Trade Connectivity and Spatial Wealth Inequality in Developing Asia

:Geographic Dispersion or Heterogeneous Returns?

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Contents

1. Introduction

Trade liberalization and regional disparities

- Trade protectionism has been gaining momentum worldwide.
- Are the benefit of trade distributed evenly within countries?
- Although developing countries in Asia have achieved economic development through trade liberalization, regional disparities remain a significant issue.

$\Rightarrow$ Understanding whether trade exacerbates inter-regional inequality, and the mechanisms through which it does so, is important for formulating trade and development policies.

Related literature

A substantial body of empirical research has examined the relationship between trade & regional inequality.

However, the findings remain inconclusive.

- ✓ Topalova (2007): trade liberalization has heterogeneous effects across regions in India.
- ✓ McCaig (2011) : tariff reductions lowered poverty rates in Vietnam.
- ✓ Liu et al.（2022）: exports to OECD countries widened income inequality in Taiwan.

⇒ Findings vary considerably across countries, and no consensus has emerged on whether trade increases or reduces inequality.

⇒ A possible reason is that the mechanisms linking trade to regional inequality differ across countries.

⇒ Yet most studies focus on whether trade widens inequality, rather than how it does so.

Research questions

RQ1: To what extent does trade connectivity contribute to spatial wealth inequality within developing countries?

RQ2: Are regional disparities driven by the geographic dispersion of trade connectivity, or by heterogeneous returns to trade connectivity across regions?

Policy implications:

- If geographic dispersion dominates:

  → Spatial redistribution through infrastructure investment

- If heterogeneous returns dominate:

  → Strengthening absorptive capacity through industrial policy & human capital investment

Countries in the Estimation Sample

A comparative analysis of four developing countries in South and Southeast Asia, Cambodia, the Philippines, Bangladesh, and Nepal, is conducted to answer the research questions.

Why these countries?

- **Commonality**: Economic growth under trade liberalization, but persistent regional inequality.
- **Differences:** Geographic conditions (coastal landlocked, archipelagic) and stages of infrastructure development.

	2001	2023	2001	2023
	GDP per capita (current US$)		GDP percap growth (annual %)	
Bangladesh	395	2551	3.3	4.5
Cambodia	328	2430	5.7	3.7
Nepal	241	1382	3.1	2.1
Philippines	970	3804	0.8	4.7
Low income	332	714	1.3	-2.9
Lower middle income	553	2493	2.3	4.7
High income	22083	48608	1.1	1.1
	Trade (% of GDP)		Gini index	
Bangladesh	32.1	31.0	33.4 (2000)	30.9 (2022)
Cambodia	111.8	134.2	39.6 (2004)	32.2 (2020)
Nepal	55.8	41.6	43.8 (2003)	30.0 (2022)
Philippines	84.9	67.4	47.7 (2000)	39.3 (2023)
Low income	38.9	52.7		
Lower middle income	45.0	55.6		
High income	50.6	63.0		

Major exports
- BGD: garments
- KHM: garments, footwear
- NPL: agricultural products
- PHL: electronics, IT services

Source: World Development Indicators

- ✓ Income level: From around 2001 to 2023, Bangladesh, Cambodia, and Nepal moved from low-income to lower-middle-income status, while the Philippines remained a lower-middle-income economy throughout.
- ✓ All four countries are developing economies that have achieved sustained per capita GDP growth.
- ✓ Since 2000, Bangladesh and Cambodia have grown mainly through labor-intensive manufacturing exports, the Philippines through electronics and IT exports, while Nepal has had a narrower and less export-led growth pattern, with exports concentrated in a small number of goods and tourism-related services

Analytical Framework:

- Spatial accounting framework using a DHS-based wealth index as the dependent variable
- Regional trade connectivity index as the main explanatory variable.
- RQ1 and RQ2 are addressed through a normalized variance decomposition.
- Comparison of the coefficient of variation of trade connectivity (CV_{TC}) and returns (CV_{β}).

Major findings:

- Trade connectivity is not the main driver of wealth inequality
- Geographic dispersion is dominant in Bangladesh, Cambodia, and Nepal, whereas heterogeneous returns are dominant in the Philippines.

Contributions of this Paper:

- Proposes a new descriptive and accounting framework for decomposing the relationship between trade and regional inequality.
- Shows that inconsistent findings in the existing literature may stem from differences in underlying mechanisms.
- Identifies two channels—uneven connectivity and heterogeneous returns—and provides an empirical basis for setting policy priorities.

2. Analytical framework

Spatial accounting framework:

- Decomposing the factors contributing to wealth levels in each region.
- Wealth level at household *h* in region *i* in year *t* : w_{ht} is determined by economic and geographic factors Z_{it} and trade connectivity in the region *i*, TC_{it}.
- The average wealth level in region *i*:

$$\mu_{it} = E[w_{ht} \mid i] = F(TC_{it}, Z_{it})$$

$$\mu_{it} = F(TC_{it}, Z_{it}) \approx \alpha + \beta_i TC_{it} + \gamma' Z_{it} + u_{it}$$

Decomposition of spatial wealth inequality:

$$Var(\mu_i) = Var\,(\beta \cdot\ TC_i + \gamma' Z_{it} + u_{it})$$

$$Var(\mu_i) = Var\,(\beta \cdot TC_i) + Var(r_i) + 2\,Cov(\beta \cdot TC_i, r_i)$$

$$r_i = \gamma' Z_{it} + u_{it}$$

$$Var(\mu_i) = Var(\beta \cdot TC_i) + Var(r_i) + 2\,Cov(\beta \cdot TC_i, r_i)$$

$$Var(\beta \cdot TC_i) = \underbrace{\bar{\beta}^2 \cdot Var(TC_i)}_{\text{Geographic dispersion}} + \underbrace{\overline{TC}^2 \cdot Var(\beta_i)}_{\text{Heterogeneous returns}} + \underbrace{2\bar{\beta} \cdot \overline{TC} \cdot Cov(TC_i, \beta_i)}_{\text{Covariance}}$$

The unit of $\bar{\beta}^2$ and $\overline{TC}^2$ differ, these are normalized using the coefficient of variation (CV)

$$CV_{TC} = \frac{SD(TC_i)}{|\overline{TC}|},\ CV_{\beta} = \frac{SD(\beta_i)}{|\overline{\beta}|}$$

Normalized by $\bar{\beta}^2$ and $\overline{TC}^2$,

$$\frac{Var(\beta_i \cdot TC_i)}{\overline{\beta^2} \cdot \overline{TC_i^2}} = CV_{TC}^2 + CV_{\beta}^2 + 2\rho \cdot CV_{TC} \cdot CV_{\beta}, \qquad \rho = Cor(TC_i, \beta_i)$$

- $CV_{TC}^2 > CV_{\beta}^2$: The main cause of disparity is geographic dispersion
- $CV_{TC}^2 < CV_{\beta}^2$: The main cause of disparity is heterogeneous returns
- ρ>0: the higher the connectivity, the higher the rate of return ⇒ widening disparities
- ρ<0: the higher the connectivity, the lower the rate of return ⇒ narrowing disparities

Step 1: Random effects model

$$\mu_{it} = \alpha + \beta TC_{it} + \delta_1\left(TC_{it} \times \tilde{X}_{it}^1\right) + \delta_2\left(TC_{it} \times \tilde{X}_{it}^2\right) + \delta_3\left(TC_{it} \times \tilde{X}_{it}^3\right)$$

$$+\gamma_1 X_{it}^1 + \gamma_1 X_{it}^2 + \gamma_1 X_{it}^3$$

$$+ \phi_1 Elevation_i + \phi_2 Roads + \phi_3 Water + \mu_i + T_t + \varepsilon_{it}$$

$\tilde{X}_{it}^1$:industrial structure: share of labor in agricultural sector/manufacturing sector

$\tilde{X}_{it}^2$:human capital: the average education level

$\tilde{X}_{it}^3$:urbanization: nighttime light density

Step2: Normalized Variance Decomposition Using the Coefficients

Using $\widehat{\beta_i}$ and the variation in TC_i, decompose the contribution of TC.

3. Data description

Wealth index at regional level

- DHS-based Wealth Measure: household wealth is measured using the Wealth Index from the Demographic and Health Surveys (DHS).
- DHS uses a two-stage random sampling design balanced across urban and rural areas.
- Households are grouped into georeferenced clusters (about 20–30 households each).
- The Wealth Index is a standardized asset-based measure constructed from housing conditions, access to utilities, and ownership of durable goods and livestock.

Average Regional Wealth in region i

$$\mu_{it} = \frac{\sum_{h \in i} \omega_h WI_h}{\sum_{h \in i} \omega_h}$$

μ_{it}: average wealth in region i at year t

$h \in i$: household in region i

ω_{it}: weight of household h

Trade Connectivity index

- Regional trade connectivity is measured by an original Trade Connectivity Index (TC).
- The index captures each region’s access to international markets.
- It is based on distance from a region’s population center to the nearest international port, and trading partner countries.
- It is further adjusted for partner demand/production and import tariffs, net of distance and time costs.

Trade connectivity index

$$TC_{it} = \left(C_{m \to s}^{port}\right)_t^{-\phi} \sum_{o \neq home} \frac{D_{o,k,t} \cdot \left(1 - \tau_{k,t}^{o \leftarrow home}\right)}{\left(C_{i \to o.t}\right)^{\theta}}$$

Domestic access

Distance from region i to the nearest port. It varies across regions within a country

International access

$D_{o,k,t}$: partner demand: GDP of trading partners
Larger markets increase connectivity

$\tau_{k,t}^{o \leftarrow home}$: tariff barriers, lower tariffs increase effective connectivity

$C_{i \to o.t}$: international distance: Sea distance from the nearest port to the largest port of partner country, common to all regions within a country

TC varies across regions through domestic access and across years through tariffs and partner demand.

50km Grid-cell

- Unit of analysis: 50-km grid cells
- For cross-country comparison across Bangladesh, Nepal, Cambodia, and the Philippines,

⇒Because admin2 boundaries differ greatly in size and configuration across countries, which limits comparability.

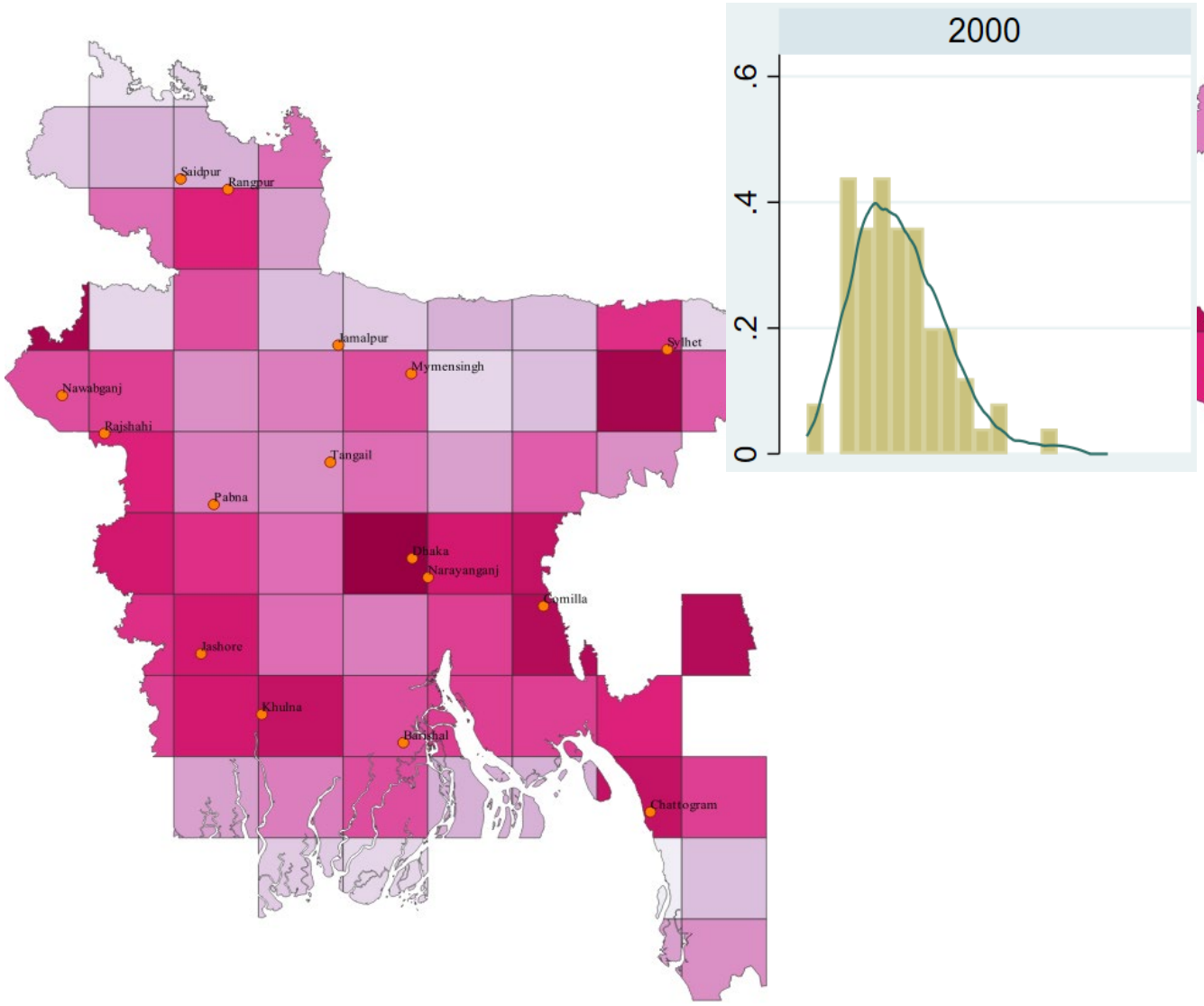
- Therefore, aggregate the data into uniform 50-km grid cells rather than relying on country-specific administrative units.
- This provides a set of spatial units of broadly comparable size across countries.

3. Data description

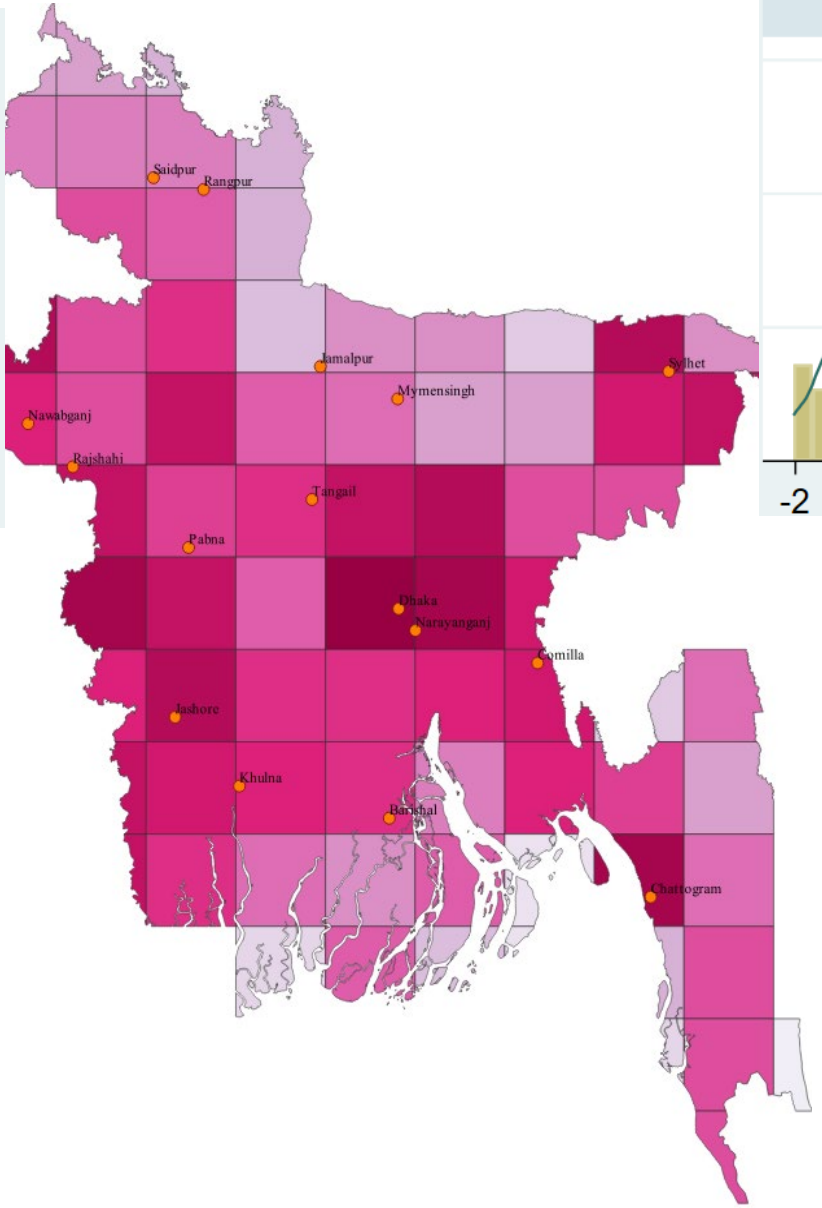
Descriptive statistics

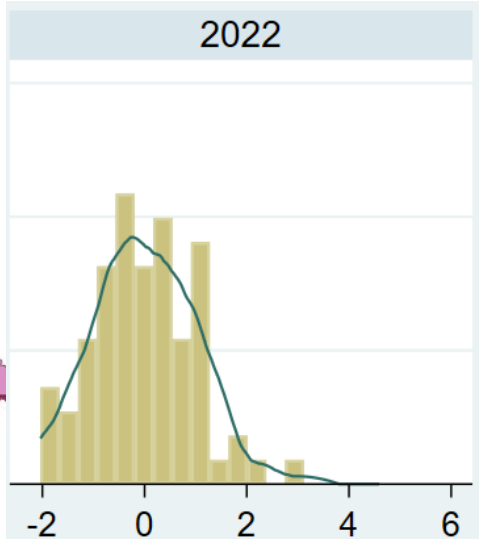
Wealth index by 50km grid-cell, Bangladesh

2000



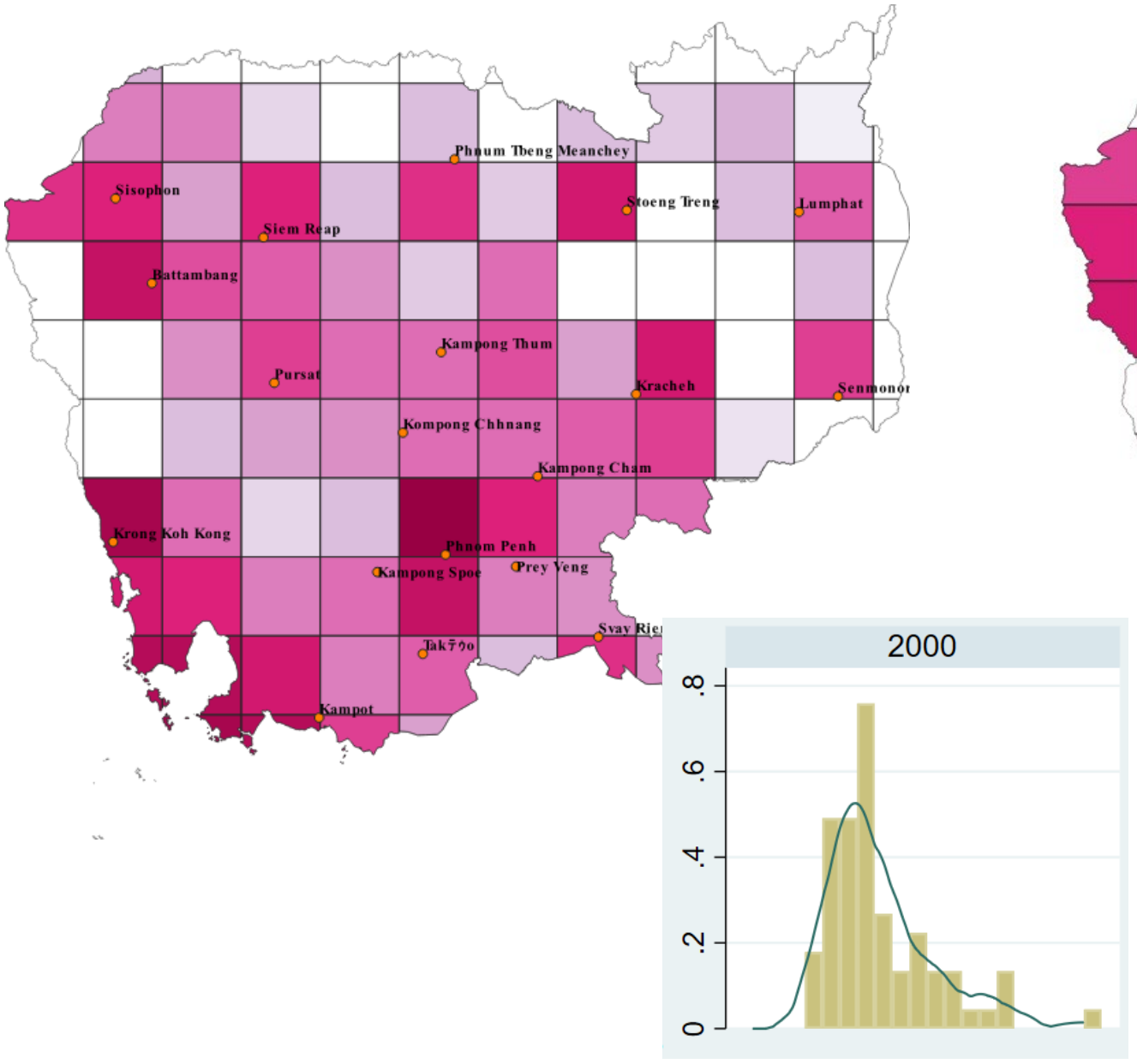
2022



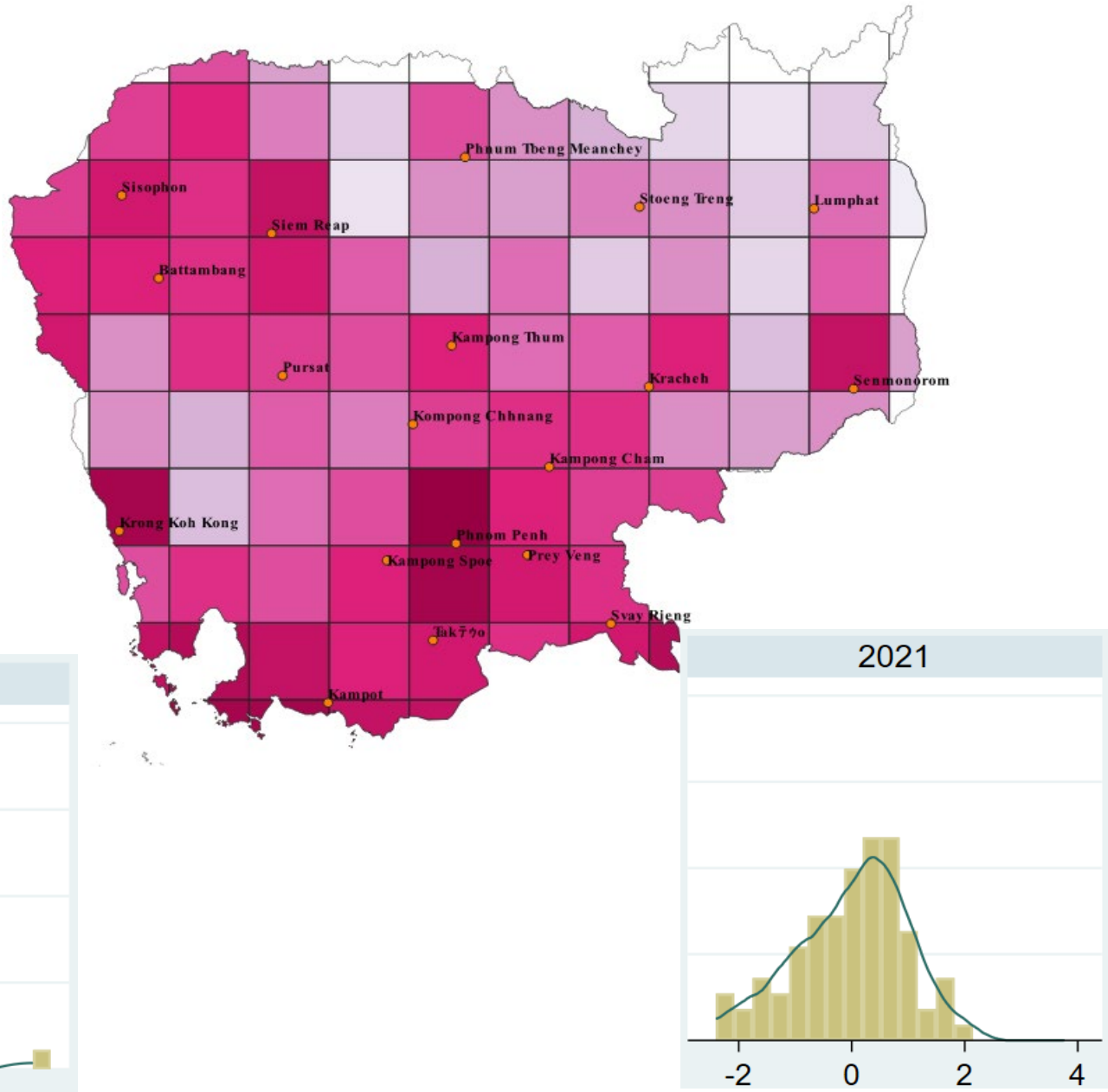


Wealth index by 50km grid-cell, Cambodia

2000

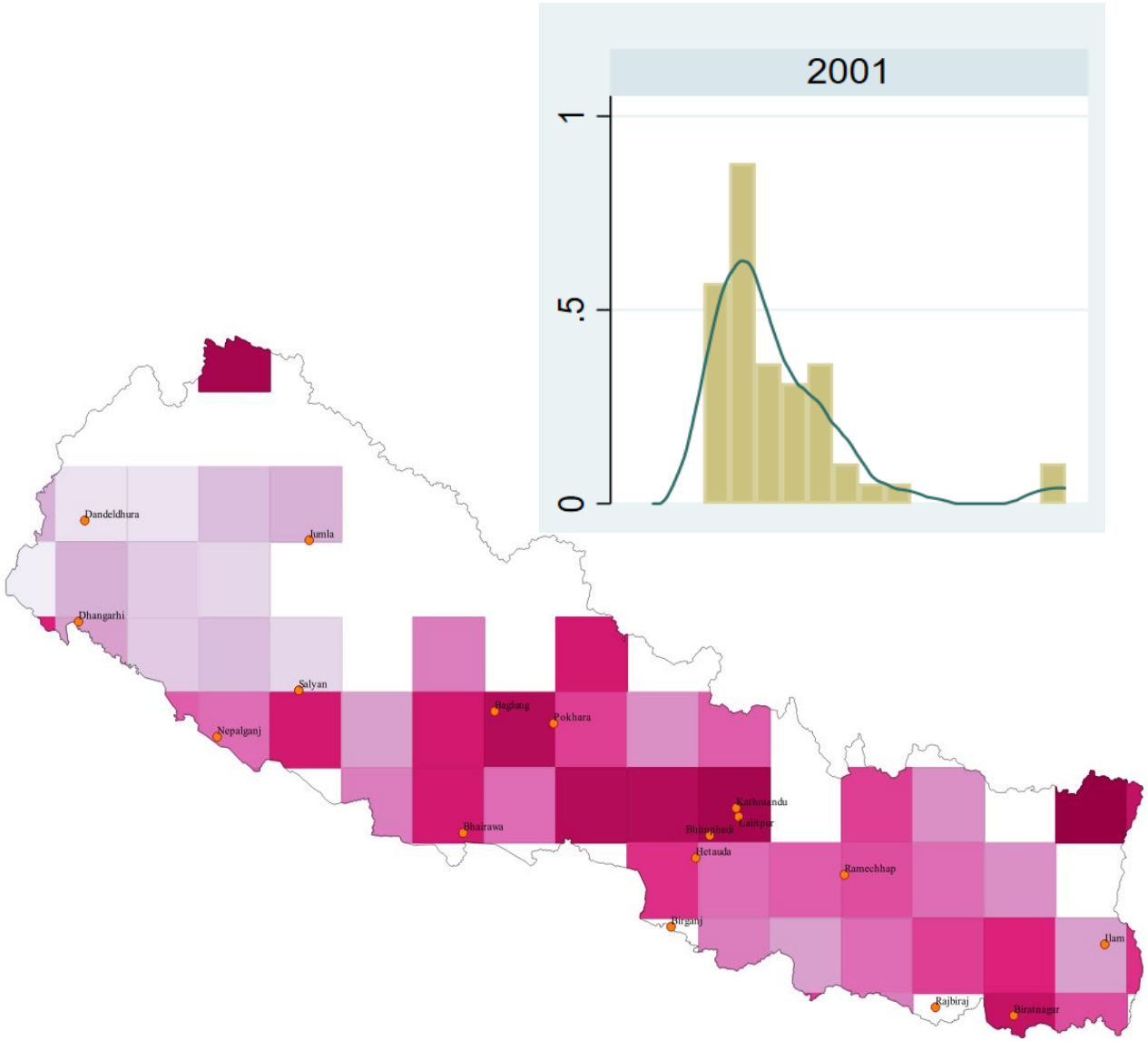


2021

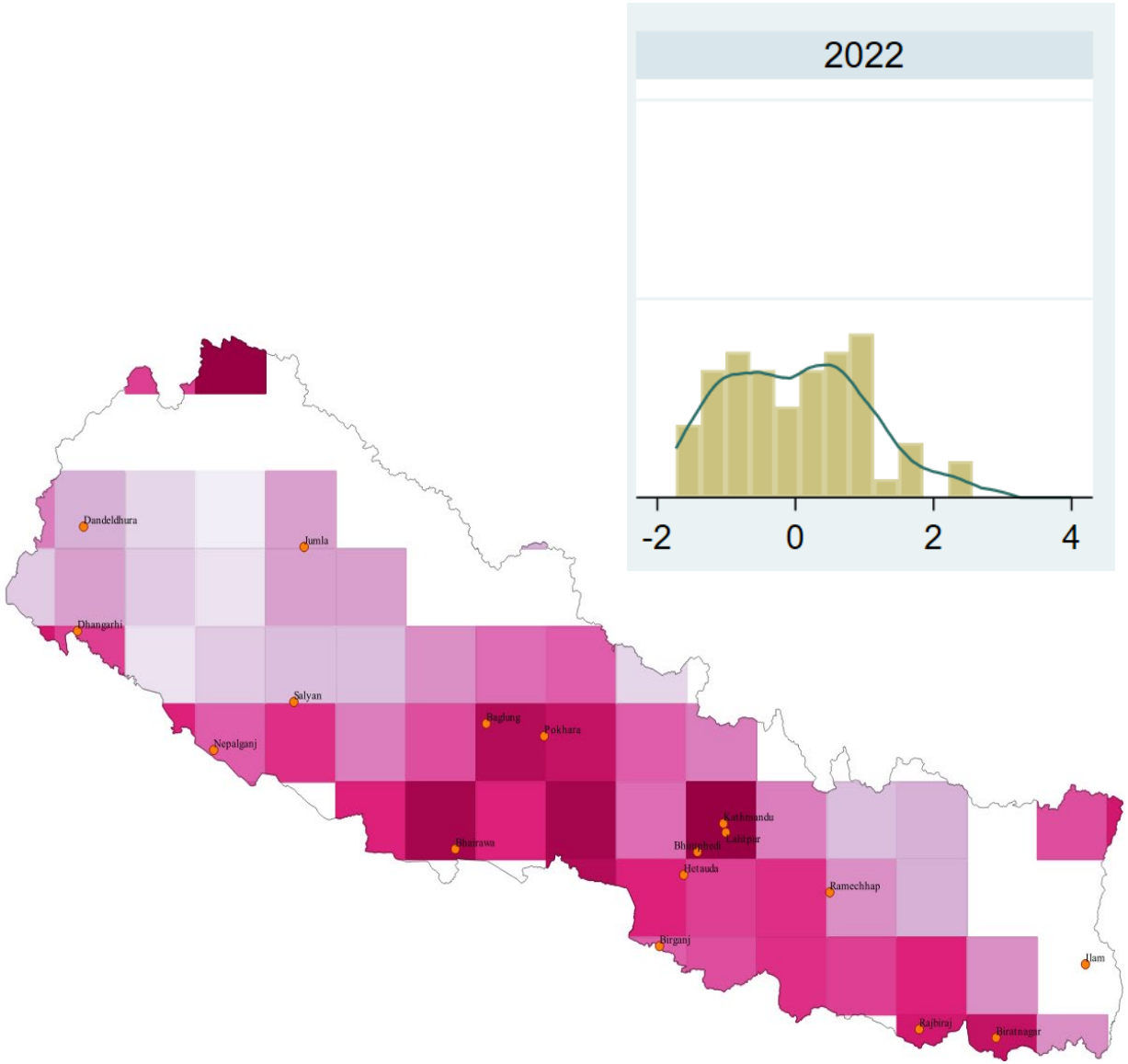


Wealth index by 50km grid-cell, Nepal

2001

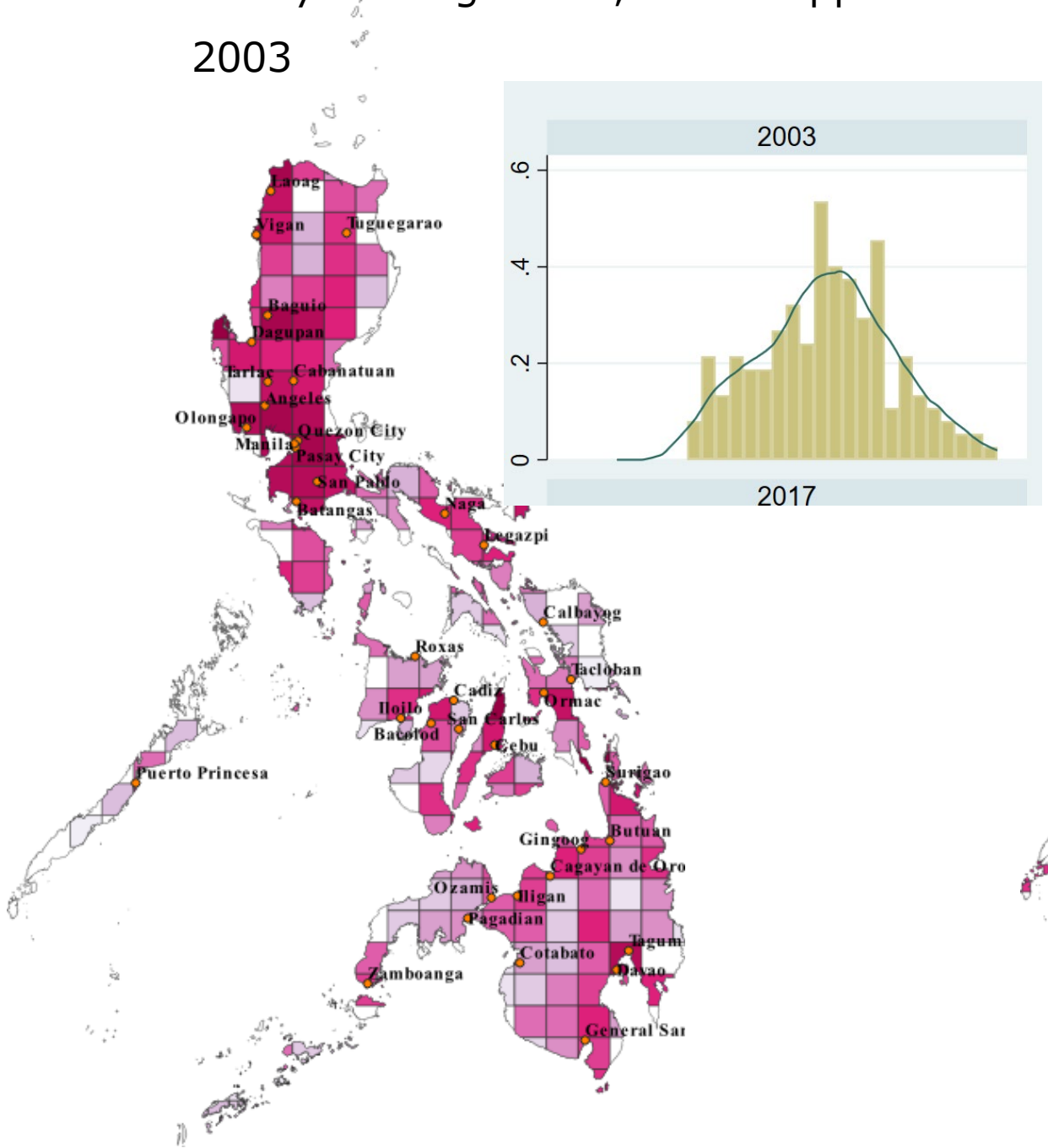


2022

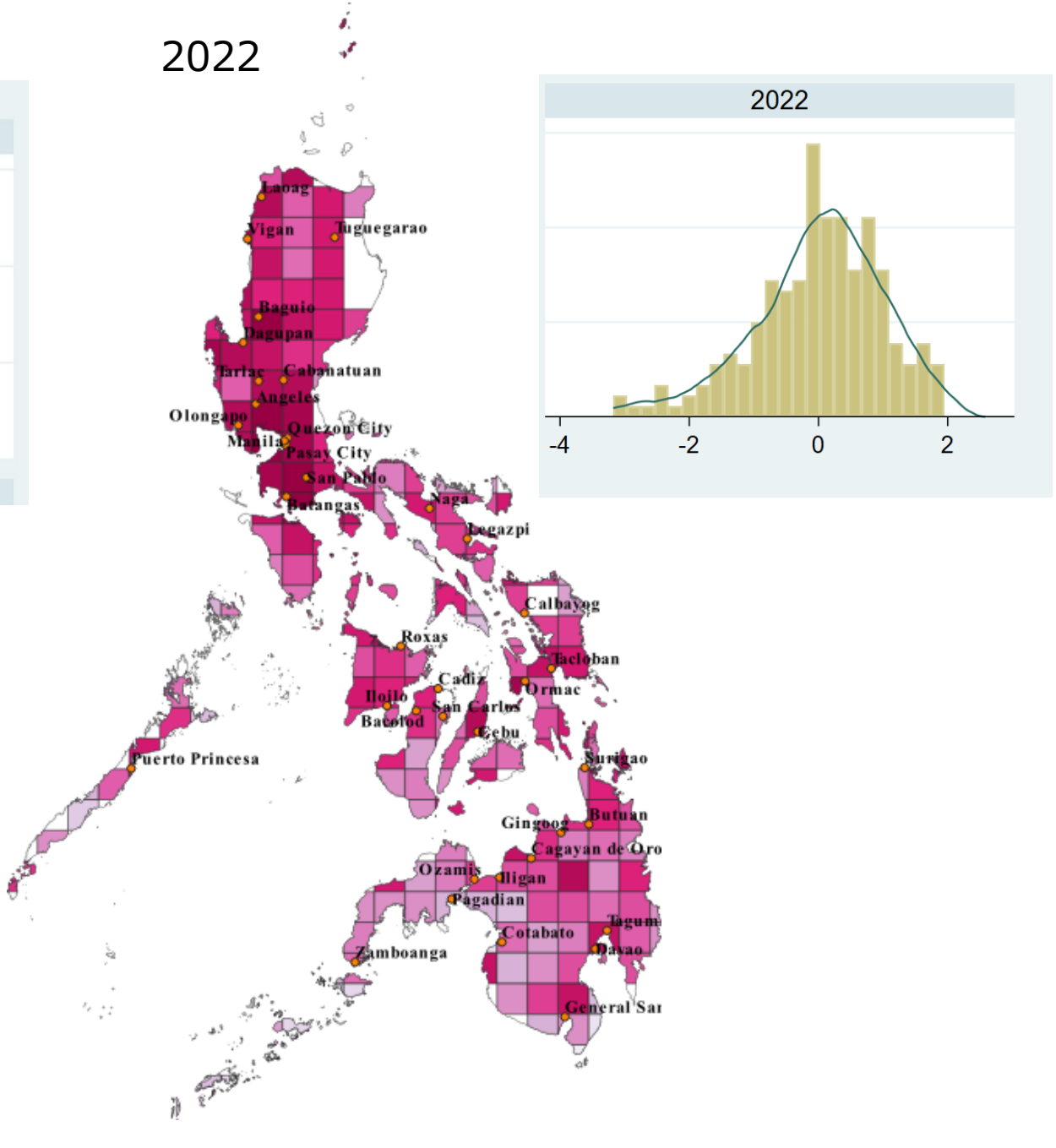


Wealth index by 50km grid-cell, The Philippines

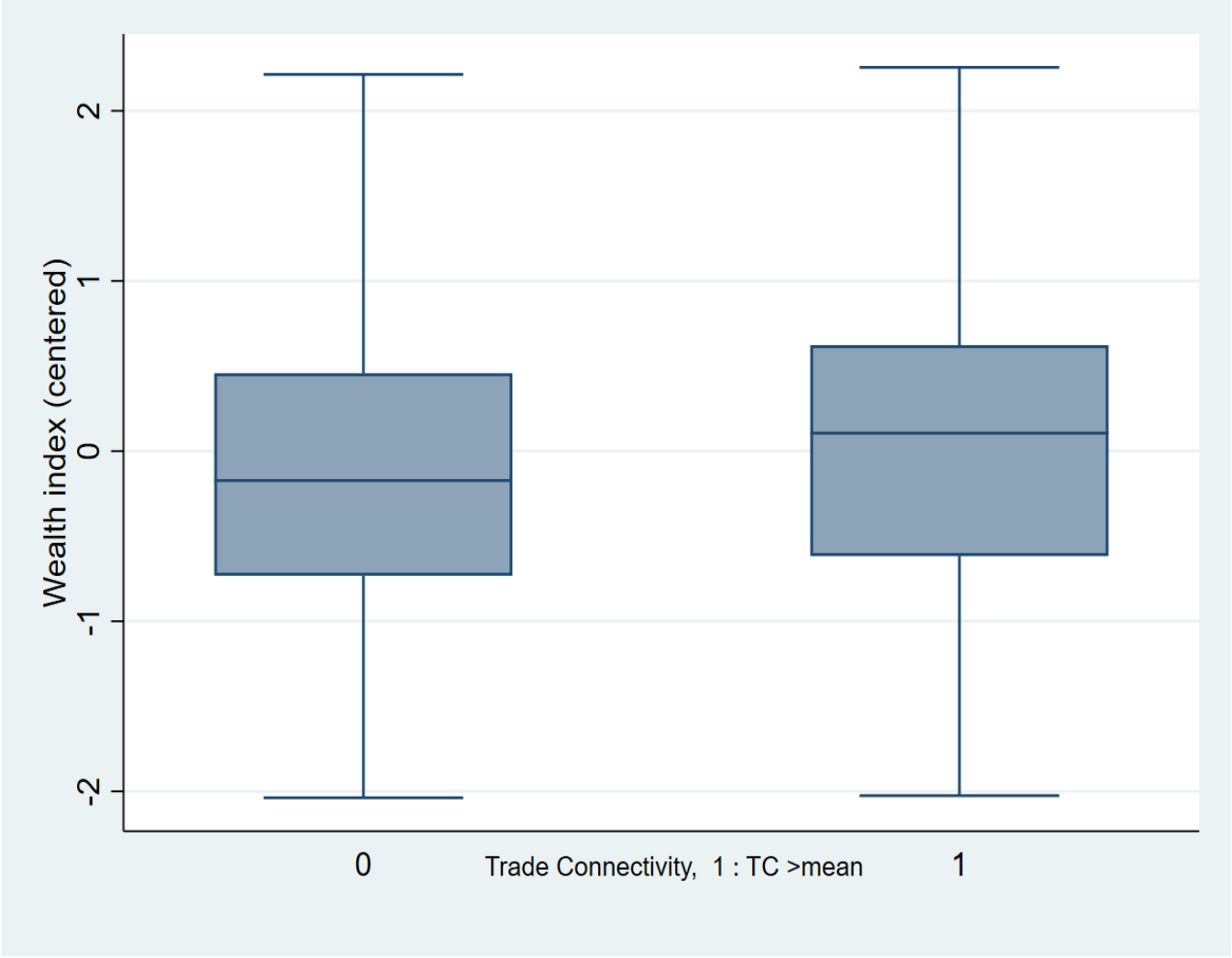
2003

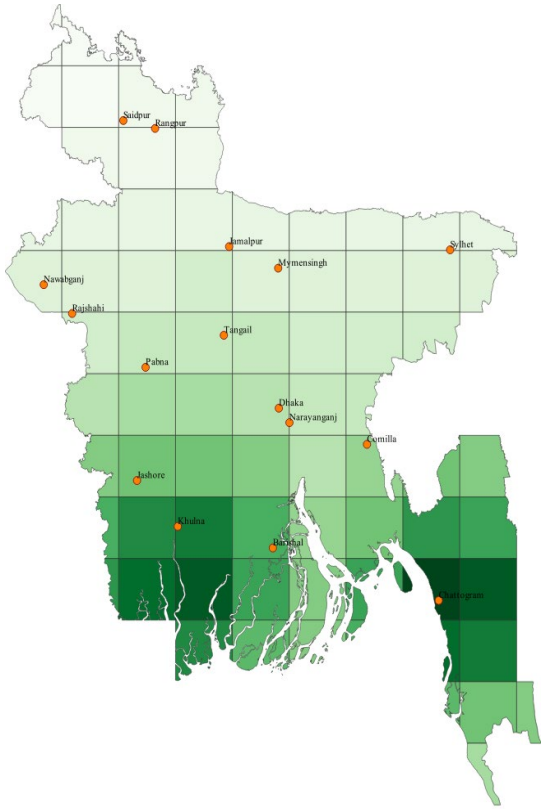


2022

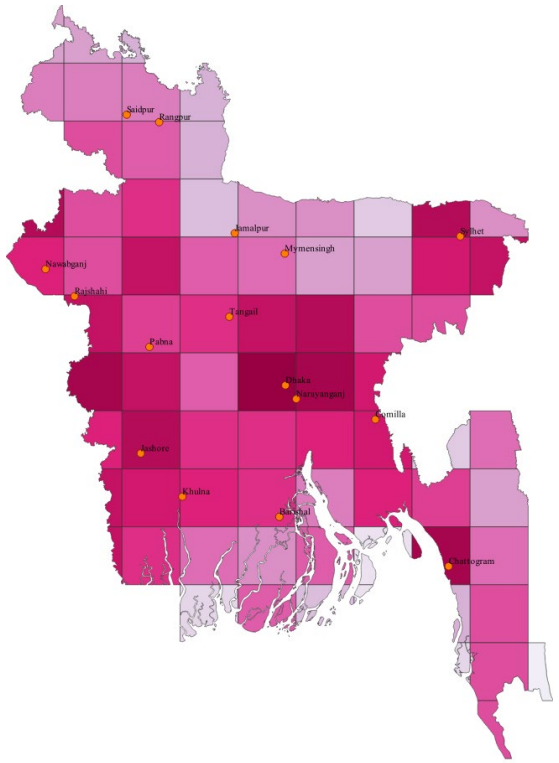


Wealth index and Trade Connectivity, Bangladesh



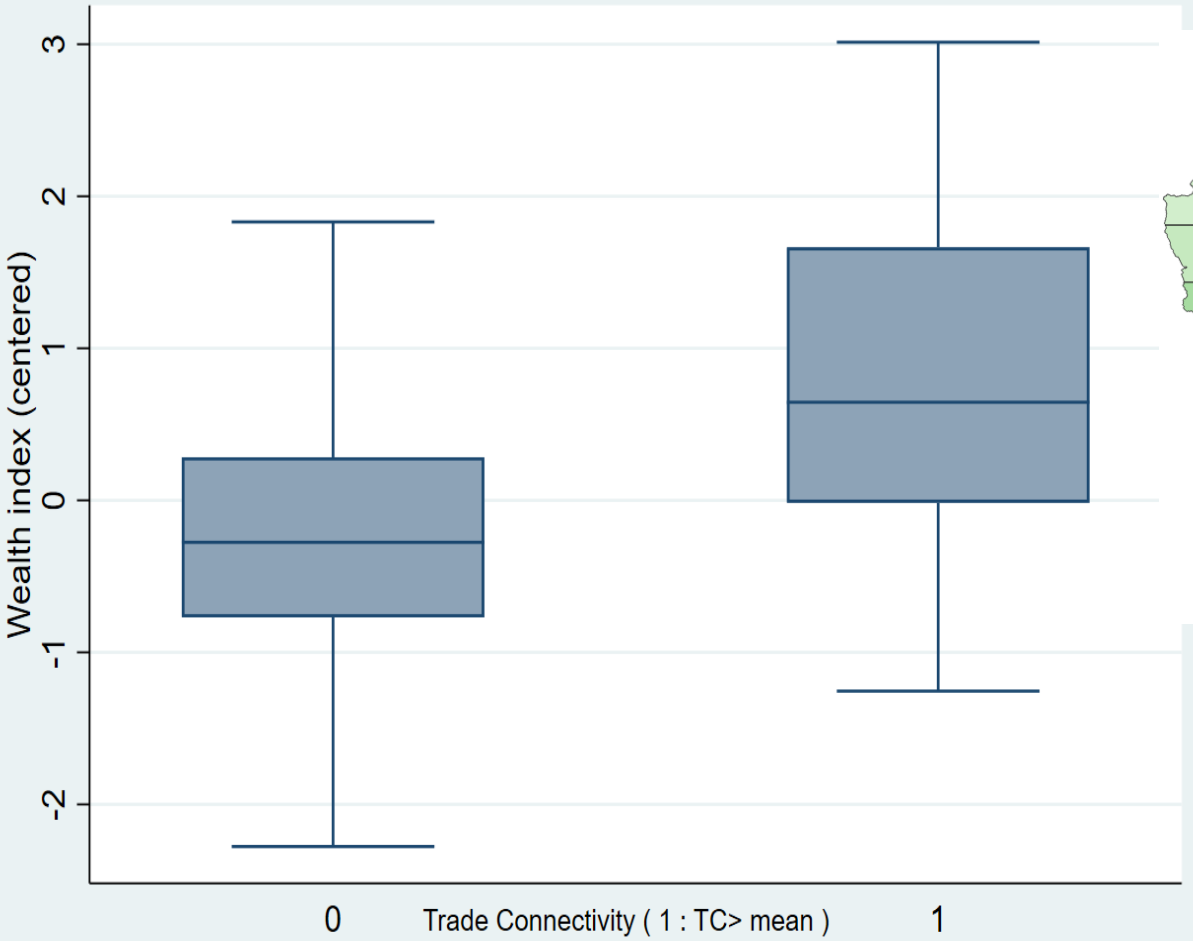


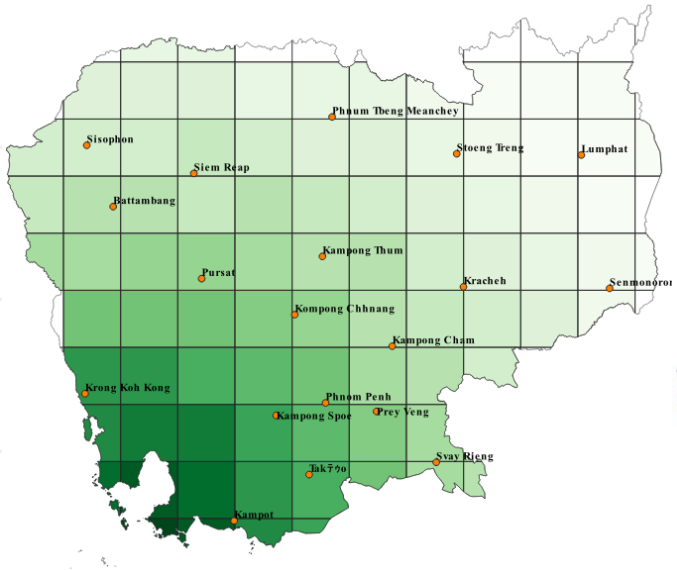
Trade Connectivity



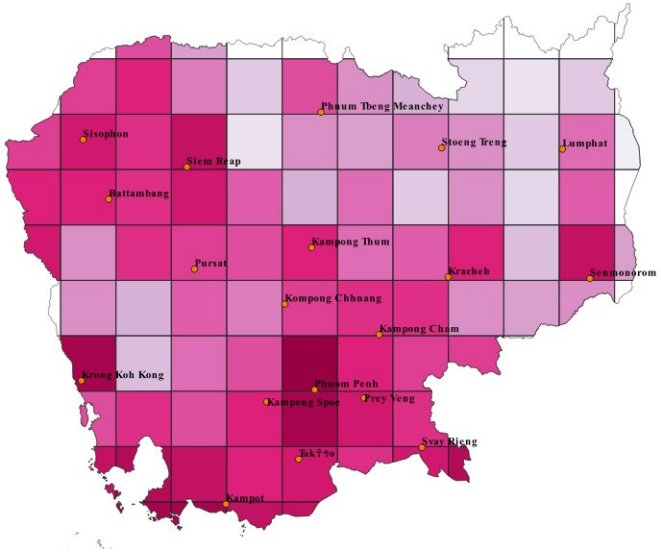
Wealth index, 2022

Wealth index and Trade Connectivity, Cambodia



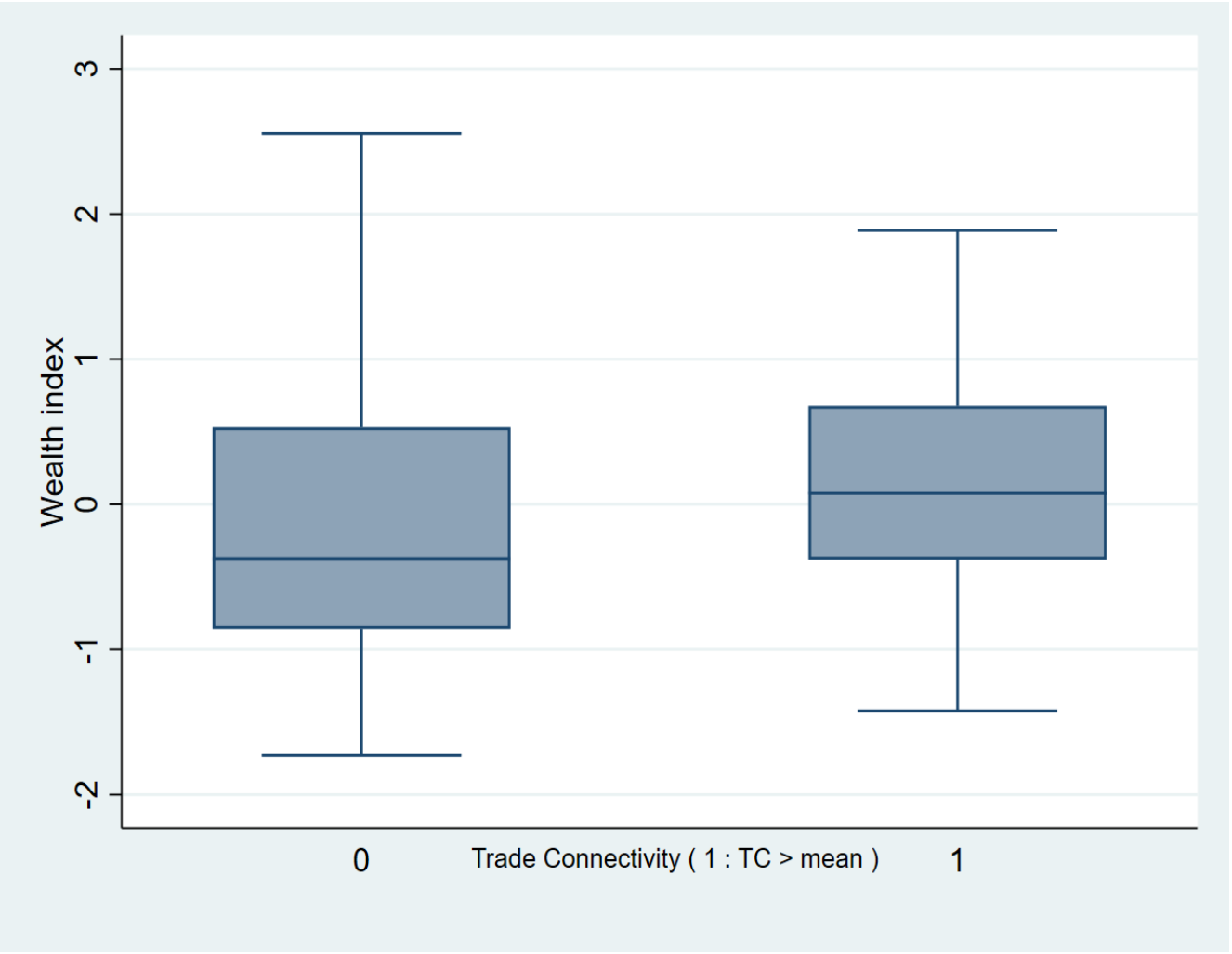


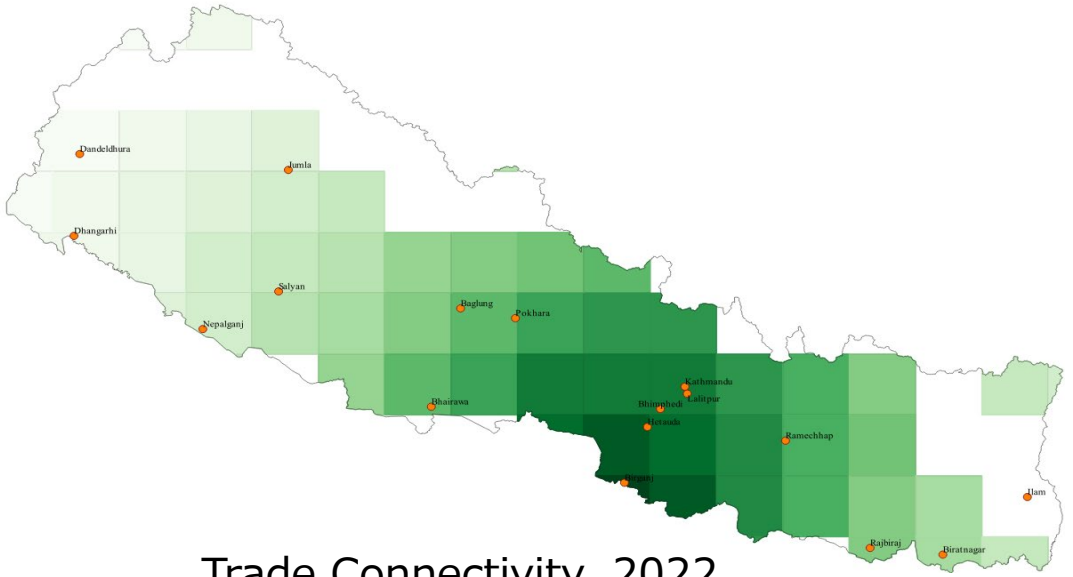
Trade Connectivity



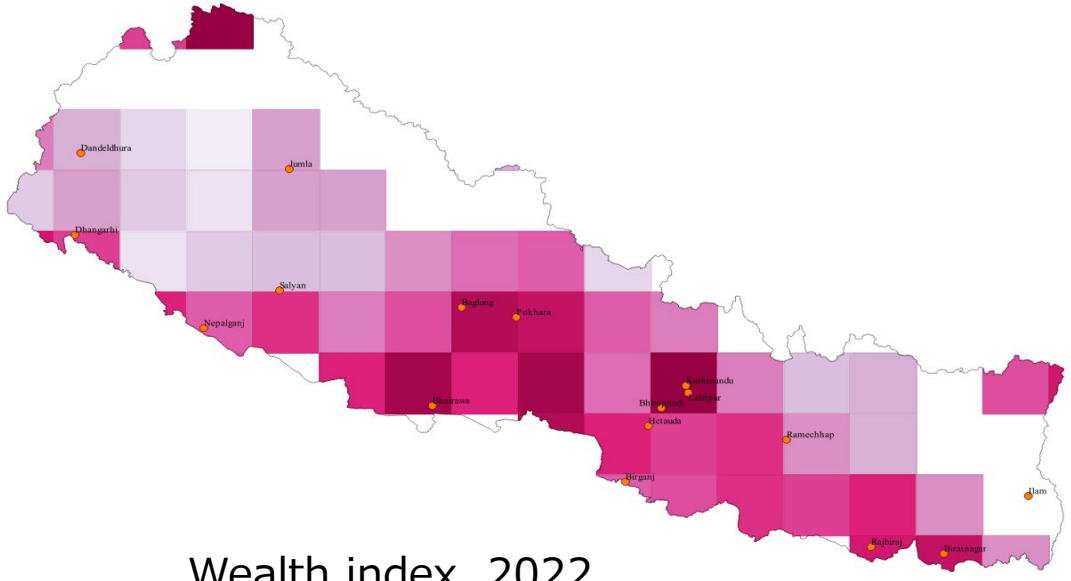
Wealth index, 2021

Wealth index and Trade Connectivity, Nepal



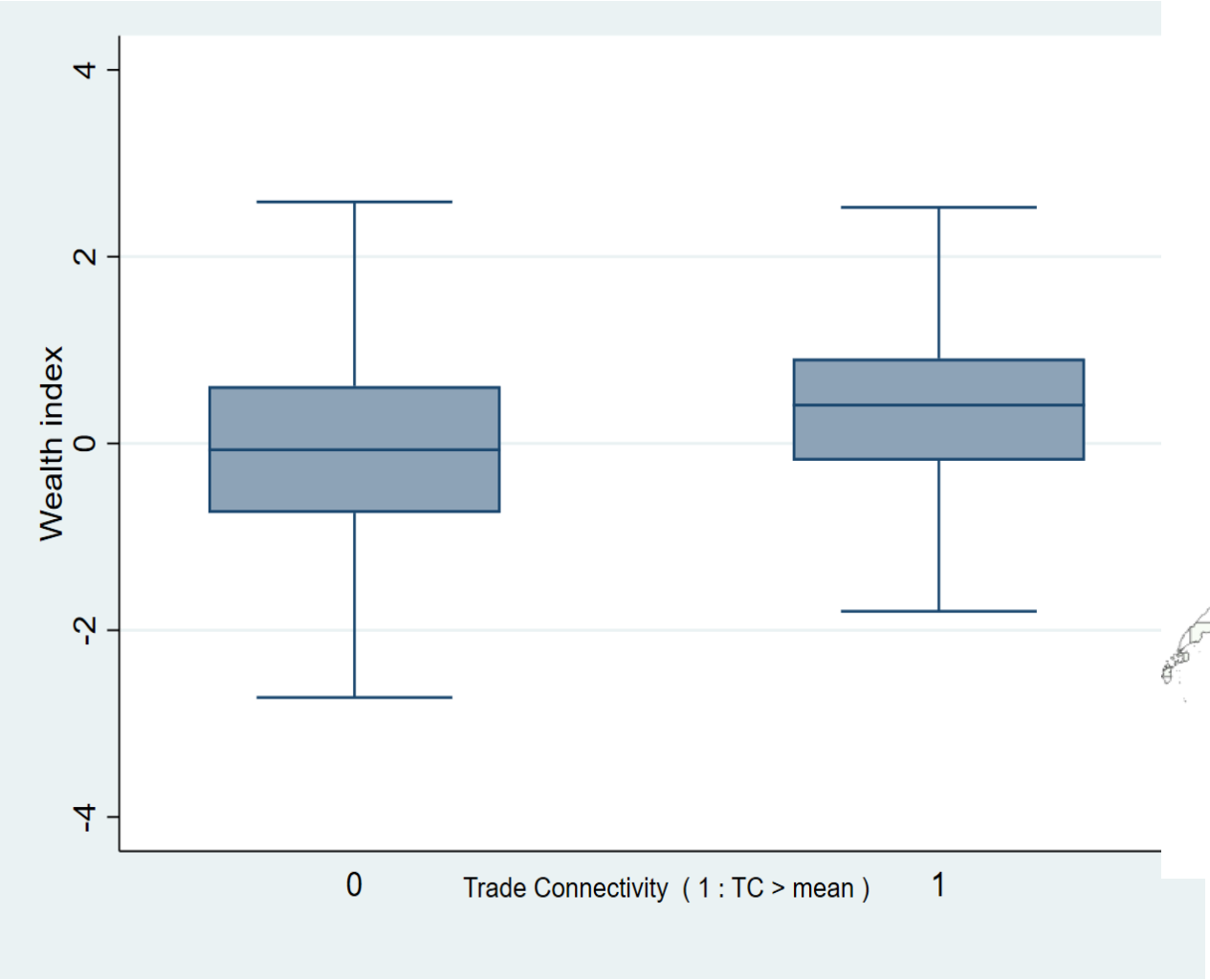


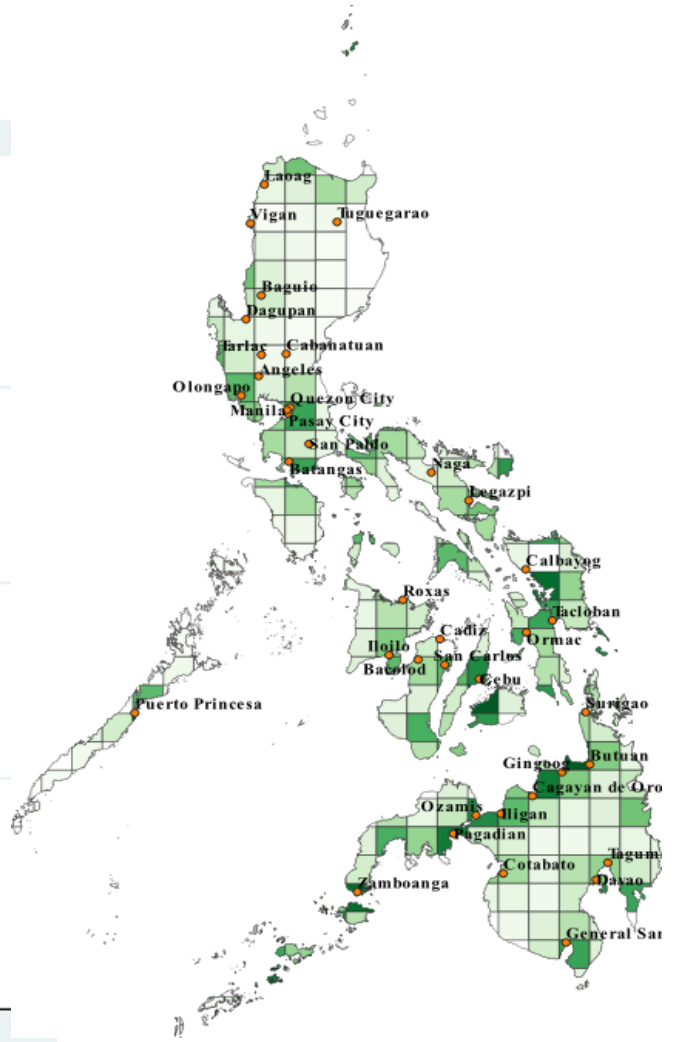
Trade Connectivity, 2022



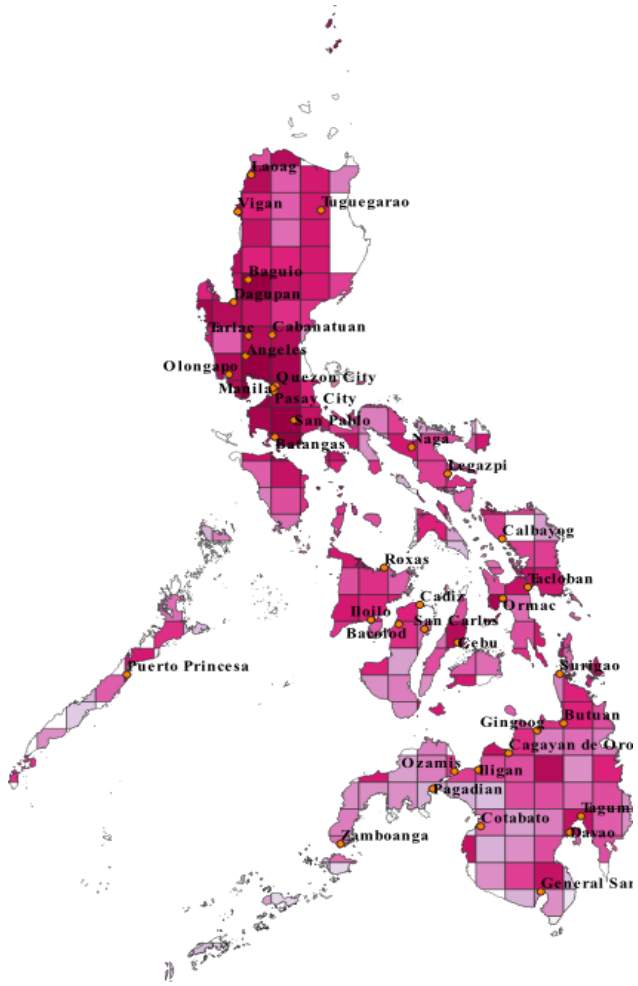
Wealth index, 2022

Wealth index and Trade Connectivity, Philippines





Trade Connectivity



Wealth index, 2023

4. Results

4.1 Baseline estimation

4.2 Normalized variance decomposition

4.1 Estimation results of RE model

	Bangladesh		Cambodia		Nepal		The Philippines	
	Coefficient	Rt std err.	Coefficient	Rt std err.	Coefficient	Rt std err.	Coefficient	Rt std err.
Trade Connectivity (TC)	0.139	(0.0461) ***	0.075	(0.0371) **	0.364	(0.1004) ***	-0.001	(0.0017)
TradeConnecitivity * Share of Agriculture	-0.105	(0.2909)	0.034	(0.0643)	0.912	(0.1746) ***	-0.017	(0.0152)
TradeConnecitivity * Share of Manufacture	1.010	(0.2678) ***	0.031	(0.0740)	3.262	(1.3200) ***	0.041	(0.0149) ***
TradeConnecitivity * HumanCapital (Educational level)	0.021	(0.1192)	-0.043	(0.0351)	0.077	(0.0609)	0.003	(0.0021)
TradeConnecitivity * Urbanization	-0.096	(0.0227) ***	-0.037	(0.0175) **	-0.134	(0.0336) ***	-0.001	(0.0009)
Share of Agriculture	-1.152	(0.4225) ***	-2.345	(0.2812) ***	-2.594	(0.3238) ***	-2.378	(0.3685) ***
Share of Manufacture	-0.493	(1.0759)	-0.789	(0.3969) **	-0.843	(1.5206)	-1.233	(0.4827) ***
HumanCapital (Educational level)	0.883	(0.1723) ***	0.313	(0.0486) ***	0.378	(0.0924) ***	0.123	(0.0809)
Urbanization	0.713	(0.2574) ***	0.692	(0.3325) **	1.016	(0.3057) ***	-0.019	(0.0811)
Elevation_mean	0.015	(0.0258)	-0.006	(0.0056)	0.001	(0.0020)	0.006	(0.0020) ***
Infrastructure (Road length)	316.9	(129.21) ***	264.3	(151.30) *	98.5	(65.45)	286.5	(44.01) ***
Water ways length	-1351.6	(414.04) ***	-128.2	(333.85)	-666.7	(221.66) ***	500.5	(190.59) ***
Year_1	-0.082	(0.0698)	-0.029	(0.0693)	-0.007	(0.0763)	-0.021	(0.0610)
Year_2	-0.068	(0.0981)	-0.038	(0.0818)	-0.007	(0.0849)	0.075	(0.0635)
Year_3	-0.031	(0.0722)	-0.028	(0.0881)	-0.049	(0.1075)	0.082	(0.0664)
Year_4	0.005	(0.0792)	-0.024	(0.0858)	-0.070	(0.1060)		
Constant	-3.164	(5.3641)	0.950	(1.1735)	-0.034	(0.3895)	-1.851	(0.3615) ***
sigma_u	0.466		0.202		0.252		0.552	
sigma_e	0.462		0.425		0.452		0.545	
rho	0.505		0.184		0.237		0.50657188	
Number of obs (groups)	345	(77)	388	(87)	283	(66)	766	(239)
R-squared: Between	0.607		0.8604		0.7674		0.4777	

4.2 Variance Decomposition of TC and Wealth disparity

	Bangladesh	Cambodia	Nepal	Philppines
Overall contribution of trade connectivity (%)	2.23%	1.20%	10.17%	0.72%
Residuals (%)	97.77%	98.80%	89.83%	99.28%
Trade connectivity				
Share of Geographic Dispersion (%)	98.616	105.996	112.8018	22.3979
Share of Heterogeneity of returns (%)	4.521	5.132	7.9966	73.3962
Share of covariance (%)	-3.136	-11.128	-20.7984	4.2059
Heterogeneity in returns				
β (mean return)	0.139	0.07508	0.36379	-0.00132
SD (β)	0.046	0.03937	0.17757	0.00400
CV : coefficient of variation	0.328	0.52435	0.48810	3.03272
share of regions with β <0, %	0.58%	1.03%	3.89%	67.23%

Answer to RQ1:

- In all four countries, most spatial wealth inequality (89–99%) is not explained by trade connectivity.
- Regional wealth inequalities are driven mainly by differences in region-specific conditions, such as infrastructure, terrain, and agricultural productivity.
- The effect of trade connectivity is exceptionally large in Nepal.

$\Rightarrow$ One possible reason is that, as a landlocked country, Nepal has structurally large regional disparities in access to ports (dry ports).

Answer to RQ2:

- In Bangladesh, Cambodia, and Nepal, geographic dispersion, the uneven distribution of trade connectivity, is the dominant channel.
- In the Philippines, heterogeneous returns appear more important, although the result is statistically weak.
- Thus, in most countries, regional disparities are driven mainly by spatial differences in connectivity, suggesting that infrastructure and logistics improvements in inland and remote areas can help reduce inequality.
- In the Philippines, by contrast, the key issue is that similar levels of trade connectivity generate different wealth outcomes across regions, highlighting the importance of industrial structure, human capital, and agglomeration.
- The covariance term is negative in Bangladesh, Cambodia, and Nepal, suggesting diminishing returns to connectivity, but positive in the Philippines, where highly connected regions also enjoy higher returns.

5. Conclusion

- The overall effect of trade connectivity on regional disparities is limited.
- In all four countries, the total contribution of trade connectivity is low (0.7–10.2%), indicating that it is not a major driver of inequality.
- Nepal is a partial exception, where the contribution is relatively larger, suggesting that improvements in connectivity may have a meaningful effect on disparities.
- Although the overall effect is small, the underlying mechanisms differ across countries.
- In Bangladesh, Cambodia, and Nepal, geographic dispersion is the dominant channel, whereas in the Philippines, heterogeneous returns are more important though evidence is statistically weak.
- Accordingly, reducing regional disparities may require different policies: improving trade connectivity in geographically disadvantaged regions in the former group, and strengthening human capital and promoting industrial agglomeration in secondary cities in the latter.

Thank you!