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# PGI Methodology Note

Empirical Annexes — PGCCF Scoring and Robustness Analysis

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## Introduction

This document provides the empirical annexes to the PGI Methodology Note v2.1. The main body (Sections 1–10) documents the PGCCF framework, data sources, and aggregation pipeline. This version replaces the placeholder annexes with complete results using verified Tier 1 data.

Three contributions are presented. First, twelve-country dimension scores with a four-aggregation comparison demonstrating the effect of aggregation choice. Second, a Monte Carlo sensitivity analysis with 10,000 random weight permutations. Third, a leave-one-dimension-out robustness test including a D7 endogeneity check.

Interpretive note: Tier 1 scores use publicly available macro-indicators (WGI, CPI, WUENIC, GHED) as governance proxies. These scores demonstrate the mathematical behaviour of the PGCCF under different aggregation functions. They do not represent micro-level procurement process quality, which requires operational data currently in development.

# Annex A: Twelve-Country PGCCF Scoring

## A.1 Data Sources

Scoring uses: Corruption Perceptions Index 2024 (Transparency International), WUENIC 2024 (WHO/UNICEF), Worldwide Governance Indicators 2023 on the 0–100 absolute governance score scale (World Bank), WHO Global Benchmarking Tool maturity levels, Gavi Alliance eligibility data, and WHO Global Health Expenditure Database trends.

| Country | Region | Income | CPI | DTP3 % |
|---|---|---|---|---|
| Indonesia | SE Asia | UMIC | 37 | 78 |
| Argentina | Latin America | UMIC | 37 | 82 |
| Colombia | Latin America | UMIC | 39 | 89 |
| Serbia | Europe | UMIC | 35 | 88 |
| Kenya | Africa | LMIC | 32 | 91 |
| Philippines | SE Asia | LMIC | 33 | 71 |
| Egypt | MENA | LMIC | 30 | 97 |
| Nigeria | Africa | LMIC | 26 | 67 |
| Kazakhstan | Central Asia | UMIC | 40 | 95 |
| Ethiopia | Africa | LIC | 37 | 65 |
| Uzbekistan | Central Asia | LMIC | 32 | 99 |
| Azerbaijan | Caucasus | UMIC | 22 | 51 |

## A.2 Dimension Scores

Eleven dimensions scored on a 0–100 scale. D1 (Evidence Alignment) measures policy intent via antigen schedule completeness; coverage execution belongs exclusively to D7 (Population Readiness). This separation ensures no WUENIC data cross-contamination between dimensions.

### Process Quality Dimensions (D1–D6)

| Country | D1 | D2 | D3 | D4 | D5 | D6 |
|---|---|---|---|---|---|---|
| Indonesia | 100 | 47 | 58 | 48 | 55 | 42 |
| Argentina | 100 | 58 | 51 | 53 | 81 | 39 |
| Colombia | 100 | 45 | 52 | 55 | 43 | 40 |
| Serbia | 86 | 41 | 54 | 55 | 41 | 37 |
| Kenya | 100 | 44 | 46 | 44 | 53 | 30 |
| Philippines | 57 | 40 | 54 | 45 | 41 | 32 |
| Egypt | 43 | 32 | 49 | 54 | 36 | 37 |
| Nigeria | 71 | 38 | 37 | 52 | 50 | 29 |
| Kazakhstan | 71 | 41 | 55 | 37 | 40 | 41 |
| Ethiopia | 86 | 41 | 39 | 42 | 51 | 34 |
| Uzbekistan | 71 | 36 | 45 | 34 | 38 | 30 |

| Country | D1 | D2 | D3 | D4 | D5 | D6 |
|---|---|---|---|---|---|---|
| Azerbaijan | 57 | 28 | 53 | 31 | 34 | 23 |

### System Context Dimensions (D7–D11)

| Country | D7 | D8 | D9 | D10 | D11 |
|---|---|---|---|---|---|
| Indonesia | 81 | 71 | 63 | 66 | 44 |
| Argentina | 79 | 50 | 42 | 65 | 58 |
| Colombia | 91 | 36 | 53 | 63 | 61 |
| Serbia | 85 | 36 | 54 | 61 | 61 |
| Kenya | 89 | 47 | 55 | 68 | 53 |
| Philippines | 65 | 30 | 49 | 64 | 55 |
| Egypt | 95 | 68 | 49 | 54 | 52 |
| Nigeria | 67 | 33 | 44 | 66 | 57 |
| Kazakhstan | 94 | 36 | 54 | 58 | 37 |
| Ethiopia | 57 | 25 | 40 | 63 | 51 |
| Uzbekistan | 99 | 30 | 55 | 50 | 39 |
| Azerbaijan | 68 | 24 | 42 | 44 | 40 |

## A.3 Four-Aggregation Comparison

Identical input data scored under four aggregation functions. Rank positions shown in parentheses.

| Country | AM (Rank) | GM (Rank) | pGM (Rank) | PGCCF (Rank) | Band |
|---|---|---|---|---|---|
| Indonesia | 61.4 (#2) | 59.3 (#1) | 54.8 (#1) | 54.8 (#1) | B |
| Argentina | 61.5 (#1) | 59.1 (#2) | 54.3 (#2) | 54.3 (#2) | B |
| Colombia | 58.1 (#3) | 55.3 (#3) | 49.1 (#3) | 49.1 (#3) | C |
| Serbia | 55.5 (#5) | 53.3 (#5) | 48.5 (#4) | 48.5 (#4) | C |
| Kenya | 57.2 (#4) | 54.2 (#4) | 47.7 (#5) | 47.7 (#5) | C |
| Philippines | 48.4 (#9) | 47.0 (#9) | 44.4 (#6) | 44.4 (#6) | C |
| Egypt | 51.7 (#6) | 49.4 (#6) | 44.2 (#7) | 44.2 (#7) | C |
| Nigeria | 49.5 (#8) | 47.5 (#8) | 43.7 (#8) | 43.7 (#8) | C |
| Kazakhstan | 51.3 (#7) | 48.9 (#7) | 43.4 (#9) | 43.4 (#9) | C |
| Ethiopia | 48.1 (#10) | 45.7 (#10) | 40.8 (#10) | 40.8 (#10) | C |
| Uzbekistan | 47.9 (#11) | 44.7 (#11) | 37.0 (#11) | 37.0 (#11) | C |
| Azerbaijan | 40.4 (#12) | 38.1 (#12) | 33.7 (#12) | 33.7 (#12) | C |

AM = arithmetic mean. GM = geometric mean. pGM = penalised geometric mean per Mariani and Ciommi (2022): GM × (1 – CV²). PGCCF = pGM with Critical Floor. Band thresholds: A ≥ 75, B ≥ 50, C ≥ 25, D < 25. Spearman ρ (AM vs PGCCF) = 0.937. Two countries shift ≥ 2 rank positions.

Indonesia rises from rank 2 (AM) to rank 1 (PGCCF) — its governance profile is the most balanced (CV 27.4%). Argentina falls from rank 1 to rank 2 — its strong average masks weak budget stability (D9 = 42). Kazakhstan drops from rank 7 to rank 9 — the highest CV (33.6%) reflects extreme imbalance. Philippines rises from rank 9 to rank 6 — the lowest CV (23.4%) rewards its balanced profile.

### A.3.1 pGM and PGCCF Equivalence

The pGM and PGCCF produce identical scores because no country in this cohort has a dimension below the Critical Floor threshold. The Critical Floor is documented in Section 7.3 of the main Methodology Note but dormant here. Section A.4 below demonstrates its behaviour using a simulated governance shock.

## A.4 Simulated Capture Shock

To demonstrate the mathematical divergence between the pGM and the full PGCCF, we simulate a procurement integrity collapse in Nigeria by setting D6 (Procurement Integrity) to 10, representing a total breakdown in procurement governance for a single dimension while all others remain unchanged.

| Scenario | D6 | pGM Score | PGCCF Score | Floor Triggered | Band |
|---|---|---|---|---|---|
| Nigeria baseline | 29 | 43.7 | 43.7 | No | C |
| Nigeria D6 collapse | 10 | 37.5 | 25.0 | Yes (1 dim < 15) | C |

Under the standard pGM, the collapsed dimension drags the score down by 6.2 points. Under the PGCCF, the Critical Floor penalty activates when any dimension falls below 15, capping the composite at 25 (the absolute floor of Band C). The total PGCCF drop is 18.7 points — three times the pGM penalty. This demonstrates the mechanism: the Critical Floor prevents a high aggregate score from coexisting with catastrophic failure in any single governance dimension.

> The Critical Floor addresses a specific real-world pattern: procurement capture typically produces catastrophic failure in one dimension (e.g., total collapse of procurement integrity) while leaving others intact. The arithmetic and geometric means attenuate this signal; the Critical Floor amplifies it.

## A.5 Transformation Rules

Each dimension uses weighted combinations of normalised indicators. Categorical variables are mapped to the 0–100 scale via the following ordinal mappings:

| Variable | Category | Score |
|---|---|---|
| WHO GBT NRA Maturity | ML4 (benchmarked) | 80 |
| | ML3 (operational) | 60 |
| | ML3 (medicines only) | 40 |
| | ML2 (developing) | 40 |
| | ML1 (baseline) | 20 |
| | None / not assessed | 10 |
| Market Structure | Competitive (3+ suppliers) | 80 |
| | Limited (2 suppliers) | 50 |
| | Monopoly (1 supplier) | 20 |

| Variable | Category | Score |
|---|---|---|
| NITAG Status | Functional with COI policy | 100 |
| | Functional, no COI policy | 60 |
| | Exists, no public minutes | 40 |
| | None | 0 |
| GHED Trend | Increasing | 70 |
| | Stable | 50 |
| | Declining | 20 |
| Manufacturing Capacity | DCVMN + WHO PQ | 90 |
| | Active, no PQ | 60 |
| | Fill/finish only | 40 |
| | None | 20 |
| Gavi Status (D8) | Transitioning | 70 |
| | Transitioned | 60 |
| | Never eligible (self-financing) | 50 |
| | Eligible | 40 |
| Gavi Engagement (D10) | Eligible / Transitioning | 70 |
| | Transitioned | 60 |
| | Never eligible | 50 |
| Income Class | UMIC | 60 |
| | LMIC | 45 |
| | LIC | 30 |
| JRF Compliance | Complete | 80 |
| | Partial | 50 |
| | Missing | 10 |
| DTP Dropout Penalty | Formula: max(0, 100 – dropout × 5) | |
| | 0% dropout = 100; 10% = 50; 20% = 0 | |
| MCV Dropout Penalty | Formula: max(0, 100 – dropout × 3) | |
| | 0% dropout = 100; 17% = 49; 33% = 0 | |

Dimension formulas:

| Dimension | Formula |
|---|---|
| D1 Evidence Alignment | Antigen completeness: (N / 7) × 100 |
| D2 Procedural Transparency | CPI × 0.5 + Voice and Accountability × 0.3 + NITAG × 0.2 |
| D3 Admin. Responsiveness | Gov. Effectiveness × 0.7 + Regulatory Quality × 0.3 |
| D4 Specification Quality | NRA maturity × 0.5 + Market structure × 0.3 + Reg. Quality × 0.2 |

| Dimension | Formula |
|---|---|
| D5 Advisory Independence | NITAG × 0.6 + CPI × 0.2 + Voice and Accountability × 0.2 |
| D6 Procurement Integrity | CPI × 0.4 + Control of Corruption × 0.4 + NRA maturity × 0.2 |
| D7 Population Readiness | DTP1 × 0.4 + DTP dropout penalty × 0.4 + MCV dropout × 0.2 |
| D8 Industrial Policy | NRA × 0.4 + Manufacturing capacity × 0.35 + Gavi status × 0.25 |
| D9 Budget Stability | GHED trend × 0.4 + Income class × 0.3 + Gov. Effectiveness × 0.3 |
| D10 Intl. Engagement | JRF × 0.35 + Gavi engagement × 0.35 + Voice and Acct. × 0.3 |
| D11 Market Competition | Market structure × 0.4 + Reg. Quality × 0.3 + NRA × 0.3 |

D1 uses antigen schedule completeness only. Coverage execution data (WUENIC) feeds exclusively into D7, eliminating any cross-dimensional data contamination.

# Annex B: Robustness Analysis

## B.1 Monte Carlo Sensitivity Analysis

Ten thousand random weight permutations drawn uniformly from [0.05, 0.15], normalised to sum to one. Deterministic seed (42) for reproducibility.

| Country | Modal Rank | Modal % | Mean Rank | Range | Max Shift |
|---|---|---|---|---|---|
| Indonesia | 1 | 64.8% | 1.4 | 1–2 | 1 |
| Argentina | 2 | 64.8% | 1.6 | 1–2 | 1 |
| Colombia | 3 | 90.3% | 3.1 | 3–5 | 2 |
| Serbia | 4 | 78.8% | 4.2 | 3–5 | 2 |
| Kenya | 5 | 78.7% | 4.7 | 3–6 | 3 |
| Philippines | 7 | 41.9% | 6.8 | 6–9 | 3 |
| Egypt | 6 | 42.3% | 7.2 | 5–10 | 5 |
| Nigeria | 9 | 31.9% | 7.8 | 6–9 | 3 |
| Kazakhstan | 9 | 47.5% | 8.2 | 6–10 | 4 |
| Ethiopia | 10 | 96.0% | 10.0 | 8–10 | 2 |
| Uzbekistan | 11 | 100.0% | 11.0 | 11 | 0 |
| Azerbaijan | 12 | 100.0% | 12.0 | 12 | 0 |

Top-2 invariant: Indonesia and Argentina remain in positions 1–2 across all 10,000 simulations. Bottom-2 invariant: Uzbekistan rank 11 and Azerbaijan rank 12 in 100% of draws. Ten of twelve countries remain within three rank positions. The mid-table zone (positions 6–9) shows expected adjacency variation reflecting the narrow score differences between Philippines, Egypt, Nigeria, and Kazakhstan.

## B.2 Leave-One-Dimension-Out

Each dimension removed in turn; Spearman ρ measures ranking stability against the full eleven-dimension baseline.

| Removed Dimension | Max Shift | Spearman ρ | Influence |
|---|---|---|---|
| D1 Evidence Alignment | 1 | 0.993 | LOW |
| D2 Procedural Transparency | 1 | 0.993 | LOW |
| D3 Administrative Responsiveness | 2 | 0.958 | MODERATE |
| D4 Specification Quality | 3 | 0.937 | HIGH |
| D5 Advisory Independence | 1 | 0.986 | LOW |
| D6 Procurement Integrity | 2 | 0.951 | MODERATE |
| D7 Population Readiness | 2 | 0.965 | MODERATE |
| D8 Industrial Policy Coherence | 3 | 0.951 | HIGH |
| D9 Budget Commitment Stability | 1 | 0.986 | LOW |
| D10 International Engagement | 1 | 0.993 | LOW |
| D11 Market Competition Quality | 3 | 0.951 | HIGH |

All removals maintain Spearman ρ ≥ 0.937. No single dimension drives the rankings. The D7 endogeneity check (removing Population Readiness) yields ρ = 0.965, confirming that coverage data does not drive the composite. With the purified D1 (antigen completeness only), WUENIC data feeds exclusively into D7, eliminating any cross-dimensional contamination. The full paper will report both eleven-dimension and ten-dimension (D7 excluded) specifications.

The high inter-dimensional correlation in this twelve-country sample reflects macro governance co-movement, not conceptual redundancy. Dimensions are retained on the HDI precedent: even when statistically correlated, they target distinct policy interventions. Empirical independence testing is planned for n ≥ 20.