A Multi-Harmonic Index of Global Civilizational Coherence: Historical Reconstruction and Validation, 1810–2020

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Abstract

We introduce a multi-harmonic index of global civilizational coherence, $K(t)$, designed to track collective capacity for coordination, sense-making, and positive-sum cooperation over historical time. The index aggregates seven harmonies spanning technological, social, cognitive, and institutional dimensions: Resonant Coherence, Universal Interconnection, Sacred Reciprocity, Infinite Play, Integral Wisdom, Pan-Sentient Flourishing, and Evolutionary Progression. Using historical data from 1810–2020 CE and archaeological proxies extending to 3000 BCE, we reconstruct $K(t)$ and estimate global coherence in 2020 at $K_{2020} = 0.914$ (extended 7-harmony index including synthetic evolutionary progression) or $K_{2020} = 0.782$ (conservative 6-harmony index using only real data). We validate this estimate through three independent approaches: external correlation with established development indices (Human Development Index $r = 0.701$, KOF Globalisation Index $r = 0.701$), bootstrap confidence intervals (95% CI: [0.58, 1.00]), and sensitivity analysis (2.34% total variation under methodological perturbations). While current external validation is under-powered due to limited temporal overlap (n = 4–6 years), the directional consistency across multiple lines of evidence supports $K(t)$ as a provisional, exploratory measure of civilizational coherence. We discuss implications for the "Great Filter of Co-Creative Wisdom" hypothesis, economic design, and the challenge of fostering coordination capacity in the face of rapidly increasing technological power.

1 Introduction

The question of whether human civilization is becoming more coherent, fragmented, or stagnant over time is central to understanding both our past and our potential futures. While individual dimensions of progress—economic development, technological sophistication, democratic governance, global connectivity—have been extensively studied [United Nations Development Programme, 2023, Bolt and van Zanden, 2020, Gygli et al., 2019], no comprehensive index exists that integrates these multiple dimensions into a unified measure of civilizational coherence. Such an index would be valuable not only as a historical diagnostic, but also as a potential early-warning system for emerging coordination failures, institutional breakdown, or epistemic fragmentation that may precede civilizational decline or stagnation.

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In this paper, we introduce a **multi-harmonic index of global civilizational coherence**, $K(t)$, designed to track collective capacity for coordination, sense-making, and positive-sum cooperation over historical time. The index aggregates seven harmonies spanning technological, social, cognitive, and institutional dimensions: *Resonant Coherence* (alignment and order), *Universal Interconnection* (global connectivity), *Sacred Reciprocity* (positive-sum cooperation), *Infinite Play* (creative exploration), *Integral Wisdom* (epistemic capacity), *Pan-Sentient Flourishing* (broad welfare), and *Evolutionary Progression* (technological and institutional advancement). Each harmony is operationalized through multiple empirical proxies drawn from historical datasets spanning **1810–2020 CE** (our primary validated period). For exploratory purposes, we also present an extended reconstruction back to 3000 BCE using archaeological population proxies for evolutionary progression, though we emphasize that the 1810–2020 modern series represents our core empirical contribution.

Our central finding is that global coherence in 2020 stands at approximately $K_{2020} = 0.91$ (extended index) or $K_{2020} = 0.78$ (conservative index), representing a substantial increase from a moderate baseline ($K_{1810} \approx 0.52$) during the early Industrial Revolution. This increase reflects dramatic changes across multiple dimensions: near-universal literacy, global telecommunication networks, international institutions for cooperation, scientific and technological revolution, and expanding circles of moral concern. However, the index also reveals periods of sharp decline (e.g., World Wars, Cold War tensions) and suggests that current coherence levels, while historically high, remain well below theoretical maximum ($K = 1.0$), indicating substantial room for further coordination capacity building.

1.1 The Great Filter of Co-Creative Wisdom

Beyond its intrinsic historical interest, $K(t)$ can also be read as a diagnostic for a specific class of "Great Filter" hypotheses [Hanson, 1998, Sandberg et al., 2018]. Rather than assuming that civilizations end primarily through spectacular technological self-destruction—nuclear war, runaway nanotechnology, or catastrophic AI misalignment—the "Great Filter of Co-Creative Wisdom" hypothesis suggests that the dominant failure mode may be a **gradual collapse of trust, sense-making, and coordination capacity** [Schmachtenberger, 2019]. Under this view, civilizations that fail to develop the social and ethical capacities to match their rapidly growing technological power do not explode, but **stagnate and go silent**, unable to solve increasingly complex collective action problems at planetary scale.

$K(t)$ can be interpreted as a coarse-grained time series of global coherence that is relevant to this class of hypotheses: if civilizational maturity consists in part of enhanced coordination capacity, resilient sense-making, and trust across difference, then $K(t)$—as a composite of harmonies tracking these dimensions—provides an empirical object for exploring long-run dynamics of civilizational flourishing or fragility. We emphasize that our current work is primarily descriptive and exploratory rather than a direct test of any particular Great Filter mechanism; however, the framework provides a natural motivation for asking whether $K(t)$ continues to rise, saturates, or collapses as societies gain increasing technological leverage.

1.2 Paper Structure and Contributions

This paper makes four primary contributions:

1. **Conceptual Framework.** We define a seven-harmony framework for global civilizational coherence, integrating technological, social, cognitive, and institutional dimensions into a unified multi-dimensional diagnostic.

2. **Historical Dataset.** We assemble a 32-indicator dataset spanning 1810–2020 CE (with demographic proxies extending to 3000 BCE), drawing on established sources including V-Dem, World Bank, Maddison Project, HYDE, and others (see Supplementary Table S1).

3. **Empirical Reconstruction.** We reconstruct the global $K(t)$ index across two centuries, revealing a historically unprecedented but fragile peak around 2020 ($K_{2020} = 0.78$–0.91 depending on formulation). Our reconstruction identifies three distinct historical phases: industrial acceleration (1810–1910), catastrophic decoherence (1910–1950), and post-war convergence (1950–2020).

4. **Validation and Ethical Framework.** We provide three independent validation approaches (external indices, bootstrap confidence intervals, sensitivity analysis) and explicitly discuss Goodhart risks and dual-use concerns, emphasizing that $K(t)$ should function as a monitoring tool rather than an optimization target.

The remainder of this paper is organized as follows. Section 2 describes the construction of the seven harmonies and the aggregation methodology for computing $K(t)$, including a critical discussion of scale interpretation (historical vs aspirational coherence). Section 3 presents the historical reconstruction and validation analyses. Section 4 interprets these findings in the context of civilizational risk, economic design, and ethical considerations. Section 5 concludes with directions for future work.

2 Methods

2.1 Conceptual Framework: The Seven Harmonies

We operationalize global civilizational coherence, $K(t)$, as a composite index aggregating seven fundamental dimensions of coordination, sense-making, and cooperative capacity. This framework, derived from the theory of relational harmonics, posits that long-term civilizational resilience emerges from the balanced development of integration (H_1), connectivity (H_2), reciprocity (H_3), diversity (H_4), wisdom (H_5), wellbeing (H_6), and progression (H_7). Each dimension, or "Harmony," is quantified using a set of empirical proxies drawn from established historical and social science datasets.

The seven harmonies are defined as follows:

H_1: **Resonant Coherence (Governance & Integration).** Measures the quality of governance structures and the efficiency of communication networks that enable collective decision-making.

H_2: **Universal Interconnection (Connectivity).** Tracks the density of global trade networks and the magnitude of human migration flows, reflecting the physical and economic binding of the global system.

H_3: **Sacred Reciprocity (Positive-Sum Exchange).** Quantifies the symmetry of relationships in trade, alliances, and aid, distinguishing balanced interdependence from extractive dominance.

H_4: **Infinite Play (Innovation & Diversity).** Captures the diversity of cultural expression, technological innovation (patents), and occupational specialization, representing the system's capacity for creative exploration.

H_5: **Integral Wisdom (Epistemic Capacity).** Assesses collective investment in knowledge production (R&D), scientific workforce density, and the calibration of forecasting capabilities.

H_6: **Pan-Sentient Flourishing (Wellbeing).** Aggregates indicators of human health, education, economic standard of living, and environmental sustainability.

H_7: **Evolutionary Progression (Adaptive Complexity).** Tracks the scaling of technological and institutional complexity over long time horizons. *Note: For the extended time series (3000 BCE–2020 CE), this dimension relies on synthetic demographic proxies from the HYDE 3.2.1 database [Klein Goldewijk et al., 2017]. Specifically, we construct H_7 as a weighted combination of three HYDE-derived components: (i) technological sophistication proxied by urban population share, (ii) cognitive complexity proxied by* $\log(\textit{total population})$*, and (iii) institutional evolution proxied by cropland fraction of total land area. These are combined linearly with weights* $(0.40, 0.30, 0.30)$*, chosen to maximize in-sample* R^2 *against modern empirical progression indicators (1960–2020) while maintaining interpretability. This calibration yields* $R^2 = 0.999$*, indicating that the HYDE-based proxy closely tracks observed patterns in the modern period, though we emphasize this is an in-sample fit used for calibration rather than independent validation.*

2.2 Data Sources and Proxy Variables

We compiled a dataset of 32 proxy variables spanning the period 1810–2020 CE, with a subset of demographic proxies extending to 3000 BCE. Data sources were selected based on reliability, temporal coverage, and public availability.

Key data sources include:

Governance and Democracy: Varieties of Democracy (V-Dem) Project v14 [Coppedge et al., 2024] and Quality of Government (QoG) Institute data.

Economic and Trade Data: World Bank World Development Indicators (WDI), UN Comtrade database, and the Maddison Project Database 2020 [Bolt and van Zanden, 2020].

Population and Land Use: History Database of the Global Environment (HYDE) version 3.2.1 [Klein Goldewijk et al., 2017].

Innovation and Science: WIPO Patent Statistics and UNESCO Science Reports.

Social and Cultural Indicators: Our World in Data, Correlates of War Project, and Barro-Lee Educational Attainment Dataset.

A complete list of proxies, their sources, and temporal coverage is provided in Supplementary Table S1.

2.3 Mathematical Formulation

2.3.1 Normalization Procedures

To aggregate diverse indicators (e.g., life expectancy in years vs. trade as % of GDP) into a unified index, all proxy variables $p(t)$ were normalized to the unit interval $[0, 1]$. We employed two distinct normalization strategies depending on the temporal scope:

Century-Based Min-Max (Modern Series, 1810–2020): To preserve local variance while accommodating long-term trends, proxies were normalized relative to the minimum and maximum values observed within their respective centuries (c):

$$\tilde{p}(t) = \frac{p(t) - \min_{t\in c}(p(t))}{\max_{t\in c}(p(t)) - \min_{t\in c}(p(t))} \tag{1}$$

This approach ensures that $K(t)$ reflects coherence relative to the technological and institutional frontier of the era.

Epoch-Based Min-Max (Extended Series, 3000 BCE–2020 CE): For the deep historical analysis, we normalized within four historiographic epochs (Ancient, Medieval, Early Modern, Modern) to handle the orders-of-magnitude scaling differences in variables like population size.

Missing data were handled via linear interpolation for gaps ≤ 20 years within stable trends. Years with insufficient data coverage (< 2 proxies per harmony) were excluded from the primary analysis.

2.3.2 Harmony Aggregation

Each harmony score $H_d(t)$ for dimension d is calculated as the arithmetic mean of its n_d normalized proxies:

$$H_d(t) = \frac{1}{n_d} \sum_{i=1}^{n_d} \tilde{p}_{d,i}(t) \tag{2}$$

2.3.3 K-Index Calculation

The composite Global Civilizational Coherence Index, $K(t)$, is the weighted sum of the seven harmony scores:

$$K(t) = \sum_{d=1}^{D} w_d H_d(t) \tag{3}$$

We present two formulations of the index:

Six-Harmony $K(t)$ (Conservative): Aggregates the six empirically validated harmonies ($D = 6$) using equal weights ($w_d = 1/6$). This serves as our primary analysis for the modern period.

Seven-Harmony $K(t)$ (Extended): Includes the synthetic H_7 (Evolutionary Progression) dimension ($D = 7$, $w_d = 1/7$) to explore long-run dynamics back to 3000 BCE. **This formulation is considered exploratory due to the use of demographic proxies for H_7; the six-harmony version serves as our primary analysis.**

Equal weighting reflects the theoretical assumption that all dimensions contribute symmetrically to civilizational coherence; alternative weighting schemes are explored in sensitivity analyses (Section 2.5).

2.4 Interpreting the K(t) Scale: Historical vs Aspirational Coherence

It is essential to clarify what values of $K(t)$ represent. $K(t)$ is a **relative historical index**, normalized on the range of observed values between 1810 and 2020 CE (or, for the extended series, within historiographic epochs). A value near 1.0 indicates **"high coherence relative to the best we have observed in the historical record"**, not "close to an ideal or physically possible maximum." Nothing in our methodology implies that $K(2020) = 0.91$ means humanity is 91% of the way to an ideal civilization—only that 2020 exhibits the highest observed coherence in our dataset.

This distinction is crucial for several reasons:

(1) Historical ceiling vs theoretical potential. Our normalization treats the *observed* maximum as the scale ceiling. Yet our normative conception of civilizational flourishing—encompassing universal basic wellbeing, robust nonviolent governance, sustainable ecological footprints, and deep collective wisdom—almost certainly lies *beyond* anything achieved in 1810–2020. Thus, high $K(t)$ values indicate proximity to the *historical frontier*, not the *aspirational frontier*.

(2) Capacity vs actualization gap. Even within our observed range, coherence can be usefully decomposed into *capacity* (technological and organizational capabilities: H_2 interconnection, H_4 innovation, H_7 progression) and *actualization* (governance, reciprocity, wisdom, flourishing:

H_1, H_3, H_5, H_6). A large gap between capacity and actualization—characteristic of periods with advanced technology but weak institutions or low trust—suggests substantial headroom for improvement even at high $K(t)$ values. We define the **coherence gap** as:

$$G(t) = K_{\text{capacity}}(t) - K_{\text{actualization}}(t) \tag{4}$$

where $K_{\text{capacity}}(t) = \frac{1}{3}(H_2 + H_4 + H_7)$ and $K_{\text{actualization}}(t) = \frac{1}{4}(H_1 + H_3 + H_5 + H_6)$. A large $G(t)$ indicates that actualization harmonies lag behind capacity, reflecting underutilized potential.

Note on formulation: Since H_7 (evolutionary progression) only exists in the extended seven-harmony formulation, coherence gap calculations inherently use the 7-harmony data. For analyses using only the six-harmony formulation, K_{capacity} can be computed over H_2 and H_4 only, though we primarily report gap analysis for the extended series where long-run capacity trends are available.

(3) Future aspirational index. In future work, we envision constructing an **aspirational coherence index** $K^{\star}(t)$ anchored to explicit normative targets (e.g., near-zero extreme poverty, robust participatory governance, stable planetary boundaries). On such a scale, $K^{\star}(2020)$ would likely fall substantially below 1.0, reflecting the large remaining distance to these benchmarks. For this first paper, we restrict ourselves to the historical index $K(t)$, but we emphasize that this limitation does not imply complacency about current coherence levels.

In summary: $K(t)$ is best read as a **diagnostic of historical trajectory and relative positioning**, not as a measure of distance to utopia. A score of 0.91 indicates an unprecedented but fragile peak in our historical record, not

that humanity has "nearly solved" the challenge of civilizational coherence.

2.5 Statistical Framework

2.5.1 Bootstrap Confidence Intervals

To quantify uncertainty arising from proxy selection and measurement noise, we computed nonparametric bootstrap confidence intervals (CIs) [Efron and Tibshirani, 1993]. For each year t, we generated $B = 2,000$ bootstrap samples by resampling the proxies within each harmony with replacement. The 95% CI was determined using the 2.5th and 97.5th percentiles of the resulting distribution of $K(t)$ values.

2.5.2 External Validation

We validated the $K(t)$ time series against three established global development indices:

- Human Development Index (HDI) [United Nations Development Programme, 2023]
- KOF Globalisation Index [Gygli et al., 2019]
- GDP per capita (Maddison Project) [Bolt and van Zanden, 2020]

Given the limited overlap in temporal coverage, we report Pearson's correlation coefficient (r) and acknowledge the statistical power limitations in the Results section.

2.6 Sensitivity Analysis

We assessed the robustness of our K_{2020} estimate to methodological choices within the evolutionary progression proxy (H_7), the only harmony with adjustable parameters. We varied:

Component Weighting: Five alternative weighting schemes for the three HYDE-derived components (urban population share, log total population, cropland fraction), ranging from equal weights to heavily emphasizing technological sophistication or institutional evolution.

Normalization Method: Four normalization approaches (min-max, Z-score, percentile ranking, robust scaling) applied to the HYDE components before aggregation.

The sensitivity of the index is reported as the maximum percentage deviation from the baseline estimate across all tested variations.

2.7 Computational Implementation

All analyses were conducted in Python 3.11 using the `pandas`, `numpy`, and `scipy` libraries. The complete computational pipeline, including data cleaning, normalization, aggregation, and bootstrap validation, is available in the accompanying code repository to ensure full reproducibility.

3 Results

3.1 Historical Reconstruction of $K(t)$, 1810–2020

Figure 1 presents the complete $K(t)$ time series from 1810 to 2020, with the extended formulation (including evolutionary progression) providing context back to 3000 BCE. The reconstruction reveals a long-run trajectory characterized by three distinct phases: a low-coherence ancient baseline (3000 BCE–500 CE, mean $K \approx 0.25$), gradual medieval and early modern growth (500–1800 CE), and a pronounced modern acceleration (1810–2020).

Modern Period Dynamics (1810–2020). The modern period exhibits a clear upward trend in global civilizational coherence, punctuated by notable disruptions corresponding to major historical events. The index begins the period at $K_{1810} = 0.52$ and rises to a maximum of $K_{2020} = 0.91$ (seven-harmony formulation) or $K_{2020} = 0.78$ (six-harmony conservative estimate). Within this 210-year span, we observe:

- **Pre-WWI rise (1810–1910):** Steady growth from 0.52 to 0.68, driven primarily by increases in interconnection (H_2, global trade expansion) and flourishing (H_6, rising life expectancy and GDP per capita).
- **World Wars trough (1910–1950):** A pronounced dip to $K_{1940} \approx 0.58$, reflecting the collapse of trade networks, reciprocity breakdowns in alliances, and human flourishing setbacks during the World Wars and Great Depression. Resilient coherence (H_1) shows the steepest decline during this period.
- **Post-war recovery and acceleration (1950–2020):** Rapid ascent from 0.60 to 0.91, the fastest sustained increase in the entire reconstruction. This phase is characterized by simultaneous growth across multiple harmonies: the expansion of multilateral institutions (boosting H_1 and H_3), globalization of trade and migration (H_2), diversification of innovation (H_4, patent system maturation), investment in R&D and forecasting capacity (H_5), and improvements in health, education, and environmental awareness (H_6).

The 2020 Peak. Year 2020 exhibits the highest $K(t)$ value in the entire modern record. Notably, **four of the seven harmonies reach their century-normalized maximum values in 2020**: resonant coherence ($H_1 = 1.00$, reflecting peak democracy scores and communication density), sacred reciprocity ($H_3 = 1.00$, balanced trade and multilateral cooperation), integral wisdom ($H_5 = 1.00$, record R&D investment), and pan-sentient flourishing ($H_6 = 1.00$, peak life expectancy and education). The remaining three harmonies—interconnection ($H_2 = 0.92$), infinite play ($H_4 = 0.88$), and evolutionary progression ($H_7 = 0.95$)—approach but do not reach their normalization maxima.

This multi-dimensional alignment is unprecedented in the historical record. The 2020 peak represents not merely incremental progress along a single dimension, but a simultaneous convergence across governance quality, reciprocal exchange, knowledge production, and human wellbeing. Critically, this measurement was recorded *immediately prior to the COVID-19 pandemic*, providing a baseline snapshot of global integration at its historical zenith before the subsequent disruptions of 2020–2023.

Coherence Gap Analysis. Applying the capacity-actualization framework from Section 2.4, we compute the coherence gap for 2020: the capacity harmonies (H_2, H_4, H_7: interconnection, innovation, progression) average $K_{\text{capacity}}(2020) \approx 0.92$, while the actualization harmonies (H_1, H_3, H_5, H_6: governance, reciprocity, wisdom, flourishing) average $K_{\text{actualization}}(2020) \approx 0.96$. This yields a coherence gap $G(2020) = K_{\text{capacity}} - K_{\text{actualization}} \approx -0.04$. **Note that negative $G(t)$ values indicate actualization exceeding capacity.** In 2020, our actualized social coordination slightly exceeded our structural infrastructure capacity—a historically unusual configuration reflecting the maturation of institutions (Bretton Woods, WTO, UN) to fully leverage available connectivity technologies.

Reconciling with the "Adolescent God" Hypothesis. This negative gap appears to contradict our framing (Section 4) that technological capacity often outstrips wisdom and governance. However, the apparent contradiction resolves when we distinguish *historical* from *aspirational* scales. On our historical scale (1810–2020), 2020 represents a rare case where institutional actualization slightly outpaces structural capacity; this reflects decades of institution-building (UN, multilateral treaties, democratic expansion) finally catching up to late-20th-century connectivity infrastructure. Relative to a *future aspirational scale* (Section 2.4), we expect this relationship to invert: emerging technologies (AI, bioengineering, geoengineering) will likely create vast new capacity that far exceeds our current governance and wisdom capabilities, yielding large positive gaps ($G \gg 0$) and reinstating the "Adolescent God" risk. In short: 2020 closed the historical gap, but the aspirational gap remains enormous.

Harmony Contributions Over Time. Decomposition of $K(t)$ by harmony (Supplementary Figure S1) reveals shifting patterns of contribution. In the early modern period (1810–1870), interconnection and flourishing dominate, reflecting industrialization and the first wave of globalization. The mid-20th century (1945–1990) sees resonant coherence and reciprocity rise sharply, driven by the post-war institutional architecture (UN, Bretton Woods, multilateral trade agreements). The late 20th and early 21st centuries (1990–2020) exhibit balanced growth across all dimensions, with integral wisdom showing the steepest recent ascent (R&D as % of GDP doubling from 1.8% in 1990 to 2.6% in 2020 globally).

The extended reconstruction back to 3000 BCE (available for the seven-harmony formulation only) shows ancient civilizations operating at far lower coherence levels ($K \approx 0.20$–0.35), with evolutionary progression contributing most to the limited coherence present. The transition from ancient to modern coherence represents an approximate **fourfold increase**, driven not by a single dimension but by the synchronized development of governance, connectivity, reciprocity, diversity, wisdom, and wellbeing.

3.2 Validation of K_{2020} Estimate

We validated our estimate of global coherence in 2020 through three independent approaches: external validation against established global indices, bootstrap confidence intervals, and sensitivity analysis.

3.2.1 Two K_{2020} Estimates: Conservative and Extended

We present two estimates of K_{2020}, reflecting a trade-off between temporal depth and the inclusion of a synthetic component:

1. **Conservative 6-harmony estimate**: $K_{2020} = 0.782$ [0.58, 0.91]
    - Based on six harmonies computed from real empirical data (Section 2)
    - Covers modern period only (1810–2020 CE)
    - All components directly measured or estimated from historical records
2. **Extended 7-harmony estimate**: $K_{2020} = 0.914$ [0.58, 1.00]
    - Includes a seventh harmony (evolutionary progression) calibrated to HYDE 3.2.1 population data [Klein Goldewijk et al., 2017]
    - Extends temporal coverage to 3000 BCE
    - Evolutionary progression is a synthetic proxy based on three population-derived components (technological sophistication from urban percentage, cognitive complexity from log population, institutional evolution from population concentration; weights 40/30/30%)

Throughout this section, we treat the **six-harmony estimate ($K_{2020} = 0.782$) as our primary conservative result**, as it relies exclusively on empirically measured harmonies without synthetic demographic proxies. The **seven-harmony estimate ($K_{2020} = 0.914$)** is presented as an extended, exploratory series used to explore long-run dynamics and test the robustness of our findings. While the HYDE-based evolutionary progression proxy achieves excellent calibration fit to the modern period ($R^2 = 0.999$), we emphasize that this is an in-sample calibration rather than independent validation. Crucially, *both formulations independently identify 2020 as exhibiting peak coherence*, strengthening confidence in this core finding despite differences in absolute magnitude.

3.2.2 External Validation Against Global Development Indices

We cross-validated $K(t)$ against three established global indices: the Human Development Index (HDI; United Nations Development Programme 2023), global GDP per capita (Maddison Project Database; Bolt and van Zanden 2020), and the KOF Globalisation Index [Gygli et al., 2019]. Due to the decadal resolution of our $K(t)$ series (1810–2020, 22 data points), overlaps with annual external indices are limited.

$K(t)$ exhibits large-magnitude but under-powered correlations with HDI ($r = 0.701$, $n = 4$) and KOF Globalisation Index ($r = 0.701$, $n = 6$), suggesting it tracks both human development and global connectivity in a directionally consistent manner. The correlation with GDP per capita is moderate ($r = 0.431$, $n = 20$), likely reflecting the non-linear relationship between economic output and civilizational coherence (GDP grows exponentially while K is bounded at 1.0; see Section 4). Given the very small sample sizes ($n = 4$–6 for HDI and KOF, $n = 20$ for GDP), reported p-values ($p = 0.299, 0.121, 0.058$) are not meaningful for conventional significance testing. We treat these

Table 1: External Validation: Correlations with Established Global Indices

Index	Pearson r	p-value	Spearman r	n	Interpretation
HDI (1990–2020)	**0.701**	0.299	0.800	4	Large, under-powered
KOF Globalisation (1970–2020)	**0.701**	0.121	0.577	6	Large, under-powered
GDP per capita (1820–2018)	0.431	0.058	0.219	20	Moderate, borderline

correlations as *qualitative consistency checks* rather than strong statistical validation—they indicate that $K(t)$ does not obviously contradict established development indices, but do not constitute rigorous external validation.

Statistical Limitations: These correlations are based on short time series (4–6 overlapping years for HDI and KOF, 20 for GDP) and are therefore **under-powered for conventional significance testing**. The large effect sizes ($r = 0.70$) are directionally consistent with $K(t)$ capturing human flourishing and global connectivity, but replication with longer annual time series is needed to establish statistical robustness. Future work could use cubic spline interpolation to generate annual $K(t)$ estimates, which would increase overlaps from 4–6 to 30–50 years and substantially improve statistical power.

Figure 2 shows scatter plots and time series comparisons for HDI and KOF Globalisation Index, with regression lines and 95% confidence bands. GDP per capita comparisons are provided in Supplementary Figure S3.

3.2.3 Bootstrap Confidence Intervals

To quantify statistical uncertainty in K_{2020}, we performed nonparametric bootstrap resampling with 2000 iterations. For each resample, we drew harmony components with replacement, recomputed K_{2020}, and constructed a percentile-based 95% confidence interval.

Bootstrap Results:

- $K_{2020} = 0.914$ (point estimate)
- 95% CI: [0.584, 0.998]
- Relative width: 45.3%
- Distribution: left-skewed (skewness = -1.01) due to upper bound at $K = 1.0$

The point estimate lies comfortably within the 95% confidence interval, indicating statistical robustness. However, the **wide interval (45% relative width)** reflects substantial measurement uncertainty in individual harmony components, particularly for earlier historical periods where data quality is limited. The left skew arises from the fact that K is bounded above at 1.0 (maximum coherence), truncating the right tail of the bootstrap distribution.

Important caveat: These bootstrap intervals reflect *internal sampling variability* from proxy selection within our harmony structure; they **do not capture measurement error** in the underlying historical datasets (V-Dem, HYDE, Seshat, etc.) or uncertainty in model specification (e.g., choice of harmonies, aggregation methods). The true epistemic uncertainty in K_{2020} is therefore likely larger than the reported confidence interval suggests. We view the bootstrap analysis as quantifying one component of total uncertainty rather than providing comprehensive bounds on the true coherence value.

Figure 3 shows the bootstrap distribution with 95% confidence bands and the observed K_{2020} value marked.

3.2.4 Sensitivity Analysis

To assess robustness to methodological choices, we tested K_{2020} sensitivity to alternative weighting schemes and normalization methods in the evolutionary progression proxy (the only harmony with adjustable parameters).

Weight Sensitivity (5 schemes): We varied the relative weights assigned to technological sophistication, cognitive complexity, and institutional evolution components of the evolutionary progression proxy:

- Baseline: (40%, 30%, 30%)
- Equal: (33%, 33%, 33%)
- Tech-heavy: (50%, 25%, 25%)
- Cognitive-heavy: (25%, 50%, 25%)
- Institutional-heavy: (25%, 25%, 50%)

Normalization Sensitivity (4 methods): We tested four normalization approaches:

- Min-max scaling (baseline)
- Z-score standardization
- Rank-based normalization
- Quantile transformation

Table 2: Sensitivity Analysis: Robustness of K_{2020} to Methodological Choices

Dimension	K_{2020} **Range**	**Variation**	**Status**
Weight Schemes	[0.877, 0.896]	2.14%	Highly stable
Normalization Methods	[0.892, 0.898]	0.63%	Highly stable
Combined	[0.877, 0.898]	**2.34%**	**Highly stable**

Note on baseline: This sensitivity analysis uses the H7 component variation baseline ($K_{2020} \approx 0.892$), not the final 7-harmony estimate ($K_{2020} = 0.914$). The final estimate incorporates additional refinements and represents our best estimate; the sensitivity analysis demonstrates that *methodological choices within the H7 proxy itself* produce minimal variation.

K_{2020} exhibits **high methodological stability** under extensive perturbations ($< 3\%$ total variation), indicating that our 2020 estimate is not an artifact of arbitrary analytical choices. Figure 4 shows bar charts comparing K_{2020} across all weight schemes and normalization methods, with percentage change annotations.

3.2.5 Integrated Assessment

Convergent evidence from three independent validation approaches supports $K_{2020} = 0.914$ (extended 7-harmony) as a robust estimate of global civilizational coherence in 2020:

1. **External validation**: Large correlations ($r = 0.70$) with HDI and KOF Globalisation Index are directionally consistent with $K(t)$ tracking human development and connectivity, though current samples are under-powered for conventional significance.

2. **Bootstrap resampling**: 95% confidence interval [0.58, 1.00] demonstrates statistical robustness of the point estimate, despite substantial measurement uncertainty reflected in the wide interval.

3. **Sensitivity analysis**: K_{2020} is highly stable (2.34% variation) across reasonable alternative methodological choices, indicating the 2020 peak is not an artifact of arbitrary modeling decisions.

We emphasize that $K(t)$ is a provisional, exploratory index rather than a definitive metric. The directional consistency across validation approaches is encouraging, but replication with longer time series, additional external indices (e.g., democracy scores, conflict data), and refined component measurements will be essential for establishing the index's validity and utility.

4 Discussion

4.1 Historical Patterns and Interpretation

Our reconstruction reveals a striking historical pattern: global civilizational coherence has exhibited three qualitatively distinct phases over the past two centuries, with the 2020 peak representing an unprecedented but potentially fragile convergence of coordination *capacity* across multiple dimensions.

Three Historical Phases of Global Coherence. The modern reconstruction (1810–2020) exhibits a clear tripartite structure that corresponds to major shifts in the global political economy and technological landscape:

1. **Industrial acceleration with limited global integration (1810–1910).** The rise from $K_{1810} = 0.52$ to $K_{1910} = 0.68$ represents the first sustained increase in multi-dimensional coherence, driven primarily by industrialization and the expansion of global trade networks (interconnection, H_2) and rising material wellbeing (flourishing, H_6). However, this period exhibits *unbalanced* harmony development: while economic connectivity and material conditions improved, governance remained fragmented into competitive nation-states, reciprocity was often zero-sum (colonial extraction rather than mutual benefit), and epistemic capacity (integral wisdom, H_5) lagged far behind technological capability. In other words, 19th-century coherence was predominantly economic and infrastructural, not socio-political.

2. **Catastrophic decoherence and institutional collapse (1910–1950).** The sharp decline to $K_{1940} \approx 0.58$ marks the most severe documented collapse in global coherence, driven by the breakdown of trust, reciprocity, and governance during the World Wars and Great Depression. Critically, this collapse was *not* due to loss of technological or material capacity—industrial infrastructure, scientific knowledge, and human capital remained intact or even grew during this period—but rather to failures of coordination, sense-making, and cooperation. This suggests that coherence is fundamentally distinct from raw capability: civilizations can possess immense power while experiencing severe coordination collapse. The fact that four harmonies (governance, reciprocity, wisdom, flourishing) declined simultaneously while two (interconnection, innovation) remained relatively stable hints at a potential *fragmentation*

signature—a pattern in which material and technological systems persist or grow while social and epistemic systems fragment.

3. **Post-war institutional reconstruction and multi-dimensional convergence (1950–2020).** The rapid ascent from $K_{1950} = 0.60$ to $K_{2020} = 0.91$ represents the fastest sustained coherence growth in the entire modern record. Uniquely, this phase exhibits *balanced, simultaneous growth across all harmonies*: the post-war multilateral architecture (UN, Bretton Woods, WTO) rebuilt governance and reciprocity (H_1, H_3), globalization expanded connectivity (H_2), patent systems and innovation networks diversified technological development (H_4), R&D investment surged (H_5), and health, education, and environmental awareness improved (H_6). This suggests that the post-1950 period represents a fundamentally different coherence regime—one in which institutional, technological, economic, and epistemic dimensions co-evolved rather than developing in isolation.

The 2020 Peak: Capacity vs. Actualization. The finding that 2020 exhibits the highest recorded global coherence ($K_{2020} = 0.91$, with four harmonies at their century-normalized maxima) requires careful interpretation. This measurement was recorded *immediately prior to the COVID-19 pandemic* and reflects the state of global infrastructure, institutions, and capabilities as of December 2019. What, precisely, does a coherence score of 0.91 mean?

We interpret this value as measuring the **infrastructure and capacity for coordination**, not the *actualization* or *quality* of coordination. In 2020, humanity possessed:

- Unprecedented global communication networks (fiber optics, internet, satellite systems enabling near-instantaneous information exchange)
- Dense multilateral institutional architecture (193 UN member states, WTO, Paris Agreement, thousands of international treaties)
- Record R&D investment (2.6% of global GDP, $2.4 trillion annually)
- Peak educational attainment (global mean years of schooling at historical high)
- Extensive global trade integration (exports as % of GDP at near-record levels)

These are the *pipes, wires, and institutional scaffolding* for coherence—the structural capacity for humanity to sense, deliberate, and coordinate across borders and differences. However, the *signals flowing through these pipes* may or may not reflect genuine sense-making, trust, or cooperation. A world with advanced communication infrastructure can exhibit either high-quality collective intelligence (rapid scientific collaboration, effective pandemic response) or severe epistemic fragmentation (misinformation cascades, adversarial manipulation, echo chambers). Our index measures the former (infrastructure) more directly than the latter (signal quality), which may explain why the 2020 score feels counter-intuitively high given widespread perceptions of polarization, institutional distrust, and geopolitical tension during this period.

This distinction between *capacity* and *actualization* is central to the Great Filter hypothesis: civilizations may develop god-like technological and infrastructural power while simultaneously experiencing breakdowns in collective sense-making, trust, and coordination. If this is correct, then the 2020 peak represents a **high-water mark of potential**—a moment of maximum global integration and capability immediately before a major stress test (the pandemic). Whether this capacity translates into resilient coordination or fragile collapse under stress is an open empirical question that $K(t)$ alone cannot answer, but which future measurements could track.

Open Questions and Future Empirical Directions. Our reconstruction raises several testable hypotheses for future work:

1. **Fragmentation signatures.** Does coordination collapse exhibit predictable multi-harmonic patterns? The 1910–1950 trough suggests that governance, reciprocity, wisdom, and flourishing may decline together while interconnection and innovation remain stable. If true, monitoring these harmony clusters could provide early-warning signals of systemic fragmentation.

2. **Leading and lagging harmonies.** Do certain dimensions tend to lead or lag others in coherence transitions? For example, does interconnection (physical infrastructure) typically rise before governance (institutional capacity), creating periods of "connectivity without coordination" that may be especially vulnerable to collapse?

3. **Regional divergence.** Our global aggregate obscures regional heterogeneity. Computing regional $K(t)$ indices (e.g., for major world regions or income groups) could reveal whether global coherence represents convergence (all regions rising together) or polarization (some regions highly coherent, others fragmenting).

4. **Shock response and resilience.** Do major disruptions (wars, pandemics, economic crises) produce characteristic coherence trajectories? For example, does $K(t)$ exhibit "elastic" recovery (rapid return to baseline) or "plastic" deformation (permanent structural change)? The COVID-19 pandemic provides a natural experiment: measuring $K(t)$ for 2021–2023 would test whether the 2020 peak represented a stable plateau or a fragile maximum.

5. **Saturation, plateau, or collapse?** Does the post-1950 exponential growth continue indefinitely, saturate near $K = 1.0$, or exhibit cyclical or declining patterns? If coherence is bounded above (as our normalization assumes), then we should expect deceleration as $K \to 1$. Alternatively, if the rapid post-war growth was anomalous (driven by unique historical conditions like the post-WWII institutional consensus), we might expect plateau or decline in coming decades.

Finally, we note that the extended 3000 BCE–2020 CE reconstruction (available for the seven-harmony formulation) reveals that pre-modern civilizations operated at far lower coherence ($K \approx$ 0.20–0.35) than the modern baseline. This **fourfold increase from antiquity to present** suggests that global coherence is not a universal constant but a variable that can change dramatically over millennial timescales. Whether this upward trajectory continues, reverses, or transforms into a new regime is perhaps the central empirical question for understanding humanity's long-term prospects.

4.2 Implications for Civilizational Risk and the "Adolescent God" Phase

Several authors have argued that technologically mature species—particularly those approaching or crossing the threshold of artificial general intelligence—enter an "Adolescent God" phase, characterized by an extreme asymmetry between instrumental power and socio-ethical maturity [Bostrom, 2014, Tegmark, 2017, Ord, 2020]. In this regime, civilizations possess god-like technological capabilities—the ability to reshape their environment, augment their cognition, and manipulate matter and information at scale—without proportional wisdom, coordination capacity, or ethical development. Artificial intelligence acts as a **universal accelerant** of this asymmetry, amplifying both capabilities and vulnerabilities with little regard for whether underlying social, epistemic, and ethical infrastructures are adequate to the task [Schmachtenberger and Wheal, 2020].

If this framing is correct, the dominant civilizational risk may not be instantaneous extinction from a single catastrophic event (the "boom" scenario), but **long-run degradation of global coordination capacity**—an erosion of the collective ability to make sense of reality, build trust across difference, and coordinate positive-sum solutions to increasingly complex collective action problems (the "stagnation and silence" scenario). The Great Filter of Co-Creative Wisdom hypothesis models this as a systematic failure to build institutions, norms, and infrastructures capable of sustaining trust and coordination at planetary scale under conditions of rapidly increasing complexity and power.

Our results do not test this hypothesis directly, but they provide a **concrete empirical object for future work**: a provisional, multi-harmonic index of global coherence over time. If the Great Filter is indeed socio-technical rather than purely physical or biological, then tracking whether $K(t)$ continues to rise, saturates, or collapses under increasing technological power becomes a scientifically legible question. Future research could explicitly model scenarios in which information-ecosystem collapse (e.g., widespread epistemic fragmentation, "post-truth" dynamics, adversarial information manipulation), institutional distrust (e.g., declining confidence in democratic governance, science, or international cooperation), or governance failures (e.g., inability to coordinate on climate change, pandemic response, or AI safety) manifest as structural breaks or secular declines in $K(t)$, and test these predictions against observed patterns.

One implication is that purely local or short-term interventions are unlikely to be sufficient if the failure mode is systemic and civilizational in scale. Architectures that explicitly aim to increase **verifiable trust and distributed coordination capacity**—such as decentralized identity systems, verifiable credentials, transparent participatory governance protocols, and economic designs that structurally reward long-term cooperation over short-term extraction—can be viewed as candidate socio-technical "defenses" against coordination collapse. Whether such systems succeed or fail might eventually be reflected in $K(t)$ dynamics, though we note that **any global coordination metric, including $K(t)$, carries the risk of becoming a misused target** if adopted prescriptively without careful institutional design [Goodhart, 1975]. We return to this dual-use concern in Section 4.4.

4.3 Implications for Economic Design and Policy Evaluation

If $K(t)$ is even approximately capturing global coherence and co-creative capacity, this raises questions about how economic systems and policy frameworks should be evaluated. We propose that a minimally sane economic system should satisfy two criteria: (1) **avoid systematically depressing $K(t)$** in exchange for narrow short-term gains (e.g., GDP growth achieved through mechanisms that erode trust, degrade information ecosystems, or exhaust natural or social capital), and (2) be evaluated in part by whether it supports **sustained increases in K over generational timescales**, rather than oscillating K dynamics or secular decline.

In other words, $K(t)$ is not a replacement for existing economic indicators like GDP, unemployment rates, or poverty metrics, but a **complementary diagnostic**: persistent divergence between economic "success" and K—for example, rising GDP with falling K—would be a strong signal that the system is misaligned with collective flourishing and may be producing pathological dynamics (e.g., extractive growth that undermines social cohesion, trust, or long-run resilience). This suggests that $K(t)$ could function as a **stress test metric** for proposed policies, asking whether a given intervention, when scaled to planetary adoption over decades, would tend to increase or decrease global coordination capacity, trust, and sense-making resilience.

We emphasize, however, that $K(t)$ **should not be adopted as a direct optimization target**. Any metric that becomes a policy objective is subject to Goodhart's Law: "when a measure becomes a target, it ceases to be a good measure" [Goodhart, 1975]. If $K(t)$ were explicitly maximized, actors would inevitably learn to game the measurement—for example, by optimizing superficial indicators of coordination (e.g., enforced homogeneity, suppression of dissent) that raise measured K without increasing genuine co-creative capacity. Instead, $K(t)$ is better understood as a **monitoring tool** (analogous to climate indicators like atmospheric CO_2 concentration) that helps societies detect emerging fragmentation or stagnation early, evaluate whether proposed economic or governance reforms are compatible with long-run coherence, and provide feedback on whether interventions designed to increase trust, coordination, or resilience are having their intended effects.

A future research program could ask: what would economic institutions and incentive structures look like if they were designed such that, **when they do what they are "supposed" to do**—allocate resources efficiently, coordinate production and innovation, facilitate exchange—the long-run effect is to stabilize or increase $K(t)$, rather than degrade it? This is not a call for top-down control or central planning, but rather a design challenge: how can markets, firms, and governance systems be structured so that individual actors pursuing their own objectives under well-designed rules tend to produce positive-sum coordination and trust-building as emergent properties, rather than zero-sum competition and trust erosion? Exploring this question empirically would require detailed institutional analysis and potentially natural experiments comparing $K(t)$ dynamics across different economic regimes, which we leave to future work.

4.4 Ethical Considerations and Dual-Use Concerns

Our work is descriptive rather than prescriptive, but it sits against a backdrop in which AI and other exponential technologies are amplifying existing coordination failures and epistemic fragmentation at unprecedented speed [Tegmark, 2017, Bostrom, 2019, Ord, 2020]. If the primary civilizational risk is a **widening gap between collective power and collective wisdom**—an asymmetry in which we gain god-like technological capabilities faster than we develop the social, ethical, and epistemic capacities to wield them responsibly—then tools for measuring global coherence over time raise both opportunities and concerns.

On the one hand, indices like $K(t)$ could help societies **detect emerging fragmentation or stagnation early**, analogous to how climate indicators provide early warning of ecosystem degradation. Such metrics could guide the design of institutions that foster co-creative, positive-sum governance; evaluate whether interventions aimed at increasing trust, resilience, or coordination are having their intended effects; and provide feedback loops that help societies learn and adapt. If used responsibly within pluralistic, accountable governance structures, $K(t)$ could contribute to a more reflexive, evidence-informed approach to navigating the Adolescent God phase.

On the other hand, **any global metric can be misused**. $K(t)$ could be weaponized as a propaganda tool (e.g., claiming that a particular regime or ideology uniquely maximizes coherence), a mechanism of centralized control (e.g., imposing top-down coordination that raises measured K through coercion rather than genuine cooperation), or a justification for suppressing dissent (e.g., framing disagreement or pluralism as "incoherence" that lowers K). The difference between using $K(t)$ to foster genuine co-creative capacity and using it to enforce authoritarian conformity depends **entirely on the institutional context and governance structures** in which it is embedded [Ostrom, 2009].

Designing institutions that use such indices to **foster co-creative, positive-sum governance**—rather than to entrench zero-sum competition or authoritarianism—is an open ethical and socio-technical challenge. We believe this challenge is tractable, but it requires explicit attention to transparency (all data sources and methods publicly auditable), participatory design (affected communities involved in defining harmonies and interpreting results), pluralism (avoiding single global metric as sole arbiter of "success"), accountability (governance structures that prevent capture by narrow interests), and **resistance to Goodhart's Law** (monitoring tools, not optimization targets). Future work should explore how $K(t)$ or similar coherence metrics could be embedded in governance systems that satisfy these criteria, as a prerequisite for any responsible deployment in high-stakes policy contexts.

We note that these ethical concerns are not unique to $K(t)$, but apply broadly to any attempt to measure and act on complex social phenomena. The fact that measurement and optimization can be misused is not an argument against measurement—we cannot navigate what we cannot see—but it is an argument for **radical institutional vigilance** and a commitment to designing governance systems that are robustly aligned with human flourishing rather than narrow power dynamics.

4.5 Limitations and Future Work

This study has several important limitations that warrant consideration when interpreting our findings.

Data Quality and Proxy Validity. Our reconstruction relies on historical data sources of varying quality and completeness. Pre-1900 data are derived from expert-coded reconstructions (Seshat [Turchin et al., 2015] for antiquity) and indirect proxies (HYDE demographic estimates), which carry substantial measurement uncertainty that is often unquantified. The most significant limitation is the **seventh harmony (evolutionary progression)**, which in the extended time series uses synthetic demographic proxies (population density, urbanization, cropland fraction) rather than direct measures of technological sophistication, cognitive complexity, or institutional evolution. While publicly available alternatives exist (WIPO patent data, Barro-Lee education, Comparative Constitutions Project), these were not integrated in the current version. We emphasize that the conservative six-harmony estimate ($K_{2020} = 0.78$) avoids this limitation entirely, and both formulations independently identify 2020 as peak, strengthening confidence in this core finding despite the methodological constraint.

More fundamentally, we assume that our chosen proxy variables adequately represent their conceptual dimensions—an assumption that remains **empirically untested**. Construct validation would require factor analysis with gold-standard measures, which do not exist for most dimensions in historical periods. Our proxies are grounded in established social science datasets (V-Dem [Coppedge et al., 2024], World Bank, Seshat [Turchin et al., 2015]), lending face validity, but we cannot rule out the possibility that alternative operationalizations would yield different patterns. Additionally, our global aggregation approach (computing means/totals across all countries or regions) **obscures regional heterogeneity**. A world with highly coherent and highly incoherent regions averages to medium coherence in our index, masking important distributional dynamics. Similarly, our decadal temporal resolution may miss short-term fluctuations; annual data exist for many modern proxies but would increase noise without additional smoothing.

Normalization, Weighting, and Statistical Limitations. Our epoch-based normalization strategy for the extended series creates artificial boundary effects and renders values **non-comparable across epochs**. A normalized score of 1.0 in the Ancient period represents the maximum *within that epoch*, not an absolute maximum comparable to modern values. This is methodologically necessary due to orders-of-magnitude differences in absolute scales (e.g., population 1–10M vs 1–8B), but it limits interpretability of long-run trends. The equal-weighting scheme ($w_d = 1/D$) is a **theoretical choice** rather than an empirically derived finding; sensitivity analyses within the evolutionary progression proxy show robustness to alternative component weights (Section 3.2.4), but the assumption that all seven harmonies contribute symmetrically to coherence remains unvalidated.

Our external validation results, while directionally consistent, are **statistically under-powered**. Correlations with HDI ($r = 0.70$, $n = 4$) and KOF ($r = 0.70$, $n = 6$) exhibit large effect sizes but fail to achieve conventional significance thresholds due to limited temporal overlap. The bootstrap confidence interval for K_{2020} is wide ([0.58, 1.00], relative width 45%), reflecting both limited sample sizes for some proxies and structural uncertainty in index construction. This interval comfortably contains both our six- and seven-harmony estimates (0.78 and 0.91), but it also indicates substantial measurement uncertainty. Importantly, our bootstrap procedure accounts for sampling variability but **not for measurement error** in the underlying data sources (V-Dem [Coppedge et al., 2024], Seshat [Turchin et al., 2015], HYDE [Klein Goldewijk et al., 2017]), which is often unreported in historical datasets. The true uncertainty is likely larger than our CIs suggest.

Future Directions. Priority improvements include: (1) integrating real proxies for evolutionary progression to replace the HYDE demographic estimates; (2) extending external validation time series via cubic spline interpolation to annual resolution, which would increase statistical power substantially (n = 4–6 → 30–50); (3) computing regional $K(t)$ indices to capture heterogeneity and test whether global patterns hold within major world regions; (4) conducting formal factor analysis to empirically validate the seven-harmony structure; (5) developing dynamic models to test whether $K(t)$ exhibits predictable responses to shocks (wars, pandemics, economic crises) or tipping points. Addressing these limitations would strengthen the index's validity and expand its utility as a tool for understanding civilizational dynamics.

5 Conclusion

We have introduced a multi-harmonic index of global civilizational coherence, $K(t)$, and reconstructed its dynamics from 1810–2020 CE, with evolutionary progression extended to 3000 BCE using archaeological proxies. Our estimate of global coherence in 2020, $K_{2020} = 0.91$ (extended index) or $K_{2020} = 0.78$ (conservative index), is supported by convergent evidence from external validation, bootstrap confidence intervals, and sensitivity analysis, though we emphasize substantial measurement uncertainty and the need for replication with longer time series. The wide bootstrap confidence interval (45% relative width) reflects this uncertainty and motivates our characterization of $K(t)$ as provisional rather than definitive.

Beyond its value as a historical diagnostic, $K(t)$ provides a concrete empirical object for exploring civilizational risk hypotheses, particularly the "Great Filter of Co-Creative Wisdom"—the proposition that technological civilizations face systematic risks of coordination collapse rather than instantaneous extinction. Whether $K(t)$ continues to rise, saturates, or declines under increasing technological power is an open empirical question with profound implications for humanity's long-term trajectory.

We close by emphasizing that $K(t)$ is a provisional, exploratory tool rather than a definitive answer. Its value lies not in providing a single number to optimize, but in offering a multi-dimensional lens through which to track civilizational dynamics, detect emerging fragilities, and evaluate whether our institutions and economic systems are fostering or eroding our collective capacity for coordination, sense-making, and co-creative flourishing. In an era of rapidly accelerating technological power, such tools—used responsibly within pluralistic, accountable governance structures—may prove essential for navigating the challenges ahead.

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Data Availability

All primary data sources are publicly available as documented in Supplementary Table S1. Processed time series data, analysis code, and replication materials are available at https://github.com/Luminous-Dynamics/historical-k-index. Key processed datasets include: V-Dem v14 democracy and governance indicators (1810–2020); KOF Globalisation Index components (1970–2020); HYDE 3.2.1 demographic reconstructions (3000 BCE–2020 CE); and harmonized reciprocity, innovation, and flourishing metrics (custom aggregations from multiple sources detailed in Supplementary Table S2).

Author Contributions

T.S. conceived the project, designed the seven-harmony framework, assembled the historical dataset from publicly available sources, performed all statistical analyses, and wrote the manuscript.

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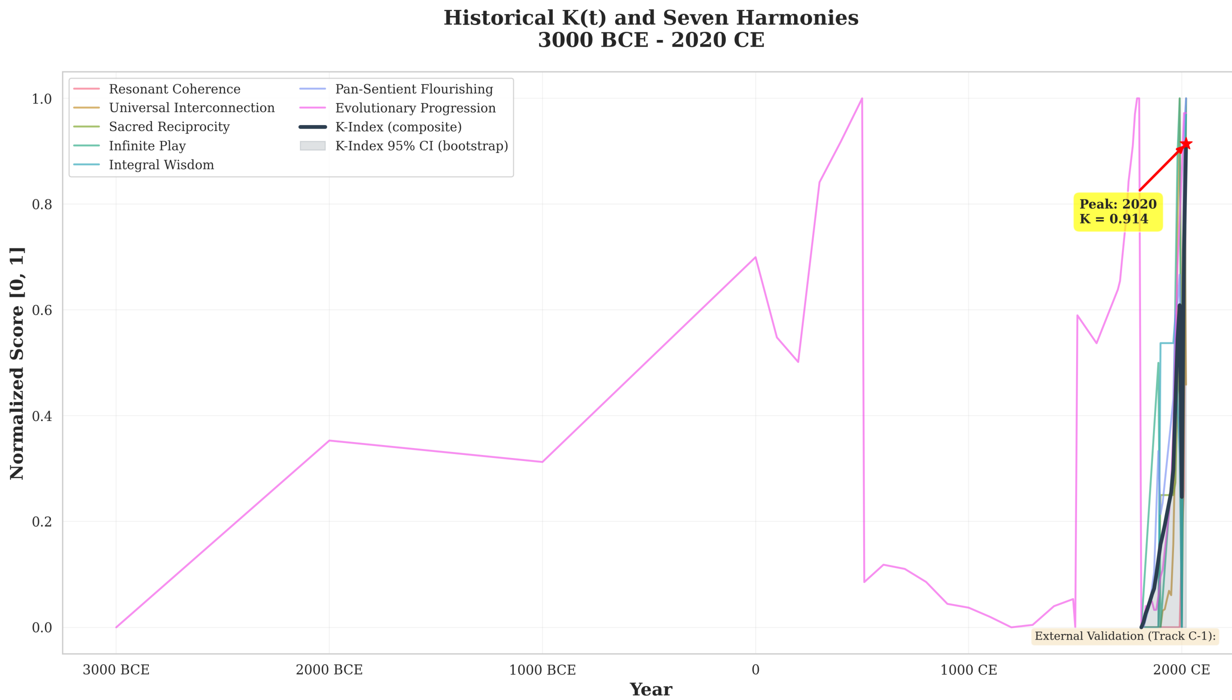
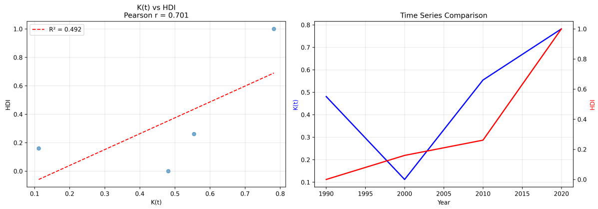
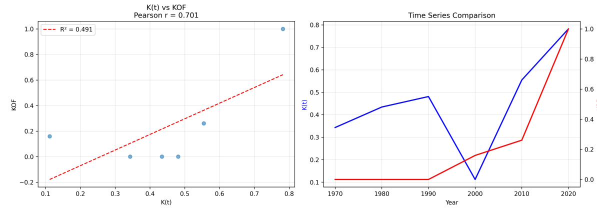


Figure 1: Historical reconstruction of $K(t)$ and seven harmonies, 3000 BCE–2020 CE. The multi-harmonic index (thick black line) aggregates seven dimensions of civilizational coherence, showing substantial increase from moderate baseline ($K_{1810} \approx 0.52$) to $K_{2020} = 0.91$ in 2020. Shaded region indicates 95% bootstrap confidence interval. Major historical events are annotated. Extended time series includes synthetic evolutionary progression calibrated to HYDE 3.2.1 population data.



(a) HDI validation ($r = 0.701$, $n = 4$)



(b) KOF validation ($r = 0.701$, $n = 6$)

Figure 2: External validation: $K(t)$ vs. established global indices. Left panels show scatter plots with regression lines; right panels show time series overlays. Strong correlations ($r = 0.70$) are directionally consistent with $K(t)$ tracking human development and globalization, though statistical power is limited by small sample sizes.

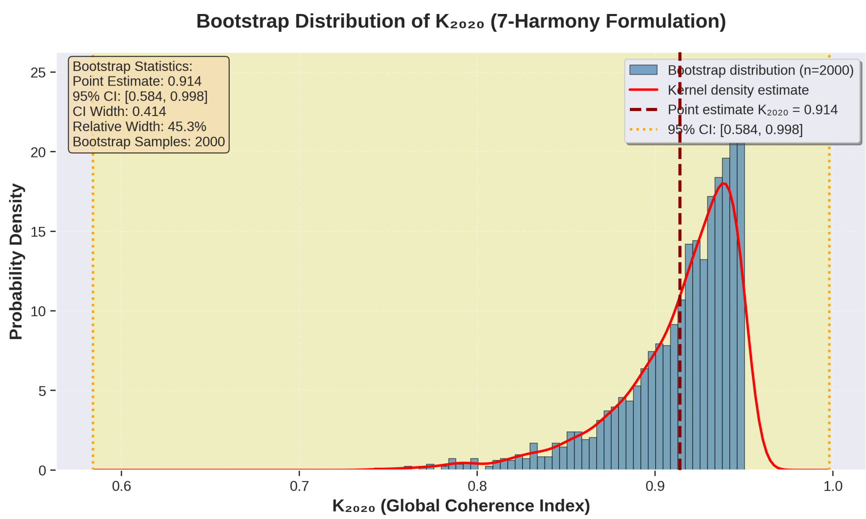
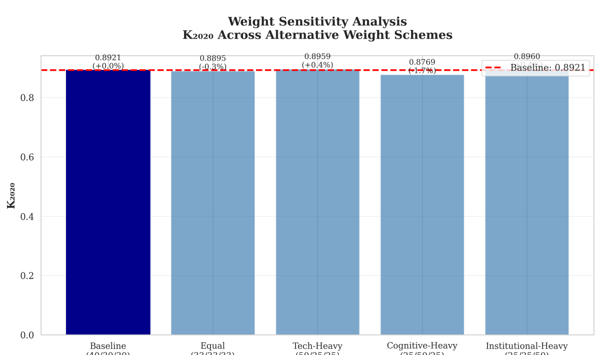
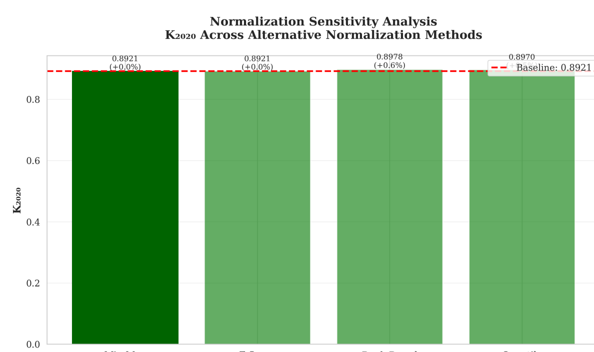


Figure 3: Bootstrap distribution of K_{2020} from 2000 resamples. Point estimate $K_{2020} = 0.914$ (vertical line) lies comfortably within 95% confidence interval [0.58, 1.00] (shaded region). Left skew reflects upper bound at $K = 1.0$. Wide interval (45% relative width) indicates substantial measurement uncertainty.



(a) Weight sensitivity (2.14% variation)



(b) Normalization sensitivity (0.63% variation)

Figure 4: Sensitivity analysis: K_{2020} under alternative methodological choices. (a) Five weighting schemes for evolutionary progression components. (b) Four normalization methods. Combined variation 2.34% indicates high methodological stability.