Scalar Extraction in Platform Capitalism:
A Field-Theoretic, Economic, and Algorithmic Theory of Extractive Social Networks and Their Non-Extractive Redesign

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Abstract

Contemporary social platforms instantiate a dynamical system that concentrates visibility potential Φ, suppresses agency vectors $\mathbf{v}$, and amplifies informational entropy S. We formalize this extraction as a field theory in which $\nabla\Phi \cdot \mathbf{v} < 0$ and $\nabla S \cdot \mathbf{v} > 0$, forcing visibility to oppose agency and disorder to grow with effort. We derive necessary and sufficient conditions for extraction, introduce Lyapunov stability guarantees for non-extractive regimes, treat visibility markets as monopsonistic auctions over attention labor, and provide adversarial thresholds for Sybil, entropy, and collusion attacks. We propose an enforceable constitutional architecture for non-extractive networks using scalar caps, cooperative credit decay, entropy damping, and reservoir-based visibility recirculation. The result is a falsifiable, measurable, and implementable theory of sociotechnical extraction and its reversal.

Keywords: attention economics, entropy regulation, network field theory, auction markets, digital governance, extractive platforms, cooperative ranking.

Contents

Preliminaries

0.1 Modeling Assumptions

1. Visibility potential $\Phi_x \geq 0$ represents realizable impression capacity, not content quality.
2. Agency vectors $\mathbf{v}_x$ represent effective action flow, not intent or sentiment.
3. Entropy S_x measures uncertainty in reach, not semantic randomness.
4. Attention capacity is finite and saturating: $C_{\text{effective}} < \infty$.
5. Time is discrete and synchronous.
6. Economic inputs influence only Φ, not $\mathbf{v}$ directly.
7. Network size N is large enough for mean-field behavior.

0.2 Symbol Reference Table

Symbol	Meaning	Units / Interpretation
Φ_x	Visibility potential	expected impressions/window
$\mathbf{v}_x$	Agency vector	normalized action influence
S_x	Informational entropy	uncertainty in reach (nats)
$\mathcal{C}_x$	Cooperative credit	bounded, decayed, non-transferable
ρ	Credit retention factor	$(0, 1)$, forgetfulness rate
ζ	Entropy damping rate	must exceed attack noise
κ	Extraction bifurcation	phase change control
$C_{\text{effective}}$	System visibility capacity	total sustainable attention

Part I — Foundations of Extraction

Interpretive bridge. We begin by defining extraction in formal terms: visibility opposes agency, and entropy grows with effort.

1 Axioms and Definitions

Definition 1.1 (Extractive Platform)**.** A platform is extractive if:

1. Φ is artificially scarce but purchasable,
2. $\mathbf{v}$ cannot increase Φ without payment,
3. $\mathbf{v}$ increases S rather than reducing it,
4. platform profit grows with S,
5. users cannot resolve visibility uncertainty without payment.

Axiom 1.1 (Visibility Conservation Violation)**.** *In non-extractive communication systems, visibility is conserved: $\sum_x \Phi_x = C$. Extractive platforms violate conservation via:*

$$\sum_x \Phi_x < C \quad \textit{and} \quad \frac{\partial}{\partial t} C_{available} < 0$$

Axiom 1.2 (Agency Opposition). *Platform gradients oppose agency:*

$$\nabla\Phi \cdot \mathbf{v} < 0$$

Axiom 1.3 (Entropy Alignment). *User actions increase entropy in the system:*

$$\nabla S \cdot \mathbf{v} > 0$$

Lemma 1.1 (Extraction Criterion). *A system extracts iff:*

$$\mathbb{E}[\nabla\Phi \cdot \mathbf{v}] < 0 \quad \wedge \quad \mathbb{E}[\nabla S \cdot \mathbf{v}] > 0$$

Remark 1.1. This corresponds to the phenomenology of "work harder, reach less".

Example 1.1. A creator posts organically, reaches 50 users, pays to boost to 500, then returns to 20. Effort increased, entropy increased, reach fell: extraction confirmed.

2 Visibility Conservation and Its Violation

Definition 2.1 (Visibility Budget). A network has a *visibility budget C* if total reach capacity is bounded:

$$\sum_x \Phi_x \leq C$$

with extraction iff:

$$\frac{dC_{\text{effective}}}{dt} < 0$$

Lemma 2.1 (Auction Crowding Law). *If paid visibility $\Phi^{(\$)}$ expands:*

$$\sum_x \Phi_x^{(organic)} = C - \Phi^{(\$)}$$

then organic visibility contracts as payment grows.

Placeholder: Potential field diagram of visibility well formation

Figure 1: Scalar potential becomes a central well when unbounded.

3 Lyapunov Stability of Non-Extractive Regimes

4 Stability and Bifurcation

Let total system energy be:

$$\mathcal{H} = \tfrac{1}{2} \sum_x \|\nabla\Phi_x\|^2 + \alpha\|\mathbf{v}_x\|^2 + \beta S_x^2$$

Theorem 4.1 (Stability Condition). *The system is non-extractive and convergent if:*

$$\frac{d\mathcal{H}}{dt} \leq -\lambda\mathcal{H}, \quad \lambda > 0$$

Remark 4.1. Extraction destabilizes by flipping the sign on $\nabla\Phi \cdot \mathbf{v}$.

Define critical extraction parameter:

$$\kappa = \mathbb{E}[\nabla S \cdot \mathbf{v}] - \mathbb{E}[\nabla\Phi \cdot \mathbf{v}]$$

Theorem 4.2 (Extraction Phase Transition).

$$\kappa > 0 \implies \textit{runaway centralization and entropy expansion}$$

This induces instability in Φ and chaotic entropy forcing.

Part II — Political Economy of Visibility

Interpretive bridge. We now embed the field model into economic exchange.

4.1 GSP Auction Extraction

$$\mathbb{E}[b_i - v_i] > 0$$

Small bidders systematically overpay relative to value under incomplete information.

Definition 4.1 (Attention Monopsony)**.**

$$\max_{\pi} V(\pi) - W(\pi) \quad \text{with} \quad \pi < \pi_{\text{competitive}}$$

Part III — Cognitive and Affective Extraction

User affect evolves as:

$$\dot{\mathbf{a}} = A\mathbf{a} + B\mathbf{u} + \xi(t)$$

Theorem 4.3 (Manipulability)**.** *User is manipulable if:*

$$\rho(A) > 1 - \|B\|$$

Part IV — Adversarial Extraction and Attack Surfaces

5 Sybil Harvesting Attack

Attackers deploy m fake accounts to siphon scalar credit.

Let G be interaction graph, L its Laplacian.

Theorem 5.1 (Sybil Detectability Bound)**.** *If attacker controls m nodes, detection is impossible when:*

$$m > \frac{\lambda_2(L)}{\lambda_{\max}(L)} \cdot N$$

where $\lambda_2(L)$ is the Fiedler value.

6 Entropy Flooding

The attacker injects noise vectors η_x to force:

$$\nabla S \cdot \mathbf{v} \gg 1$$

Countermeasure:

$$\partial_t S = -\zeta S + \kappa \nabla^2 S$$

must satisfy:

$$\zeta > \|\eta\|_{\max}$$

to guarantee damping.

Part V — Constitutional Design

$$\Phi_x \leq \Phi_{\max}, \quad 0 < \rho < 1, \quad \zeta > \|\eta\|, \quad C_{\text{effective}} > 0$$

Corollary 6.1. *Visibility must be a flow, not an accumulating capital.*

Part VI — Implementation and Validation

6.1 Open Parameters

Part V — Governance, Constitutional Design, and Power-Bounded Platforms

A non-extractive platform is not merely an algorithmic object but a constitutional object: a system of power constraints, auditability, budgeted influence, and binding commitments on allocation.

7 Constitutional Constraints for Influence

A platform constitution is defined as a tuple:

$$\mathcal{C} = (\mathcal{R},\ \mathcal{L},\ \mathcal{B},\ \mathcal{A})$$

where:

- $\mathcal{R}$ = ranking rules,
- $\mathcal{L}$ = limits on visibility accumulation,
- $\mathcal{B}$ = budget on extractable attention,
- $\mathcal{A}$ = audit and enforcement mechanisms.

Definition 7.1 (Visibility Constitutional Cap)**.** A platform respects constitutional influence limits if there exists a constant $\Phi_{\max}$ such that for all users x:

$$\Phi_x \leq \Phi_{\max}$$

and cumulative systemic visibility never exceeds:

$$\sum_x \Phi_x \leq C_{\text{global}}$$

Proposition 7.1 (No Infinite Amplification)**.** *If visibility gains are bounded by:*

$$\Phi_x(t+1) = \min(\Phi_{\max},\ \Phi_x(t) + \Delta\Phi_x)$$

then no actor can asymptotically monopolize platform attention, even under strategic amplification.

Proof. Trivial from monotone bounded convergence: $\Phi_x(t)$ is increasing but bounded above; hence $\lim_{t\to\infty} \Phi_x(t) \leq \Phi_{\max}$. □

8 Governance by Dual-Ledger Influence Accounting

Ledger	Tracks	Transferability	Purpose
Φ-ledger	Visibility allocated	Non-transferable	Social reach cap
$\mathcal{C}$-ledger	Cooperative credit earned	Non-transferable, decays	Reward pro-social contribution

Credit update law:

$$\mathcal{C}_x(t+1) = \rho\mathcal{C}_x(t) + \sum_{a \in \mathcal{A}_x} \omega_a \quad \text{with} \quad 0 < \rho < 1$$

Theorem 8.1 (Decay Prevents Credit Hoarding)**.** *If $0 < \rho < 1$, then for any bounded reward stream,*

$$\lim_{t \to \infty} \mathcal{C}_x(t) < \frac{\max_a \omega_a}{1 - \rho}$$

Proof. This is a standard geometric series bound. □

9 Escrowed Visibility and Time-Locked Reach

Define visibility aging kernel:

$$\Phi_x(t) = \Phi_x(0)e^{-\lambda t}$$

Redistribution reservoir:

$$\mathcal{V}_{\text{pool}}(t+1) = \mathcal{V}_{\text{pool}}(t) + \sum_x \lambda\Phi_x(t)$$

Redistribution rule:

$$\Phi_{\text{grant}}(y) \propto \frac{\mathcal{C}_y}{\sum_z \mathcal{C}_z}$$

Corollary 9.1. *Visibility becomes a flow, not an asset class.*

10 Collective Governance Operators

Operator	Meaning	Action
$\mathcal{G}_0$	Cap adjustment	Modify $\Phi_{\max}$
$\mathcal{G}_1$	Credit policy	Modify ρ or ω
$\mathcal{G}_2$	Distribution rule	Change ranking kernel
$\mathcal{G}_3$	Anti-collusion	Apply decorrelation penalties
$\mathcal{G}_4$	Noise suppression	Increase entropy damping ζ

Governance objectives solve:

$$\min_{\mathcal{G}} \mathcal{E}(\mathcal{G}) \quad \text{subject to} \quad U_{\text{user}}(\mathcal{G}) \geq U_{\min}$$

Part VI — Implementation as Enforceable Infrastructure

11 System Architecture

Module	Role
Influence Ledger	Enforce Φ bounds
Credit Ledger	Track decayed cooperative reward
Ranking Engine	Reciprocity-weighted ordering
Audit Layer	Public verification of invariants
Reservoir	Time-decay recycling of visibility
Threat Monitor	Detect sybils, collusion, flooding
Governance Kernel	Perform $\mathcal{G}_k$ updates

12 Core Ranking Algorithm (Reference Implementation)

Algorithm 1 Constitutional Reciprocity Ranking

Require: Candidate posts C, citizen x, credit ledger $\mathcal{C}$

```
for post y ∈ C do
    score ← α₁R(x, y) + α₂S(x, y) + α₃C_y
    score ← score · exp(−λΦ_y)                      ▷ TTL-weighted decay penalty
    score ← score ·(1 − collusion_penalty(x, y))

        Filter by Φ_y ≤ Φ_max
        Return top-k by score
```

13 Anti-Sybil Infrastructure

Theorem 13.1 (Sybil Resistance Criterion)**.** *Let L be the graph Laplacian of verified social links. An attacker controlling m sybils is undetectable if:*

$$m > \frac{\lambda_2(L)}{\lambda_{\max}(L)} N$$

Hence sybil resistance requires maximizing spectral gap λ_2.

14 Entropy Control Protocol

Proposition 14.1. *Entropy remains bounded iff:*

$$\zeta > \|\eta_{attack}\|_\infty$$

15 Metric Dashboard for Live Inspection

Metric	Meaning
$\mathrm{Var}(\Phi)$	Concentration of visibility
$\mathcal{E}$	Net extraction pressure
$\frac{dC_{\text{effective}}}{dt}$	Shrinking attention budget
$\zeta - \|\eta\|_\infty$	Safety margin vs entropy attack
ρ	Credit decay rate
λ	Visibility half-life

16 Implementation Roadmap

1. **Phase 1 — Simulation**: Validate bounded coherence.
2. **Phase 2 — Closed Pilot**: 100–1000 users.
3. **Phase 3 — Constitutional Enforcement**: Activate caps, decay.

4. **Phase 4 — Governance Rollout**: Enable $\mathcal{G}_k$ voting.
5. **Phase 5 — Adversarial Hardening**: Stress tests.

Part VII — Empirical Science Program

17 Observable Field Variables

- Longitudinal measurement of $\Phi, \mathbf{v}, S$
- Calibrating κ on real platform traces
- Implementing constitutional ranking layers
- Differentiating organic vs monetary field components

18 Core Falsifiable Hypotheses

H1. $C_{\text{effective}}(t)$ decreases as $\mathcal{E}(t)$ increases.

H2. Φ_{max} reduces Gini coefficient.

H3. $\rho < 1$ bounds credit inequality.

H4. $\zeta > \|\eta\|$ stabilizes $S(t)$.

H5. Extraction collapses agency rank.

H6. Reservoir increases reach diversity.

19 Primary Measurement Instruments

19.1 Visibility Gini Index

$$G = \frac{\sum_i \sum_j |\Phi_i - \Phi_j|}{2n \sum_i \Phi_i}$$

19.2 Effective Coherence Capacity

$$C_{\text{effective}} = I(M_0; M_k)$$

20 Controlled Experiments

Experiment 1 — Extraction Stress Test: Increase $\mathcal{E}(t)$, track collapse.
Prediction: $C_{\text{effective}} \downarrow$, $S(t) \uparrow$, $\text{rank}(T) \downarrow$.

21 Natural Experiments

Sudden Policy Shock: Algorithm changes $\rightarrow$ difference-in-differences on G, $C_{\text{effective}}$.

22 Benchmark Datasets

| Dataset Type | Purpose | |—|—| | Message cascades | $C_{\text{effective}}$ | | User-session logs | $\mathbf{v}$ | | Visibility histograms | Gini | | Reply graphs | Reciprocity |

23 Failure Modes That Would Falsify the Thesis

If all six hypotheses fail simultaneously, the RSVP critique is empirically invalid.

Part VIII — Mathematical Proof Appendix

23.1 Boundedness of Credit Under Decay

Lemma 23.1 (Geometric Credit Bound)**.** *If* $|\Delta_i(t)| \leq B$*, then:*

$$|\mathcal{C}_i(t)| \leq \frac{B}{1-\rho}$$

Proof. Unrolling:

$$\mathcal{C}_i(t) = \rho^t \mathcal{C}_i(0) + \sum_{k=0}^{t-1} \rho^k \Delta_i(t-k-1)$$

Geometric series bound yields the result. □ □

23.2 Monotonic Collapse of Coherence

Theorem 23.1 (Extraction-Coherence Collapse)**.** *If* $\nabla\mathcal{E}(t)$ *increases concentration, then:*

$$C_{\mathit{eff}}(t) \to 0 \quad \textit{monotonically}$$

Part XII — System Architecture Specification

23.3 Core Architectural Requirements

1. Field observability
2. Enforced visibility cap
3. Credit decay valve
4. Entropy damping control
5. Agency rank monitoring
6. Recycling reservoir

23.4 Safety Trigger Surfaces

Interventions fire when:

$$G(\Phi) > 0.62, \tag{1}$$
$$S(t) - S(t-1) > \delta, \tag{2}$$
$$\mathrm{rank}(T) < k_{\min}, \tag{3}$$
$$C_{\mathrm{eff}}(t) < \epsilon. \tag{4}$$

23.5 Formal Compliance Statement

RSVP-compliant iff:

$$\forall t : \begin{cases} \Phi_i(t) \le \Phi_{\max} \\ 0 < \rho < 1 \\ S(t) \le S_0 \\ \mathrm{rank}(T(t)) \ge k_{\min} \end{cases}$$

Part XIII — Game-Theoretic Adversary Modeling

23.6 Adversarial Strategy Space

Adversary controls:

$$\mathcal{E}_A(t),\ \eta_A(t),\ \sigma_A(t)$$

Utility:

$$U_A = \lambda_1 \int \mathcal{E}_A + \lambda_2 \int \eta_A + \lambda_3 \int \sigma_A - \lambda_4 D(t)$$

Platform minimizes:

$$\mathcal{L}_{\text{plat}} = \alpha_1 G(\Phi) + \alpha_2 S(t) + \alpha_3 \max(0, k_{\min} - \text{rank}(T)) + \alpha_4(1 - C_{\text{eff}})$$

23.7 Canonical Attack Archetypes

Attack	Strategy	Effect
Visibility Flooding	$\mathcal{E}_A \neq 0$	$G(\Phi) \uparrow$
Entropy Shock	$\eta_A \gg 0$	$S(t) \uparrow$
Agency Collapse	$\sigma_A \to 1$	$\text{rank}(T) \downarrow$
Credit Siphon	fake loops	$\mathcal{C}_i \to \infty$

23.8 Stability Conditions

Platform stable if:

$$\rho < 1,\ \Phi_{\max} < \infty,\ \zeta > \eta_{\max},\ k_{\min} > 1$$

23.9 Adversarial Phase Transitions

$$\Omega_A = \frac{\mathcal{E}_A + \eta_A + \sigma_A}{\zeta + (1 - \rho) + k_{\min}}$$

Regimes: $\Omega_A < 1$ (stable), $= 1$ (critical), > 1 (collapse).

Part XIV — Auditor and Verification Protocol

23.10 Verifiable Field Log Commitments

Commitment chain:

$$h_t = \mathrm{Hash}(\mathcal{F}(t) \,\|\, h_{t-1})$$

23.11 Zero-Knowledge Proofs

Prove:

$$\mathrm{ZK}_1 : \forall i,\ \Phi_i \leq \Phi_{\max} \tag{5}$$
$$\mathrm{ZK}_5 : G(\Phi) \leq G_{\max} \tag{6}$$

23.12 Audit Verdict

$$V = 1 \text{ if all proofs valid}$$

Repeated failure → governance takeover.

23.13 Proof of Non-Extraction (PoNE)

$$\Delta\mathcal{E}(t) \leq \delta_{\mathrm{safe}}$$

Part XV — Simulation Harness

```python
import numpy as np
import networkx as nx
from scipy.stats import entropy

class PlatformField:
    def __init__(self, n_agents=1000, rho=0.97, phi_max=10.0):
        self.n = n_agents
        self.rho = rho
        self.phi_max = phi_max
        self.Phi = np.random.rand(n_agents)
        self.C = np.zeros(n_agents)
        self.actions = np.random.randint(0, 20, size=n_agents)
        self.T = np.zeros((20,20))

    def update_credit(self, delta):
        self.C = self.rho * self.C + delta
        return self.C

    def update_visibility(self, extraction_strength=0.1):
        grad = np.gradient(self.Phi)
        self.Phi = self.Phi + extraction_strength * grad
        self.Phi = np.clip(self.Phi, 0, self.phi_max)
        return self.Phi

    def update_action_transitions(self):
        for i in range(len(self.actions)-1):
            a, b = self.actions[i], self.actions[i+1]
            self.T[a,b] += 1
        self.T /= (self.T.sum(axis=1, keepdims=True) + 1e-6)
        return self.T

    def gini_visibility(self):
        diff = np.abs(self.Phi[:,None] - self.Phi[None,:])
        return diff.sum() / (2 * self.n * self.Phi.sum())

    def entropy_attention(self):
        p = self.Phi / (self.Phi.sum() + 1e-9)
        return entropy(p)

    def action_rank(self):
        return np.linalg.matrix_rank(self.update_action_transitions())

    def inject_noise(self, scale=0.2):
        self.Phi += np.random.randn(self.n) * scale
        self.Phi = np.clip(self.Phi, 0, self.phi_max)

    def step(self, extraction=0.1, noise=0.0):
        self.update_visibility(extraction)
        self.update_credit(np.random.randn(self.n) * 0.05)
        if noise: self.inject_noise(noise)
        return {
            "gini": self.gini_visibility(),
            "entropy": self.entropy_attention(),
            "rank": self.action_rank(),
        }

```