%	17%	0.93	100%	130%	1.30
Jamaica	45	38	25	-32%	5%	-0.16	-29%	29%	-0.98
Mexico	41	29	28	0%	5%	-12.12	12%	67%	5.62
Nicaragua	50	40		-1%			41%		
Panama	30	28	28	19%	18%	0.94	44%	54%	1.23
Paraguay	30	24		-6%			56%		
Peru	39	29	19	-8%	40%	-4.67	21%	150%	7.29
Puerto Rico	25	18	18	-47%	-47%	1.00	-52%	-34%	0.66
Sint Maarten (Dutch part)				-4%			94%		
St. Kitts and Nevis	22	18	7	-35%	53%	-1.50	-45%	65%	-1.46
St. Lucia	26	22	15	-35%	-1%	0.04	-35%	14%	-0.41
St. Martin (French part)				-28%			87%		
St. Vincent	18	16	12	-33%	-9%	0.27	-47%	-21%	0.45
Suriname	21	22	14	9%	65%	7.31	7%	57%	8.17
Trinidad and Tobago	26	21		-21%			-22%		
Turks and Caicos Islands	19	21	19	46%	61%	1.32	125%	119%	0.96
Uruguay	24	21	14	-13%	30%	-2.34	-10%	53%	-5.55
Venezuela	32			0%			38%		
Virgin Islands (U.S.)	15			-51%			-59%		
North America (NAC)									

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Table A.2: Global changes in youth (Age 6-12) and primary teachers

	Youth to teacher			2000 to 2020			1980 to 2020		
	Ratios			% change		Rate ratio	% change		Rate ratio
Country by region	1980	2000	2020	Youth	Teachers	Δ%T/Δ%Y	Youth	Teachers	Δ%T/Δ%Y
Bermuda	23	11	9	-17%	0%	0.00	-23%	99%	-4.33
Canada	18	21		0%			12%		
United States	17	18	18	4%	5%	1.04	25%	17%	0.69
South Asia (SAS)									
Afghanistan	131	129	56	82%	324%	3.94	201%	611%	3.03
Bangladesh	109	81	39	0%	106%	-297.99	35%	279%	7.93
Bhutan	82	53	31	-18%	42%	-2.34	16%	211%	13.47
India	73	61	38	2%	62%	27.02	47%	180%	3.83
Maldives		18	9	-7%	74%	-9.94	65%		
Nepal	98	46	20	-11%	103%	-9.64	49%	624%	12.71
Pakistan	108	71	89	37%	10%	0.27	172%	231%	1.35
Sri Lanka	39	36	32	4%	18%	4.50	3%	27%	10.45
Europe & Central Asia (ECA)									
Albania		37	25	-48%	-23%	0.48	-47%		
Andorra	16	15	13	15%	26%	1.71	34%	63%	1.87
Armenia		37	35	-35%	-31%	0.89	-32%		
Austria	28	20	16	-11%	10%	-0.90	-23%	35%	-1.57
Azerbaijan		35	29	-9%	7%	-0.81	17%		
Belarus		29	36	-19%	-34%	1.83	-23%		
Belgium	22	14	13	8%	19%	2.41	-2%	69%	-30.54
Bosnia and Herzegovina			23	-47%			-61%		
Bulgaria		27	22	-25%	-5%	0.19	-47%		
Croatia		33	22	-18%	19%	-1.07	-36%		
Cyprus	37	28	18	-5%	48%	-9.80	19%	143%	7.72
Czechia	47	23		-8%			-25%		
Denmark	15	12	10	-3%	22%	-6.77	-13%	32%	-2.46
Estonia		15	13	-19%	-3%	0.19	-30%		
Faroe Islands				-6%			-12%		
Finland	18	20	16	-5%	19%	-3.84	-1%	12%	-7.91
France	20	17	17	7%	1%	0.15	-6%	10%	-1.67
Georgia	35	27	12	-23%	84%	-3.71	-37%	95%	-2.58
Germany		29	22	-15%	10%	-0.67			
Gibraltar	21	24	14	22%	117%	5.41	0%	53%	413.42
Greece	29	17	10	-9%	63%	-6.60	-29%	116%	-3.97
Greenland				-28%			-23%		
Hungary		18	17	-23%	-19%	0.82	-38%		
Iceland	19	13	10	5%	43%	8.41	15%	125%	8.12
Ireland	34	18		28%			2%		
Isle of Man				-1%			4%		
Italy	23	15	15	-3%	-3%	0.95	-39%	-9%	0.23
Kazakhstan		35	29	21%	46%	2.18	17%		
Kosovo				-38%			-28%		
Kyrgyz Republic	64	44	46	17%	14%	0.79	56%	120%	2.13
Latvia	34	25	13	-37%	18%	-0.47	-42%	49%	-1.17
Liechtenstein		15	10	-7%	38%	-5.46	-7%		
Lithuania	56	27	23	-45%	-36%	0.80	-48%	25%	-0.53
Luxembourg	18	14	9	24%	90%	3.74	45%	185%	4.12
Moldova	63	42	37	-43%	-36%	0.83	-41%	0%	0.00
Monaco	21	23	12	2%	97%	42.96	27%	116%	4.25
Montenegro				-19%			-28%		
Netherlands		11	10	-7%	4%	-0.60			
North Macedonia		40	20	-34%	32%	-0.93	-42%		
Norway	18	11	9	6%	35%	6.43	-1%	98%	-100.86
Poland		12	13	-23%	-29%	1.26	-24%		
Portugal	17	13	13	-16%	-17%	1.04	-45%	-26%	0.57
Romania	49	32	31	-28%	-26%	0.94	-49%	-20%	0.40
Russian Federation	65	39	36	-8%	0%	0.04	-7%	66%	-9.04
San Marino	18	8	10	32%	8%	0.25	4%	91%	21.07
Serbia			24	-25%			-37%		
Slovak Republic		31	27	-24%	-13%	0.54	-28%		
Slovenia		24	7	1%	240%	360.29	-21%		

Continued on next page

Table A.2: Global changes in youth (Age 6-12) and primary teachers

	Youth to teacher			2000 to 2020			1980 to 2020		
	Ratios			% change		Rate ratio	% change		Rate ratio
Country by region	1980	2000	2020	Youth	Teachers	Δ%T/Δ%Y	Youth	Teachers	Δ%T/Δ%Y
Spain	36	17	14	16%	36%	2.28	-27%	84%	-3.13
Sweden	20	13	12	3%	9%	2.97	11%	80%	7.33
Switzerland	24	16	11	1%	50%	44.54	-1%	117%	-186.01
Tajikistan		39	38	28%	33%	1.16	115%		
Turkmenistan			43	17%			91%		
Türkiye	41	36	30	1%	19%	27.94	13%	53%	4.14
Ukraine		44	32	-23%	7%	-0.30	-29%		
United Kingdom	22	21	21	10%	14%	1.32	0%	4%	9.40
Uzbekistan	50	37	36	-1%	1%	-0.54	56%	118%	2.11
East Asia & Pacific (EAS)									
American Samoa	16			-30%			22%		
Australia	20	18		21%			24%		
Brunei Darussalam	19	14	11	-4%	28%	-6.55	43%	155%	3.60
Cambodia	39	57	46	-7%	15%	-2.19	108%	78%	0.72
China	33	27	19	-22%	10%	-0.45	-32%	17%	-0.53
Fiji	27	33	18	-9%	64%	-7.21	10%	63%	6.51
French Polynesia	20	16		-20%			3%		
Guam	19			-14%			10%		
Hong Kong SAR, China	33	25	14	-29%	27%	-0.93	-30%	62%	-2.09
Indonesia	38	24	19	11%	41%	3.77	25%	154%	6.17
Japan	30	21	18	-11%	4%	-0.33	-46%	-10%	0.21
Kiribati	25	35	29	28%	53%	1.90	86%	62%	0.72
Korea, Dem. People's Rep.			30	-19%			-32%		
Korea, Rep.	54	33	17	-31%	35%	-1.14	-50%	59%	-1.17
Lao PDR	42	39	31	-2%	26%	-13.84	70%	132%	1.87
Macao SAR, China	45	33	18	-15%	61%	-4.17	21%	207%	9.83
Malaysia	31	24	16	6%	57%	9.58	70%	230%	3.30
Marshall Islands		17		-24%			10%		
Micronesia	14	24	28	-17%	-29%	1.76	7%	-46%	-6.80
Mongolia	74	55	45	17%	45%	2.59	52%	151%	2.88
Myanmar	71	45	33	-7%	27%	-3.63	5%	128%	24.18
Nauru	14	25	34	14%	-15%	-1.06	118%	-8%	-0.07
New Caledonia	21			-4%			10%		
New Zealand	20	22	17	10%	41%	4.07	10%	30%	3.08
Northern Mariana Islands				-22%			76%		
Palau		19		-28%			-31%		
Papua New Guinea	62	62	34	59%	190%	3.23	159%	376%	2.36
Philippines	37	40	31	16%	48%	3.10	74%	111%	1.51
Samoa	25	28		15%			6%		
Singapore	33	31	18	-16%	42%	-2.61	0%	78%	-213.38
Solomon Islands	44	26	29	58%	45%	0.78	161%	297%	1.84
Taiwan	38	22	14	-38%	-5%	0.12	-47%	40%	-0.85
Thailand	30	25	14	-22%	41%	-1.85	-32%	46%	-1.46
Timor-Leste		60	28	57%	232%	4.05	99%		
Tonga	26	23	23	2%	3%	1.42	-10%	0%	0.03
Tuvalu		21	11	-6%	72%	-12.37	39%		
Vanuatu	24	23	4	42%	783%	18.76	123%	1,317%	10.69
Vietnam	43	36	31	-5%	11%	-2.22	25%	74%	2.96

Note: Data come from the World Bank World Development Indicators. Global regions are aggregated into the seven World Bank analytical groupings—Sub-Saharan Africa (SSA), Middle East and North Africa (MEA), Latin America and the Caribbean (LAC), North America (NAC), South Asia (SAS), Europe and Central Asia (ECA), and East Asia and Pacific (EAS). If we are unable to calculate the percentage changes and rate ratio due to the data limitation, the fields are left blank. Percentage changes in the table are computed as: $\frac{\text{Outcome}_{2020,\text{country}} - \text{Outcome}_{\text{year,country}}}{\text{Outcome}_{\text{year,country}}} \times 100$.

A.3 Western Europe and East Asia: Population, Teachers, and Schools

In this section, we provide additional details on changing patterns of primary school students, primary teachers, and schools in Western Europe and East Asia. Tables A.3 and A.4 present decade levels and percentage changes respectively, in the number of schools, teachers, students, and child population, covering the period from 1960 to 2020. Table A.5 presents pupil to teacher and pupil to school ratios from 1960 to 2020. The details in the tables complement Figure 3 in the main text.

Table A.3: East Asia and Western Europe: schools, teachers, students, and children levels

	East Asia				Western Europe				
Years	China	Japan	Korea	Taiwan	Austria	Germany	France	Netherlands	Switzerland
Number of primary schools (1000s)									
1960	726.5	26.9			4.4				
1970	961.1	24.8	6.0		4.0				
1980	917.3	24.9	6.5	2.4	3.5		60.7		
1990	766.1	24.8	6.3	2.5	3.4	18.0	56.7	9.3	
2000	553.6	24.1	5.3	2.6	3.4	17.3	53.0	7.8	
2010	257.4	22.0	5.9	2.7	3.2	16.3	49.0	7.5	4.5
2020	158.0	19.5	6.1	2.6	3.0	15.4	45.1	6.7	4.6
Number of primary school teachers (1000s)									
1960	2,693.0	360.7			21.5				17.4
1970	3,612.0	367.9	101.1		24.8				20.9
1980	5,499.0	468.0	119.1	69.1	27.5		291.5		25.2
1990	5,582.0	444.2	136.8	82.6	29.4	181.0	309.9		30.4
2000	5,860.0	407.6	140.0	101.6	33.9	215.4	317.7	131.7	36.6
2010	5,617.0	419.8	176.8	99.6	32.6	228.4	316.1	182.0	44.1
2020	6,434.2	422.6	189.3	97.0	37.3	237.8	321.0	137.3	54.8
Number of primary school students (mil.)									
1960	93.8	12.6			0.5				0.6
1970	105.3	9.5	5.7		0.6				0.5
1980	146.3	11.8	5.7	2.2	0.4		6.1		0.4
1990	122.4	9.4	4.9	2.4	0.4		5.8	1.5	0.4
2000	130.1	7.4	4.0	1.9	0.4	3.4	5.4	1.6	0.5
2010	99.4	7.0	3.3	1.5	0.3	2.8	5.6	1.6	0.4
2020	107.3	6.3	2.7	1.2	0.3	2.8	5.4	1.5	0.5
Number of children ages 6–12 (mil.)									
1960	120.0	14.7			0.7				0.6
1970	135.0	11.1	6.6		0.9				0.6
1980	183.2	13.9	6.5	2.7	0.8		5.9		0.6
1990	142.8	10.8	5.7	2.8	0.6	5.9	5.4	1.3	0.5
2000	159.5	8.5	4.6	2.3	0.7	6.2	5.2	1.4	0.6
2010	113.3	8.2	3.9	1.8	0.6	5.3	5.5	1.4	0.6
2020	124.8	7.6	3.2	1.4	0.6	5.2	5.6	1.3	0.6

Note: Data come from the corresponding country's official website. For details on the data source, see Appendix B.

Table A.4: East Asia and Western Europe: schools, teachers, students, and children changes

	East Asia				Western Europe				
Years	China	Japan	Korea	Taiwan	Austria	Germany	France	Netherlands	Switzerland
Percentage change in primary schools									
2020 vs 1960	-78%	-27%			-31%				
2020 vs 1970	-84%	-21%	3%		-24%				
2020 vs 1980	-83%	-22%	-6%	8%	-13%		-26%		
2020 vs 1990	-79%	-21%	-3%	6%	-11%	-14%	-20%	-29%	
2020 vs 2000	-71%	-19%	16%	1%	-10%	-11%	-15%	-14%	
2020 vs 2010	-39%	-11%	5%	-1%	-5%	-5%	-8%	-11%	2%
Percentage change in primary school teachers									
2020 vs 1960	139%	17%			73%				214%
2020 vs 1970	78%	15%	87%		50%				162%
2020 vs 1980	17%	-10%	59%	40%	35%		10%		117%
2020 vs 1990	15%	-5%	38%	17%	27%	31%	4%		80%
2020 vs 2000	10%	4%	35%	-5%	10%	10%	1%	4%	50%
2020 vs 2010	15%	1%	7%	-3%	14%	4%	2%	-25%	24%
Percentage change in primary school students									
2020 vs 1960	14%	-50%			-33%				-7%
2020 vs 1970	2%	-34%	-53%		-42%				0%
2020 vs 1980	-27%	-47%	-52%	-47%	-13%		-11%		20%
2020 vs 1990	-12%	-33%	-45%	-50%	-7%		-6%	-2%	29%
2020 vs 2000	-18%	-14%	-33%	-39%	-12%	-15%	0%	-9%	12%
2020 vs 2010	8%	-10%	-18%	-23%	6%	0%	-2%	-9%	22%
Percentage change in children ages 6–12									
2020 vs 1960	4%	-49%			-14%				4%
2020 vs 1970	-8%	-32%	-52%		-31%				-7%
2020 vs 1980	-32%	-46%	-50%	-47%	-23%		-6%		-1%
2020 vs 1990	-13%	-30%	-44%	-50%	-6%	-12%	3%	4%	12%
2020 vs 2000	-22%	-11%	-31%	-38%	-11%	-15%	7%	-7%	1%
2020 vs 2010	10%	-8%	-18%	-22%	2%	0%	1%	-8%	10%

Note: Data come from the corresponding country's official website. For details on the data source, see Appendix B. Percentage changes in the table are computed as: $\frac{\text{Outcome}_{2020,\text{country}} - \text{Outcome}_{\text{year,country}}}{\text{Outcome}_{\text{year,country}}} \times 100$.

Table A.5: East Asia and Western Europe: schools, teachers, students, and children ratios

	East Asia				Western Europe				
Years	China	Japan	Korea	Taiwan	Austria	Germany	France	Netherlands	Switzerland
Ratio (Primary school students)/(Pimrary Schools)									
1960	129	469			117				
1970	110	383	964		150				
1980	159	474	872	920	116		101		
1990	160	378	769	947	110		102	164	
2000	235	306	763	741	117	194	103	212	
2010	386	318	564	571	103	174	113	220	96
2020	679	323	440	446	115	184	120	224	115
Ratio (Children ages 6–12)/(Primary schools)									
1960	165	546			157				
1970	141	449	1,114		217				
1980	200	556	997	1,094	222		98		
1990	186	437	903	1,135	187	330	96	135	
2000	288	352	881	871	199	359	99	182	
2010	440	374	668	673	183	324	113	191	122
2020	790	387	523	534	196	340	124	197	132
Ratio (Primary school students)/(Primary school teachers)									
1960	35	35			24				33
1970	29	26	57		24				25
1980	27	25	48	32	15		21		17
1990	22	21	36	29	13		19		14
2000	22	18	29	19	12	16	17	12	13
2010	18	17	19	15	10	12	18	9	10
2020	17	15	14	12	9	12	17	11	10
Ratio (Children ages 6–12)/(Primary school teachers)									
1960	45	41			32				33
1970	37	30	66		35				31
1980	33	30	54	38	28		20		24
1990	26	24	42	34	21	33	18		18
2000	27	21	33	22	20	29	17	11	16
2010	20	20	22	18	18	23	18	8	13
2020	19	18	17	14	16	22	17	10	11

Note: Data come from the corresponding country's official website. For details on the data source, see Appendix B.

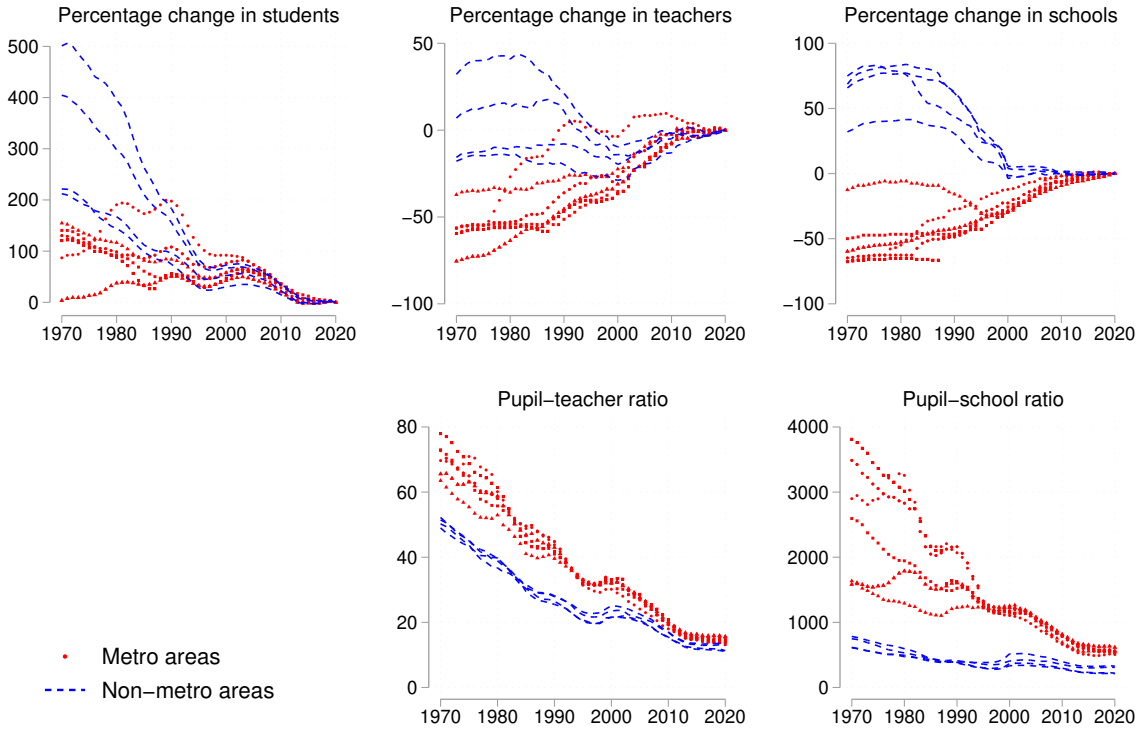
A.4 Korea: Population, Teachers, and Schools in Metropolitan and non-Metropolitan Areas

In this section, we provide additional details on the changing patterns of primary school students, primary teachers, and schools within South Korea. Figure A.8 presents province and metropolitan city level percentage changes in students, teachers, and schools. It also presents pupil-teacher and pupil-school ratios. While variations exist within both metro and non-metro areas, the contrast across these two categories is much more pronounced.

Figure A.9 presents the number of school closures categorized by closure types from 1982 to 2015, considering both closures of full primary schools as well as the closure of primary branch schools. Two notable observations are as follows: there is a significant shift in school closure policy around the year 2000, and this pattern is consistent across school types. However, the number of statistics from Korea indicate similar pattern, whether or not branch schools are included (see Appendix Figure A.9)

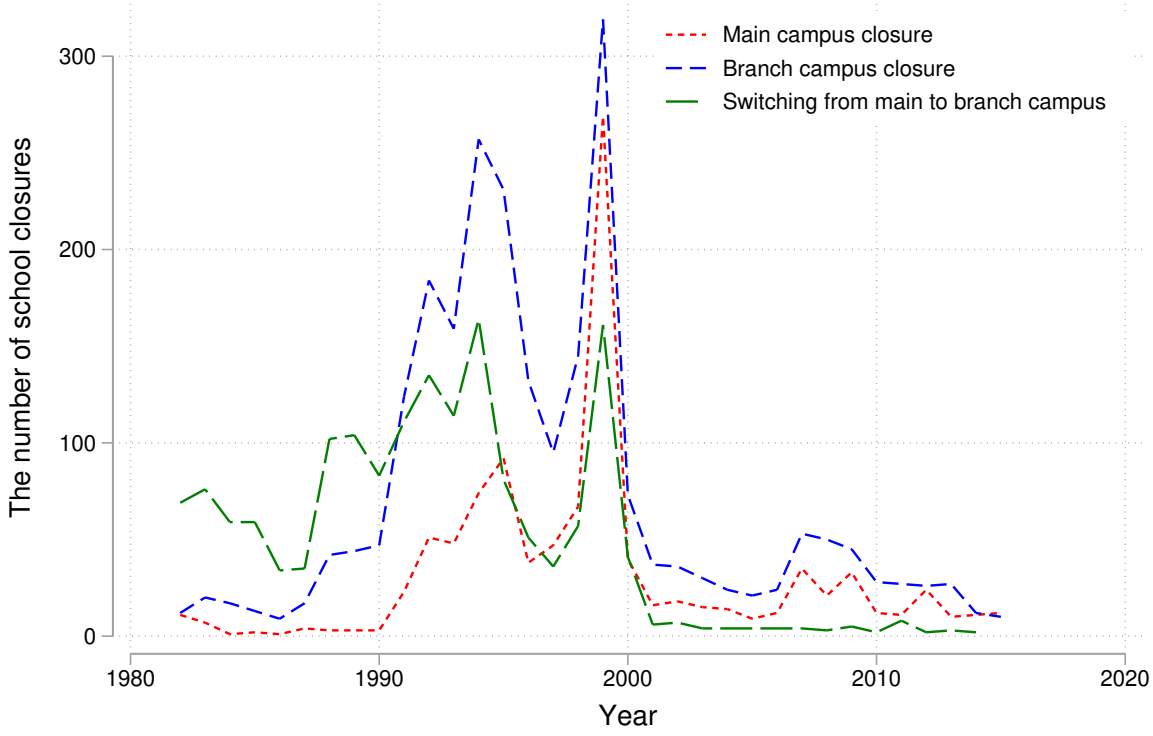
Lastly, in Table A.6, we present details on i) the number of primary school students, teachers, and schools, ii) percentage changes for the periods 2020-1970 through 2020-2010, and iii) primary school student and school and teacher ratios.

Fig. A.8. Primary education in Korea: demographic contraction, schools, and teachers in metropolitan cities and non-metropolitan provinces between 1971 and 2020



Note: The data source is Korean Educational Statistics Service (KESS). Both private and public schools are included. The metropolitan areas include the capital area (Seoul, Incheon, Gyeong-gi), metropolitan cities (Busan, Daegu, Daejeon, Gwangju, Ulsan), and Sejong. Non-Metropolitan areas include all other areas (Gangwon, Chungbuk, Chungnam, Jeonbuk, Jeonnam, Gyeongbuk, Gyeongnam, Jeju). To simplify the graph, I group neighbor provinces into bigger categories: Chungbuk-Chungnam (Chungcheong area), Jeonbuk-Jeonnam (Jeolla area), Gyeongbuk-Gyeongnam (Gyeongsang area), and Seoul-Incheon-Gyeong-gi (capital area). To facilitate comparisons of trends across areas, for each area, the value shown along the y-axis for the top three figures is the percentage change in each corresponding variable as of 2020, which is computed as: $\frac{\text{Outcome}_{\text{year,area}} - \text{Outcome}_{\text{2020,area}}}{\text{Outcome}_{\text{2020,area}}} \times 100$.

Fig. A.9. Primary education in Korea: primary school closures between 1982 and 2015



Note: The data source is the Korean Ministry of Education Press Release. Both private and public schools are included. "Branch campus" is used to refer to a location or subsidiary school that is derived from or affiliated with the main campus of an institution, where it is run by a few teachers. It is common in rural areas where the number of students is too small to run a separate complete school.

Table A.6: Korea: schools, teachers, and students

	Capital and metropolitan areas										Non-metropolitan areas								
	All	Capital area			Metropolitian and special self-governing cities						All	Provinces					Special provinces		
Years	All	Seoul	Incheon	Gyeong-gi	Busan	Daegu	Daejeon	Gwangju	Sejong[†]	Ulsan	All	Chung-buk	Chung-nam	Gyeong-buk	Gyeong-nam	Jeon-nam	Gang-won	Jeju	Jeon-buk
Panel A: Number of primary schools, teachers, and students																			
Number of primary schools																			
1970	1,309	206	50	613	99	81	74	50	32	105	4,652	372	510	890	731	881	607	108	553
1980	1,525	291	55	676	137	86	79	54	34	113	4,962	397	546	948	782	954	618	114	603
1990	1,881	463	103	684	221	118	79	83	29	101	4,454	337	536	890	701	821	499	115	555
2000	2,312	532	174	835	267	178	110	109	22	85	2,955	247	410	492	449	462	367	106	422
2010	2,893	587	226	1,145	298	214	138	145	22	118	2,961	259	408	494	495	433	353	106	413
2020	3,164	607	253	1,298	304	230	148	155	49	120	2,956	258	410	473	505	429	347	113	421
Number of primary school teachers (1000s)																			
1970	37.4	10.6	2.0	8.4	4.1	3.9	2.6	2.4	0.6	2.7	63.7	6.0	7.1	11.5	8.8	12.4	7.1	1.2	9.4
1980	51.5	17.9	2.5	10.6	7.4	4.2	2.8	2.7	0.6	2.8	67.5	6.2	7.4	12.5	9.0	13.5	7.5	1.6	9.8
1990	72.5	25.4	4.5	16.7	10.4	5.7	2.9	3.2	0.5	3.1	64.3	5.4	7.5	12.0	10.2	11.6	7.4	1.8	8.4
2000	86.7	25.3	7.2	26.5	9.8	6.5	3.9	3.8	0.4	3.3	53.3	4.9	6.5	9.5	9.9	8.1	5.7	1.9	6.9
2010	114.8	29.3	9.5	40.4	11.0	8.7	5.6	5.6	0.5	4.2	62.0	5.9	8.0	10.4	12.6	8.3	6.5	2.4	7.9
2020	123.1	28.6	10.1	46.8	10.1	8.9	6.0	6.0	2.1	4.3	66.2	6.7	9.3	10.3	13.8	8.3	6.6	2.9	8.3
Number of primary school students (1000s)																			
1970	2,531	770	136	469	287	282	192	191	32	172	3,218	310	349	570	428	630	371	64	494
1980	3,005	1,169	148	510	446	243	154	163	26	146	2,653	222	280	491	364	538	292	76	389
1990	3,109	1,142	208	656	457	255	120	134	12	124	1,759	153	205	318	309	290	188	56	240
2000	2,773	759	246	889	295	216	126	127	8	107	1,247	124	143	218	269	164	123	47	160
2010	2,277	566	183	848	197	168	109	116	8	82	1,022	105	131	164	228	124	100	44	127
2020	1,867	410	157	762	154	123	80	86	29	67	826	85	120	129	191	92	73	41	95
Panel B: Percentage changes in the number of primary schools, teachers, and students																			
Percentage change in primary schools																			
2020 vs 1970	142%	195%	406%	112%	207%	184%	100%	210%	53%	14%	-36%	-31%	-20%	-47%	-31%	-51%	-43%	5%	-24%
2020 vs 1980	107%	109%	360%	92%	122%	167%	87%	187%	44%	6%	-40%	-35%	-25%	-50%	-35%	-55%	-44%	-1%	-30%
2020 vs 1990	68%	31%	146%	90%	38%	95%	87%	87%	69%	19%	-34%	-23%	-24%	-47%	-28%	-48%	-30%	-2%	-24%
2020 vs 2000	37%	14%	45%	55%	14%	29%	35%	42%	123%	41%	0%	4%	0%	-4%	12%	-7%	-5%	7%	0%
2020 vs 2010	9%	3%	12%	13%	2%	7%	7%	7%	123%	2%	0%	0%	0%	-4%	2%	-1%	-2%	7%	2%

Continued on next page

Table A.6: Korea: schools, teachers, and students

	Capital and metropolitan areas										Non-metropolitan areas								
	All	Capital area			Metropolitian and special self-governing cities						All	Provinces					Special provinces		
Years	All	Seoul	Incheon	Gyeong-gi	Busan	Daegu	Daejeon	Gwangju	Sejong†	Ulsan	All	Chung-buk	Chung-nam	Gyeong-buk	Gyeong-nam	Jeon-nam	Gang-won	Jeju	Jeon-buk
Percentage change in primary school teachers																			
2020 vs 1970	229%	171%	400%	456%	146%	129%	129%	147%	251%	59%	4%	11%	31%	-11%	57%	-33%	-7%	130%	-12%
2020 vs 1980	139%	60%	295%	340%	37%	112%	119%	128%	235%	56%	-2%	8%	25%	-17%	54%	-39%	-12%	83%	-16%
2020 vs 1990	70%	13%	123%	180%	-3%	56%	105%	88%	357%	37%	3%	26%	24%	-14%	35%	-29%	-10%	61%	-2%
2020 vs 2000	42%	13%	41%	77%	4%	36%	55%	58%	426%	29%	24%	37%	43%	9%	40%	2%	16%	55%	20%
2020 vs 2010	7%	-2%	6%	16%	-7%	2%	9%	8%	328%	3%	7%	14%	16%	0%	10%	0%	2%	21%	4%
Percentage change in students																			
2020 vs 1970	-26%	-47%	15%	62%	-47%	-57%	-58%	-55%	-8%	-61%	-74%	-73%	-66%	-77%	-55%	-85%	-80%	-37%	-81%
2020 vs 1980	-38%	-65%	6%	49%	-66%	-50%	-48%	-47%	15%	-54%	-69%	-62%	-57%	-74%	-48%	-83%	-75%	-47%	-76%
2020 vs 1990	-40%	-64%	-25%	16%	-66%	-52%	-34%	-36%	144%	-46%	-53%	-44%	-41%	-59%	-38%	-68%	-61%	-28%	-61%
2020 vs 2000	-33%	-46%	-36%	-14%	-48%	-43%	-37%	-32%	249%	-37%	-34%	-31%	-16%	-41%	-29%	-44%	-40%	-13%	-41%
2020 vs 2010	-18%	-28%	-14%	-10%	-22%	-27%	-27%	-25%	282%	-17%	-19%	-19%	-8%	-21%	-16%	-25%	-26%	-8%	-25%
Panel C: Primary school student and school and teacher ratios																			
Ratio (Primary school students)/(Primary school)																			
1970	1,934	3,739	2,724	766	2,900	3,487	2,594	3,811	998	1,635	692	834	685	641	586	715	611	594	894
1980	1,970	4,016	2,692	755	3,257	2,830	1,945	3,016	752	1,292	535	560	512	518	466	564	473	668	644
1990	1,653	2,466	2,022	959	2,068	2,162	1,523	1,620	417	1,228	395	455	382	357	441	353	377	487	432
2000	1,199	1,428	1,412	1,065	1,105	1,216	1,143	1,163	384	1,254	422	503	349	442	599	354	334	441	378
2010	787	964	811	741	662	783	790	799	350	692	345	406	320	332	460	286	283	415	307
2020	590	675	620	587	505	533	539	558	602	562	280	330	293	273	378	215	212	359	225
Ratio (Primary school students/Primary school teachers)																			
1970	68	73	68	56	70	73	73	78	52	64	51	51	49	49	48	51	52	52	52
1980	58	65	58	48	60	58	56	61	40	53	39	36	38	39	40	40	39	49	40
1990	43	45	46	39	44	45	41	42	26	40	27	29	27	26	30	25	26	31	29
2000	32	30	34	34	30	33	32	33	21	32	23	25	22	23	27	20	22	25	23
2010	20	19	19	21	18	19	20	21	15	19	17	18	16	16	18	15	15	19	16
2020	15	14	16	16	15	14	13	14	14	16	12	13	13	13	14	11	11	14	11

Note: Data come from the Korean Educational Statistics Service (KESS). For details on the data source, see Appendix B.

† Sejong is the only special self-governing city, similar to Washington D.C. in the United States. Percentage changes in the table are computed as: $\frac{\text{Outcome}_{2020,\text{region}} - \text{Outcome}_{\text{year,region}}}{\text{Outcome}_{\text{year,region}}} \times 100$.

Aggregate national statistics for Korea are provided in Appendix Tables A.3, A.4 and A.4.

B Data sources by Country, Teachers, Schools, and Students

Data and statistical programs used by the paper is available at our project website.

B.1 Global

Our primary source for global data is World Bank Indicators (2023) and World Population Prospects (United Nations 2024). From the World Population Prospects, we extract annual data on the child population aged 6 to 12, while from the World Development Indicators we use data on the number of students and teachers in primary education as well as fertility rates, GDP per capita (PPP, constant 2021 international $), and per pupil government expenditure on primary education (% of GDP per capita), covering the years 1960 to 2021.

In our global level analysis, we focus our analysis on variations over time by seven World Bank analytical groupings. While this classification may not fully capture within-group heterogeneity, we adopt it because it includes all economies and effectively reflects broad regional trends and differences. The seven analytical groupings are visualized on this map: World Bank Analytic Groupings (World Bank 2017). While population data calculations may be subject to inconsistencies (Murray et al. 2018), and the reported number of teachers might not fully capture local situations such as teacher absenteeism (Bold et al. 2017), we adhere to our sources as our focus is on the overall trend rather than exact population estimation. The downloaded data files are named *Data_Extract_From_World_Development_ Indicators_including_ratio.xls* and *world_bank_global_fertility.xls* in the replication package.

Teacher data in the World Bank database is collected by the UNESCO Institute for Statistics based on official responses to its annual education survey. All data are aligned with the International Standard Classification of Education (ISCED) to ensure comparability of education programs across countries. The current version of ISCED was formally adopted by UNESCO Member States in 2011. Reference years correspond to the school year for which the data are reported. In some countries, the school year spans two calendar years; in such cases, the reference year reflects the year in which the school year ended.

Primary school age varies across countries, so we use the population aged 6 to 12 as a uniform demographic unit to facilitate international comparisons. The UNESCO Institute for Statistics (UNESCO Institute for Statistics 2022) defines the school-age population as the number of persons who, according to national laws or regulations, are expected to attend a given grade or level of education. Because definitions of primary school age differ across countries, we adopt a consistent definition of the school-age population. In addition, we confirm the robustness of our findings by using a broader group of children aged 0 to 14 as an alternative measure. This broader definition captures shifts in the school-age population and exhibits more stable patterns (see Appendix A.1).

Regarding the countries included in Figure 2, out of the 211 countries and economies for which we possess data, 77 countries have information on either population or teachers, while 134 countries provide data on both. Specifically, 36 out of 75 East Asia & Pacific and European & Central Asian countries, 24 out of 64 American and South Asian countries, and 17 out of 72 African countries are not included due to the absence of relevant data. Germany is not included for example, due to the changes in data from the reunification. For the full list of countries, see Table A.1.

B.2 East Asia

Our compilation of education resource statistics in East Asia and Western Europe is based on official statistics from each economy, which may lead to variations in resource definitions. For example, Korean statistics include branch schools, whereas Japanese statistics do not. However, as discussed in A.4, the trend over time remains consistent regardless of whether branch schools are included. Given our main focus on longitudinal trends, this consistency alleviates concerns about differences in school resource definitions across economies.

B.2.1 Mainland China

Our source for Chinese data is Chinese National Bureau of Statistics (2023). We specifically extract annual data on the number of elementary schools, teachers, and students spanning the years 1949 to 2021. Elementary schools include six grades. The downloaded data file is named *Data_China_School_Teachers_Students.xlsx* in the replication package.

Our Chinese school data considers the number of full primary schools. There are also teaching points and other types of incomplete primary schools, which also experienced reductions of similar scales (Ding and Zheng 2015; Hannum, Liu, and Wang 2021). We focus on full primary schools because the data on that extends across six decades, and also because teaching points generally only have early primary grades with children moving to full primary schools to complete primary education. According to the Ministry of Education, which published online the number of teaching points between 1997 and 2020, the number of teaching points decreased from 207,485 in 1997 to 90,295 in 2020, a reduction of 57%. During the same time frame, the number of full primary schools decreased from 628,840 to 157,979, a reduction of 75%.

B.2.2 Korea

Our source for Korean data is Korean Educational Statistics Service (2023). We specifically extract annual data on the number of elementary schools, teachers, and students spanning the years 1965 to 2021. Elementary schools include six grades. The downloaded data file is named *Korean elementary school 1965-2021.xlsx* in the replication package.

During the period of analysis, multiple metropolitan cities gained independence from their respective provinces and were designated as metropolitan cities. For example, in 1982, Daegu became a metropolitan city separate from Gyeongbuk. The designation of a metropolitan city leads to a sudden increase in counts in the area from 0, and a corresponding decrease in the province from which it was originally a part. For instance of Daegu, the school count is 0 before 1982 and 86 in 1982. To account for this, we assign the count number from the metropolitan area in the year of independence to the years before the designation and subtract it from the original province after considering trends in the corresponding province.[B.1] The complete list of changes in metropolitan cities is as follows (year-city-province): 1982-Daegu-Gyeongbuk, 1982-Incheon-Gyeong-gi, 1986-Gwangju-Jeonnam, 1988-Daejeon-Chungnam, 1997-Ulsan-Gyeongnam, 2013-Sejong-Chungnam.

Branch campuses are not included in the school count. The number of teachers includes both regular and contract teachers. It also includes teachers on leave of absence.

[B.1] For instance, the number of schools in Gyeongbuk province in 1965 is 84% of the number of schools in 1982. The number of schools in Daegu in 1965 will be assigned 84% of the number of schools in 1982.

B.2.3 Japan

Our source for Japanese data is Statistics of Japan (2023). We specifically extract annual data on the number of elementary schools, teachers, and students spanning the years 1948 to 2021. Elementary schools include six grades. The downloaded data files are named *japan_school_count_1948_2022.xlsx*, *japan_student_count_1948_2022.xlsx*, and *japan_teacher_count_1948_2022.xlsx* in the replication package.

The number of schools includes national, public, and private institutions. The number of schools is for the main campus and branch campuses combined. The number of teachers includes full-time teachers.

B.2.4 Taiwan

Our source for Taiwanese data is Taiwanese Ministry of Education (2023). We specifically extract annual data on the number of elementary schools, teachers, students, and enrollment ratio spanning the years 1976 to 2021. Elementary schools include six grades. The downloaded data files are named *taiwan_students_count_by_levels_1976_2021.csv*, *taiwan_teachers_count_by_levels_1976_2021.csv*, *taiwan_schools_count_by_levels_1976_2021.csv*, and *taiwan_gross_enrollment_ratio_by_levels_1976_2021.csv* in the replication package.

B.3 Europe

According to the "Standard Country or Area Codes for Statistical Use" published by the United Nations, the countries in Western Europe include Austria, France, Germany, Liechtenstein, Luxembourg, Monaco, the Netherlands, and Switzerland. We focus on countries with a population of at least one million people with the exception of Belgium, where national education statistics are not available.

B.3.1 Germany

Our source for German data is German Federal Statistical Office (2023a, 2023b). We specifically extract annual data on the number of elementary schools and teachers from 1992 to 2020, and the number of students from 1998 to 2021. Elementary schools include four grades. The downloaded data files are named *germany_schools_classes_bystates_30years.xlsx* (tab 2.1 for the number of schools and tab 7.1 for the number of teachers) and *germany_students_total_24years.xlsx* in the replication package.

Teachers include full-time employed (Vollzeitbeschäftigte), part-time (Teilzeitbeschäftigte) employed, and hourly employed (Stundenweise beschäftigte) teachers.

B.3.2 Austria

Our source for Austrian data is Statistics Austria (2023). We specifically extract annual data on the number of elementary schools, teachers, and students spanning the years 1923 to 2020. Elementary schools include four grades. The downloaded data files are named *austria_school_count_1923_2020.ods*, *austria_students_count_1923_2020.ods*, and *austria_teachers_count_1923_2020.ods* in the replication package.

When it comes to school data, there is a discontinuity in the time series between 2002/03 and 2003/04 due to changes in school counting methodology. Starting from 2006/07, the data

includes schools with foreign curricula. Additionally, from 2003/04 onwards, it encompasses institutions managed by private school providers. Regarding student data, complete data is not available from 2003/04 to 2005/06, and values for this period were partially estimated. From 2006/07 onwards, the data includes schools with a foreign curriculum. Since 2003/04, it also includes facilities operated by private school owners. As for teacher data, due to allocations in assigning teachers to school types, there may be rounding differences to the school type total. Notably, teaching staff at federal sports academies and schools and academies of health sciences are excluded. From 2006/07 onwards, the data includes schools with a foreign curriculum.

B.3.3 France

Our source for French data is French Ministry of National Education and Youth (2019) and French Directorate of Evaluation, Forecasting and Performance Monitoring (2023). We specifically extract annual data on the number of elementary schools, teachers, and students spanning the years 1984 to 2022. Primary education comprises three years of pre-elementary levels and five years of elementary levels. The downloaded data files are named *1984-2022 rers.pdf*, *france_students_count_1960_2019.xlsx*, *france_teachers_rers2021_2008_2020.xlsx*, and *france_teachers_rers2022_2015_2021.xlsx* in the replication package.

We use public primary education data including both elementary and pre-elementary levels. There are multiple reasons for this. First, pre-elementary education has been free since 1883 and the enrollment rate of 3-year-old children was 90% and that of 4-year-olds was virtually 100% in the 1970s (Dumas and Lefranc 2010). Second, data availability is limited if we only focus on elementary education. However, our analysis shows the qualitatively same results even if we focus on elementary education.

Over the period of yearbooks, the coverage regions change. Yearly statistics include overseas departments (Guadeloupe, Guyane, Martinique, and La Réunion) since year 1999 and also include Mayotte since 2011. Also, there are slight data inconsistencies across yearbooks when it comes to the number of teachers in the years 1992 and 1987. Those changes and inconsistencies make jumps between years. To handle this issue, we remove the gap between years by subtracting the gaps from previous years.

B.3.4 Netherlands

Our source for Dutch data is Statistics Netherlands (2023a, 2023b). We specifically extract annual data on the number of elementary schools and students from 2003 to 2017 and the number of teachers from 2003-2017. Elementary schools include eight grades. The downloaded data files are named *netherlands_student_school_count_1990_2021.xlsx* and *netherlands_teachers-in-primary-education_2003_2017.xlsx* in the replication package.

B.3.5 Switzerland

Our source for Swiss data is Historical Statistics of Switzerland (HSSO) (2023) and Federal Statistical Office Switzerland (2023a, 2023b). We specifically extract data on the number of elementary students from 1864 to 1999 with intervals of 4 to 8 years, and the number of teachers from 1864 to 1961 with intervals of 4 to 8 years and from 2010 to 2020 annually. We also extract annual data on the number of elementary schools from 2010 to 2020. Elementary schools include four to six grades depending on the canton. The downloaded data file is named *swiss_data_students_teachers_schools.xlsx* in the replication package.

C Methods

Statistical programs used by the paper are functionalized and available at our project website.

C.1 Data Interpolation and Extrapolation

After data collection, we interpolate and extrapolate when there are gaps in years in the data. For each country or location and across all variables, we compute year-by-year percentage changes, as well as changes over 5, 10, 15, and 20-year intervals. This process involves both interpolation to derive values within existing data points and extrapolation to estimate values up to 5 years beyond, aligning with the nearest decade breakpoints. In instances such as Afghanistan, where there are data gaps for specific years (1983, 1987, and 1992), we use interpolation to fill these gaps and extrapolate to determine values for 2020 based on the changes observed between 2018 and 2019. Meanwhile, for Austria, where historical data is not available on an annual basis, we apply interpolation techniques to generate more frequent, annualized predictions for earlier decades. We provide a detailed accounting of the number of imputed data points for each economy on this webpage, which compares the raw and interpolated global cross-national time series.

C.1.1 Interpolation

We calculate percentage changes by taking the difference between consecutive data points and dividing it by the prior level. This approach allows us to estimate potential percentage changes across multiple years even when there are gaps with missing data. Our methodology assumes a constant growth rate between years, enabling us to compute annualized percentage changes. The formula for our annual percentage change is outlined below:

$$annualPercentChange_{(from\ t'\ to\ t'+1)} = \left(\left(\frac{schoolTeacherOrStudent_{t+\tau}}{schoolTeacherOrStudent_t} \right)^{\frac{1}{\tau}} - 1 \right), \quad \text{(C.1)}$$

where the percentage change is for all $t \leq t' \leq t+\tau-1$. Using $annualPercentChange_{(from\ t'\ to\ t'+1)}$, we interpolate to generate missing in-between data values when τ is larger than 1. When t is the initial year or $t+\tau$ is the final year of available data, we construct $annualPercentChange_{(from\ t'\ to\ t'+1)}$ based on the latest or earliest two years of available data, and generate predictions for values up to five years beyond the available data end times.

The annual percentage change is exact where we know the level of schools, teachers, or students in the current year and the year immediately after. But it is based on growth trend "linear" interpolation when we have years of missing data in between. We use the interpolated annual percentage changes to fill in gaps in levels.

C.1.2 Extrapolation

We extrapolate before the start and after the end of the data timeframes. The extrapolation does not exceed going 5 years forward and going 5 years backward. Moreover, extrapolation only happens within years in which there is at least one variable, among variables for the country, that has non-missing values. Extrapolation is meant to help with situations, for instance, where we have data up to 2019, but for consistency of comparison, it would be useful to extend the data to 2020 by extrapolating 1 year forward.

In instances where a country's data is accessible only from 1980 onwards, we permit extrapolation back to 1980 for a maximum of 5 years. Specifically, because we generally have population data from 1960 to 2020 for all countries, we will not be extrapolating prior to 1960 or after 2020. In the case of Korea, where data starts in 1965, we do not extrapolate to any years before 1965, but if one of the Korean variables has data starting from 1970, we extrapolate between 1965 and 1970. For Germany, unification happened in 1992. We do not have data in 1990, preventing us from computing change from 1990 to 2000. We extrapolate from 1992 back 5 years to 1987, generating a value for 1990.

We take the difference between consecutive data points at both ends of the available data and divide it by the prior level to get percentage changes. We assume a constant growth rate in extrapolation. Given these, our formula when extrapolating forward is shown below:

$$extrapolatedValue_{t-1} = value_t \times \frac{1}{1 + changeRate_{from\ t\ to\ t+1}} \,. \tag{C.2}$$

In the same manner, we can extrapolate forward.

C.2 Percentage change

To maintain consistency in data presentation, we establish the year 2020 as our baseline for calculating percentage changes in Figures 1, 3, and 4. The base year 2020 percentage changes, Y_t, is computed for each data point X_t using the following formula:

$$Y_t = (X_t - X_{2020})/X_{2020} \,. \tag{C.3}$$

To facilitate discussions, we also compute percentage changes from year t to year 2020, using year t as the base year. When we describe percentage changes in the main text and appendix Tables, we compute base year t percentage changes, Z_t, which is equal to:

$$Z_t = (X_{2020} - X_t)/X_t \,. \tag{C.4}$$

The base year 2020 and base year t percentage changes are related via the following relationship:

$$Z_t = (-Y_t)/(Y_t + 1) \,. \tag{C.5}$$

C.3 Pupil to Teacher Ratio, and Growth Rate Ratio

Let C_t, P_t, T_t, and S_t represent the number of children, students, teachers, and schools at time t in a particular region, country and subnational administrative unit. The children and pupil to teacher and children and pupil to school ratio at time t are defined as $\frac{C_t}{T_t}$, $\frac{P_t}{T_t}$, $\frac{C_t}{S_t}$, and $\frac{P_t}{S_t}$, respectively. We present and discuss these statistics through out the text.

In addition to these ratios, we also construct and discuss growth rate ratios of teacher count with respect to the number of children (ages 0-14) in the main text and Appendix Table A.2. The growth rate ratio of teachers with respect to children (teacher-children growth rate ratio) in year t is defined as:

$$rateRatio_{t,t+\tau} = \frac{\%\Delta T_{t,t+\tau}}{\%\Delta C_{t,t+\tau}} \,, \tag{C.6}$$

where $\Delta T_{t,t+\tau}$ and $\Delta C_{t,t+\tau}$ are changes in the number of teachers and children between time t and

$t + \tau$. The % symbol means we convert changes in levels to percentage changes in teachers and children. Thus, the teacher-children growth rate ratio quantifies the responsiveness of teachers to changes in the school-age population over time, expressed as the percentage change in teachers relative to percentage changes in child population between years t and $t + \tau$. A growth rate ratio that is equal to 1 indicates that shifts in the number of teachers are keeping pace with population changes, preserving the existing children to teacher ratio, despite population dynamics.

C.3.1 Per primary pupil expenditure

We use data on national GDP per capita (PPP, constant 2021 international $) and per-pupil government spending on primary education (reported as % of GDP per capita) from World Bank Indicators (2023). The data is available for most countries, but only available for a sparse set of years. For each country-year in which the data is available, we compute the dollar level of per primary pupil expenditure as the product of GDP per capita and per-pupil government spending on primary education. For each country, we then compute an average level of per primary pupil expenditure between 2000 and 2020 by averaging over the years between 2000 and 2020 in which data is available.