

Mining and Schooling in Mongolia: Large-Scale and Informal Mining, Provincial Enrollment, and What the Newer Data Show

Second edition, verified. A research report extending Melissa Khasbagan, "The Effects of Large-Scale and Informal Mining in Mongolia on Economic and Education Outcomes" (undergraduate paper, Stanford). Extension, data gathering, verification and figures prepared with AI assistance. Prepared 9 September 2026.

About this edition

The first edition of this report was produced in a single pass. This edition re-examined it claim by claim. Every quantitative statement was traced to a primary source or marked as unverifiable, figures that disagree across sources were reconciled rather than chosen, the paper's causal language was narrowed to what its design supports, and the original findings were tested against provincial data for 2023 to 2025 that were not available when the paper was written. Two sections are new: Section 5, which extends the paper's provincial comparison through 2025 using the National Statistical Office's public database, and Section 10, on what the evidence implies for Mongolia's future. Appendix A lists every claim checked and its status. Appendix B documents the data used.

The main corrections to the first edition are these. The often-quoted figure of "over 56,000 children in child labour, more than half in hazardous work" combined two different statistics; the correct reading is given in Section 1. The claim that Oyu Tolgoi dividends would not begin until 2041 was overtaken by an agreement in June 2026. The livestock herd never stood at 20 million in 1990; it was 25.9 million. The "600,000 herders moved to cities" figure could be traced only to journalism that cites no source, and has been replaced with census and registration data. Several air pollution figures from the companion paper were correct but needed their definitions stated. None of the corrections reverses the paper's central finding; several sharpen it.

Plain summary

Mongolia's economy runs on what comes out of the ground. Mining supplied about a quarter of GDP, 90 percent of exports, and more than 30 percent of government revenue in 2022, and about 29 percent of GDP and 87 percent of exports in 2023 (EITI). The question this report examines is what that dependence does to schooling in the provinces where the mines are.

The original paper compared Mongolia's 21 provinces (aimags) between 2000 and 2022 with difference-in-differences methods and National Statistical Office data. Four high-

producing provinces, Tuv, Selenge, Orkhon, and Umnugovi, were treated as mining provinces and compared with the other 17. Taken together, mining provinces showed no significant difference in enrollment. Split into provinces dominated by large industrial mines (Umnugovi, Orkhon) and provinces where informal, small-scale gold mining is widespread (Tuv, Selenge), the two groups moved in opposite directions: enrollment, per capita GDP and industrial sales rose in the first group relative to the comparison provinces, while enrollment, graduate counts and per capita GDP fell in the second. Inside Umnugovi, the districts covered by Oyu Tolgoi's 2015 community agreement showed higher dependency ratios and more truck inspections a year later but no measurable change in school outcomes.

Provincial data for 2023 to 2025, retrieved for this edition, show that the first half of that pattern has persisted and widened: the large-scale mining provinces' enrollment advantage over the comparison provinces grew from about 4 points to about 6 points at primary level. The second half has weakened: the informal mining provinces' enrollment deficit, which was 5 to 8 points in 2015 to 2018, had closed by 2025. Whether that reflects the partial formalization of artisanal mining, the 2020 census re-basing of population estimates, or something else, the data cannot say.

Three cautions apply throughout. The paper's estimates are associations from a design with two treated units per group and a borrowed treatment definition, not causal effects. Gross enrollment ratios can rise because unregistered migrants' children enroll while the official population count does not change, so "enrollment up" is not the same as "children better educated". And the household-level literature on Oyu Tolgoi finds that completion among older teenagers fell even as incomes rose. The report closes with what the evidence implies for a country whose herd lost nearly a fifth of its animals in two winters, whose coal revenue depends on a Chinese steel industry now in decline, and whose children score well below the OECD average in every subject PISA tests.

Abstract

This report extends and verifies an undergraduate difference-in-differences study of mining and education outcomes across Mongolia's 21 aimags, 2000 to 2022. The original study finds no significant aggregate association between high mining production and gross enrollment, but divergent associations once treatment provinces are split by mining type. Aimags dominated by large-scale licensed mines (Umnugovi, Orkhon) show higher primary and secondary enrollment for both sexes, higher per capita GDP, and higher industrial sales, alongside fewer schools, kindergartens, and full-time students relative to comparison aimags. Aimags characterized by informal artisanal gold mining (Tuv, Selenge) show lower enrollment at every level, fewer grade 9 and 12 graduates, and lower per capita GDP and industrial sales. A soum-level analysis within Umnugovi around the 2015 Oyu Tolgoi Cooperation Agreement finds higher dependency ratios and truck inspections in partner soums but no change in school outcomes. Using National Statistical Office tables for 2005 to 2025, this edition shows that the large-scale group's enrollment advantage persisted and widened after 2022 while the informal group's deficit

closed, that student numbers in the large-scale aimags have grown by about a third since 2019 against 15 percent in the comparison aimags, and that Umnugovi's nominal GDP per capita reached about six times the comparison-aimag mean in 2023 and 2024, the coal export boom, and about four times in 2022 and 2025. The report reconciles conflicting statistics on child labour, ger-district population, and mineral revenue savings; records the June 2026 Oyu Tolgoi shareholder agreement, the 2024 sovereign wealth fund law and its first distributions; and sets out, with sources, what the evidence implies for Mongolia's demographic, climatic, fiscal and educational future. Every quantitative claim is listed with its verification status in Appendix A.

1. Why mining and schooling are linked in Mongolia

Mongolia's economy was reshaped twice in a generation. The first shock was the collapse of the socialist system in the early 1990s, followed by the dzuds, the severe winter disasters of 1999 to 2002, which the source paper reports killed an estimated 11 million animals and pushed rural households away from herding. The second was the development of world-class mineral deposits: Oyu Tolgoi copper-gold in the South Gobi, discovered in 2001; the Tavan Tolgoi coking coal fields; and the Soviet-era Erdenet copper mine in Orkhon.

The scale of the transformation is visible in the national accounts. The World Bank's 2020 Country Economic Memorandum states that "since the advent of large-scale mining in 2004, Mongolia's economy has grown at an average rate of 7.2 percent per year" (World Bank 2020). Total natural resource rents, the World Bank's measure of the surplus earned from extraction above production cost, rose from 4.6 percent of GDP in 2003 to 42.2 percent in 2011, fell to about 10 percent in the 2015 to 2016 commodity bust, and climbed to 33.1 percent in 2021, the latest year in the World Development Indicators (Figure 2). By 2022 the Extractive Industries Transparency Initiative reported that mining accounted for 25 percent of GDP, 90 percent of exports, more than 30 percent of government budget revenue, 57 percent of industrial production and 42 percent of investment, while employing about 4 percent of the workforce (EITI Mongolia country page). The 18th EITI reconciliation report, published November 2024, gives 28.7 percent of GDP, 86.5 percent of export revenue and 29.9 percent of budget revenue for 2023 (EITI Mongolia 2024b).

That last figure is the crux. A sector that produces a quarter to a third of output but employs few workers transmits its effects to households mainly through public revenue, migration and household labour rather than wages, and each channel reaches schools differently.

Public revenue. Since 2020, half of mining royalty revenue has been allocated to the General Local Development Fund; in that year 172.6 billion MNT was allocated to the fund and 165.7 billion MNT passed to provincial local development funds (EITI Mongolia). Whether this money reaches classrooms depends on local budgeting, and the EITI reports do not trace it to the aimag level.

Migration. Mining projects attract workers and families, many never registered locally. UNICEF's 2017 study found that the registered population of Tsogttsetsii soum, home to Tavan Tolgoi, grew from 2,198 in 2008 to 7,017 in 2015, with an unregistered population assumed at 12,000 to 16,000; in Khanbogd, the soum nearest Oyu Tolgoi, there were about 6,000 registered residents and 7,000 mobile people (UNICEF 2017). A 2023 commentary in the Mongolian press put Khanbogd's registered population at 8,660 in 2022 with a floating population of around 20,000 (ikon.mn 2023). Umnugovi's registered mid-year population rose from 47,355 in 2000 to 78,247 in 2025, a 65 percent increase against 50 percent nationally (NSO, table DT_NSO_0300_002V1). Schools are funded and built for the registered population.

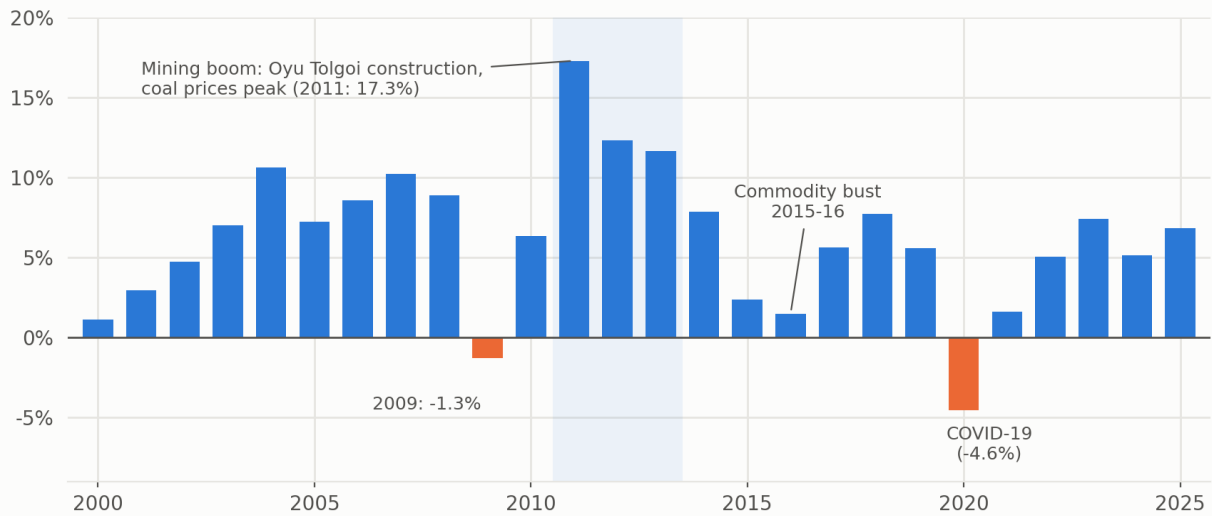
Household labour. In informal mining areas the sector's pull runs through the family. Here the statistics need care, because "child labour in Mongolia" is several different numbers (Figure 10). The ILO's 2016 policy brief, drawing on a re-analysis of the 2011 to 2012 National Child Labour Survey, put over 56,000 children aged 5 to 17, about 10 percent of the age group, in child labour; the ILO and NSO's own 2013 report on the same survey counted 43,545 in child labour and 10,398 in hazardous work. The brief's statement about hazardous work refers to "over half of 15 to 17 year olds" working in construction and mining, not to all child labourers, and the first edition of this report misread it (ILO 2016; US Department of Labor 2015). The two most recent surveys give higher figures under broader definitions: the NSO and ILO Child Labour Survey 2021 to 2022 counted 207,951 economically active children (24.4 percent of 5 to 17 year olds), 138,525 in child labour (16.3 percent) and 58,233 in hazardous work (6.8 percent), with rates of 30.0 percent in rural areas against 10.2 percent in urban areas; the 2023 Social Indicator Sample Survey, using the UNICEF MICS definition, found 11.7 percent (NSO and ILO 2024; NSO and UNICEF 2024). Most of this work is herding and fetching water and fuel: the survey report states that five in ten child labourers collect water and firewood and three in ten herd animals (NSO and ILO 2024). It counts 2,904 children in prohibited occupations, mining among them, but does not tabulate mining separately. The evidence that children work in mines therefore comes from small purposive studies, above all the 2008 ILO and National Human Rights Commission study of 232 children and 50 parents at informal mines in eight aimags, which found 56 percent of the children working underground and 53 percent injured at work (ILO briefing note on occupational safety and health in mining, undated).

Urbanization. The urban share of the population rose from 56.7 percent in 2000 to 71.1 percent in 2025 (World Bank WDI). Ulaanbaatar's mid-year population grew from 777,397 in 2000 to 1,785,075 in 2025, about half the country (NSO, DT_NSO_0300_002V1); one recent estimate citing UNHCR puts rural-to-capital migration at "over 818,000 individuals" between 1990 and 2024 (Forced Migration Review 2025). The figure of "600,000 former herders, a fifth of the population" that appears in the source paper's companion essay and in the first edition of this report could be traced only to 2018 journalism that cites no source, and is not used here.

National enrollment statistics therefore look reassuring (Figure 3) while individual mining districts can look very different. That gap is the subject of the original paper and of this extension.

Mongolia's growth has tracked the mining cycle

Real GDP growth, annual %, 2000-2025. Orange bars mark years of contraction; shaded band marks the 2011-2013 boom.



Source: World Bank, World Development Indicators (API, accessed 9 Sep 2026). Indicator NY.GDP.MKTP.KD.ZG.

Figure 1. Real GDP growth, 2000 to 2025. Source: World Bank WDI. The 2011 peak of 17.3 percent coincides with Oyu Tolgoi construction and high coal prices; contractions in 2009 and 2020 reflect the global financial crisis and the COVID-19 pandemic.

2. What the existing evidence says

2.1 The resource curse literature the paper draws on

The paper's starting point is the cross-country resource curse literature. Sachs and Warner (1999) documented that countries with high shares of resource-based exports grew more slowly over the following two decades, with Malaysia and Mauritius as counterexamples that diversified into manufacturing. Papyrakis and Gerlagh (2004) found that the direct effect of resources on growth is positive but that indirect effects through corruption, lower investment, reduced openness, worse terms of trade and lower schooling turn the net effect negative. The schooling channel motivates the paper directly. Beegle, Dehejia and Gatti (2004), using community shocks and rice prices as instruments in Vietnam, found that children who worked were less likely to be in school five years later and completed less schooling, though they earned more in the short run; this is the mechanism the paper suspects in informal mining areas.

2.2 Mongolia-specific evidence available when the paper was written

The paper relies on two bodies of Mongolian evidence. UNICEF's 2017 study of mining-related in-migration documented that Khanbogd's school held 880 pupils against a baseline capacity of 360, ran in two shifts, and ranked last among 21 schools in Umnugovi; that Tsogttsetsii's oldest school held 829 pupils against a capacity of 440; that schools in the South Gobi mining soums ran at "from 50 per cent to 250 per cent" over

capacity; that Mandal soum in Selenge was almost 50 percent over; and that children of migrant miners were sometimes left in child-headed households for months (UNICEF 2017, pp. 24 to 35). The ILO's work on informal gold mining includes the 2006 baseline survey of Bornuur and Zaamar soums in Tuv (Navch et al. 2006) and the 2016 policy brief. The paper also cites surveys finding that around 70 percent of dropouts from informal gold mining are boys and that most left school in grade 5.

For the treatment definition, the paper uses Batdelger and Zagdbazar (2022), published in Resources Policy, who argue that while the resource sector does not necessarily benefit a country at the national level, "at a local level, the picture is different". Using EITI reconciliation reports for 2006 to 2018 and a threshold of 100 billion MNT in production, they identify Tuv, Selenge, Orkhon and Umnugovi as aimags where household real income differs significantly from non-producing aimags.

2.3 Newer academic work

Three more recent studies are directly relevant and were not used by the original paper.

Narantungalag (2021, 2025), using the Household Socio-Economic Survey for 2008 to 2016 and a difference-in-differences design around Oyu Tolgoi, finds that a ten percent increase in mining activity was associated with rises of about 2.2 and 2.3 percent in household income and food consumption, that medical spending rose without more illness, and, most relevant here, that households in the mining region reduced education spending while their attainment rose faster than the control group, a pattern the author attributes to the increased availability of health and education facilities, partly through corporate social responsibility spending.

Zhou (2019), using the same survey for 2007 to 2016 with the October 2009 Oyu Tolgoi investment agreement as the event, reports mixed results for Umnugovi: annual salaries rose by over three million MNT against about 2.3 million nationally and adult vocational education rose four percentage points relative to control, but secondary completion among 18 to 20 year olds fell 15 percentage points against 8 nationally, and the share of children under 12 without formal education rose 18 points relative to control. These findings sit uneasily with the original paper's province-level result of higher enrollment in large-scale aimags, a tension taken up in Section 7.

The artisanal sector has also changed. planetGOLD reports that artisanal mining peaked at around 100,000 people in the 2000s, was legally recognized in 2010 through an amendment to the Minerals Law, had its regulation revised in 2017 and 2022, and today involves 40,000 to 60,000 miners, about a third of them women, with 120,000 to 180,000 dependants; it estimates that 16 percent of the sector has been formalized and that mercury, although banned, is still used clandestinely (planetGOLD 2023; planetGOLD Mongolia project page). During a 2019 to 2022 suspension of key regulatory clauses, it reports a 300-fold increase in illegal mining offences, 45,286 people in unlawful mining, and 15 deaths (planetGOLD 2023).

3. Data and design

3.1 Data

The paper draws on the National Statistical Office (NSO) at two levels. At the aimag level it assembles annual data for all 21 aimags from 2000 to 2022: gross enrollment ratios (GER) for primary (grades 1 to 5), secondary (grades 6 to 9) and basic (grades 1 to 9) education, each by sex; full-time grade 9 and grade 12 graduates; full-time students; per capita GDP; numbers of schools, kindergartens and preschool children; pupil-teacher ratios; and sales of industrial production. At the soum (district) level, available only from 2015, it collects new entrants, kindergartens, students, schools, population density, the dependency ratio, and bus and truck inspections. Descriptive statistics show 374 aimag-year observations for enrollment, with a mean primary GER of 96.4 percent and secondary GER of 94.8 percent; the Umnugovi soum panel has 236 observations.

3.2 Design

The paper runs three difference-in-differences comparisons (Figure 5).

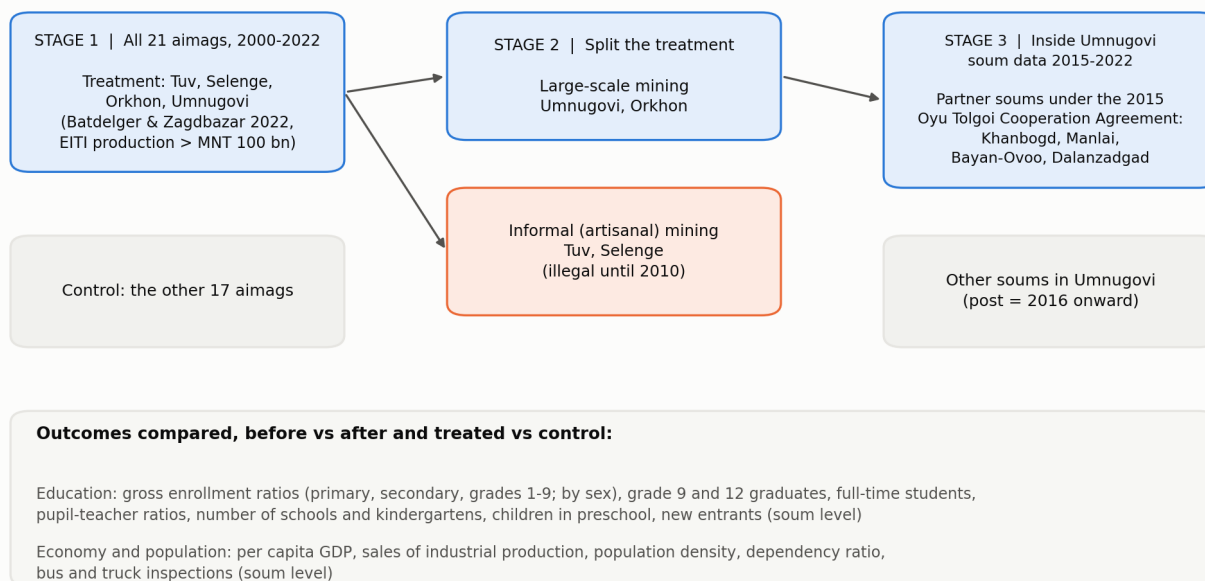
Stage 1 compares the four high-producing aimags identified by Batdelger and Zagdbazar (2022) with the other 17 aimags, regressing each outcome on a treatment-after indicator with year and aimag fixed effects.

Stage 2 divides the four treated aimags into two groups and re-runs the comparison for each against the non-producing aimags: large-scale mining aimags, where production comes from formally licensed industrial mines (Umnugovi with Oyu Tolgoi and Tavan Tolgoi; Orkhon with Erdenet), and informal mining aimags, where artisanal gold mining is widespread (Tuv, where the paper cites an estimate that about 100,000 people, or 20 percent of the rural workforce, are involved in informal gold mining; and Selenge, where the Boroo and Gatsuurt license areas attracted 3,000 artisanal miners between October 2015 and March 2016 after Centerra Gold paused and then sold its operations). The paper's text does not print the assignment explicitly; the grouping used in this report is inferred from its background section.

Stage 3 restricts attention to Umnugovi's soums from 2015 to 2022 and compares the four partner soums of the April 2015 Oyu Tolgoi Cooperation Agreement (Khanbogd, Manlai, Bayan-Ovoo and Dalanzadgad), under which Oyu Tolgoi pledged US\$5 million per year to the Gobi Oyu Development Support Fund, with the other soums in the province. "After" is defined as 2016 onward.

How the study is built: three difference-in-differences comparisons

Illustrative diagram of the paper's design, not a data chart. Stage 2 aimag assignment is inferred from the paper's background section.



Source: design as described in Khasbagan, 'The Effects of Large-Scale and Informal Mining in Mongolia on Economic and Education Outcomes'.

Figure 5. Illustrative diagram of the paper's design (not a data chart). Stage 2 aimag assignment is inferred from the paper's background section.

3.3 Limits the paper acknowledges, and two it does not

The paper is candid about four weaknesses.

First, **treatment assignment is borrowed**. Production statistics for individual mines are not centralized, so the paper adopts Batdelger and Zagdbazar's four aimags rather than constructing its own intensity measure. This risks excluding aimags with substantial mining (Dornogovi, or the Bayangol iron mine in Selenge and Darkhan that the paper's own table lists among the five largest) and treats mining as a binary switch rather than a dose.

Second, **the two mining types coexist**. Selenge hosts both the formerly large-scale Boroo mine and artisanal miners in Mandal suum; Umnugovi and Orkhon also have small-scale activity. The Stage 2 split captures a difference in dominant mining type, not a clean separation.

Third, **populations are undercounted**. Gross enrollment ratios divide enrolled pupils by the official school-age population. When the denominator omits unregistered migrants, GER can rise mechanically while the true share of children in school falls. The paper interprets a GER above 100 percent as a possible sign of children missing from the count rather than of over-enrollment.

Fourth, **suum data begin only in 2015**. Stage 3 has no pre-2015 baseline at the suum level, so the design cannot test for parallel pre-trends.

Two further limits emerged in this edition's work with the NSO tables. The **transition to a 12-year school system**, phased in from 2008, produced cohort gaps that appear as national collapses in graduate counts: grade 9 graduates fell from 53,752 in 2014 to 21,149 in 2015, and grade 12 graduates from 40,537 in 2017 to 16,440 in 2018 (NSO, DT_NSO_2002_057V1). Year fixed effects absorb the national shock, but any aimag whose cohort structure differed will show a spurious "effect" on graduate counts in those years. And the **denominators of the gross enrollment ratios are periodically re-based**: several aimag series shift by five to ten points in the years around the 2010 and 2020 censuses, most visibly Tuv's primary GER, which fell from 105.1 in 2013 to 87.2 in 2017 and returned to 101.6 by 2025. Some of the paper's "informal mining" result may be an artefact of the timing of these revisions rather than of anything that happened in schools.

3.4 What the design can and cannot support

The following distinction is kept throughout the report. The paper's regressions establish **associations**: after conditioning on aimag and year fixed effects, outcomes in the treated aimags moved differently from outcomes in the comparison aimags after the treatment date. They do not establish that mining **caused** the movement, because treatment was not assigned at random, the treated groups contain two aimags each, pre-trends were not tested, and the treatment date is common to aimags whose mines opened decades apart. A reader who wants the causal claim needs the design improvements listed in Section 9. Where this report says "rose" or "fell", it means "rose or fell relative to the comparison group in the paper's estimates"; where it offers a mechanism, it is an interpretation consistent with the pattern, not a tested one.

4. Findings of the original paper

4.1 Stage 1: high-producing aimags versus the rest

When the four high-producing aimags are pooled, mining production has no statistically significant association with total primary GER, with secondary GER for males or females, with basic (grades 1 to 9) GER, or with sales of industrial production. On its face, mining appears not to matter for provincial schooling.

4.2 Stage 2: the split by mining type

Pooling hides two opposing patterns (Figure 6).

In **large-scale mining aimags**, relative to non-producing aimags, the paper reports statistically significant increases in primary GER for both sexes, in secondary GER for both sexes, in basic GER for both sexes, and in the primary pupil-teacher ratio. Per capita GDP and sales of industrial production rise. At the same time, the number of full-time students in general education schools, the number of general education schools, the number of children in preschool, and the number of kindergartens all fall. The overall pupil-teacher ratio shows no significant change.

In **informal mining aimags**, relative to non-producing aimags, there is no increase in any selected education or economic variable. Primary, secondary and basic GER fall for both sexes; full-time grade 9 graduates, grade 12 graduates and full-time students fall; and the primary pupil-teacher ratio falls. Per capita GDP and sales of industrial production also fall. The number of schools, children in preschool, kindergartens and the overall pupil-teacher ratio show no significant change.

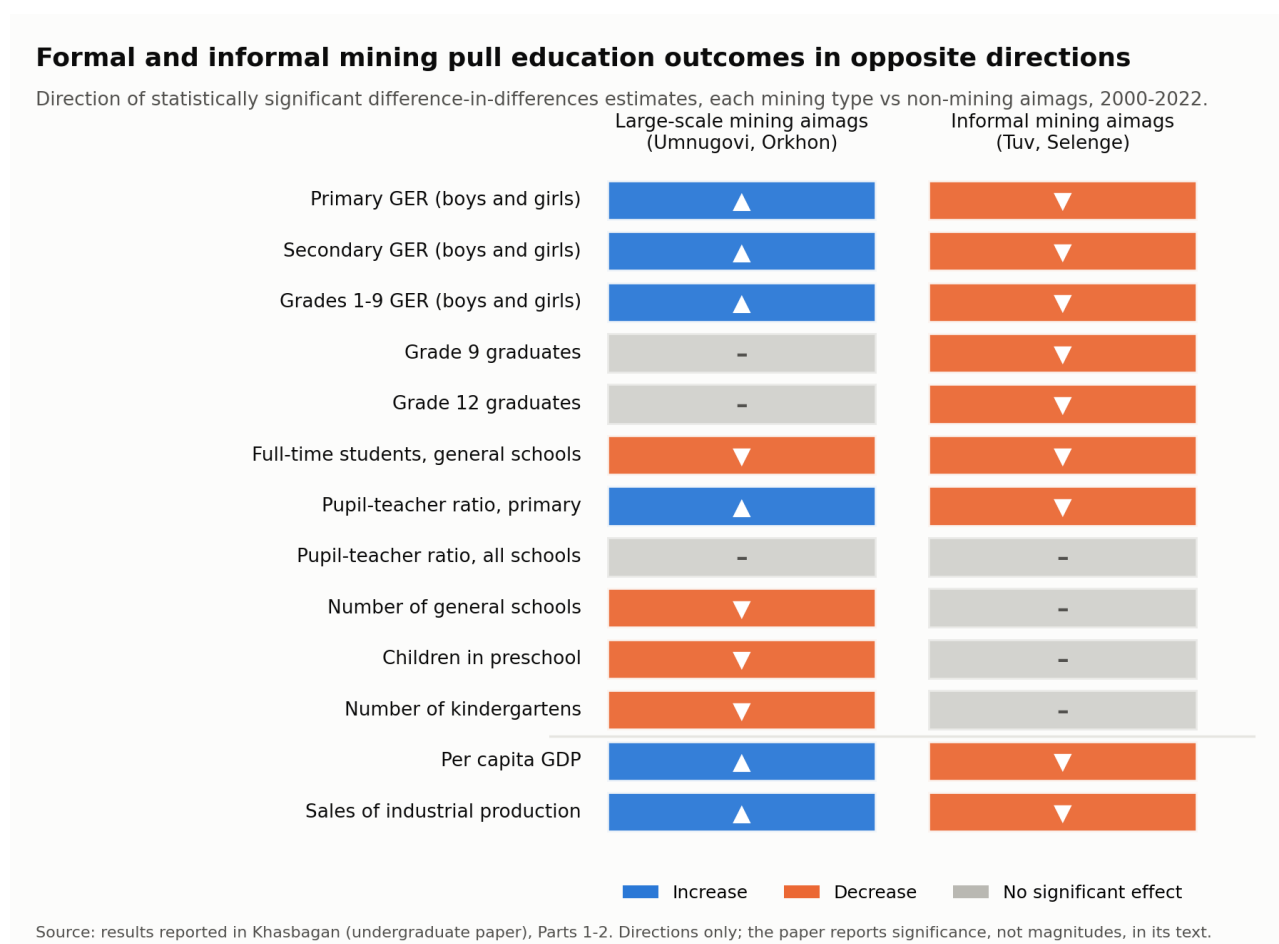


Figure 6. Direction of statistically significant estimates reported in the paper, by outcome and mining type. The paper reports directions and significance in its text; coefficient magnitudes are not reproduced here.

4.3 Stage 3: inside Umnugovi after the 2015 Cooperation Agreement

One year after the Cooperation Agreement, partner soums show increases in the dependency ratio and in the number of truck inspections, both significant at the 10 percent level, relative to other soums in Umnugovi. There are no significant associations with new entrants to school, the number of kindergartens, full-time students, the number of schools, population density, or bus inspections.

The paper's conclusion is modest: mining brings economic activity, but in-migration, family separation and lack of supervision can harm children's education even when children do not work in mines, and different types of mining have different effects.

5. Do the findings hold after 2022? A provincial extension to 2025

5.1 What was done

The NSO publishes its aimag-level education and economic tables through a public database interface (data.1212.mn). For this edition, the gross enrollment ratio by aimag, grade and sex for 2005 to 2025, the number of schools, kindergartens and full-time students by aimag for 2000 to 2025, grade 9 and grade 12 graduates for 2002 to 2024, and GDP per capita by aimag for 2000 to 2025 were retrieved on 9 September 2026 (Appendix B). The paper's grouping was applied: large-scale (Umnugovi, Orkhon), informal (Tuv, Selenge), and the 17 comparison aimags, with Ulaanbaatar excluded. For each outcome and year the mean of each treatment group was compared with the mean of the comparison group.

This is a descriptive extension, not a re-estimation. It does not reproduce the paper's regressions, which condition on aimag fixed effects and a specific treatment date, and it says nothing about statistical significance. What it can show is whether the direction of the paper's findings continued into the three years after its panel ended.

5.2 Enrollment

Figure 7 plots the gap between each treatment group and the comparison mean. In the **large-scale aimags** the primary enrollment advantage was 2 to 3 points from 2015 to 2020, 4.3 points in 2022, and 6.4 points in 2025; at secondary level the advantage was 3.5 points in 2015, between 5 and 8 points from 2016, and 6.2 points in 2025. The paper's finding of higher enrollment in large-scale aimags has therefore persisted and, at primary level, grown.

In the **informal aimags** the picture has changed. The primary enrollment deficit was 5.4 to 6.1 points from 2015 to 2018, narrowed to about 3 points from 2019 to 2022, and turned into a small advantage of 1.1 points in 2025; the secondary deficit narrowed from 8.0 points in 2015 to 1.0 point in 2025. Tuv accounts for most of the change: its primary GER rose from 87.2 in 2017 to 101.6 in 2025, and its secondary GER from 86.8 in 2018 to 97.4, taking it from well below the comparison mean to three points above it. Selenge's ratios rose more modestly, from 93.3 to 97.7 at primary level, and remain just below the comparison mean of 98.6.

Three readings are possible and the data cannot separate them. The first is that formalization of artisanal mining and the end of the 2019 to 2022 regulatory suspension reduced the pull of the diggings on families. The second is that Tuv's earlier low ratios were partly an artefact of population estimates that were revised after the 2020 census, so the "deficit" was smaller than it looked. The third is that in-migration to Tuv's soum centres, which lie within commuting distance of Ulaanbaatar, or the reclassification of schools, changed the numerator. Whichever applies, the paper's informal-mining result should now be described as a finding for the years up to about 2020 rather than as a standing feature of those provinces.

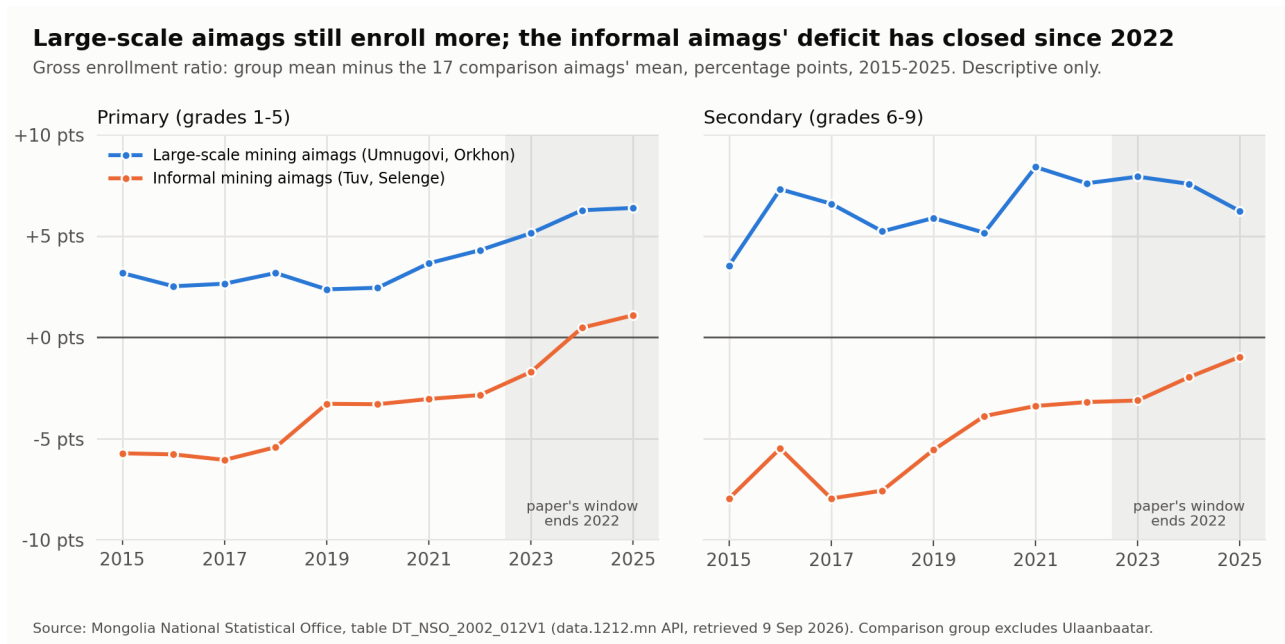


Figure 7. Gross enrollment ratio, treatment-group mean minus the mean of the 17 comparison aimags, percentage points, 2015 to 2025. Source: NSO table DT_NSO_2002_012V1. Descriptive; not a regression estimate.

5.3 Students, schools and kindergartens

The paper found fewer full-time students, schools and kindergartens in the large-scale aimags relative to comparison aimags over 2000 to 2022. The post-2019 data run the other way for students. Full-time students in Umnugovi rose from 13,400 in 2019 to 18,300 in 2025, a 37 percent increase, and in Orkhon from 21,500 to 27,900, a 30 percent increase; the comparison-aimag mean rose about 15 percent. The gap between the large-scale group and the comparison group, which was within half a thousand pupils until 2018, reached 4,400 pupils in 2025 (NSO, DT_NSO_2001_004V1). This is consistent with in-migration and with the opening of the Khanbogd complex in 2018 and the Dalanzadgad complex in 2024 and 2025. The school count in the large-scale aimags rose from 21 to 24 between 2015 and 2025 while the comparison mean stayed at about 26, and the kindergarten gap closed from 2.4 fewer in 2017 to 0.7 more in 2025 (NSO, DT_NSO_2001_002V1, DT_NSO_2001_011V1). The paper's "fewer schools and kindergartens" result therefore describes the period before the company-funded facilities arrived and is no longer visible in the levels.

The informal aimags have more schools (34 against 26) and more kindergartens (40 against 35) than the comparison mean, and their student counts have grown at about the comparison rate. Tuv's kindergarten count fell from 49 in 2017 to 41 in 2025.

5.4 Graduates

Grade 9 graduates in both treatment groups have exceeded the comparison mean since 2021, by about 270 and 290 pupils respectively in 2024; grade 12 graduates in the large-scale aimags exceeded the comparison mean by 151 in 2024, the first year with a clear

gap since the 12-year transition (NSO, DT_NSO_2002_057V1). The paper's finding of fewer graduates in informal aimags is not visible in the 2021 to 2024 counts. The series are, however, dominated by the cohort gaps of 2015 and 2018 described in Section 3.3 and should not be over-read.

5.5 Output per person

Figure 8 shows nominal GDP per capita. Umnugovi's rose from 15.9 million MNT in 2021 to 61.0 million in 2023 and 60.2 million in 2024, the two record years for coal exports, before falling to 44.3 million in 2025 as coal prices dropped; the comparison-aimag mean was 9.5 million in 2023 and 12.0 million in 2025. Orkhon stood at 38.8 million in 2025, above Ulaanbaatar's 37.5 million. Selenge (18.3 million) and Tuv (14.6 million) were above the comparison mean but below the national figure of 26.2 million (NSO, DT_NSO_0500_011V1). The paper's finding of higher per capita GDP in large-scale aimags has therefore strengthened; its finding of lower per capita GDP in informal aimags, which was relative to the comparison trend, is not visible in the levels for 2021 to 2025. Two qualifications matter: the series is nominal, and the denominator is the registered population, so Umnugovi's figure overstates output per resident by whatever share of residents is unregistered.

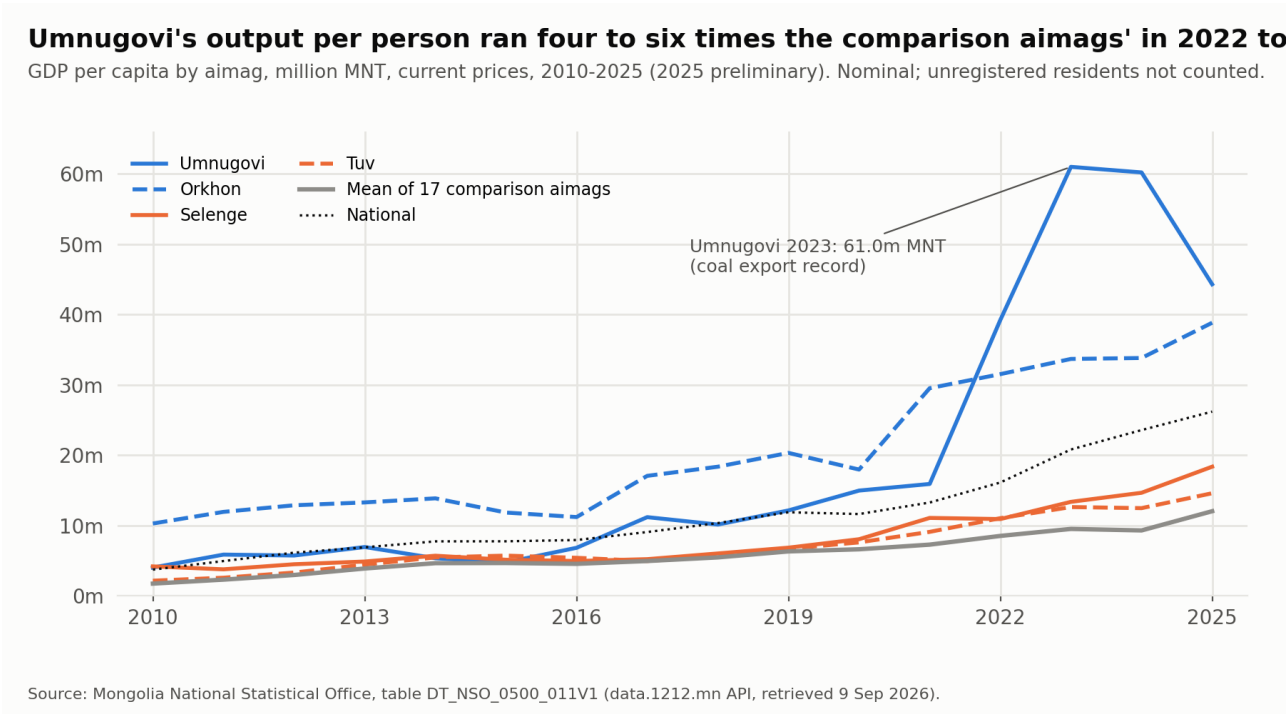


Figure 8. GDP per capita by aimag, million MNT at current prices, 2010 to 2025 (2025 preliminary). Source: NSO table DT_NSO_0500_011V1.

5.6 Summary of the extension

Paper's finding (2000 to 2022)	Direction in NSO data, 2023 to 2025	Status
Higher primary and secondary GER in large-scale aimags	Advantage persists; primary gap widened from 4.3 to 6.4 points	Holds

Paper's finding (2000 to 2022)	Direction in NSO data, 2023 to 2025	Status
Higher per capita GDP in large-scale aimags	Umnugovi about six times the comparison mean in 2023 and 2024, four times in 2025	Holds, strengthened
Fewer full-time students in large-scale aimags	Students growing faster than comparison since 2019	Not visible after 2019
Fewer schools and kindergartens in large-scale aimags	School count rising; kindergarten gap closed	Not visible in levels after 2022
Lower GER at every level in informal aimags	Deficit closed by 2024 to 2025, driven by Tuv	Weakened; a finding for the years to about 2020
Fewer grade 9 and 12 graduates in informal aimags	Above comparison mean 2021 to 2024	Not visible; series affected by cohort gaps
Lower per capita GDP in informal aimags	Above comparison mean in levels	Not visible in levels
No significant associations with school outcomes in Oyu Tolgoi partner soums	Dalanzadgad School No. 6 opened March 2025 with 1,200 places and 1,470 pupils by April	Facilities arrived after the panel

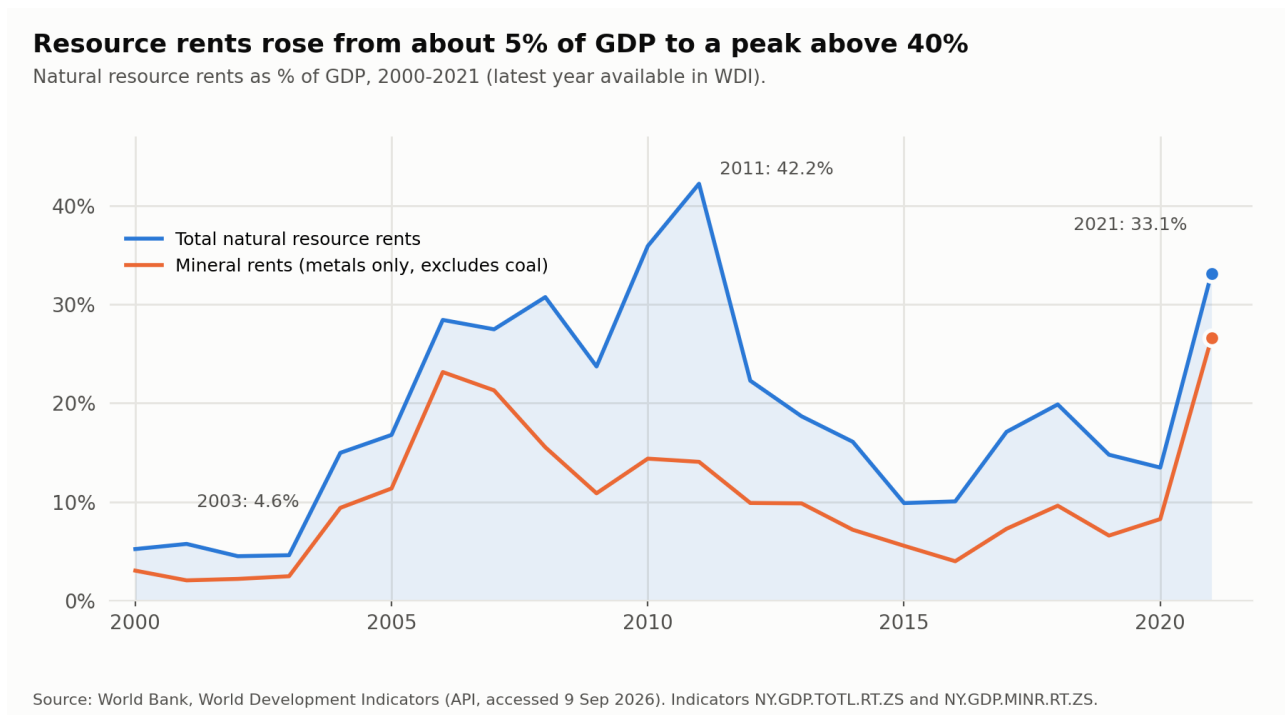
The pattern is coherent. The features of the large-scale aimags that reflect money (output, enrollment, student numbers) have persisted or grown; the features that reflected a lag in public provision (schools, kindergartens) have caught up, partly through company-funded facilities; and the disadvantages of the informal aimags have faded in the data, for reasons the data cannot identify.

6. What the newer data add

This section reports data gathered in September 2026. It is separate from the original paper's evidence and from the extension in Section 5.

6.1 The macro cycle the paper's panel sits inside

Figure 1 shows that the paper's window covers one complete boom and bust and the start of a second boom. Growth rose from 1.1 percent in 2000 to 17.3 percent in 2011, slowed to 1.5 percent by 2016, contracted 4.6 percent in 2020, and recovered to 7.4 percent in 2023, 5.1 percent in 2024 and 6.8 percent in 2025 (World Bank WDI). The World Bank projects 5.0 percent for 2026 and the IMF 5.8 percent (World Bank 2026a; IMF 2026). Real GDP per capita roughly tripled, from US\$1,598 in 2000 to US\$4,882 in 2025 in constant 2015 dollars, and Mongolia was reclassified as an upper-middle-income country in 2024 (World Bank 2026b). A single "after" indicator across this period averages over years of expansion and retrenchment.



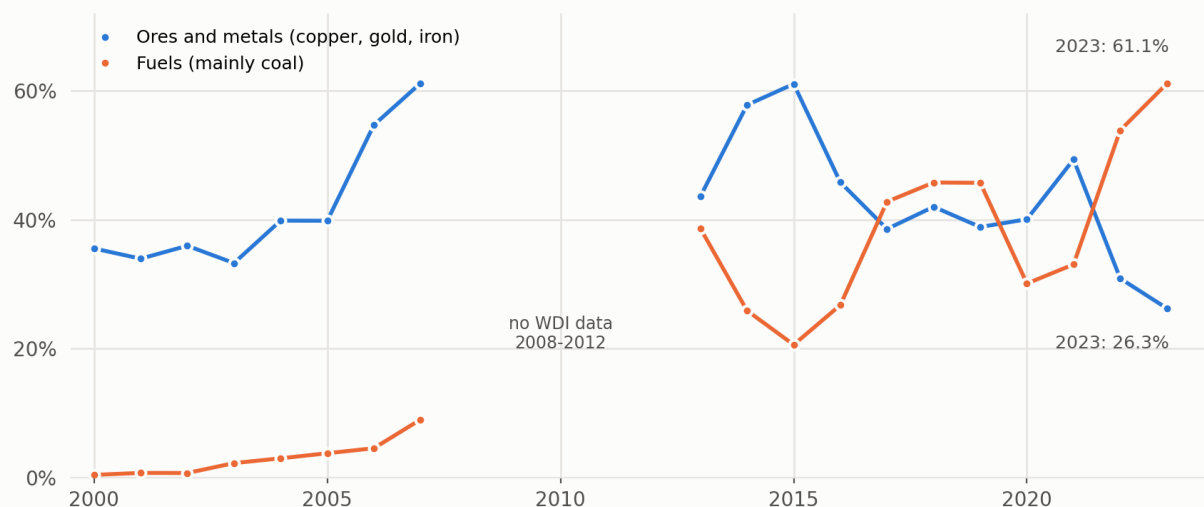
*Figure 2. Total natural resource rents and mineral (metal) rents as a share of GDP.
 Source: World Bank WDI, latest year 2021. The gap between the two lines is largely coal.*

6.2 A shift from metals to coal, and the 2025 price collapse

Figure 4 shows a compositional change that matters for the paper's treatment groups. In 2007, ores and metals made up 61.2 percent of merchandise exports and fuels 9.0 percent. By 2023 the positions had reversed: fuels, overwhelmingly coal, were 61.1 percent and ores and metals 26.3 percent (World Bank WDI). Coal exports reached a record 83.7 million tonnes worth US\$8.6 billion in 2024 (Montsame 2025a). In 2025 volumes rose again, to 83.9 million tonnes according to the Mongolian Coal Association as reported by Xinhua, or 90.0 million tonnes according to Sxcoal and Mysteel (the sources do not explain the difference), but the value fell by about a third to US\$5.8 billion as the average price dropped to about US\$64 a tonne (Xinhua 2026; Mysteel 2026). In January 2025 mineral royalty receipts were 86.1 percent below the previous January and total government revenue 36.7 percent lower (Mongolia Weekly 2025). The IMF's price path for Mongolian bituminous coal runs from US\$131 a tonne in 2023 to US\$107 in 2024 and US\$66.5 in 2025, and it records mining revenue falling from 11.7 to 9.0 percent of GDP between 2024 and 2025 (IMF 2026). Volumes recovered strongly in 2026, with 74.4 million tonnes exported in the first eight months, 50.8 percent more than a year earlier (Mongolian Customs figures reported by Open.kg, 9 September 2026). Coal is mined mainly in Umnugovi and trucked, and from 2027 railed, to China, so Umnugovi has been exposed since 2022 to a coal cycle rather than the copper cycle of the earlier boom.

Exports have shifted from metals toward coal

Share of merchandise exports, %, 2000-2023. Together the two groups made up roughly 87% of exports in 2023.



Source: World Bank, World Development Indicators (API, accessed 9 Sep 2026). Indicators TX.VAL.MMTL.ZS.UN and TX.VAL.FUEL.ZS.UN.

Figure 4. Share of merchandise exports, 2000 to 2023. Source: World Bank WDI. No data are reported for 2008 to 2012.

6.3 Enrollment and learning at the national level

Figure 3 shows national gross enrollment from the World Bank series. Primary GER stood near 100 percent through the early 2000s, spiked to 121.8 percent in 2010, and drifted down to 92.3 percent in 2024; secondary GER rose from 62.4 percent in 2000 to 92.1 percent in 2005 and has stayed between 88.7 and 98.5 percent where data exist (World Bank WDI). The NSO's own national series gives 97.2 percent primary and 97.9 percent secondary for 2024 (NSO, DT_NSO_2002_012V1); the two series use different population bases, which is itself a warning about the denominator.

Enrollment is not learning. In its first PISA participation, in 2022, Mongolia scored 425 in mathematics, 378 in reading and 412 in science against OECD averages of 472, 476 and 485; in PISA 2025 it scored 419, 374 and 424 against 463, 461 and 482, with 43.1 percent of students below the baseline proficiency level in science (OECD 2026). UNICEF reports that the share of primary pupils reaching numeracy proficiency fell from 53.5 percent in 2019 to 38.2 percent in 2021 (UNICEF Mongolia, education page). The World Bank's Human Capital Index for Mongolia is 0.61: a child can expect 13.2 years of schooling but only 9.2 learning-adjusted years (World Bank HCI 2020).

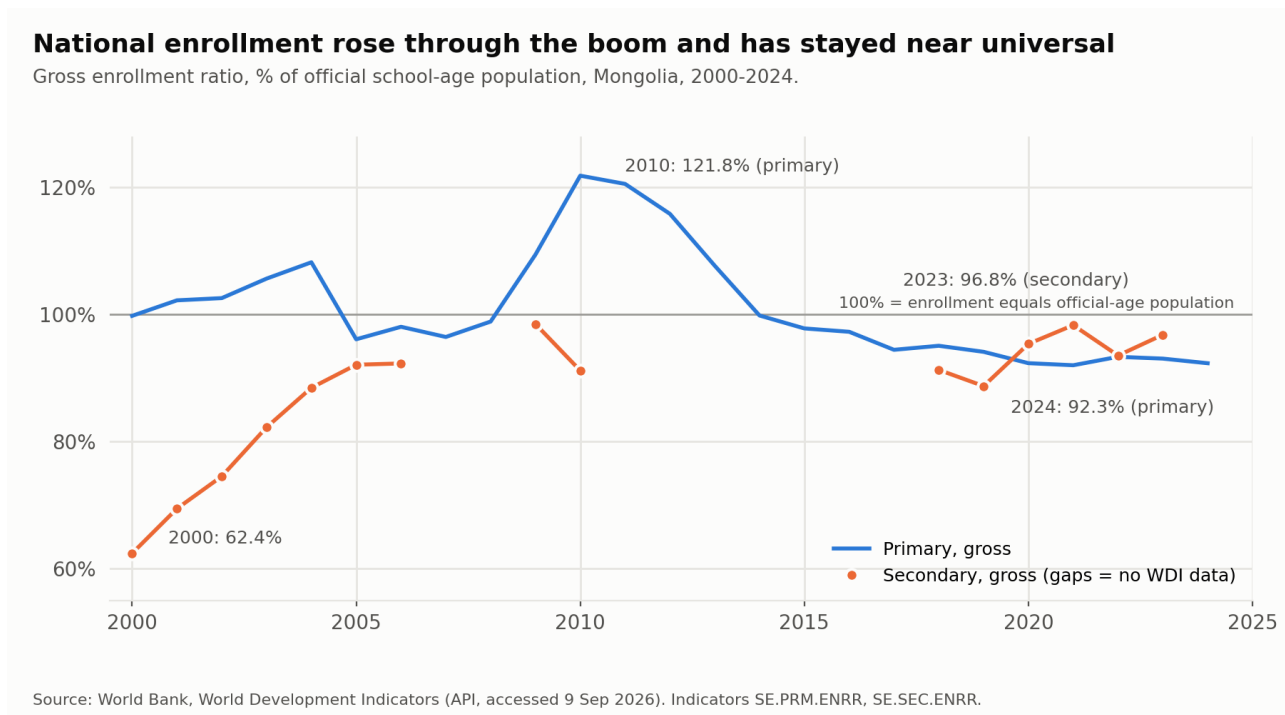


Figure 3. Gross enrollment ratios. Source: World Bank WDI. Gaps in the secondary series are years with no reported value.

6.4 School capacity

The capacity problem UNICEF documented in Khanbogd in 2016 has moved. In May 2024, 47 schools in Ulaanbaatar were running three shifts; by the 2025 to 2026 school year the city reported only five, after leasing 27 buildings, although some classes still held 50 to 70 pupils against a prior-year average of 33 (UB Post 2025; Government of Mongolia 2025). In Umnugovi, the Dalanzadgad School No. 6 funded by the Oyu Tolgoi agreement was commissioned on 29 March 2025 with 1,200 places and, according to a report the following month, already held 1,470 pupils transferred from two overcrowded schools (Oyu Tolgoi 2025; Eguur 2025). The Khanbogd complex, opened in December 2018 with 640 school and 200 kindergarten places at a cost of 7.2 billion MNT, ended multi-shift schooling there (Montsame 2018). No 2023 to 2026 report on Khanbogd or Tsogttsetsii capacity was found.

6.5 Oyu Tolgoi since the paper's window

Sustainable production from the Oyu Tolgoi underground mine began in March 2023. In 2025 the mine produced 345,000 tonnes of copper in concentrate, 61 percent more than in 2024, and 198,000 tonnes in the first half of 2026; output is expected to average about 500,000 tonnes a year from 2028 to 2036 (Argus 2026; Rio Tinto 2026). Rio Tinto's June 2026 release reports around 17,000 employees, 97.8 percent Mongolian, and US\$6.1 billion paid in taxes, fees and other payments to Mongolia since 2010 (its operations page gave about 21,000 employees for 2024); Oyu Tolgoi LLC reports US\$20.6 billion spent in-country over the same period (Rio Tinto 2026; Rio Tinto operations page; Oyu Tolgoi

2025b). The company reports recycling 86.4 percent of the water it used in the first quarter of 2026, drawing the rest from the saline Gunii Hooloi aquifer (Oyu Tolgoi 2026).

The ownership dispute that the first edition described as unresolved has moved.

Mongolia holds 34 percent and Rio Tinto 66 percent; the project carried about US\$12 billion of debt to Rio Tinto in early 2026, and state dividends once expected in 2019 were projected for 2041 (EU Reporter 2026). After parliamentary hearings in December 2025 and demands in February 2026, the two sides agreed in principle on management fees in May 2026 and, on 30 June 2026, "to adjust the shareholder loan interest rate" and "to bring forward distributions to shareholders", with a review every three years; the Prime Minister put the saving at US\$6.2 billion and said dividends were expected in 2026, and the 2027 budget projects 3.5 trillion MNT of Oyu Tolgoi dividends (Rio Tinto 2026; Mining Insight 2026; Montsame 2026a). The new rate and fee levels were not disclosed.

6.6 Revenue, corruption and the 2024 wealth fund

EITI's 2022 reconciliation report records 5,252.4 billion MNT of government revenue from extractives, of which 151.5 billion MNT went to local governments; the three largest taxpayers were Erdenet (1,785.4 billion MNT), Erdenes Tavan Tolgoi (1,052.6 billion) and Oyu Tolgoi (589.3 billion) (EITI Mongolia 2024a). The report gives no full breakdown by aimag and notes missing submissions for Selenge and Dornogovi.

From 4 December 2022 to early January 2023, thousands protested over alleged theft of coal from Erdenes Tavan Tolgoi. Estimates of missing coal ranged from 300,000 to 6.4 million tonnes (Dashpurev 2024); by 2024, 378 individuals were under investigation and 63 had been sent to court (Dashpurev 2024). The former chief executive was sentenced to five years and nine months for bribery and money laundering, reduced to three years and nine months on appeal, with 9.9 billion MNT confiscated; Mongolian press reports in 2026 describe the wider case as stalled (Ergelt 2025; Eguur 2026). The scandal is the Papyrakis and Gerlagh corruption channel operating in the aimag the paper codes as large-scale.

The policy response included the Law on the Sovereign Wealth Fund, in force from 9 May 2024, with a Future Heritage Fund, a Development Fund and a Savings Fund. The Savings Fund was seeded with 500 billion MNT from the state's 34 percent holdings in Erdenet, Oyu Tolgoi and Tavan Tolgoi (Montsame 2024). Its first distribution, decided in August 2025, credited 131 billion MNT to the notional accounts of 3,565,966 citizens, 36,446 MNT each, taking each balance to about 175,400 MNT; the accounts can be used for health, education and housing, not withdrawn as cash, and the government projects a balance of 500,000 MNT per citizen by the end of 2026 (Ministry of Labour and Social Protection 2025; Sovereign Wealth Fund 2025). The IMF notes that the Savings Fund, 1.2 percent of GDP, "is not available as it has been lent to banks" for subsidized mortgages, and that the Future Heritage Fund, 5.8 percent of GDP at end-2025, cannot be drawn before 2030 (IMF 2026; World Bank 2024a). This is the institutional answer to the World Bank's 2020 finding that "out of every dollar in mineral revenues Mongolia has generated over the past 20 years, only one cent has been saved for future generations" (World Bank 2020).

6.7 Child labour and informal mining

The reconciled child labour statistics are given in Section 1 and Figure 10. Two points bear on informal mining. First, the surveys that produce the headline numbers do not tabulate mining separately (the 2021 to 2022 survey counts 2,904 children in prohibited occupations of all kinds), so the number of children in artisanal mines today is unknown. Second, the incentive has strengthened: gold reached an all-time high of US\$5,608 an ounce in January 2026 and stood at US\$4,402 on 9 September 2026, and the Bank of Mongolia bought 11.9 tonnes of precious metal in the first eight months of 2026, 54.4 percent more than a year earlier, from 93 enterprises and 39 individual traders (Montsame 2026b). What share came from artisanal miners is not published. The US Department of Labor's 2024 report continues to list artisanal mining among the sectors in which Mongolian children work and to find that the minimum-age provisions of the 2021 Labour Law "do not provide penalties" (US Department of Labor 2024).

6.8 The capital: where the migrants go

Because the migration the paper describes ends in Ulaanbaatar, the capital's ger districts are part of the same story. Their population is usually put at about 800,000, which the Asian Development Bank in 2013 called 60 percent of the city and 30 percent of the country; with the city at 1.8 million and the country at 3.6 million in 2025, the same 800,000 would be closer to 45 percent of the city and 22 percent of the country, and more recent estimates put the ger-area share of the city at 55 to 60 percent (ADB 2013; Montsame 2022; World Bank 2024b). Roughly 200,000 to 220,000 of these households heat with solid fuel through the winter. Source apportionment studies attribute between 56 and 80 percent of the city's winter fine particulate pollution to their stoves, depending on the metric and the year (World Bank 2013; ADB 2019; Parliament of Mongolia 2025).

The raw coal ban of 15 May 2019 in six central districts, with subsidized briquettes at 150,000 MNT a tonne, reduced winter mean PM_{2.5} by 37 percent in its first season by one peer-reviewed measure and by 40 percent according to a later parliamentary summary (Ganbat et al. 2020; Parliament of Mongolia 2025). Annual mean PM_{2.5} for the city fell from 62 micrograms per cubic metre in 2019 to 25.7 in 2024, still five times the current WHO guideline, and the city was ranked the world's most polluted major city on 8 February 2026 (IQAir 2025, 2026). The cost of the switch fell on the households that made it: carbon monoxide poisonings in the ban districts rose from 33 fatal and 151 non-fatal in the two years before the ban to 91 fatal and 1,633 non-fatal in the three years after, a roughly six-fold rise in incidence (Sambu et al. 2023). A study of child respiratory admissions found no significant change after adjusting for the pandemic (Dickinson-Craig et al. 2025). The World Bank's 2011 estimate of the city's annual health cost from air pollution, US\$177 to 727 million with a mean of US\$463 million, remains the most cited (World Bank 2011).

6.9 Data that could not be obtained

Full texts of Narantungalag (2025) and Batdelger and Zagdbazar (2022) were inaccessible (abstracts from RePEc). No aimag-level EITI revenue table was located. The

2024 official poverty rate, the current share of schools running multiple shifts nationally, and the number of children in artisanal mining are not published. The original 2008 ILO and NHRC study of child miners is no longer online; its figures are taken from the ILO's later briefing note. These gaps are listed in the sources file.

7. Interpretation: why formal and informal mining diverge

The paper's central result is that the same national statistic, gross enrollment, moves in opposite directions in the two kinds of mining aimag, and the extension shows the first half of that pattern persisting. The evidence suggests four mechanisms, and two reasons to be cautious about the result itself. Each mechanism is an interpretation consistent with the data, not a tested effect.

Payrolls and public revenue flow through formal mines. Large-scale mines pay traceable taxes, royalties and community contributions: Oyu Tolgoi's 589.3 billion MNT in 2022, Erdenet's 1,785.4 billion, and the US\$5 million annual Development Support Fund. Narantungalag and Zhou find that incomes rose in Umnugovi relative to other aimags. Informal mining generates no such stream: artisanal gold is sold outside the tax system and earnings are low (about US\$2 a day in 2005, per the ILO). The paper's finding that per capita GDP and industrial sales fell in informal aimags relative to trend is consistent with the loss of a formal anchor (Boroo's closure in 2015, Centerra's exit in 2018) and its replacement by activity that does not register in provincial output.

A hypothesis: formal mines add school capacity, informal mining drains it. The clearest mechanism for higher enrollment in large-scale aimags is the arrival of company-funded facilities, first Khanbogd's 840-place complex in 2018 and then Dalanzadgad's 1,400-place complex in 2024 and 2025, together with the local development fund transfers that began in 2020. The extension shows student numbers in the large-scale aimags rising faster than in the comparison aimags from 2019, which is what one would expect when capacity and in-migration arrive together. In informal mining areas the ILO and UNICEF evidence points the other way: parents leave for the diggings, teenage boys follow, and children are left in child-headed households.

Migration inflates the numerator in one case and drains it in the other. Gross enrollment divides pupils by the official school-age population. In Umnugovi, migrants' children enroll while their families remain unregistered, so the numerator grows faster than the denominator; UNICEF found 880 pupils in a Khanbogd school built for 360. This yields a higher GER, a higher primary pupil-teacher ratio (which the paper finds), and no necessary improvement in learning. In Tuv and Selenge, families move toward diggings outside soum centres, and the children who move are not always re-enrolled.

Fewer, larger schools in large-scale aimags. Fewer schools and kindergartens alongside higher enrollment over 2000 to 2022 is consistent with consolidation: in-migration concentrates in a few soum centres while outlying herder settlements empty,

and the 2018 and 2025 complexes are large single facilities. The catch-up in school and kindergarten counts after 2022 fits this reading.

First reason for caution: household evidence. Zhou (2019) finds secondary completion among 18 to 20 year olds fell 15 percentage points in Umnugovi against 8 nationally, and that children under 12 without formal education rose 18 points relative to control; Narantungalag finds attainment rose but education spending fell. One reconciling reading is that gross enrollment, which counts over-age and migrant pupils, rose while completion and quality for residents deteriorated under overcrowding, as UNICEF's finding that Khanbogd's school ranked last in the province suggests. On this reading the divergence is real, but "enrollment up" should not be read as "children better educated". The national PISA and numeracy results in Section 6.3 make the same point at a larger scale.

Second reason for caution: measurement. The informal-aimag result rests heavily on Tuv, whose enrollment ratios moved by 15 points in ways that track census re-basing as closely as they track mining. The graduate counts are distorted by the 12-year transition. A result that appears in the treated years and disappears afterward is what one would expect from a measurement artefact as well as from a real but temporary effect. The paper's informal-mining finding should be held more loosely than its large-scale finding.

8. What could be done: complexities and options

The evidence does not point to a single prescription, and this report does not offer one. It sets out four areas where choices exist and what makes each of them difficult.

8.1 Community agreements

The Oyu Tolgoi Cooperation Agreement is Mongolia's most developed funded community agreement, and the schools it financed are tangible. Yet the paper found no significant associations with school outcomes in partner soums immediately after signing, the facilities took three to ten years to arrive, and the first of them was over capacity within a month of opening. Such agreements raise questions of lag (whether investment can be front-loaded before in-migration), coverage (Tsogttsetsii, with the largest unregistered population in UNICEF's study, is a Tavan Tolgoi soum, not an Oyu Tolgoi partner), and durability. The June 2026 shareholder agreement, which brings dividends forward, changes the state's incentives without changing the agreement's coverage. No equivalent funded agreement exists for the state-owned Erdenes Tavan Tolgoi, the company at the centre of the coal theft case.

8.2 School capacity in mining towns

The core problem documented by UNICEF is that schools are planned for registered residents while mining towns fill with unregistered ones. Options include systematic migrant registration, forecast-based rather than census-based capacity, and family-

friendly work rosters (UNICEF 2017). Each has costs: registration shifts fiscal burdens onto receiving soums, forecast-based building risks stranded assets when a mine closes, as Boroo did in Selenge, and rosters are a company decision regulators can only encourage. Ulaanbaatar's reduction of three-shift schools from 47 to five in one year shows that capacity can be added quickly when the political will exists; whether the same will reach Khanbogd or Tsogttsetsii is a question of who is counted.

8.3 Formalizing artisanal mining

Mongolia recognized artisanal mining in 2010, revised the regulation in 2017 and 2022, and now has 40,000 to 60,000 miners of whom about 16 percent are formalized (planetGOLD). Formalization brings miners into safety training, legal gold sales, and a point of contact through which children's school attendance can be monitored. But the 2019 to 2022 suspension of the regulation, which coincided with 45,286 people in unlawful mining and 15 deaths, shows how fragile it is; the surveys that measure child labour do not tabulate mining separately; the Labour Law's minimum-age provisions carry no penalties; and a gold price above US\$4,000 an ounce raises the return to digging for every household member.

8.4 Saving and distributing revenue

The 2024 Sovereign Wealth Fund law and its first distribution respond to the World Bank's one-cent observation, but the design so far routes benefits to citizens as restricted account balances, lends the Savings Fund to banks, and freezes the Future Heritage Fund until 2030. Whether the law improves schooling in mining aimags depends on decisions not yet made: whether the education use of citizen accounts is activated, whether benefits are paid per capita nationally or targeted to affected districts, whether the 50 percent local allocation of royalties continues, and whether the funds are insulated from collapses like that of January 2025, when royalty receipts were 86 percent below the previous January. The IMF's warning that public debt will breach the 60 percent fiscal-rule ceiling by 2031 under current policies is a reminder that the fund competes with the budget for the same revenue (IMF 2026).

9. Limits and what a stronger study would need

The paper's results are directional, come from a small number of treated units, and rest on a borrowed treatment definition. A stronger study would need the following.

A continuous, mine-level treatment. Mine-level production or EITI payments by soum, geocoded license areas, or distance to the nearest active mine would allow dose-response estimates and inclusion of aimags such as Dornogovi and Darkhan. EITI's company-level data, covering 110 companies in 2024, could be aggregated to soum level if license locations were merged.

Separate treatment dates. Erdenet has operated since 1978, Oyu Tolgoi's investment agreement was signed in 2009, Boroo ran from 2004 to 2015, and artisanal mining in Tuv expanded after 2001. Staggered-adoption difference-in-differences estimators and event-study plots would accommodate these dates and allow pre-trends to be checked.

Net enrollment, completion and learning. Gross enrollment is vulnerable to denominator error in exactly the places the study cares about. Net enrollment, grade-specific completion, and learning assessments, together with the Household Socio-Economic Survey used by Narantungalag and Zhou, would separate "more children in classrooms" from "children better educated".

Migration data. The paper's stated ideal, information on where in-migration comes from and its volume, remains the largest gap. Registration data, school records, and the company baselines UNICEF recommends would address the denominator problem directly.

Census-consistent denominators. The aimag GER series should be re-based to a single population estimate, or replaced by counts, before any difference-in-differences is run across a census year.

A longer soum panel. Soum data from 2015 cannot support a pre-trend test for a 2015 treatment. The NSO's database now carries soum-level tables through 2025, which would capture the Dalanzadgad complex and underground production.

Type overlap and the coal cycle. Because Selenge and Umnugovi contain both mining types, and Umnugovi has shifted from a copper to a coal cycle since 2022, the two types should be modelled as separate continuous variables within each aimag.

The practical barrier the paper faced, that provincial data had to be assembled by hand, has partly fallen: every table used in Section 5 was retrieved from the NSO's public database interface in an afternoon (Appendix B). The paper's contribution, that pooling mining types can hide effects that cancel, survives the limitations listed here and is supported by the mechanisms documented in the newer evidence. What remains uncertain is the size of the effects, their persistence, and whether the rise in gross enrollment in large-scale mining aimags reflects better schooling or simply more children in the same buildings.

10. What this means for Mongolia's future and society

This section draws the evidence together and asks what it implies over the next two decades. It reports projections only where an institution has published them, and labels them as such.

10.1 A young, urbanizing, slowly shrinking-family country

Mongolia's resident population reached 3.59 million in 2025; the 2025 census counted 3.59 million citizens and 35,446 foreign nationals, and the government projects four million by 2030 and five million by 2045 (NSO 2025; Montsame 2026c). The median age is 27.9 and about 32 percent of the population is under 15 (UN World Population Prospects 2024). The total fertility rate, which rose from 2.2 in 2000 to a peak of 3.1 in 2014, has fallen to 2.4 in 2025 (NSO). Seventy-one percent of the population is urban and about half lives in Ulaanbaatar, which the World Bank expects to reach 2.4 million by 2040, a 74 percent gain over 2018 (World Bank 2022). Some 211,600 Mongolian nationals were recorded living abroad in 2023, the largest communities in South Korea and the United States; remittances were 2.2 percent of GDP in 2024 (IOM 2024, via secondary sources; World Bank WDI). Youth unemployment was 11.7 percent in 2025 and the national rate 5.5 percent (ILO modelled estimates; NSO).

For schooling, the arithmetic is that the cohort entering school is still large but no longer growing: about 75,000 first-graders in 2026, 3 percent fewer than the year before, in a system of 1.3 million students across all levels of education, about 820,000 of them in the 900 general education schools (Montsame 2026d; NSO). The pressure on capacity is now a question of where children are, not how many there are. That makes the mining towns and the capital's ger districts the two places where the paper's problem, schools built for the registered population, will keep recurring.

10.2 A climate that is making herding harder

Average temperatures in Mongolia rose by 2.24 degrees Celsius between 1940 and 2015, well above the global average (ADB 2021). Dzuds, which journalists' accounts describe as a roughly once-a-decade event before 2000, have occurred in one year out of five since then, and the World Bank's Country Climate and Development Report expects one every three years by mid-century (Yale Environment 360 2024; World Bank 2024c). The 2023 to 2024 winter killed about 7.9 million animals, 12.3 percent of the herd and the largest loss since 2010; the herd fell from a record 71.1 million in 2022 to 57.6 million in 2024 before stabilizing at 58.1 million in 2025 (FAO 2024; NSO, DT_NSO_1001_109V1; Figure 9). More than 180,000 herder households were severely affected and agricultural GDP fell by a quarter in the first nine months of 2024 (IFRC 2025; UNDP 2025). Two-thirds of rangeland is degraded and 10 percent fully degraded; the UN put land degradation at nearly 77 percent of the country's territory when it hosted the desertification convention's conference in Ulaanbaatar in August 2026 (World Bank 2024c; UN News 2026). The World Bank estimates that a compound shock could put 20 percent of annual GDP at risk and that livestock deaths could average 4.1 million a year by 2050 (World Bank 2024c).

The number of herder households has not fallen: the NSO counts 195,526 in 2025 against 191,526 in 2000, after a trough of 145,311 in 2013 (NSO, DT_NSO_1001_027V1). But the paper's introduction, which traced the mining-era migration to the dzuds of 1999 to 2002, describes a mechanism that is now more frequent. Each severe winter pushes households toward the soum centres, the mining towns and the capital, and their children

arrive in schools that were not built for them. The migration channel in Section 1 is therefore not a feature of the 2000s; it is a recurring shock.

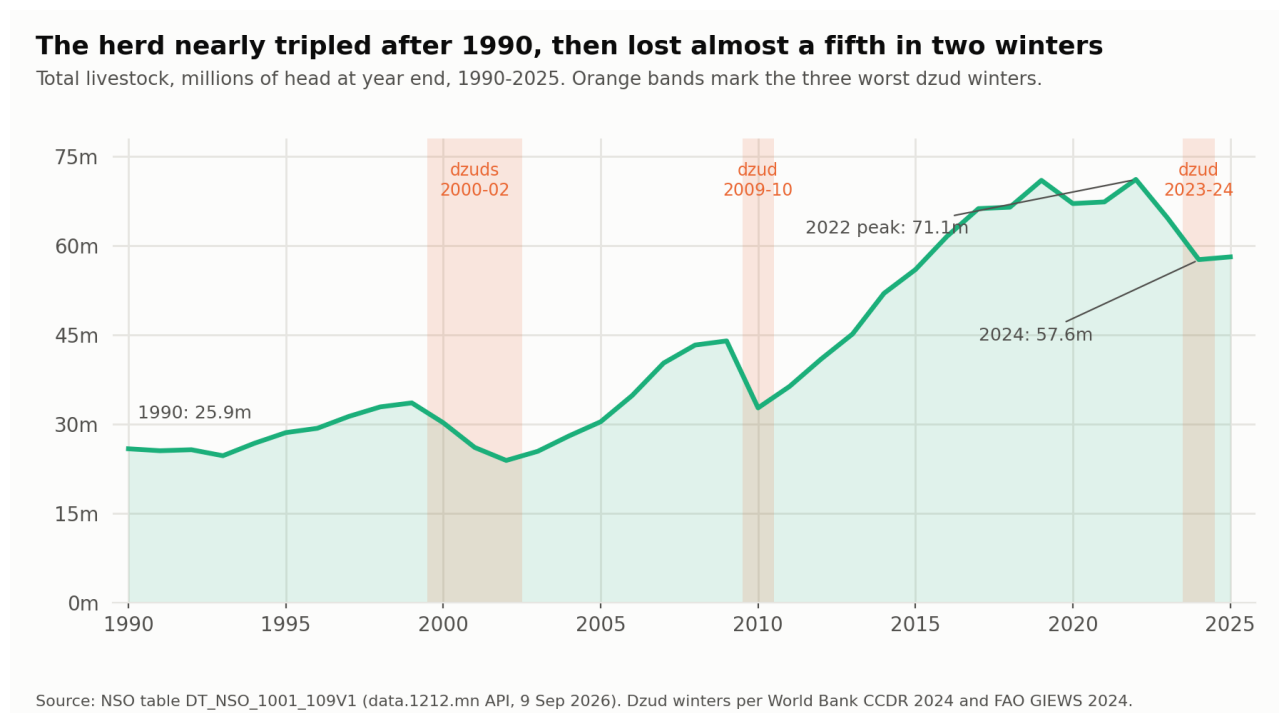


Figure 9. Total livestock, millions of head, 1990 to 2025. Source: NSO table DT_NSO_1001_109V1.

10.3 A coal economy facing a shrinking customer

Coal was 12 percent of GDP and 58 percent of exports in 2023, nearly all of it to China, which took about 60 percent of its coking coal imports from Mongolia in 2024 (World Bank 2024c; Mining Weekly 2025). The customer is contracting. China's crude steel output fell from 1,022 million tonnes in 2023 to 1,005 million in 2024 and 961 million in 2025, and the International Energy Agency expects global metallurgical coal demand to decline from 1,114 million tonnes in 2025 to 1,061 million by 2030, with China accounting for most of the fall (worldsteel 2026; IEA 2025). Mongolia's 2025 experience, record or near-record volumes at a third less revenue, is what that looks like from the supplier's side. The IMF lists "decarbonization could lead to an earlier reduction in coal exports" among the risks to the outlook and notes that coal and copper export values reached parity in 2025 (IMF 2026). The World Bank's 2024 projection was for coking coal prices to fall by about 12 percent in each of the following two years (World Bank 2024a).

Two hedges are visible. Copper: the IEA's project pipeline points to a potential 30 percent global supply shortfall by 2035, Oyu Tolgoi will produce about 500,000 tonnes a year from 2028, and the June 2026 agreement brings the state's dividends forward; but the Natural Resource Governance Institute notes that the project pipeline beyond Oyu Tolgoi "remains limited" and that nearly all copper leaves as concentrate (IEA 2025b; NRG 2025). Uranium: Orano's Zuuvch-Ovoo project, agreed in January 2025 at about US\$1.6 billion for roughly 2,500 tonnes a year over 30 years with Mongolia taking more than 51 percent of direct benefits, began construction in June 2026 (World Nuclear News 2025,

2026). Neither changes the structure the paper describes. Both are large formal mines in sparsely populated aimags; both will draw migrants; both will depend on water from deep aquifers in a region where mining already accounts for 71 percent of water demand and where only 12 of the 75 herder wells recommended by the Oyu Tolgoi expert panel in 2017 had been built by 2024 (Dialogue Earth; CAO 2017; Mongabay 2024).

10.4 A fiscal system that spends the boom

The World Bank found that "procyclical fiscal spending fueled significant growth in public consumption and investment, both increasing by over 45 percent" in 2024, and the IMF's 2026 Article IV report says the 2026 budget will not meet the 2 percent structural deficit ceiling, that sizeable public wage and pension increases have been approved for 2026 to 2027, and that public debt will rise from 45.1 percent of GDP in 2025 to about 63.7 percent by 2031 under current policies, above the 60 percent ceiling (World Bank 2024a; IMF 2026). Credit ratings improved in late 2025 (S&P to BB-, Moody's to B1), but the pattern the World Bank called "consumed 99 cents and saved one cent" has not yet been broken; the funds created in 2024 are either frozen or lent out (World Bank 2020; IMF 2026). Indirect subsidies are regressive, with about 27 percent going to the richest decile, while direct transfers cut poverty by 13 percentage points (World Bank 2024a). The national poverty rate was 27.1 percent in 2022, about 900,000 people; in 2020 the rural rate was 30.5 percent against 26.5 percent in urban areas, and no later official figure has been published (World Bank 2021; World Bank 2026b).

For schools, the relevant fact is that education spending competes with everything else the boom funds. The August 2026 supplementary budget had to find 675.5 billion MNT for education wage arrears (Capital Markets Mongolia 2026). A country that saves little in booms has little to spend in busts, and the 2025 royalty collapse showed how quickly a bust arrives.

10.5 Human capital as the binding constraint

The World Bank's 2020 memorandum argued that Mongolia's route out of mining dependence runs through its people, and it ranked the country 51st on human capital but 92nd on income, evidence of unused potential (World Bank 2020). The evidence since then is not encouraging. PISA 2025 scores were 419, 374 and 424 against OECD averages of 463, 461 and 482; 43 percent of 15-year-olds were below baseline in science (OECD 2026). Primary numeracy proficiency fell from 53.5 to 38.2 percent between 2019 and 2021 (UNICEF). Life expectancy is 67.9 years for men and 77.1 for women, a gap of 9.2 years (World Bank WDI 2024). Air pollution was attributed 1,619 deaths in 2021 nationally and more than 1,000 a year in the capital (WHO GHO; World Bank 2024c).

The paper's finding fits this picture in a specific way. Where mining is formal, children are in school but the household evidence suggests they are not completing or learning more; where mining is informal, for at least part of the period, enrollment ratios ran five to eight points below the comparison provinces. Neither pattern produces the workforce the World Bank's strategy assumes. Enrollment near 100 percent is a solved problem in

Mongolia; learning, completion and the physical conditions of schooling in the places where the population is moving are not.

10.6 A politics of distribution

The social pressure that mining generates has become the main fact of Mongolian politics. The December 2022 coal theft protests brought thousands to Sukhbaatar Square; the May and June 2025 protests over the Prime Minister's family's displays of wealth ended his government; his successor was removed by parliament in October 2025, reinstated by the Constitutional Court, and resigned in March 2026; Nyam-Osoryn Uchral became the third prime minister in under a year on 30 March 2026 (Reuters 2026). Each episode turned on the same question the paper asks at the provincial level: who benefits from the minerals, and who bears the costs. The sovereign wealth fund's per-citizen accounts, the Oyu Tolgoi dividend renegotiation and the coal theft prosecutions are three answers to that question, none yet complete.

10.7 What follows for the paper's question

Three things follow for the relationship between mining and schooling.

First, if the mechanism suggested in Section 7 is right, the divergence the paper found will recur wherever a large formal mine opens, because in-migration ahead of public provision is not specific to Oyu Tolgoi. The uranium project in Dornogovi and the coal railway to China are the next tests. The lesson from Umnugovi is that the school arrives years after the children, and is full when it opens.

Second, the informal-mining problem is likely to grow rather than fade, whatever the enrollment ratios say. A gold price near US\$4,500, a formalization rate of 16 percent, a labour law without penalties, and a climate that pushes herding households toward cash work all point the same way, and the statistics that would show it are not collected.

Third, the country's ability to pay for the answer depends on breaking a fiscal pattern that four institutions have described in the same terms for two decades. The funds now exist on paper. Whether the next boom is saved, and whether any of it reaches a classroom in Khanbogd, Tsogttsetsii or Mandal, is the open question on which the future of the paper's subject, and of much else, turns.

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Appendix A. Verification table

Every quantitative claim carried over from the first edition, the source paper or its companion essays was checked against a primary source on 9 September 2026. "Verified" means the figure and its attribution are correct as stated. "Corrected" means the figure, its definition or its date has been changed in this edition. "Qualified" means the figure is correct but needed its definition or period stated. "Dropped" means no adequate source could be found and the figure is not used.

Claim	Status	Note
Economy grew 7.2 percent a year since large-scale mining began in 2004	Verified	World Bank press release, 17 Sept 2020, verbatim
Only one cent of each mineral dollar saved for future generations	Verified	Same source, verbatim; the memorandum's text says "consumed 99 cents and saved one cent"
World Bank's four recommendations	Qualified	The memorandum's own wording (countercyclical fiscal and monetary policy; investment climate reforms and investor rights; expanding endowments, especially the young and educated, especially female, labour force; governance reforms to reduce political interference and corruption) differs from the paraphrase in the companion essay, which has been retained in simplified form

Claim	Status	Note
Mining 25 percent of GDP, 90 percent of exports, more than 30 percent of revenue (2022)	Verified	EITI Mongolia country page; 2023 values added from the 18th report
Resource rents 4.6 percent (2003), 42.2 percent (2011), 33.1 percent (2021)	Verified	WDI; no value after 2021
50 percent of royalties to General Local Development Fund; 172.6 and 165.7 billion MNT (2020)	Verified	EITI Mongolia country page
Tsogttsetsii 2,198 (2008) to 7,017 (2015), 12,000 to 16,000 unregistered; Khanbogd 6,000 registered, 7,000 mobile	Verified	UNICEF 2017, pp. 24, 27
Khanbogd school 880 pupils for 360 places, two shifts, last of 21 schools; South Gobi schools 50 to 250 percent over capacity	Verified	UNICEF 2017, pp. 27, 35
Over 56,000 children (10 percent of 5 to 17 year olds) in child labour, over half in hazardous work	Corrected	ILO 2016 brief: 56,000 and 10 percent are from a UCW re-analysis of the 2011 to 2012 survey; the NSO/ILO 2013 report gives 43,545 in child labour and 10,398 in hazardous work; "over half" refers to 15 to 17 year olds in construction and mining only
ILO/NHRC 2008 study: 56 percent underground, 53 percent injured, 54 percent in polluted or noisy conditions, 77 percent of parents disapproving	Verified	ILO OSH briefing note; sample 232 children and 50 parents at informal mines in eight aimags; "85 percent male" not found and dropped
Fine for employing a child under 20 dollars	Qualified	15,000 to 30,000 MNT under the 1999 Labour Law (US\$13 to 27 in 2005); the 2021 law defers penalties to the Law on Infringements and the US Department of Labor finds none specified
Children in employment 22.0 percent (2000), 10.1 percent (2007), 14.7 percent (2013)	Verified	WDI SL.TLF.0714.ZS; no later value
11.4 percent of children 5 to 14 working, 94.8 percent attending school (MICS 2018)	Verified	US DOL 2021; the 2024 edition reports 20.7 percent working and 86.4 percent attending, drawn from the 2021 to 2022 survey's broader "economically active" measure, so the two are not a trend
Urban share 56.7 percent (2000) to 71.1 percent (2025)	Verified	WDI SP.URB.TOTL.IN.ZS
600,000 former herders, a fifth of the population, moved to cities in three decades	Dropped	Traceable only to 2018 journalism (PBS SoCal, Earth Island Journal) citing no source; replaced by NSO Ulaanbaatar population and the FMR 818,000 figure
Khanbogd grew 350 percent from 2,000 to 7,000 in a decade	Qualified	New York Times 2012 not accessible; 2009 aimag figure 3,154; 2022 registered 8,660 plus about 20,000 floating (ikon.mn)
Herds grew from 20 million to 61 million after socialism	Corrected	NSO: 25.9 million in 1990; 61.5 million in 2016; peak 71.1 million in 2022; 57.6 million in 2024

Claim	Status	Note
GDP growth averaged over 10 percent in 2011 to 2015	Verified	WDI: 17.3, 12.3, 11.6, 7.9, 2.4 percent; mean 10.3
FDI 2.4 billion dollars in 2019	Verified	WDI: US\$2,443 million; 2024 US\$2,782 million
Oyu Tolgoi expected to be about 30 percent of GDP once complete	Qualified	Origin is a 2013 statement by the mine's chief executive; no current official share published; Oyu Tolgoi was about 17 percent of export revenue over 2014 to 2024
11.6 billion dollars invested in Mongolia 2010 to 2020, 13,000 jobs, third-largest taxpayer	Corrected	Not found verbatim; replaced with Rio Tinto and Oyu Tolgoi 2025 to 2026 disclosures (US\$20.6 billion in-country spend, US\$6.1 billion taxes and fees, about 17,000 employees)
Munkhbayar sentenced to 21 years	Corrected	Sentenced 28 Jan 2014 to 21 years 6 months for "acts of terrorism" after a September 2013 armed protest at Government House in which a rifle was discharged; reduced to 7 years on appeal in April 2014; released under the 2015 Amnesty Law
WRI toolkit: licenses revoked, agreements renegotiated, projects funded	Verified	WRI 2020 (STRIPE project)
Coal exports 83.7 million tonnes in 2024	Verified	Montsame, Mysteel; value US\$8.6 billion
Royalties fell 86.1 percent, revenue 36.7 percent, in January 2025	Verified	Mongolia Weekly citing Ministry of Finance
Sovereign Wealth Fund law in force 9 May 2024, three funds, 500 billion MNT seed	Verified	Montsame 2024; 2025 distributions added
Coal theft: 378 investigated, 63 sent to court	Verified	U4 2024; later sentences added
Dividends from Oyu Tolgoi projected to begin in 2041	Corrected	Overtaken by the 30 June 2026 agreement to bring distributions forward
Prime Minister as of 2026	Corrected	Nyam-Osoryn Uchral since 30 March 2026
Ulaanbaatar coldest capital; about half the population	Verified	NSO; 1,785,075 of 3,572,835 in 2025 (mid-year series)
800,000 people, a quarter of the country, in ger districts	Qualified	ADB 2013: 800,000, 60 percent of the city, 30 percent of the country; same figure is now about 22 percent of the country; share of city 55 to 60 percent in recent sources
200,000 households burn 600,000 tonnes a season, 60 percent of winter pollution	Qualified	Households 200,000 to 220,000; the 600,000 tonnes is the briquette volume set to replace 1.1 million tonnes of raw coal (Government 2018); ger stove share 56 to 80 percent depending on metric
PM2.5 averaged 256 micrograms per cubic metre in 2016, 25 times the WHO guideline	Qualified	Verbatim in UNICEF 2018, but averaging period and station are not stated and other annual series give 60 to 100; "25 times" uses the 2005 guideline of 10; against the 2021 guideline of 5 it is about 51 times
2.7-fold rise in respiratory infections; pneumonia second cause of under-five death; 40 percent lower lung function	Verified	UNICEF 2018, p. 16

Claim	Status	Note
Health cost 177 to 727 million dollars	Verified	World Bank 2011; mean US\$463 million; 2008 base
2010 Law on Air Quality	Corrected	2010 law was the Law on Air Pollution Fees; the revised Law on Air was adopted 17 May 2012
World Bank Clean Air Project	Verified	Approved April 2012, US\$15 million, extended 2019, closed 2023
2016 Law on Hygiene banned waste burning	Verified	Article 20.1.8
52 million dollars public spending 2008 to 2017	Qualified	UNDP 2019: 147.3 billion MNT public plus US\$60.7 million aid over 2008 to 2018
Raw coal ban 15 May 2019; briquettes subsidized to raw coal price at 156,000 MNT	Corrected	Ban verified; official briquette price 150,000 MNT a tonne
Ban results: 60 percent reduction in 2019; 46 to 55 percent reduction in PM	Qualified	Ganbat 2020: 46 and 55 percent refer to maximum concentrations; winter means fell 37 and 40 percent
Eight deaths and 1,000 hospitalized from carbon monoxide in winter 2019 to 2020	Qualified	Al Jazeera snapshot; WHO Bulletin data show 91 fatal and 1,633 non-fatal poisonings over three winters in the ban districts
December 2020 50 percent briquette discount costing 30 billion MNT	Qualified	Discount verified (75,000 MNT a tonne, 3 Dec 2020 to 1 Apr 2021); cost not found outside the source paper
Ulaanbaatar most polluted city on 23 October 2020	Verified	IQAir

Appendix B. Data note for the provincial extension

Source. National Statistical Office of Mongolia, statistical database at data.1212.mn, accessed through its PxWeb application interface on 9 September 2026. Tables: gross enrollment ratio by sex, grade and aimag (DT_NSO_2002_012V1, 2005 to 2025); number of general education schools by aimag (DT_NSO_2001_002V1, 2000 to 2025); full-time students by aimag (DT_NSO_2001_004V1, 2000 to 2025); number of kindergartens by aimag (DT_NSO_2001_011V1, 2000 to 2025); full-time graduates by grade and aimag (DT_NSO_2002_057V1, 2002 to 2024); GDP per capita by aimag at current prices (DT_NSO_0500_011V1, 2000 to 2025); mid-year population by aimag (DT_NSO_0300_002V1, 1990 to 2025); herder households (DT_NSO_1001_027V1, 1986 to 2025); livestock by type (DT_NSO_1001_109V1, 1970 to 2025).

Groups. Large-scale: Umnugovi, Orkhon. Informal: Tuv, Selenge. Comparison: the other 17 aimags (Arkhangai, Bayankhongor, Bayan-Ulgii, Bulgan, Darkhan-Uul, Dornod, Dornogovi, Dundgovi, Govi-Altai, Govisumber, Khentii, Khovd, Khuvsgul, Sukhbaatar, Uvs, Uvurkhangai, Zavkhan). Ulaanbaatar excluded. Region aggregates in the tables were discarded.

Method. For each outcome and year, the unweighted mean of each group was computed and the comparison mean subtracted. Enrollment ratios are for both sexes combined. No regression was estimated; no standard errors are reported. The 2025 values for GDP per capita are preliminary.

Working files. The retrieved values are saved alongside this report in `nso_data/` (`ger_total.txt`, `schools_students.txt`, `gdppc_kg.txt`, `graduates.txt`, `population_herders.txt`, `codes.py`). Aimag figures quoted in the text were re-derived from these files by script after a hand-reading error was caught in review.

Known issues. The NSO's national enrollment series differs from the World Bank's for the same years because of different population bases. Aimag enrollment ratios shift around census years. Grade 9 and grade 12 graduate counts show the cohort gaps of the transition to a 12-year system (2015 and 2018). The aimag code lists returned by the interface differ between table families and were mapped table by table; code lists and the retrieved values are in the working files accompanying this report.

Figures. Figures 1 to 4 use World Bank WDI series retrieved on 9 September 2026 (`NY.GDP.MKTP.KD.ZG`, `NY.GDP.TOTL.RT.ZS`, `NY.GDP.MINR.RT.ZS`, `SE.PRM.ENRR`, `SE.SEC.ENRR`, `TX.VAL.MMTL.ZS.UN`, `TX.VAL.FUEL.ZS.UN`). Figures 5 and 6 are drawn from the source paper. Figures 7, 8 and 9 use the NSO tables above. Figure 10 compiles the child labour statistics cited in Section 1.