

VISIBLE FROM OUTER SPACE?

Infrastructure access, regional inequality,
and disaster resilience in ASEAN and Japan

0.65

CORRELATION OF LIGHT WITH ROAD ACCESS

0.584 → 0.528

ASEAN REGIONAL INEQUALITY, 2014–2024

–25.7%

FUKUSHIMA LIGHT, MONTH OF THE QUAKE

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Nagoya University · ADBI Authors' Workshop (online)

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INFRASTRUCTURE IS MEASURED ONCE A DECADE, AND STOPS AT THE BORDER

WHY MONITORING, NOT MEASURING

\$210 BN

per year of climate-adjusted infrastructure investment
needed in Southeast Asia, 2016–2030 (5.7% of GDP)

\$102 BN

annual investment gap; the last full assessment is from
2017, with no successor

Needs assessments are costly, infrequent and national. A satellite
monitor can be updated every year, one tier below the nation.

Source: ADB (2017), *Meeting Asia's Infrastructure Needs*.

AT 01:30, THE LIGHT THAT REMAINS IS INSTALLED INFRASTRUCTURE

THE IDEA

The VIIRS satellites cross the equator at about **01:30 local time**. Homes and shops are dark; streets, highways, ports, industrial estates and public buildings are still lit.

97.3%

brightness lost overnight by a sports field (activity lighting)

4.6%

lost by an administrative building (infrastructure lighting)

We read night light as a measure of **infrastructure**, not of income.

Drone evidence from Wuhan: Li et al. (2020).

325 REGIONS, ELEVEN YEARS, THREE QUESTIONS

DATA AND ROADMAP

278 first-level regions in the ten ASEAN member states + 47 Japanese prefectures ·
VIIRS 2014–2024 · brightness around the average resident (population-weighted)

1. Access

Can access to infrastructure be seen
from orbit?

Section 2 · Jiang Qian

2. Inequality

Is the gap between regions closing?

Section 3 · Li Xiaomeng

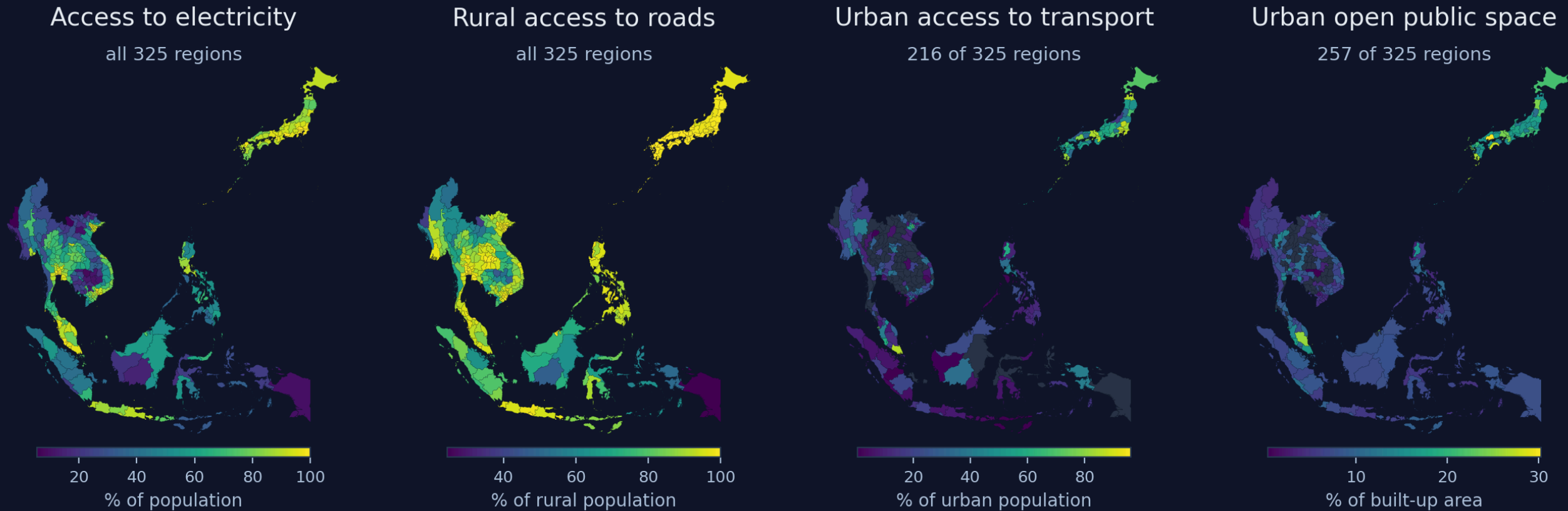
3. Disaster

Can we see infrastructure fail and
recover?

Section 4 · Carlos Mendez

NASA ALREADY MAPS ACCESS FROM ORBIT, BUT ONLY ONCE

1 · ACCESS

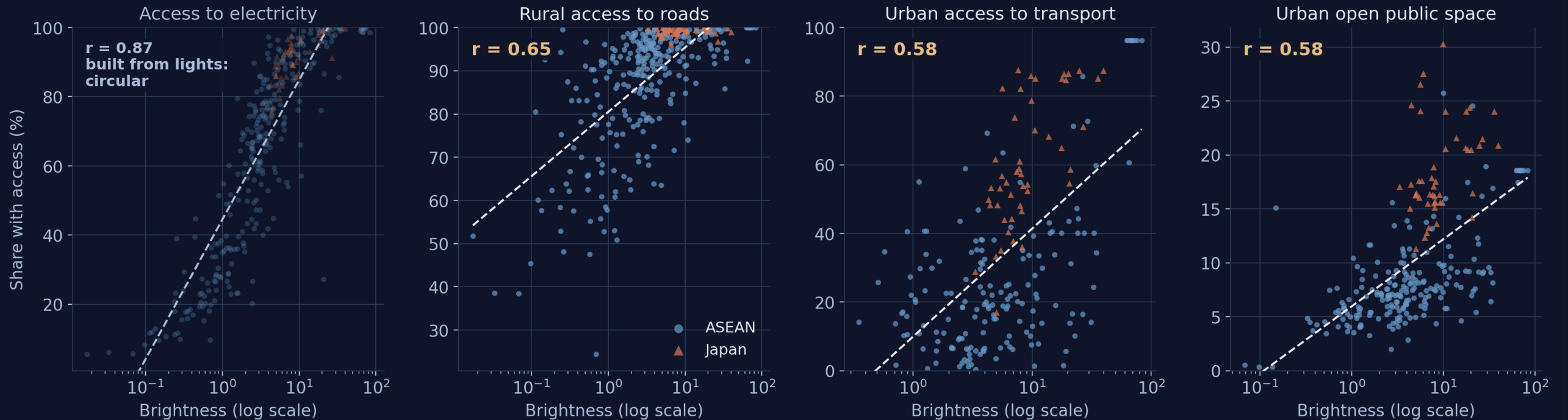


Four Sustainable Development Goal access indicators built from Earth observation, 325 regions (NASA SEDAC / CIESIN, 2023 release). Grey: indicator not defined.

Each indicator is a single snapshot: none can tell us whether access is improving.

BRIGHTER REGIONS HAVE BETTER ACCESS TO INFRASTRUCTURE

1 · ACCESS

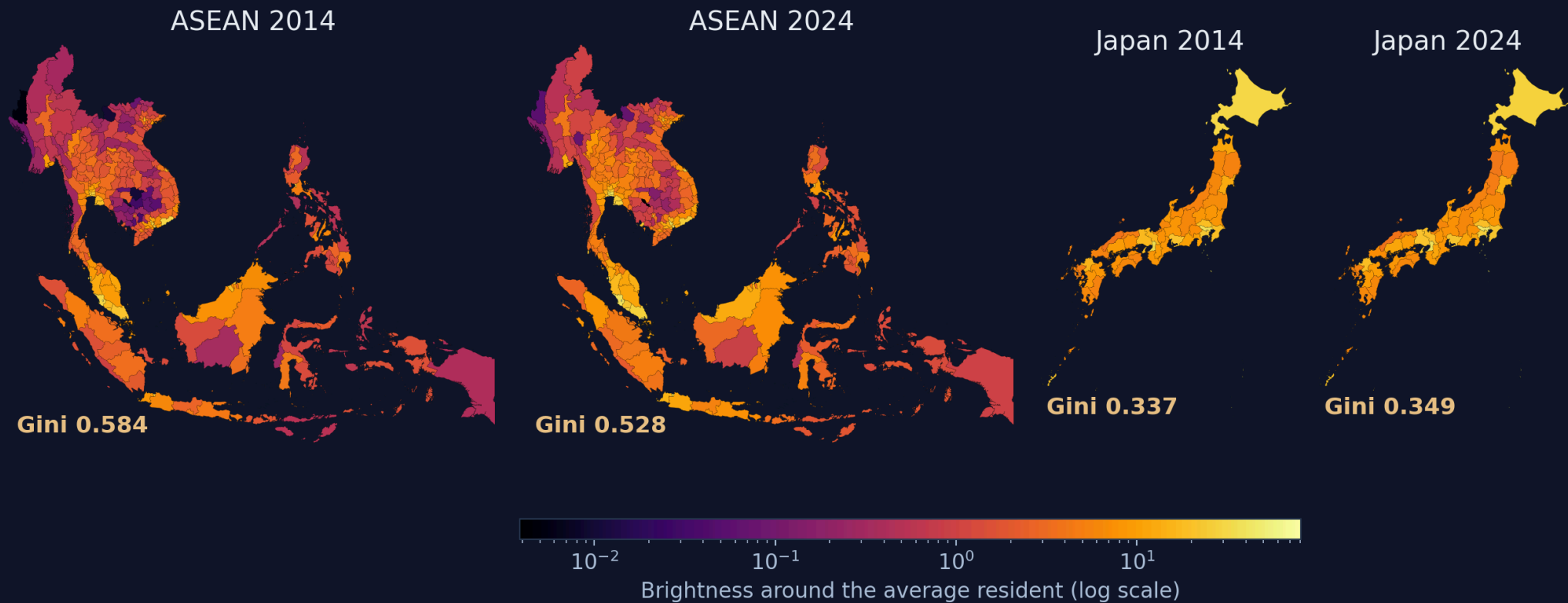


Brightness around the average resident against each access indicator, 2020. Dashed: fitted line.

Lights agree with three indicators that use no lights at all: roads 0.65, transit 0.58, open space 0.58. And lights are annual since 1992.

ASEAN BRIGHTENED, AND ITS DARKEST REGIONS BRIGHTENED MOST

2 · INEQUALITY

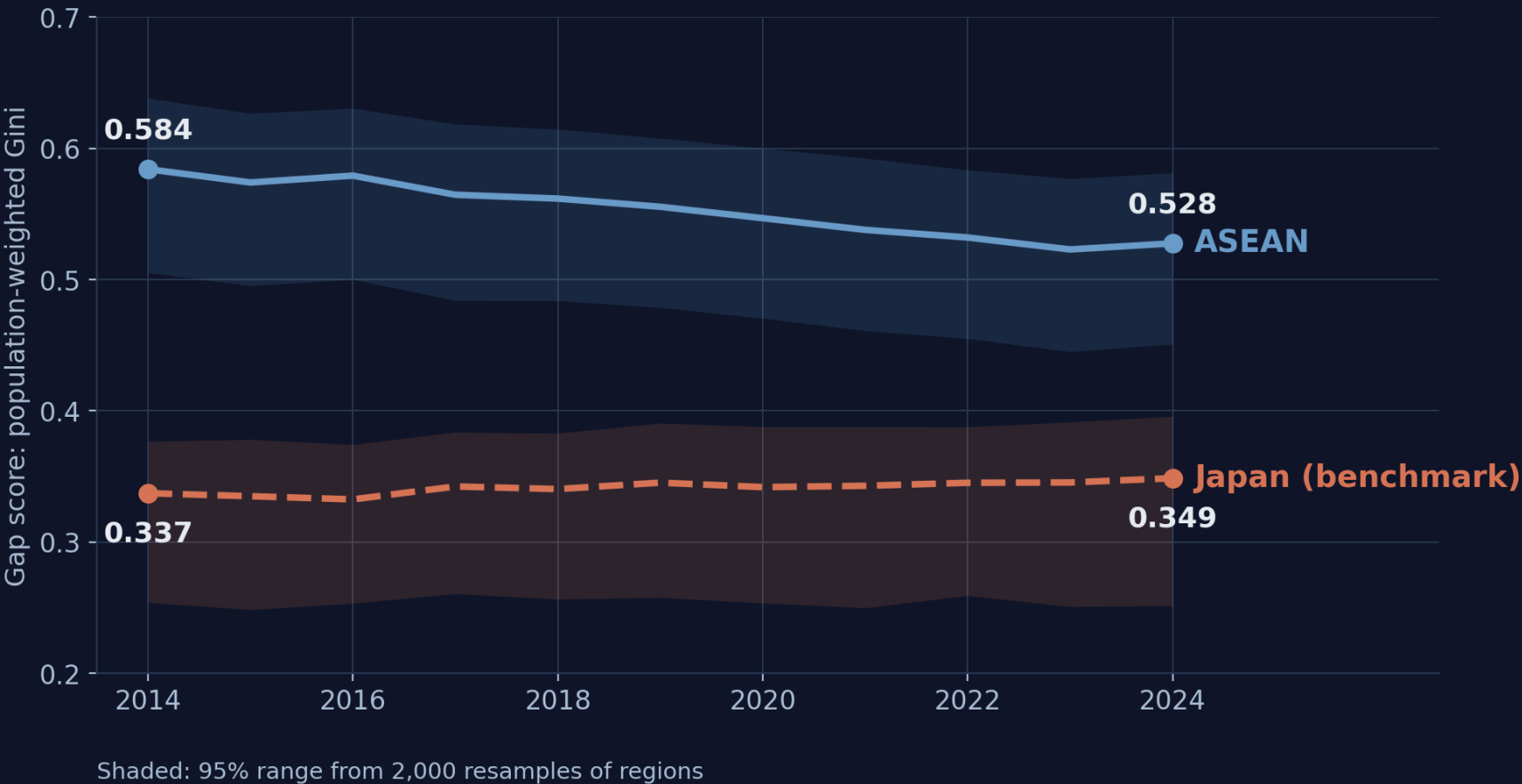


Brightness around the average resident by region, one log colour scale for all four maps; gold: the gap score (population-weighted Gini).

Japan is near-uniformly bright; its 2014 and 2024 maps are hard to tell apart.

REGIONAL INEQUALITY FELL WHILE JAPAN STAYED FLAT

2 · INEQUALITY



Gap score across 278 ASEAN regions and 47 Japanese prefectures, 2014–2024.

ASEAN: -0.057 (95% range -0.072 to -0.042), while average brightness rose. Levelling up, not levelling down.

HALF OF ASEAN LIVED BELOW JAPAN'S DIMMEST PREFECTURE. NOW A THIRD DOES.

2 · INEQUALITY

50.7% → 31.5%

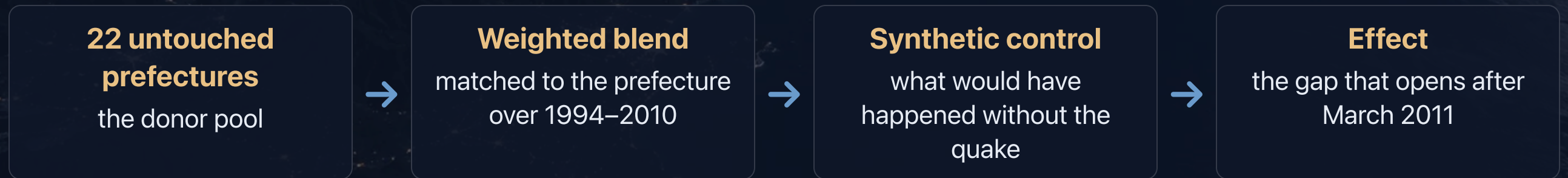
share of the ASEAN population living in regions dimmer than Shimane, 2014 → 2024 (191 → 135 of 278 regions)

This is the single number we would put in front of a finance ministry.

ONE SHOCK, THREE EXPOSURES: A SYNTHETIC CONTROL FOR EACH PREFECTURE

3 · DISASTER

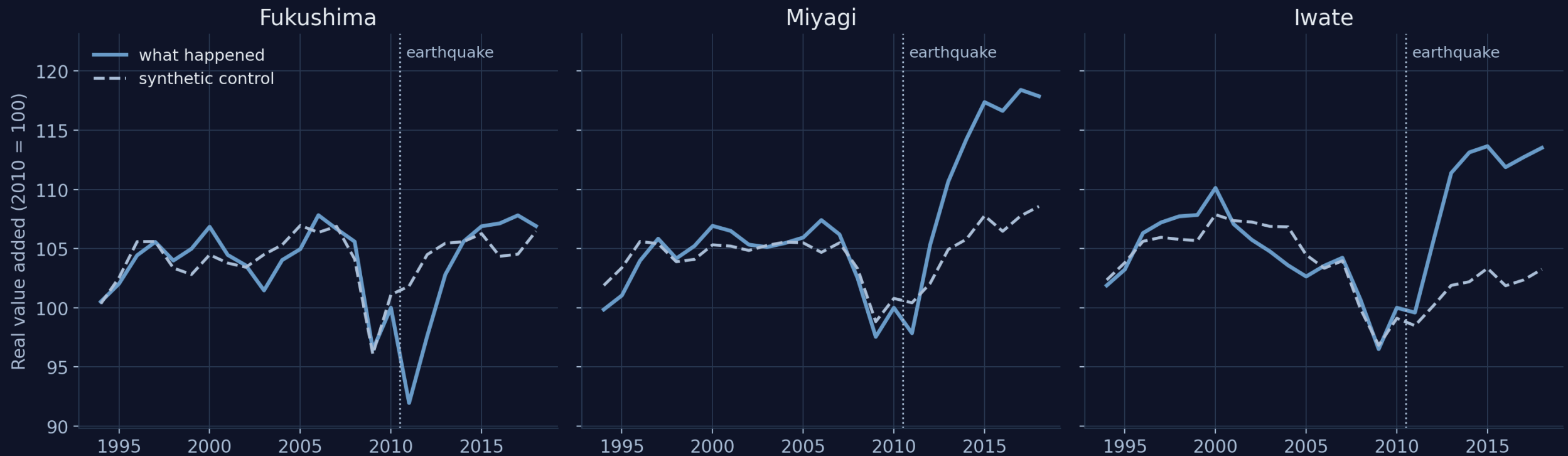
11 March 2011: the Great East Japan Earthquake hit **Fukushima, Miyagi and Iwate**. Only Fukushima also had a nuclear accident and a long evacuation.



Run three times, unchanged: official output, annual light, then monthly light.

OFFICIAL OUTPUT: FUKUSHIMA FELL DEEPEST; MIYAGI AND IWATE ENDED ABOVE

3 · DISASTER

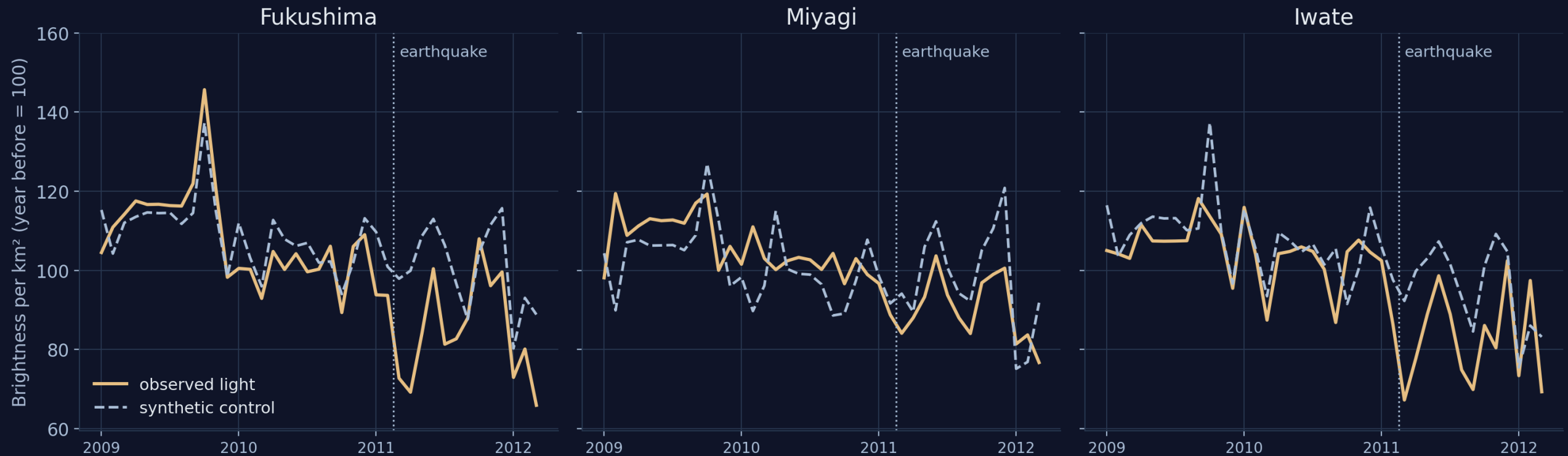


Real value added (solid) and its synthetic control (dashed), 2010 = 100.

2011: Fukushima –9.7%, Miyagi –2.6%, Iwate +1.1%. By 2018 all three are above their synthetic controls: reconstruction money, not a benefit from disaster.

MONTHLY LIGHT DROPS IN THE MONTH OF THE QUAKE, IN ALL THREE

3 · DISASTER

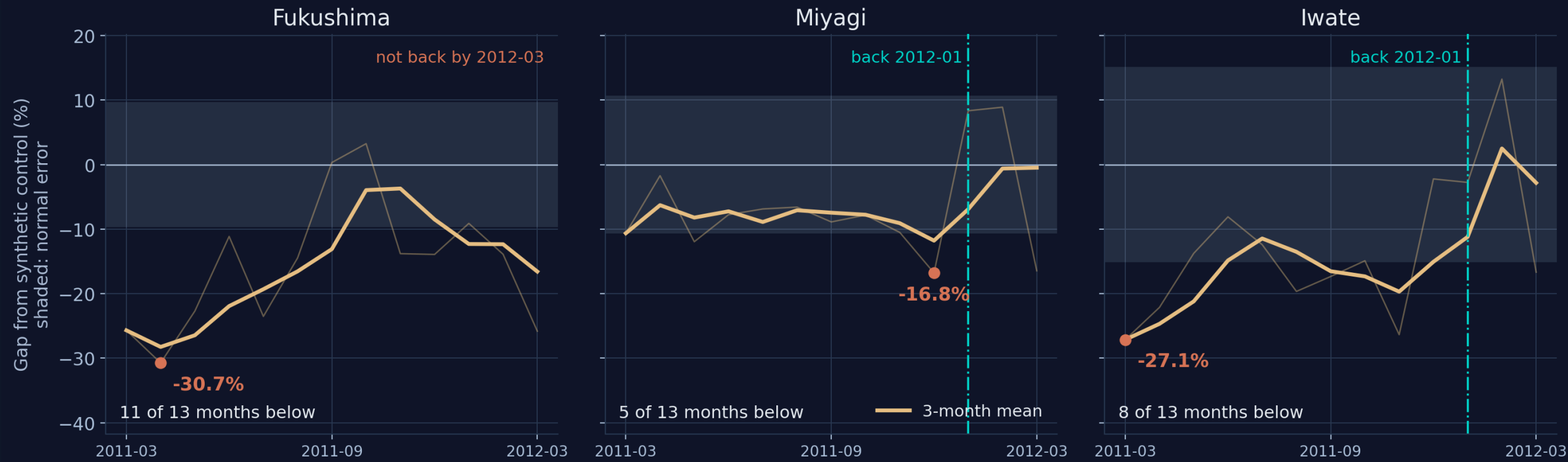


Brightness per km² against its synthetic control, month by month (year before = 100). Matched over 206 pre-quake months.

March 2011: Fukushima –25.7%, Miyagi –10.6%, Iwate –27.1% below the synthetic control.

DEPTH IS NOT DURATION: FUKUSHIMA STAYS DOWN LONGEST

3 · DISASTER

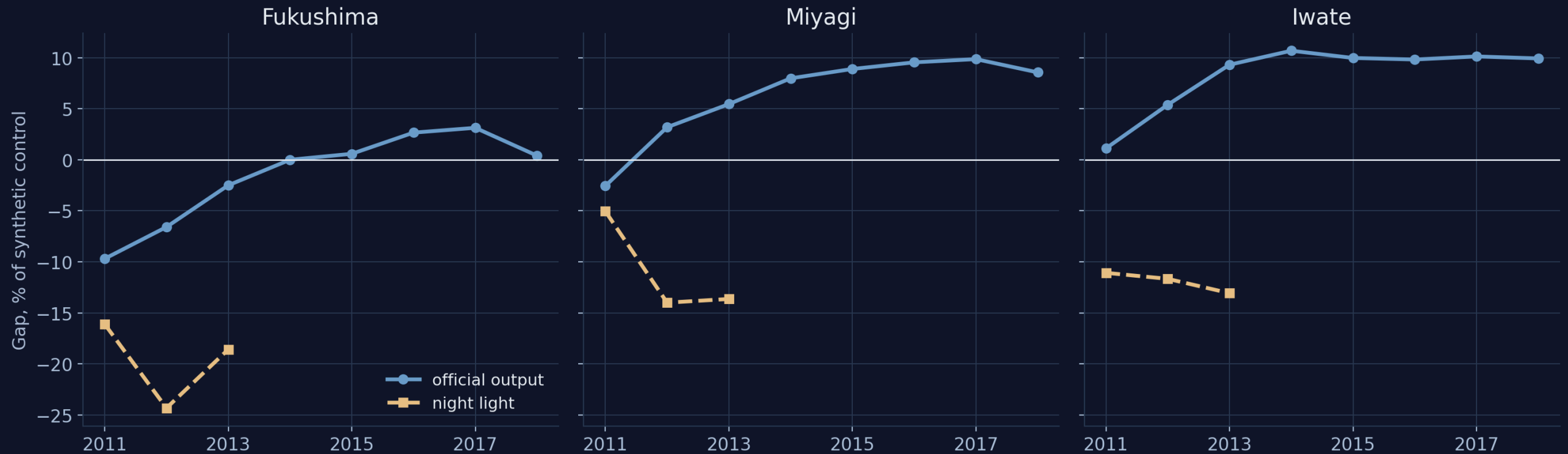


Gap from the synthetic control (%); shaded band = each prefecture's normal error before the quake; heavy line = 3-month mean.

Fukushima bottoms at -30.7% and is below its normal error 11 of 13 months; Iwate 8, Miyagi 5. Annual data cannot make this distinction.

OUTPUT RECOVERS WITH RECONSTRUCTION; LIGHT RETURNS ONLY WITH INFRASTRUCTURE

3 · DISASTER



Each gap as a percentage of the synthetic control: official output (solid) and night light (dashed), from 2011.

The two measures agree about the first year, then diverge. Rebuildable damage and denied access are different problems.

THREE POLICY OUTPUTS FROM ONE INSTRUMENT

IMPLICATIONS

Target lagging clusters

Persistent dark regions straddle borders (Myanmar–Lao PDR–Cambodia–Thailand uplands, Borneo). Target clusters, not countries, in line with ASEAN connectivity corridors.

Deficit or vulnerability?

Are the places hit deepest and longest the ones already behind? If yes, one budget line; if not, two.

An annual monitor

Updated every year at negligible cost, one tier below the nation. We propose a public dashboard that ADBI could host.

Next step: daily light. Blackouts last about four days; monthly composites average them away.

THANK YOU

Infrastructure, inequality and disaster recovery can all be monitored from outer space using new nighttime lights.

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Chapter for the ADBI volume *Building Sustainable Infrastructure in Asia and the Pacific*

carlos-mendez.org · Questions and comments are very welcome

BACKUP SLIDES

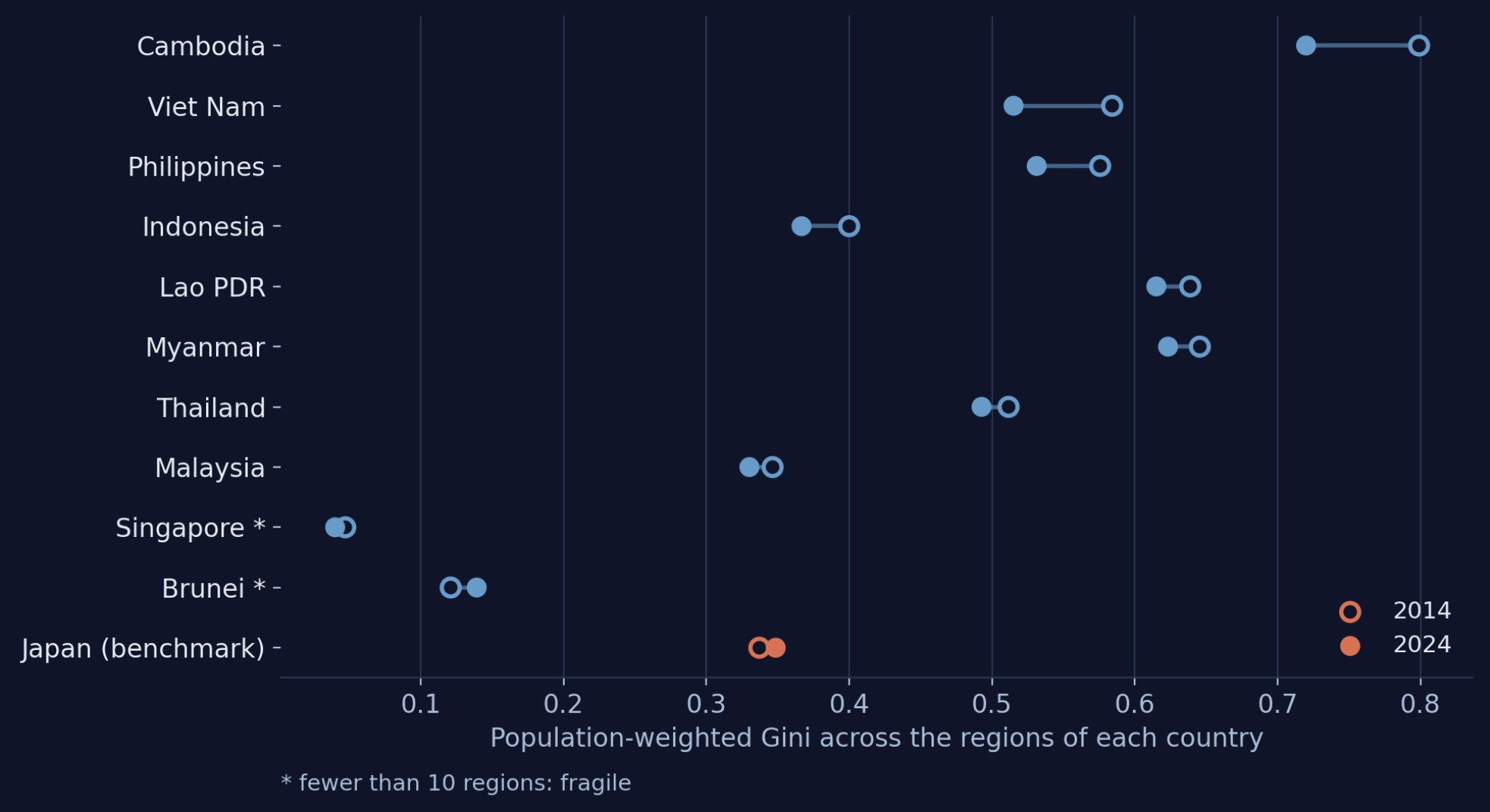
FOR QUESTIONS

B1 · HOW STRONGLY LIGHTS AGREE WITH EACH ACCESS INDICATOR

Indicator	Built from	N	Raw r	Within r	Net r	Spearman ρ
SDG 7.1.1 Electricity (circular)	VIIRS + population	324	0.87	0.81	0.76	0.90
SDG 9.1.1 Rural road access	OSM + GHSL + population	324	0.65	0.47	0.39	0.68
SDG 11.2.1 Urban transit access	OSM + GHSL + population	216	0.58	0.37	0.35	0.51
SDG 11.7.1 Urban open public space	OSM + GHSL	257	0.58	0.27	0.54	0.64

Within: each country's mean removed from both sides. Net: log population and log area held fixed. Luminosity in logs, 2020. Transit exists only where a mapped urban centre exists (216 regions).

B2 · WITHIN-COUNTRY INEQUALITY, 2014 VERSUS 2024



Population-weighted Gini across each country's own regions.

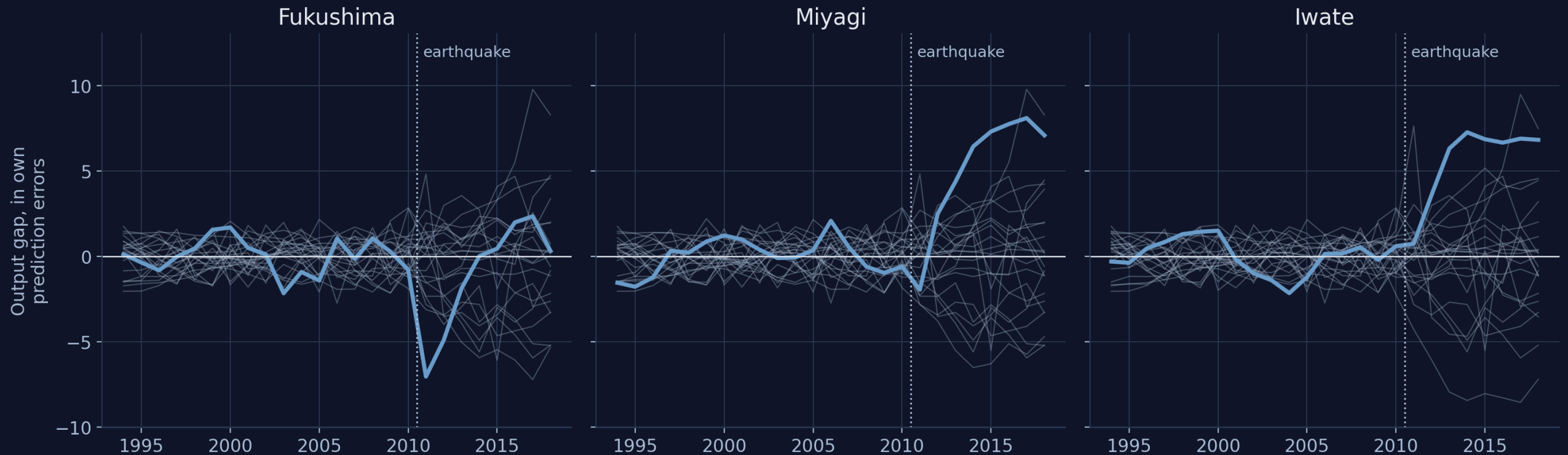
9 of 10 member states fall, but only 3 have a 95% range excluding zero: Viet Nam, the Philippines, Thailand.

B3 · THE INEQUALITY DECLINE IS ROBUST

Specification (ASEAN)	Regions	Gini 2014	Gini 2024	Change	95% range
Headline (population-weighted)	278	0.584	0.528	-0.057	[-0.072, -0.042]
Unweighted (one weight per region)	278	0.714	0.635	-0.079	[-0.089, -0.067]
Excluding ever-dark units	276	0.584	0.528	-0.057	[-0.072, -0.041]
Excluding Singapore	269	0.565	0.516	-0.050	[-0.063, -0.036]
Excluding Myanmar	261	0.572	0.512	-0.060	[-0.076, -0.044]

Paired region bootstrap, 2,000 draws, each region resampled with its full 11-year path.

B4 · OFFICIAL OUTPUT AGAINST EVERY UNTOUCHED PREFECTURE



Gap in units of each prefecture's own pre-quake prediction error; grey: the 22 donors refitted as if treated.

Placebo p-values: Miyagi 0.043, Iwate 0.087, Fukushima 0.348. The test rewards large, sustained departures, so it sees the reconstruction response more clearly than the damage.

B5 · IS THE MONTHLY LIGHT RECORD USABLE? A PRE-REGISTERED GATE

Check	Measured	Bound	Result	Consequence
Year-on-year same-month difference	0.945	0.600	pass	—
Lag-12 over lag-1 autocorrelation	0.964	0.600	pass	—
Month-to-month volatility	0.948	0.600	pass	—
Monthly composites average to the annual panel	0.000	0.005	pass	—
Hokkaido 2018-09 blackout is visible	0.050	−1.000	fail	bounds the claim
Permutation rejection rate at nominal 5%	0.273	0.120	fail	inference dropped

Bounds fixed before the gate was first run. Monthly light measures how long infrastructure stays down, not whether it went down for a few days.

B6 · WHICH LIGHT MEASURE SEES THE DISASTER?

2011 gap from the synthetic control (%)	Fukushima	Miyagi	Iwate
Mean brightness per km ² (headline)	-16.1	-5.0	-11.1
Total light emitted	-16.7	-1.4	-15.9
Population-weighted mean (inequality variable)	-12.0	+4.4	-11.3

Population weighting plays down the rural coast and evacuation zone that went dark. Match the measure to the geography of the shock.