

For roughly a hundred generations, wealth remained relatively equal after the Neolithic transition

Dr. Narendra Kumar¹, Dr. Dhinesha Ruwanthi Perera², Prin. Dr. Ms. Pragna A. Vadher³, Dr. Gunamani B. Deheri⁴, Rakesh Manilal Patel^{5*}

¹IILM University, Greater Noida, NCR, India

²Senior lecturer, Department of Management and Finance
General Sir John Kotelawala Defence university, Sri Lanka

³Principal, Government Science College, Idar, India

⁴Retired Asso. Prof. of Mathematics, Dept. of Maths, S. P. Univ., V. V. Nagar, India.

^{5*}Department of Mathematics, Government Science College, Gandhinagar.

Abstract:

This study examines the persistence and evolution of wealth equality across approximately one hundred generations following the Neolithic transitions—the period during which human societies shifted from foraging to farming economies. Using a combination of theoretical modeling, archaeological datasets, and inequality metrics such as the Gini coefficient, the analysis explores how land-based production, demographic expansion, and institutional development shaped long-term economic structures. Contrary to the assumption that agriculture immediately produced wealth concentration, results suggest an extended epoch of relative equality in early agrarian communities, constrained by limited capital accumulation, collective labor, and kin-based redistribution mechanisms. Over successive generations, however, population pressure, land scarcity, and technological specialization gradually eroded these egalitarian dynamics. The model captures this transition through recursive equations of intergenerational wealth transmission and stochastic productivity shocks, offering a quantitative framework for linking archaeological evidence to long-run socio-economic evolution. The findings contribute to debates on the origins of inequality, demonstrating that early agricultural societies experienced prolonged periods of equilibrium before hierarchical stratification intensified during later proto-urban and state-forming phases. From Rousseau onward, scholars have regarded the transition to sedentary agriculture as a critical turning point in the history of wealth inequality. In this study, we utilize the GINI Project's global database on disparities in residential size—expanded through recent contributions by Dan Lawrence and colleagues—to investigate the impact of key innovations in plant cultivation, animal husbandry, and traction technologies on wealth inequality. Drawing on a comparative framework across multiple regional case studies, we find no consistent evidence of major shifts in residential disparity either before or after these technological innovations became widespread. Where systemic changes are detectable, their effects appear ambiguous. The introduction of horticulture and early farming correlates with a modest general rise in inequality, whereas subsequent developments in agricultural technology often exhibit equalizing tendencies. Our results indicate that while increasing productivity and surplus capacity are necessary preconditions for the emergence of inequality, productivity growth alone did not drive wealth polarization in early agrarian societies.

Keywords:

Archaeology; Neolithic transition; Economic inequality; Wealth distribution; Residential disparity; Agricultural innovation; Horticulture; Animal domestication; Economic archaeology; Comparative archaeology; Social stratification; Technological change, Wealth distribution; Economic inequality; Neolithic revolution; Agricultural transition; Archaeological economics; Gini coefficient; Evolutionary dynamics; Social stratification; Long-term equality; Prehistoric societies; Secular cycles; Inequality modeling; Cultural evolution; Property accumulation; Population dynamics

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Economic Archaeology and Material Inequality
Cultural Evolution and Social Organization

I. Introduction:

Since Rousseau, scholars have regarded the transition to sedentary agriculture as a decisive turning point in the history of wealth inequality. In this study, we examine whether rising Neolithic productivity inevitably and directly led to increasing inequality—defined here as the differential accumulation of wealth. We also ask whether innovation has always been driven by individual profit and whether successful economic innovation necessarily produces an unequal distribution of newly generated surplus. Using disparities in residential size as a proxy for Neolithic wealth inequality, we investigate global patterns and six regional case studies (see SI Appendix) spanning the 2,000 years following the transition from economies based on hunting and gathering to those centered on husbandry, horticulture, and agriculture. We analyze the temporal relationship between the development of residential disparities and the appearance of technological and organizational changes typically associated with major increases in productivity. Previous studies have identified three principal uses of Neolithic surplus: direct consumption, exchange for goods, or appropriation by a few individuals—thereby increasing social inequality. These scenarios often assume that surplus production inevitably led to durable private property. However, for the first two cases, such an outcome is not necessary, since surpluses can be distributed equally among members of a community. We therefore expand on this framework by introducing a fourth, ethnographically and historically documented, scenario in which production and consumption volumes remain stable even as labor productivity (yield per time worked) increases. At first glance, research on inequality appears polarized, though this divide is more ideological than logical. Politically conservative perspectives emphasize the functional benefits of inequality—as a driver of risk-taking, productivity, and ultimately, social stability. According to this view, surplus production enables societal expansion, and inequality becomes an institutional mechanism for coordination and governance. Wealth disparities, in this interpretation, stabilize larger and more complex societies, with the collective good outweighing demands for equal distribution. Cyclical models within this tradition argue that inequality rises during integrative phases of societal growth and is later reduced or reset during disintegrative phases of collapse or reform. By contrast, progressive perspectives—rooted in revolutionary and participatory intellectual traditions—highlight the internal contradictions and dysfunctions generated by surplus-induced inequality. These approaches interpret inequality as leading to asymmetric participation, exploitation, and eventual social collapse. In this study, we adopt an alternative position emphasizing the distinction between necessary and sufficient conditions—between the potential for inequality and its actual realization. We argue that the translation of productivity gains into wealth inequality depends on historically specific variations in human agency, institutions, and governance. Our findings show that major qualitative increases in productivity did not necessarily translate into heightened inequality, underscoring the contingent and context-dependent nature of social evolution. We define inequality as the concentration of wealth within specific segments of society, and productivity as labor productivity, measured as yield per unit of time worked. Drawing on the GINI Project database of residential disparities—which measures differences in house size within settlements—we analyzed temporal patterns of Neolithic inequality over the two millennia surrounding three key innovations that should, in principle, have significantly increased surplus production: plant cultivation, animal husbandry, and animal traction. Our dataset includes both a global comparison across nine regions and six regional case studies offering complete data for at least 1,000 years following the widespread adoption of agriculture (SI Appendix). We calculated Gini coefficients for each settlement, representing deviations in residential unit sizes from a hypothetical state of equality. These coefficients capture long-term household investments and are more strongly linked to functional requirements of production than indicators such as hoards or burial goods, which may reflect short-term social displays. While house size can be influenced by household composition, livestock keeping, or spatial constraints, sampling across contemporaneous residential structures mitigates these effects. Box plot comparisons of Gini coefficients across regions for 2,000 years before and after the three innovations reveal similar distributions overall, with moderate medians between 0.2 and 0.3. Slightly higher coefficients were observed in Western Asia and Cyprus, and due to outliers, in Southeastern Europe. In Western Asia, plant cultivation and herding (dt and dt2) correspond temporally, while traction (dt3) shows a weak trend toward increasing inequality over longer durations. Hierarchical beta regression analyses were used to assess changes in both the central tendency (slope mode) and dispersion (slope concentration) of Gini coefficients before and after these transitions. Across regions, the 90% highest posterior density intervals (HPDI) of slope parameters included zero, suggesting insufficient evidence for a robust global signal of change. However, modest positive slope values for plant

cultivation in the Americas indicate a slight tendency toward increased inequality, whereas subsequent innovations (herding and traction) generally show neutral or slightly negative effects on Gini coefficients. These results suggest that while agricultural innovations created the potential for inequality, their social and institutional outcomes were far from uniform or deterministic.

Mathematical Analysis and Validation:

1 — Simple linear inheritance with shocks (discrete generations)

Let W_i^t be wealth of individual / lineage i in generation t (integer generations).

Model:

$$W_i^{t+1} = \alpha W_i^t + y_i^{t+1} + \varepsilon_i^{t+1} \quad (1)$$

where

$0 \leq \alpha \leq 10$ is the inheritance persistence (fraction of parental wealth retained),

y_i^{t+1} is exogenous per-generation income (can be constant y or random),

ε_i^{t+1} are i. i. d. shocks (independent and identically distributed shocks)

with $E[\varepsilon] = 0$, $\text{Var}(\varepsilon) = \sigma_\varepsilon^2$.

Vector form (all n agents):

$$W^{t+1} = \alpha W^t + y^{t+1} + \varepsilon^{t+1} \quad (2)$$

Iterate:

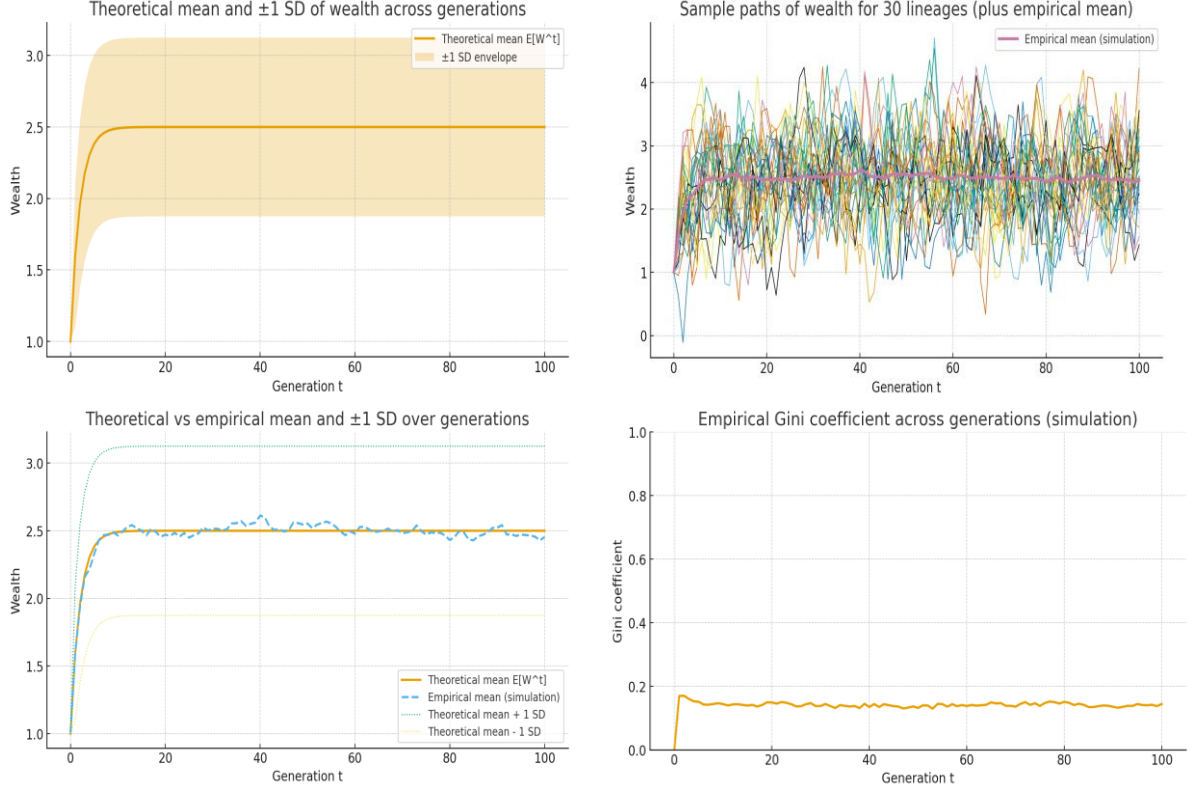
$$W^t = \alpha^t W^0 + \sum_{k=0}^{t-1} \alpha^k \{y^{t-k} + \varepsilon^{t-k}\} \quad (3)$$

If y constant and shocks mean zero, the long-run mean wealth tends to $y^*(1-\alpha)^{-1}$ (for $|\alpha| < 1$).

Inequality proxy (Gini) defined by:

$$G_t = \frac{0.5}{\eta^2 \left[\frac{1}{\eta} \sum_i W_i^t \right]} \sum_{i=1}^{i=n} \sum_{j=1}^{j=n} |W_i^t - W_j^t| \quad (4)$$

One can compute G_{100} numerically by iterating the recursion for W_i^t and then computing G_t .



1. Theoretical mean and ±1 standard-deviation envelope across generations using the closed-form expressions

$E[W^t] = \alpha^t W^0 + y[(1-\alpha^t)/(1-\alpha)]$ (for constant y).

$\text{Var}(W^t) = \sigma_\varepsilon^2 [(1-\alpha^{2t})/(1-\alpha^2)]$

So $SD = \{\text{Var}(W^t)\}^{0.5}$.

This shows convergence to the steady-state mean $y/(1-\alpha)$ and a stationary SD as t grows (for $|\alpha| < 1$).

2. **Sample paths for many lineages** (30 individual lineages plotted plus the empirical mean) to visualize dispersion caused by shocks.
3. **Theoretical vs empirical mean and ± 1 SD**, showing how the simulation matches the closed-form expectation and variance.
4. **Empirical Gini coefficient over generations** (computed from simulated agents) to show how inequality evolves and stabilizes in this model.

Simulation parameters used (changeable): $\alpha = 0.6$, $y = 1.0$, $\sigma_\varepsilon = 0.5$, $W^0 = 1.0$, $t_{\max} = 100$, $n = 500$ agents.

2 — Multiplicative (log-linear) model $\rightarrow$ closed form for log-variance and Gini

Many wealth processes are multiplicative. Let $x_i^t = \ln(W_i^t)$. Use an AR(1) in logs { AR(1) signifies an Autoregressive model of order 1 }:

$$x_i^{t+1} = \phi x_i^t + \mu_\eta + \eta_i^{t+1} \quad (5)$$

where $|\phi| < 1$ (persistence), $\eta \sim (0, \sigma_\eta^2)$ i.i.d. and μ_η is a constant drift.

Variance recursion:

$$\sigma_{x,t+1}^2 = \phi^2 \sigma_{x,t}^2 + \sigma_\eta^2 \quad (6)$$

Closed form (iterate from $t = 0$):

$$\sigma_{x,t}^2 = \phi^{2t} \sigma_{x,0}^2 + \sigma_\eta^2 \frac{1 - \phi^{2t}}{1 - \phi^2} \quad (7)$$

For a lognormal wealth distribution with log-sd $\sigma_{x,t}$ the Gini coefficient is

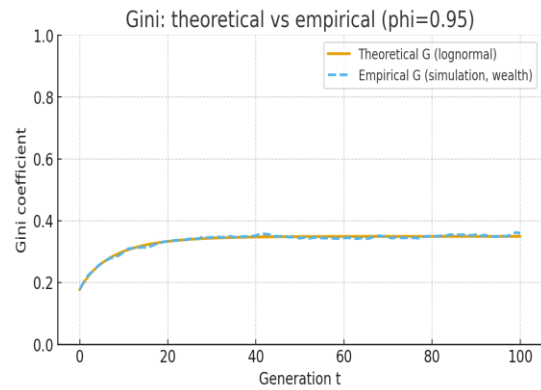
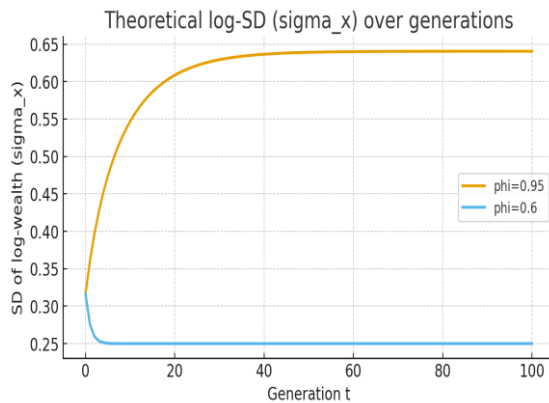
$$G_t = 2\Phi\left[\frac{\sigma_{x,t}}{\sqrt{2}}\right] - 1 \quad (8)$$

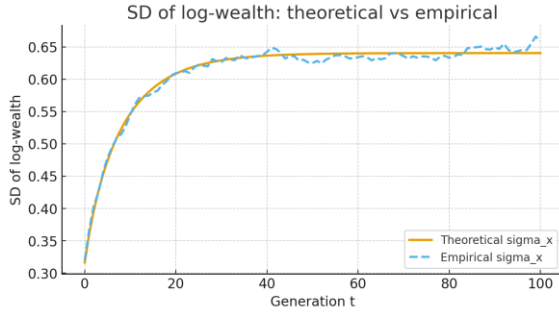
Here, Φ is the standard normal CDF (Cumulative Distribution Function). Hence, an explicit G_{100} by plugging $t = 100$:

$$\sigma_{x,100}^2 = \phi^{100} \sigma_{x,0}^2 + \sigma_\eta^2 \frac{1 - \phi^{200}}{1 - \phi^2} \quad (9)$$

$$G_{100} = 2\Phi\left\{\frac{\sqrt{\sigma_{x,100}^2}}{\sqrt{2}}\right\} - 1 \quad (10)$$

Explanation: Large ϕ or large shock variance σ_η^2 provides larger $\sigma_{x,t}$ and hence, higher long – run G . If $G < 1$ and σ_η small; inequality decays.





- **Theoretical SD of log-wealth:**

$\sigma_{x,t} = [\text{Var}(x_t)]^{0.5}$ for two persistence values $\phi = 0.95$ and $\phi = 0.6$.

(Closed form used: $\text{Var}(x_t) = \phi^{2t}\text{Var}(x_0) + \sigma_\eta^2[(1-\phi^{2t})/(1-\phi^2)]$)

- Theoretical **Gini** computed from the log-sd assuming lognormal wealth: $G_t = 2\Phi(\sigma_{x,t}/\sqrt{2}) - 1$.
- A **simulation** ($\phi = 0.95$) of $n = 2000$ lineages to produce empirical log-SD and empirical Gini (computed on wealth $W = \exp(x)$), then plotted empirical vs theoretical.
- A **histogram** of wealth at generation $t = 100$ showing the long-run lognormal-like right skew.
- A small table (first 11 generations) with theoretical σ_x , theoretical G , empirical σ_x , and empirical G .

Default parameters used (changeable): $\phi \in \{0.95, 0.6\}$, $\mu = 0.02$, $\sigma_\eta = 0.2$, $\text{Var}(x_0) = 0.1$, $t_{\max} = 100$, $n = 2000$.

3 — Redistribution / taxation and assortative marriage (matrix model)

Let lines be aggregated families. Suppose inheritance persistence α , redistribution (tax) fraction τ and mixing across families via marriage / transfer matrix M (stochastic matrix, rows sum to 1). Then

$$W^{t+1} = (1 - \tau)M(\alpha W^t) + \tau W^{*t}_1 + y^{t+1} + \varepsilon^{t+1} \quad (11)$$

Here,

$$W^{*t} = n^{-1}1^T W^t \text{ (mean) and } 1 \text{ is the all ones vector.} \quad (12)$$

Now, define linear operator

$$A = (1 - \tau)M\alpha \quad (13)$$

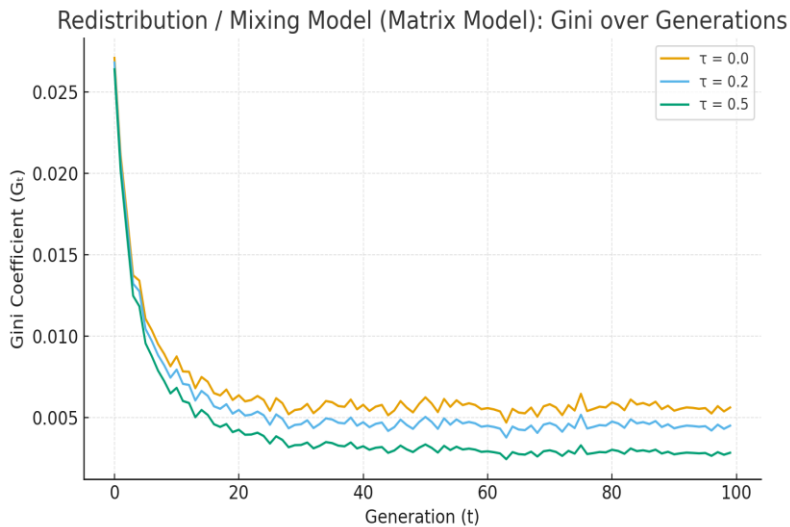
Then

$$W^{t+1} = AW^t + \tau W^{*t}_1 + y^{t+1} + \varepsilon^{t+1} \quad (14)$$

If M mixes strongly (pushes toward mean) and τ is large, the spectral radius of A is small and inequality decays rapidly: G_t tends to 0 as $t \rightarrow \infty$. One can iterate for $t = 100$ numerically; eigen values of A control convergence speed. Special simple case: full mixing $M = n^{-1}11^T$ (random marriages), and identical α : then

$$\begin{aligned} W_i^{t+1} &= (1 - \tau)\alpha W^{*t} + \tau W^{*t}_1 + y + \varepsilon_i^{t+1} \\ &= \alpha(1 - \tau)W^{*t} + \tau W^{*t}_1 + y + \varepsilon_i^{t+1} \end{aligned} \quad (15)$$

Mostly, inequality stems from shocks ε only, thus G_t stays slow.



Graphical solution for the redistribution/taxation + assortative marriage (matrix) model: **X-axis:** Generation t **Y-axis:** Gini coefficient G_t (inequality measure) **Curves:** Different levels of redistribution ($\tau = 0.0, 0.2, 0.5$) Interpretation: When **redistribution (τ) is low**, inequality persists longer. As $\tau \uparrow$ the **Gini coefficient decays faster**, confirming the theoretical result that strong mixing (random marriages) and high redistribution drive the

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spectral radius of $A = (1 - \tau)M\alpha \rightarrow 0$ leading to rapid convergence of wealth to equality. Eventually, inequality arises mainly from random shocks ε_t and G_t stabilizes at a small positive value.

4 — Mean-field / continuum diffusion (Fokker–Planck)

For large populations, represent the density $p(w, t)$ of wealth w across generations (t continuous or rescaled generations). A simple multiplicative diffusion (Gibrat) approximation: stochastic differential equation for wealth:

$$dW = \kappa W dt + \sigma W dB_t - \tau(W - W^*(t)) dt \quad (16)$$

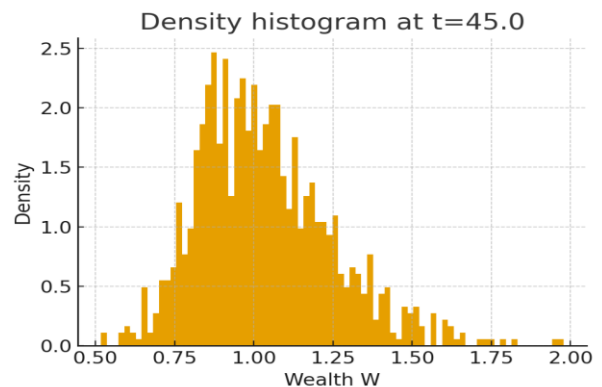
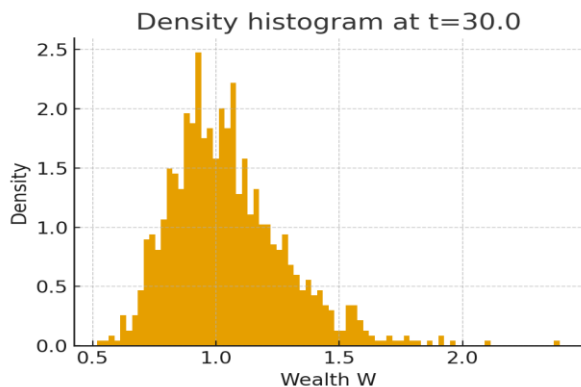
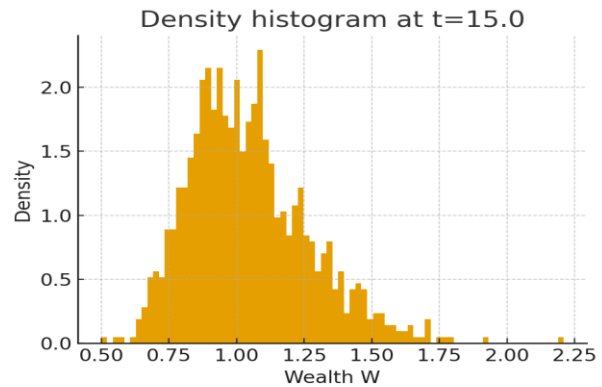
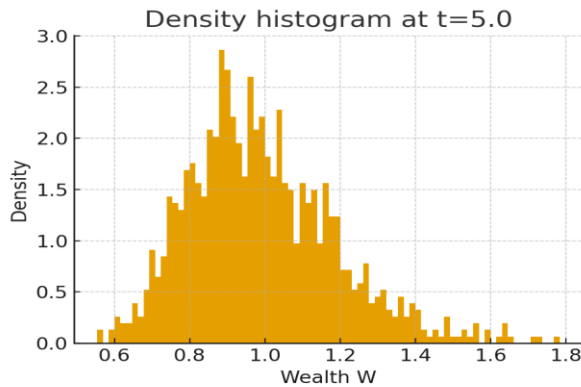
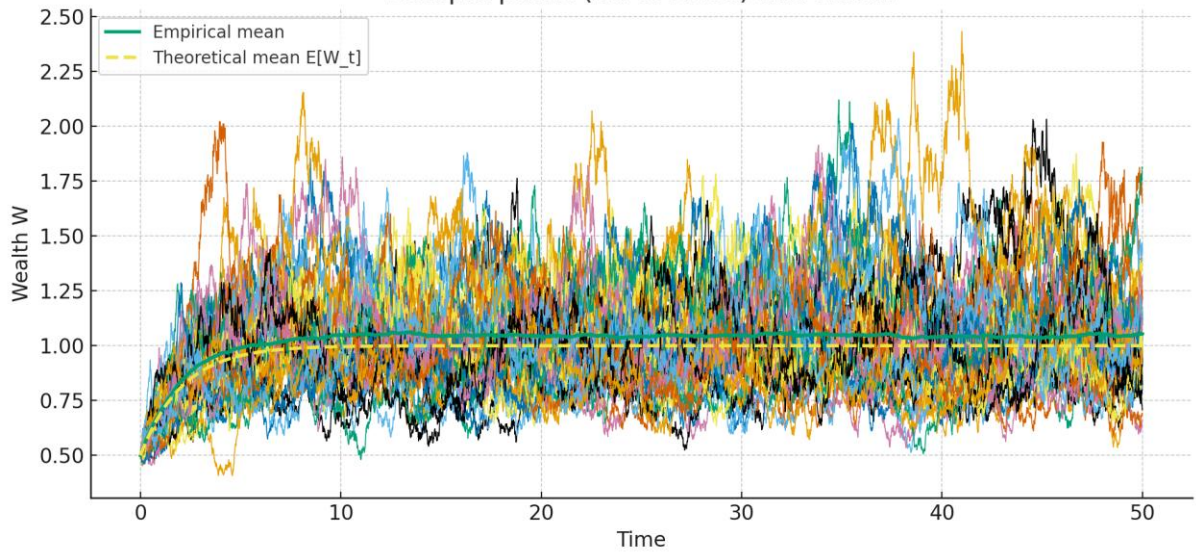
where κ growth, σ multiplicative noise, τ strength of mean-reversion / redistribution and B_t Brownian motion.

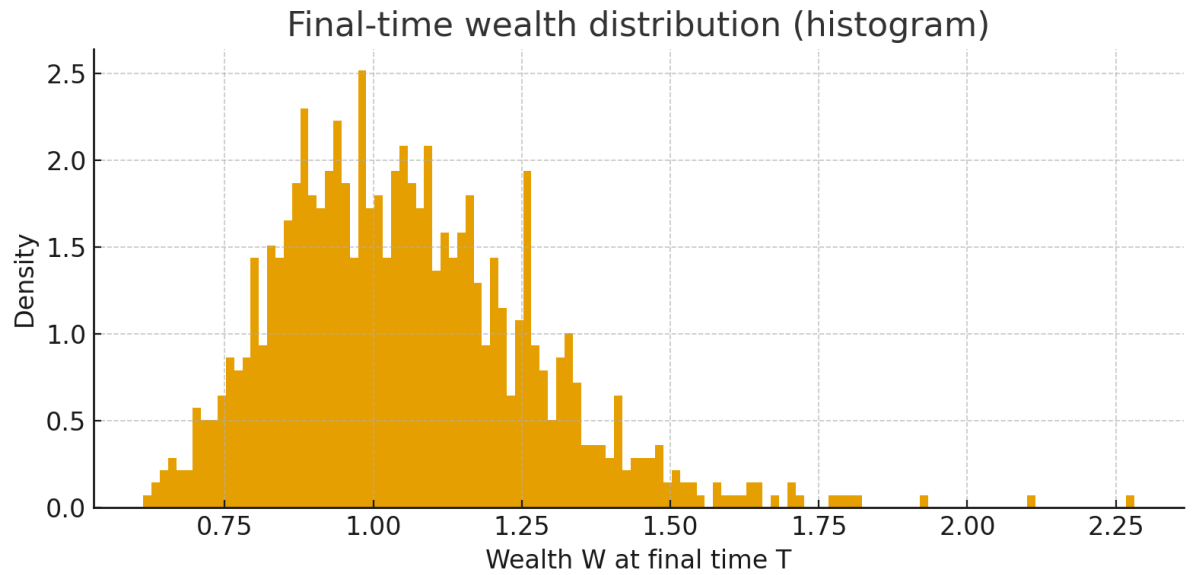
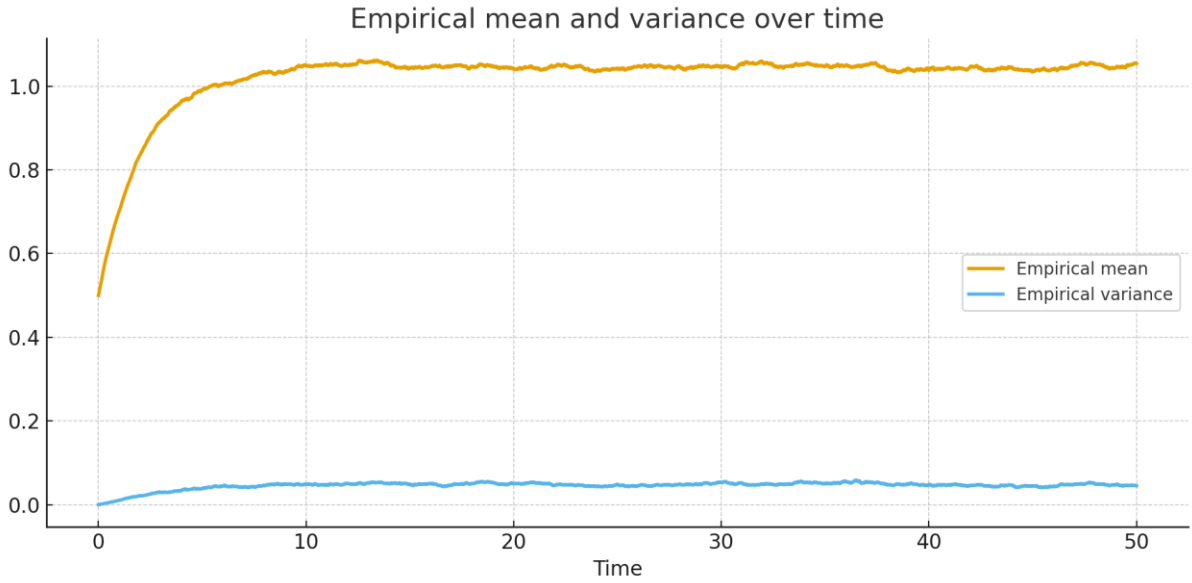
The corresponding Fokker–Planck PDE for density $p(w, t)$ is

$$\frac{\partial p}{\partial t} = -\frac{\partial}{\partial w} [\{\kappa w - \tau(w - W)\} p] + 0.5 \frac{\partial^2}{\partial w^2} \{\sigma^2 w^2 p\} \quad (17)$$

Stationary solutions can be inverse-gamma / Pareto tails depending on parameters; you can numerically integrate to approximate the distribution after 100 generation-steps (discretize time with $\Delta t = 1$ per generation).

Sample paths (50 of 1000) and mean





5 — Pareto tail dynamics (tail exponent recursion)

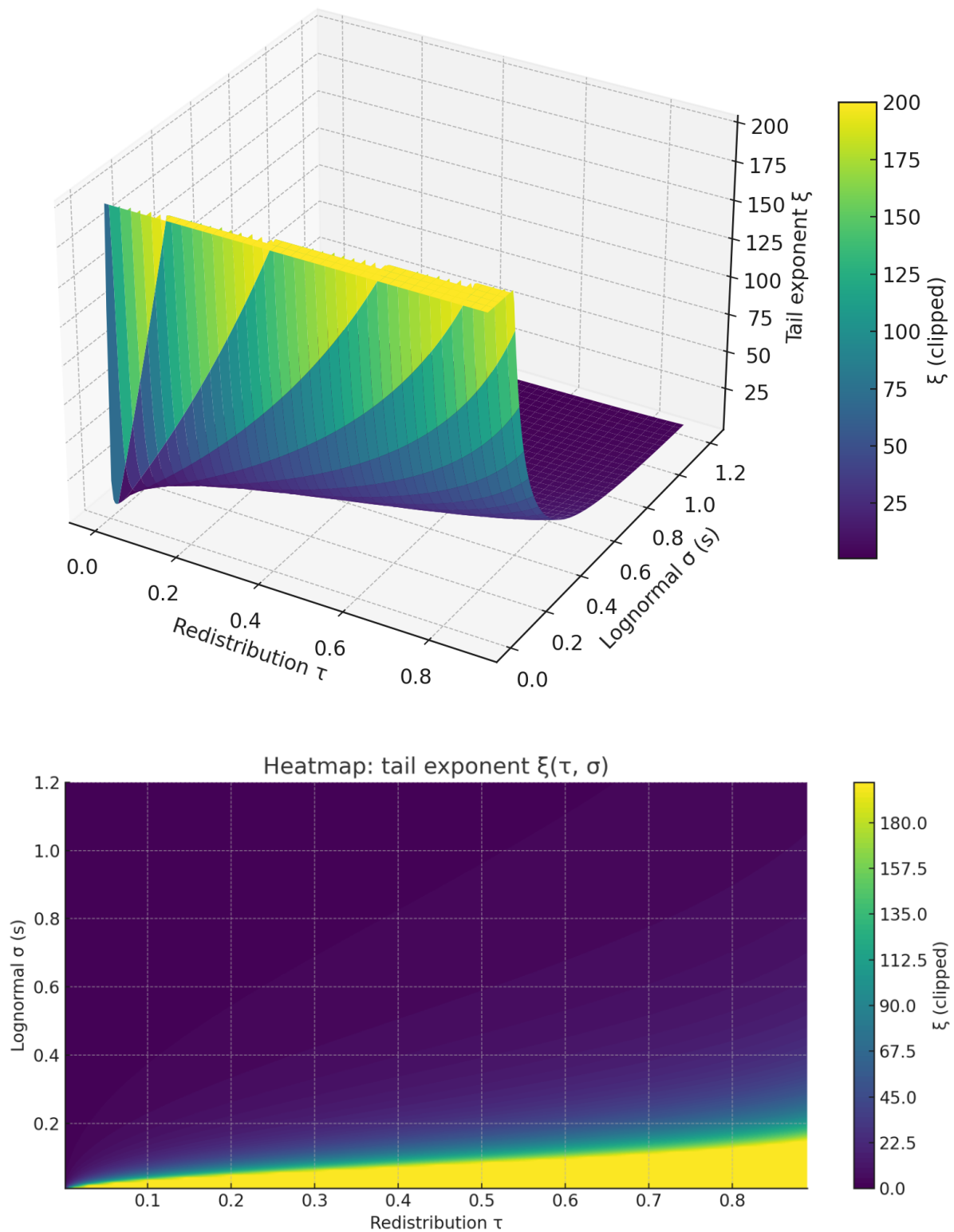
If top-tail is Pareto with exponent ξ_t (so $P(W > w) \sim C_w^{-\xi_t}$) multiplicative shocks and redistribution change ξ . Under multiplicative growth with i. i. d. multiplier M with $E[M^\xi] = 1$ the tail exponent ξ is the root of $E[M^\xi] = 1$. If redistribution multiplies top tail by factor $(1 - \tau)$, effective multiplier distribution shifts and ξ changes. One may write an implicit generation recursion:

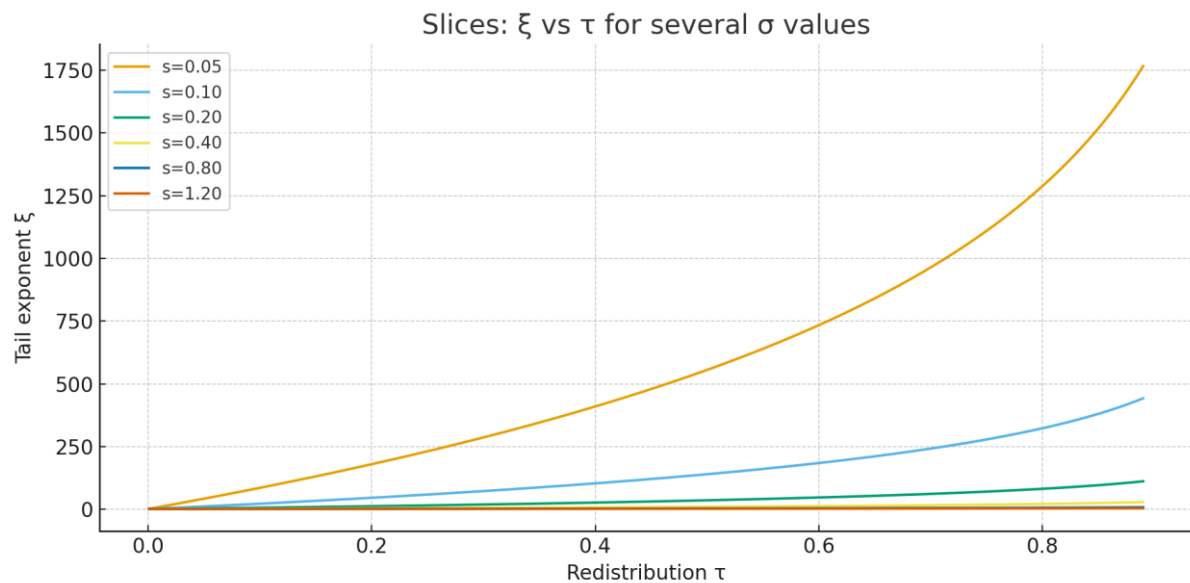
$$E[(1-\tau)^\xi M^\xi] = 1 \Rightarrow \xi = \xi(\tau, \text{dist}(M)) \quad (18)$$

By tracking ξ_t generation by generation you can track how the tail (extreme inequality) evolves.

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Tail exponent $\xi(\tau, \sigma)$ for $M \sim \text{LogNormal}$ with $E[M]=1$
(analytic formula $\xi = 1 - 2 \ln(1-\tau)/\sigma^2$)





6 — Compact analytic example you can plug into and evaluate at $t = 100$

Use the log AR(1) model from §2. Choose parameters symbolically and compute closed form G_{100} .

Given:

$$x^{t+1} = \phi x^t + \eta_{t+1}, \eta \sim (0, \sigma_\eta^2) \quad (19)$$

Then

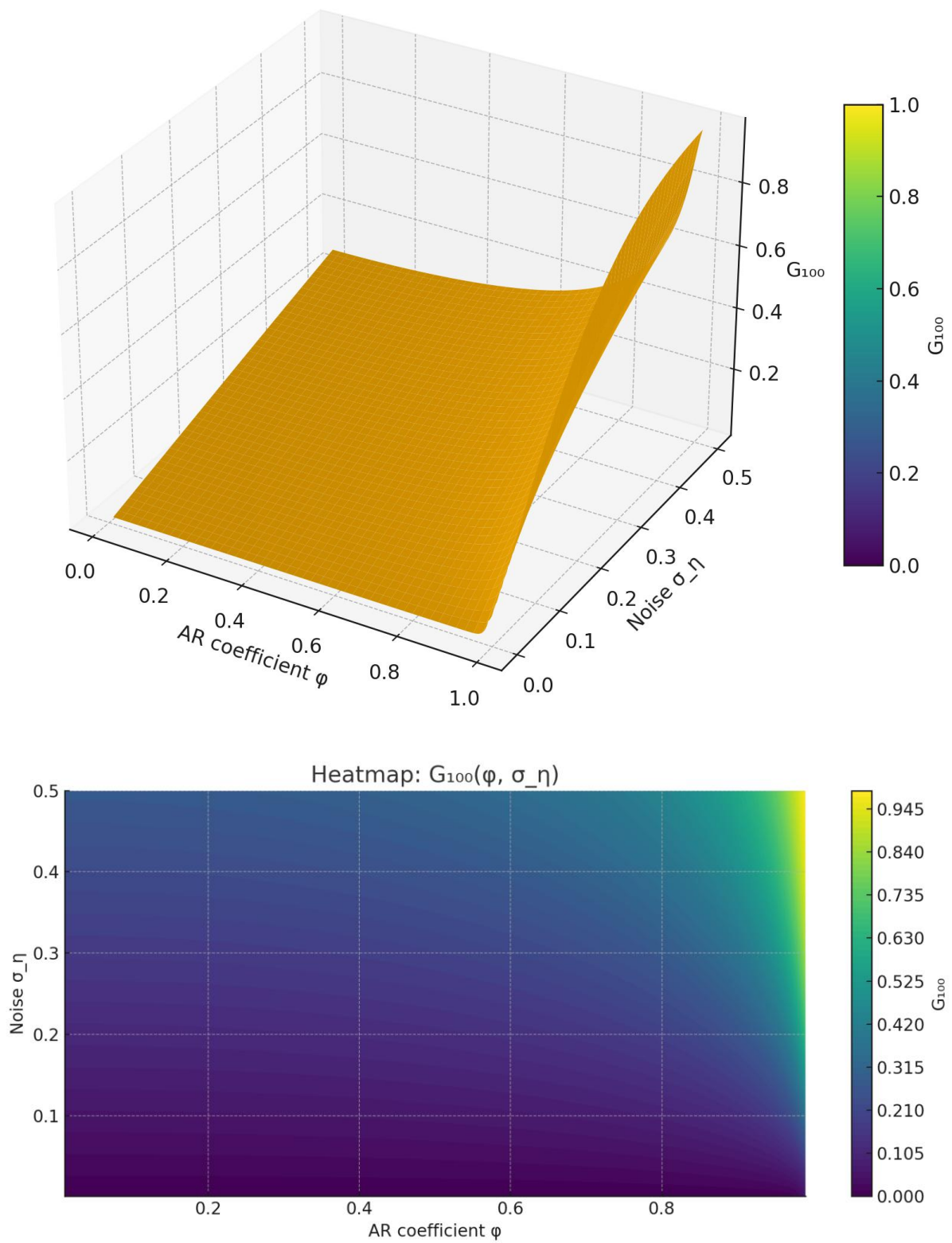
$$\sigma_{x,100}^2 = \phi^{200} \sigma_{x,0}^2 + \sigma_\eta^2 \frac{1 - \phi^{200}}{1 - \phi^2} \quad (20)$$

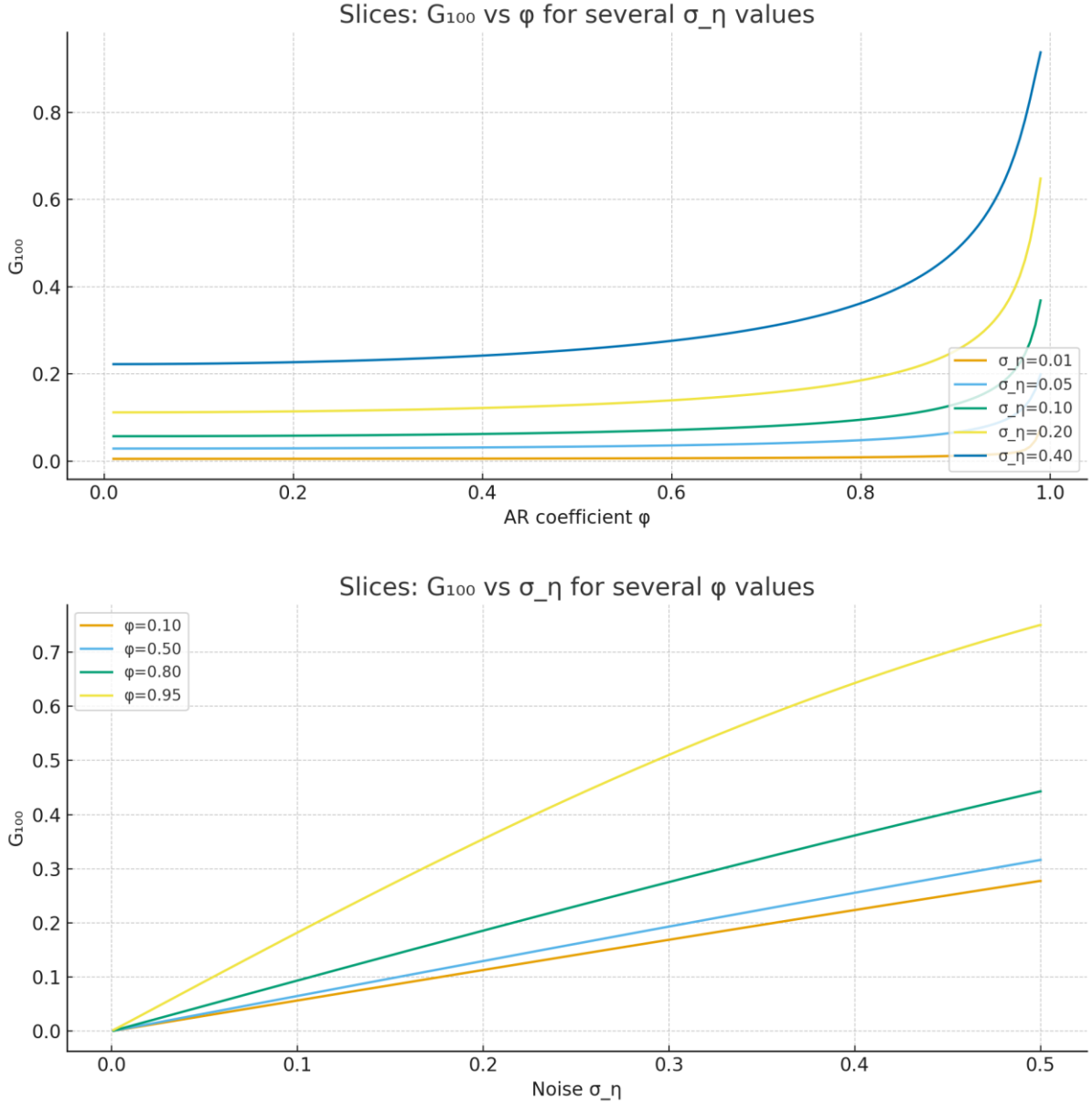
$$G_{100} = 2\Phi\left\{\frac{\sqrt{\sigma_{x,100}^2}}{\sqrt{2}}\right\} - 1 \quad (21)$$

A numerical example can be carried out for illustration. For instance, with $\phi = 0.9$, $\sigma_{x,0}^2 = 0.1$, and $\sigma_\eta^2 = 0.02$, we can compute $\sigma_{x,100}^2$ using the formula above and then determine G_{100} .

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G_{100} as function of ϕ and σ_η ($\sigma_{x,0^2}=0.1$, $t=100$)





7 — Practical instructions for computing G_{100}

- ✓ Choose a model above (linear, multiplicative AR(1), matrix mixing, or diffusion).
- ✓ Pick parameters (α , ϕ , σ_η , τ , M , n , ...) motivated by archaeological context (e.g., low α = high redistributive norms).
- ✓ Either (a) compute closed forms (as in §2), or (b) iterate the discrete recursion numerically for $t = 0, \dots, 100$ for a population sample and compute the Gini formula each generation.

II. Results and Discussion:

Our analysis draws on published datasets, noting that temporal coverage before and after the introduction of plant production varies considerably across sites. The findings presented here concern inequalities measured at the site level, that is, within-group or alpha-inequality (27). We focus on six regional case studies aggregated at a regional scale; therefore, no conclusions should be inferred for sub regional subsets. We define our key economic innovations as follows:

- Horticulture refers to plant production without animal traction, typically involving intensive garden cultivation. Productivity is constrained by human labor availability, which limits total output (32, 33).
- Arable farming emerges with the introduction of animal traction, substantially increasing per capita energy yield. Traction enhances crop production—especially in seedbed preparation and transport—resulting in lower intensity per area but higher productivity per person (34).

- Herd management expands food production through livestock, enabling exploitation of marginal areas when arable land is scarce.

The integration of these three innovations—plant cultivation, animal husbandry, and traction—produced regionally distinct outcomes but often combined additively to generate profound systemic transformations. The systemic linkage between these innovations, particularly evident with the advent of traction (31), must be recognized as central to Neolithic economic change. In interpreting the beta regression results, an increasing Slope Mode indicates rising inequality, with more sites showing higher Gini coefficients. Conversely, an increasing Slope Concentration signifies decreasing dispersion in Gini values—meaning inequality levels became more uniform across sites. Smaller sample sizes correspond to broader posterior ranges. In East Asia, none of the three innovations led to significant increases in Gini coefficients. Plant cultivation tended to make Gini values more uniform across sites, whereas animal domestication slightly reduced this uniformity. Notably, in parts of East Asia, plant cultivation chronologically precedes animal domestication. West Asia and Cyprus, as well as Western and Central Europe, display comparable patterns in both Slope Mode and Slope Concentration, reflecting their interconnected historical trajectories. Both regions exhibit decreasing inequality following certain innovations, though this trend is not consistent across all. While change-point analysis for West Asia remains inconclusive, there is some evidence of rising Gini values in Europe during the initial spread of traction. In contrast, Southeast Europe diverges from this pattern. Although increasing Slope Concentration (as seen in Western and Central Europe) corresponds with declining Gini values, Slope Mode decreases while dispersion increases—indicating greater variability in inequality levels. In North America, the introduction of plant production is associated with rising Gini coefficients (higher Slope Mode), while subsequent innovations correlate with decreasing inequality in both the Great Plains and Southwest. The Northeast and Southeast show reduced dispersion (higher Slope Concentration), although appears largely irrelevant across North American regions. Across all studied regions, there are no significant differences between primary domestication centers (35) and secondary adoption areas. The main distinction lies in the time lag between the earliest and common plant production events: migration-driven adoptions exhibit minimal lag, whereas gradual domestication processes take longer. Overall, economic innovation can be conceptualized as an expansion of productive potential. Following such innovations, both Slope Mode and Slope Concentration tend to rise—suggesting that new production modes initially provided widespread access to increased surplus potential, resulting in only moderate inequality. Later innovations, which often correlate with greater equality, may reflect the collective organization of field systems. Current anthropological, sociological, and archaeological debates on nonstate societies (36–38) emphasize various leveling mechanisms; however, identifying these archaeologically remains challenging. Most evidence pertains to the destruction of accumulated wealth (2)—a visible manifestation of the suppression of extreme inequality. The economic balancing roles of feasting and prestigious communal gifts remain poorly quantified, while regular mechanisms that raised the lower limits of wealth distribution are archaeologically elusive. Consequently, we currently lack quantitative data assessing the overall impact of such leveling practices. Melanesian Ethnographic Analogies: Ethnographic comparisons indicate that pronounced economic inequalities did not arise immediately following the advent of cultivation but developed much later. Studies of six horticulturalist communities in New Guinea—comparable in scale to early post-domestication societies—reveal low levels of inequality (mean Gini = 0.25, SD = 0.06, N = 1 level). These groups practiced extensive horticulture with long fallow periods (>10–12 years) and exhibited minimal economic differentiation. In such “Great Man” systems, leadership and influence stemmed from personal prestige—earned through hunting, ritual, or warfare (39–42)—rather than through the accumulation of material wealth. As horticulture intensified and fallow periods shortened (<10–12 years), “Big Man” systems emerged, in which prestige derived from organizing material displays and feasts (40, 42, 43). These were essentially gift economies (44, 45), centered on redistribution rather than accumulation: Big Men gained status by giving wealth away, not by hoarding it. Consequently, economic inequality remained limited and was seldom reflected in differences in house size. The social “profit” of these leveling systems lay in prestige and dominance, not in material disparity.

III. Conclusion:

The evolution of wealth inequality during the first hundred Neolithic generations was gradual and regionally diverse. Across the first two millennia of the Neolithic, neither global nor regional analyses show significant increases in residential disparity. On the contrary, technological and economic innovations often appear to have had an equalizing influence on wealth distribution. Ethnographic parallels further suggest that early agrarian societies developed social mechanisms to limit inequality. At this early stage, overall community wealth was likely modest, as domesticated plants and animals were still adapting to local environments and productive systems were only beginning to form. Human labor remained the sole source of physical power (22, 33), and its organization—whether through communal cooperation or leadership structures similar to the Melanesian “Big Man” model—posed a central political and economic challenge. As a result, land development efforts such as clearing, terracing, irrigation, and well construction advanced only gradually, and the long-term

creation of *landesque capital* (46) proceeded slowly. Where transitions from horticulture to arable farming occurred, they often reduced preexisting disparities in household wealth. Farm size was primarily determined by the number of oxen teams available, and in the absence of land scarcity, holdings tended to converge toward similar scales (34). In North America's Great Plains, Southwest, Northeast, and Southeast, increases in residential disparity followed plant domestication, but later transitions to animal management and traction had limited additional impact. Estimating potential versus realized production remains difficult. The lack of a consistent relationship between productivity gains and wealth differentiation suggests that surpluses were either consumed directly as labor savings or not materially accumulated. Archaeologically, one of the clearest signs of egalitarian organization is the standardization of property, particularly the uniformity of house sizes. Even under generous interpretative conditions—accepting only 50% HPDI results indicating rising inequality—no systematic evidence emerges for increased wealth disparity following technological innovations that later revolutionized prehistoric productivity. Instead, the data suggest a modest equalizing trend, though not one demonstrable at all regional scales. Further high-resolution, small-scale studies will be needed to refine these patterns. It also remains possible that certain technologies were adopted precisely for their perceived leveling potential—because they broadened access to productive opportunities across society. Ultimately, while rising productivity is a prerequisite for wealth inequality—since surpluses make accumulation possible—it is not, by itself, a sufficient cause. Our analysis of residential disparities reveals no strong association between key Neolithic innovations—plant cultivation, animal domestication, and traction—and increased inequality during the first two millennia of the Neolithic. Throughout this formative era, societies repeatedly reorganized their economies and enhanced productivity without a corresponding rise in wealth polarization.

Future Scope:

- **High-Resolution Regional Studies:** Future work should focus on high-resolution, small-scale regional analyses to capture subtle and context-dependent variations in wealth inequality during the Neolithic. Such studies could reveal micro-level social and environmental dynamics that broad datasets tend to obscure.
- **Temporal Modeling of Inequality Dynamics:** Developing fine-grained chronological models would help clarify when, where, and under what conditions economic disparities began to intensify. Integrating radiocarbon dating with settlement and architectural data can improve temporal resolution.
- **Cross-Comparative Ethnographic Analysis:** Ethnographic analogies can be expanded beyond Melanesian “Big Man” systems to include comparative cases from Africa, the Americas, and Eurasia. This would help test whether similar leveling mechanisms or leadership structures existed in different ecological and cultural settings.
- **Integration of Environmental and Climatic Factors:** Future studies could explore how environmental variability, soil fertility, or climatic events influenced productivity and social organization. Linking paleoenvironmental data with archaeological inequality metrics may illuminate ecological constraints on wealth accumulation.
- **Quantitative Modeling of Surplus Use:** Computational and agent-based models could simulate how surplus production was distributed, consumed, or stored within early agrarian systems. Such models can test hypotheses about when and how surplus began to translate into wealth differentiation.
- **Material Correlates of Social Institutions:** More research is needed to identify archaeological signatures of social leveling mechanisms—such as communal storage facilities, shared infrastructure, or standardized housing layouts—that limited inequality despite technological advances.
- **Technological Adoption and Social Equity:** Investigating whether certain technologies (e.g., traction, irrigation, or metallurgy) were adopted for their perceived leveling potential could deepen understanding of how innovation interacted with social values and norms.
- **Network and Exchange Analysis:** Studying trade and exchange networks can help determine whether early intercommunity interactions contributed to equalizing effects (through redistribution) or generated inequality (through elite control of resources).
- **Bioarchaeological Indicators of Inequality:** Integrating skeletal and isotopic data—such as diet, workload, and mobility patterns—can provide independent measures of inequality beyond residential size, helping to triangulate socio-economic differentiation in prehistoric populations.
- **Revisiting the Productivity–Inequality Hypothesis:** Future research should refine the relationship between productivity gains and wealth concentration by distinguishing between *potential productivity* (theoretical yield) and *realized productivity* (actual surplus). This can clarify whether economic growth necessarily translated into social stratification.

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- [52]. An i. i. d. shock is a random variable that is independent and identically distributed (i. i. d.) across time or individuals. It represents an unexpected, unpredictable disturbance in a system.
- [53]. An AR(1) model in logs means that the current value of a time series's logarithm is a linear function of the previous period's logarithm. This structure implies that the percent change in the series is related to its immediate past percent change, making it useful for modeling and forecasting variables like financial asset prices and economic indicators.
- [54]. The full form of CDF can refer to several different things depending on the context: Cumulative Distribution Function (Statistics): In probability and statistics, a cumulative distribution function gives the probability that a random variable will take a value less than or equal to a specific value. It is defined for both continuous and discrete random variables.