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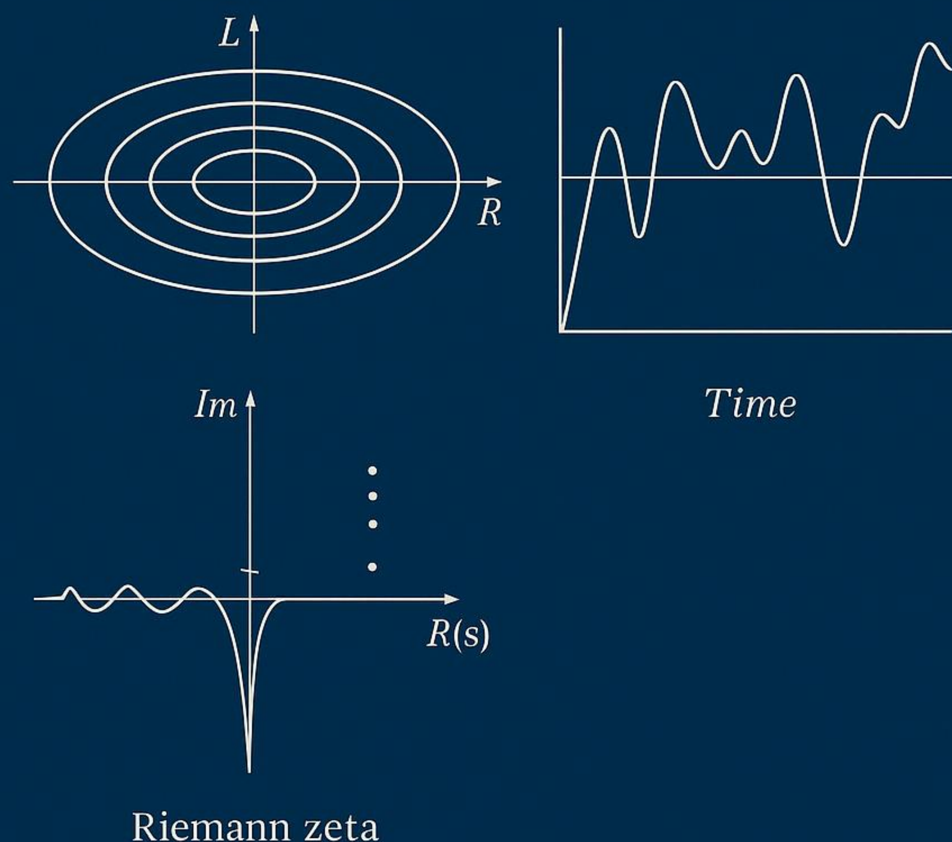

Gondauri Index (GI): Methodology for a Clay Millennium-Problems–Driven Macro-Financial Index

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Abstract

The Gondauri Index (GI) is introduced as a novel macro-financial composite index grounded in the Clay Millennium Problems and applied to economic modeling. It integrates three sub-indices: the Inequality–Ricci Subindex (IRS), measuring income distribution stability through Ricci flow dynamics; the Liquidity–Navier–Stokes Resilience (LNSR), capturing systemic robustness via fluid dynamics analogies; and the Inflation FPAS+ζ Credibility (IFC), enhancing inflation forecasting through hybrid FPAS–Riemann zeta methods. Each subindex is normalized on a 0–100 scale, with the final GI computed as a weighted geometric mean (35% IRS, 35% LNSR, 30% IFC). The methodology combines statistical calibration, normalization, and error-reduction benchmarks, ensuring reliability and policy applicability. The GI provides a consolidated, forward-looking metric for evaluating inequality, financial stability, and inflation expectations, offering policymakers and researchers a robust tool for decision-making in complex socio-economic environments.

Keywords: Gondauri Index, Ricci Flow, Navier–Stokes, Riemann Zeta, Inequality, Liquidity, Inflation Forecasting, Macro-Financial Index

Introduction

This methodology is explicitly built on three research papers authored by Davit Gondauri. Each paper operationalizes a distinct Clay Mathematics Institute (CMI) Millennium Problem in an economic setting, and together they provide the intellectual and empirical foundation for the Gondauri Index (GI). Accordingly, GI should be read as a unified application of Millennium-Problem insights to macro-financial analysis—inequality (Ricci flow), liquidity/systemic risk (Navier–Stokes), and inflation forecasting (Riemann ζ integrated with FPAS).

In other words, GI is not a standalone construct; it is the consolidated, policy-ready form of these three Millennium-inspired studies, designed to translate advanced mathematical structures into transparent indicators and reproducible procedures fit for economic policy and research workflows.

Introduction

The Gondauri Index (GI) consolidates three high-impact, innovation-led strands—Perelman/Ricci-flow inequality dynamics, Navier–Stokes–based systemic liquidity resilience, and FPAS augmented with the Riemann $\zeta(0.5+i\cdot t)$ signal—into a single, policy-relevant gauge. GI is designed to reflect whether an economy becomes more inclusive (lower inequality risk), more resilient to liquidity shocks, and more forecastable in inflation dynamics. By construction, GI rewards balanced progress across these pillars via a geometric aggregation, thereby penalizing fragility in any single dimension.

Why this matters: conventional macro-financial metrics often silo inequality, liquidity, and price stability, obscuring cross-channel feedbacks that shape real outcomes. GI integrates these channels in a mathematically coherent way: (i) the Ricci-flow lens reveals structural drivers and smoothing dynamics in inequality; (ii) the Navier–Stokes analog captures flow speeds, pressures, and residual forces central to systemic stability; and (iii) FPAS+ζ improves predictive credibility by detecting cyclical irregularities and regime shifts. The result is a compact, comparable score useful for central banks, ministries of finance, and research institutions for quarterly monitoring, scenario analysis, communication, and benchmarking.

Methodological distinctiveness: GI employs robust percentile scaling, Fourier/HMM diagnostics, and a clear decomposition into subindices (IRS, LNSR, IFC). It is implementation-ready: a transparent data table outlines sources and frequency, while the appendix provides a toy end-to-end computation. This design enables reproducibility and incremental extension (e.g., adding peers or higher-frequency nowcasts).

Foundational Research Basis

GI is grounded in three peer-reviewed works by Davit Gondauri that adapt CMI Millennium Problems to economics. Each contribution underpins one GI pillar:

- Inequality–Ricci (IRS): Perelman/Ricci-flow framework adapted to inequality dynamics with multi-indicator econometric validation; delivers structural smoothing and high explanatory power for Gini trajectories.

- Liquidity–Navier–Stokes (LNSR): Extended Navier–Stokes analog for financial systems capturing liquidity speed, pressure/stress and residual force; with Fourier coherence to business cycles for systemic resilience assessment.
- Inflation FPAS + ζ (IFC): Structural FPAS augmented by the Riemann ζ(0.5 + i·t) signal, leveraging Fourier/HMM tools to enhance forecast credibility vis-à-vis FPAS/ARIMA baselines.

Reference mapping: IRS → inequality/Ricci article; LNSR → liquidity/Navier–Stokes article; IFC → FPAS+ζ article. These three works constitute the documentary basis for GI as a separate, integrative index.

1. Concept and Architecture

The Gondauri Index (GI) is a composite indicator integrating three innovation-led pillars derived from the author's research on transforming Clay Millennium Problems into economics:

- IRS – Inequality–Ricci Subindex (Perelman/Ricci flow–based inequality dynamics);
- LNSR – Liquidity–Navier–Stokes Resilience (systemic liquidity stress and residual force);
- IFC – Inflation Forecast Credibility (FPAS + ζ(0.5 + i·t) with Fourier/HMM diagnostics).

Higher GI indicates a more inclusive, shock-resilient, and forecastable macro-financial environment.

2. Normalization (0–100)

Metric-level scores are robustly scaled between the 5th and 95th percentiles within a benchmark pool (time or cross-country). Scores are clipped to [0, 100].

Equation (1): Robust percentile scaling

$$Score_m = 100 \times \frac{x_m - p_{5}(m)}{p_{95}(m) - p_{5}(m)} \quad \text{(clip to 0–100)}$$

(1)

3. Subindex Definitions

3.1 Inequality–Ricci Subindex (IRS)

Inputs: model explanatory power for inequality (e.g., R^2), normalized projected 12-month absolute change in the Gini coefficient (penalized), and the normalized Ricci/entropy smoothing signal.

Equation (2): IRS weighted aggregation

$$IRS = 0.40 \cdot Score(R^2) + 0.40 \cdot Score\!\left(Inv|\widehat{\Delta Gini}_{12m}|\right) + 0.20 \cdot Score(\widehat{\mathcal{S}})$$

(2)

3.2 Liquidity–Navier–Stokes Resilience (LNSR)

Inputs: inverse variation of liquidity speed v_t, inverse RMS of the model residual force ε_t (balance of left/right sides of the extended Navier–Stokes analog), and Fourier coherence with the business cycle.

Equation (3): LNSR weighted aggregation

$$LNSR = 0.35 \cdot Score\!\left(InvVar(v)\right) + 0.35 \cdot Score\!\left(InvRMS(\varepsilon)\right) + 0.30 \cdot Score\!\left(Coh_{Fourier}\right)$$

(3)

3.3 Inflation Forecast Credibility (IFC)

Inputs: RMSE improvements versus FPAS and ARIMA baselines, Hidden Markov Model (HMM) phase classification accuracy, and the match between ζ-spectrum and macro cycles.

Equation (4): IFC weighted aggregation

$$IFC = 0.35 \cdot Score(\Delta RMSE_{FPAS}) + 0.25 \cdot Score(\Delta RMSE_{ARIMA}) + 0.25 \cdot Score(Acc_{HMM}) + 0.15 \cdot Score(Match_{\zeta\text{-}spec})$$

(4)

4. Composite Aggregation

The GI is the (weighted) geometric mean of subindices to reward balance and penalize weakness in any single pillar.

Equation (5): GI geometric mean

$$GI = \left(IRS^{w_1} \times LNSR^{w_2} \times IFC^{w_3} \right)^{\frac{1}{w_1 + w_2 + w_3}} \quad \text{with } (w_1, w_2, w_3) = (0.35, 0.35, 0.30)$$

(5)

5. Auxiliary Metric Definitions

Inverse-variation and inverse-residual metrics stabilize the scale and emphasize smoother, more balanced systems. RMSE deltas quantify predictive improvements of FPAS+ζ over standard FPAS/ARIMA baselines.

Equation (6): Inverse variation of liquidity speed

$$InvVar(v) = \frac{1}{1 + Var(v_t)}$$

(6)

Equation (7): Inverse RMS of residual force

$$InvRMS(\varepsilon) = \frac{1}{1 + RMS(\varepsilon_t)}$$

(7)

Equation (8): RMSE improvement vs FPAS baseline

$$\Delta RMSE_{FPAS} = 100 \times \frac{RMSE(FPAS) - RMSE(FPAS + \zeta)}{RMSE(FPAS)}$$

(8)

Equation (9): RMSE improvement vs ARIMA baseline

$$\Delta RMSE_{ARIMA} = 100 \times \frac{RMSE(ARIMA) - RMSE(FPAS + \zeta)}{RMSE(ARIMA)}$$

(9)

6. FPAS + ζ Integration

Let π denote inflation. The FPAS+ζ model augments the structural FPAS prediction with a calibrated ζ-signal capturing cyclical irregularities along the critical line. The α parameter is fit (e.g., by minimizing RMSE on a validation window).

Equation (10): FPAS+ζ inflation model

$$\pi_{FPAS+\zeta} = \pi_{FPAS} + \alpha \cdot \left(\zeta(0.5 + i \cdot t) - \overline{\zeta}\right)$$

(10)

Here t may be modeled as a transformed macro time base (e.g., linked to log-levels of GDP, M3, policy rate, etc.), and $\overline{\zeta}$ denotes a smoothed reference (e.g., moving average) to avoid drift. Fourier/HMM diagnostics are used to quantify cycle matching and regime-dependence.

7. Data, Updates, and Validation

Coverage and frequency: IRS (quarterly), LNSR (monthly/quarterly depending on liquidity data), IFC (monthly with quarterly roll-ups). Benchmark scaling pools: country-historical and/or a regional peer set. Validation includes rolling backtests, stability charts, and Diebold–Mariano tests.

8. Interpretation Scale

GI ∈ [0, 100]. Suggested bands: 80–100 = High resilience & inclusivity; 60–79 = Moderate/Improving; <60 = Vulnerable/Watchlist.

9. Citation Notes

This document consolidates and operationalizes methodological elements from three research lines: (i) inequality dynamics via Ricci/Perelman flow; (ii) liquidity/systemic risk via extended Navier–Stokes analog and Fourier diagnostics; (iii) inflation forecasting via FPAS augmented with $\zeta(0.5 + i \cdot t)$, Fourier and HMM tools.

Equation (A5): GI (numeric, corrected)

$$GI = \left(0.00^{w_1} \times 0.00^{w_2} \times 0.00^{w_3}\right)^{\frac{1}{w_1 + w_2 + w_3}} \\ \text{with } (w_1, w_2, w_3) = (0.35, 0.35, 0.30) \\ \approx 0.00$$

(A5)

Author's Note: Applied Millennium Program (AMP)

The Applied Millennium Program (AMP) is an ongoing research initiative led by Davit Gondauri that translates the Clay Mathematics Institute's Millennium Problems into operational economic and financial models. AMP's mission is to bridge advanced mathematics and policy by:

• Designing tractable analogs (Ricci flow for inequality; Navier–Stokes for liquidity/systemic risk; Riemann ζ for inflation cycles);

• Validating models with national statistics, central-bank indicators, and market data, emphasizing reproducibility and open science;

• Publishing transparent code/data artifacts (e.g., versioned CSVs and notebooks) to enable independent replication, peer benchmarking, and quarterly surveillance;
• Curating integrative, policy-ready indices (e.g., the Gondauri Index) that communicate complex dynamics in a compact, comparable format.

AMP is being expanded to multi-country panels and higher-frequency nowcast modules, with periodic releases planned on open repositories (e.g., Zenodo/OSF) to maximize accessibility, reuse, and scholarly impact.

Conclusion

Finally, we underscore that the Gondauri Index (GI) is an explicit synthesis of Davit Gondauri's three studies that embed CMI Millennium Problems into economics. By design, GI separates into IRS, LNSR, and IFC, each directly rooted in one of those papers, and recombines them through a geometric aggregation to produce a single, policy-ready score.
The Gondauri Index (GI) operationalizes a unified, innovation-centric view of macro-financial health. By blending inequality dynamics (IRS), liquidity/systemic resilience (LNSR), and inflation forecast credibility (IFC), GI enables a balanced assessment that is sensitive to structural and cyclical forces alike. The geometric aggregation rewards economies that avoid single-pillar fragility and achieve concurrent progress across inclusivity, stability, and predictability.

In practice, GI supports quarterly surveillance, peer benchmarking, policy dialogue, and forward-looking scenario work. Its modular architecture allows extensions—additional indicators, higher-frequency nowcasting, or cross-country panels—while retaining transparency via robust scaling and published code/data artifacts. As such, GI is not merely a score but a reproducible framework that translates advanced mathematical insights into actionable economic intelligence.

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