AI Economic Series

The Economics of Digital Intelligence Capital: Endogenous Depreciation and the Structural Jevons Paradox

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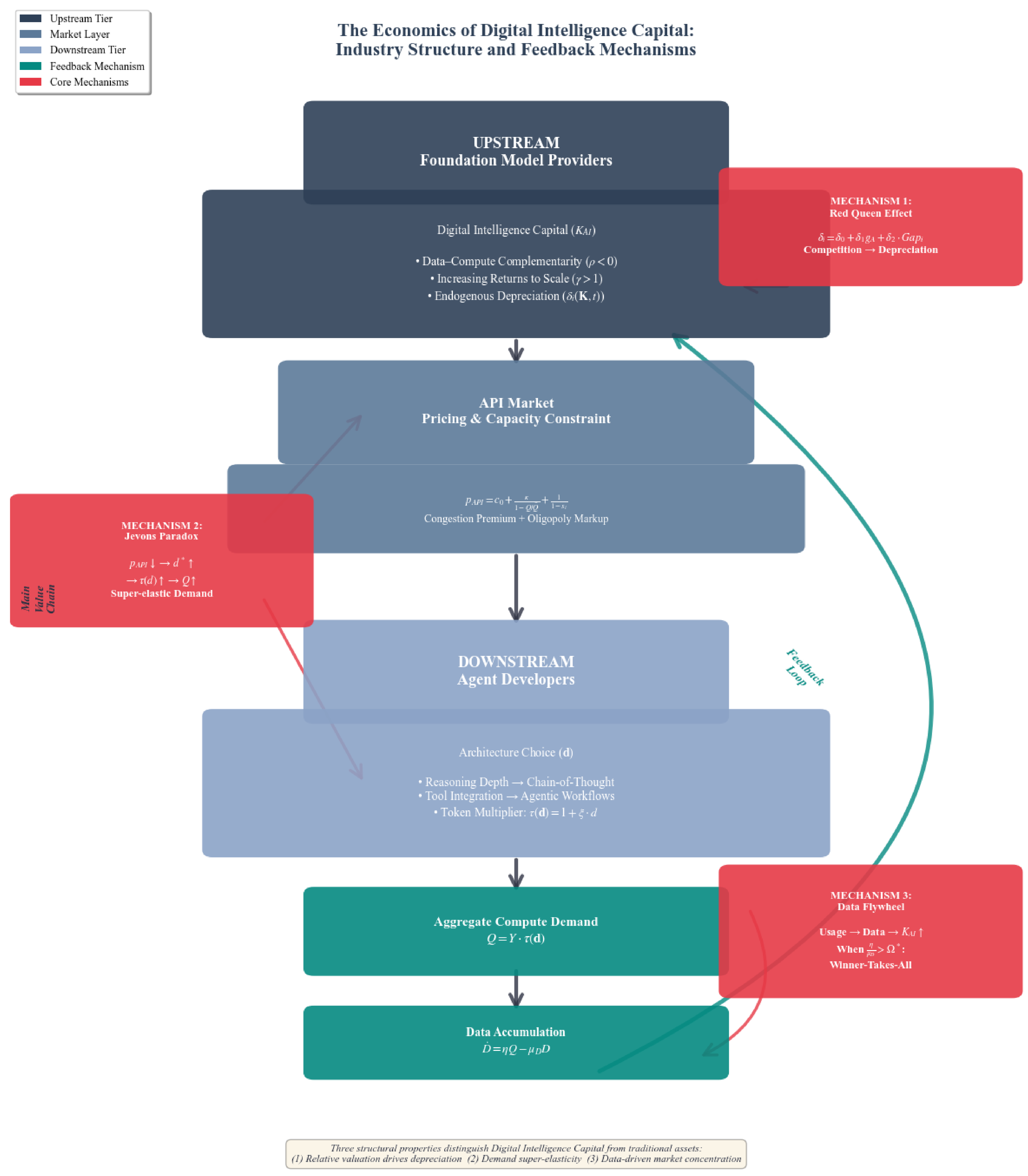
Background &Motivation

- Artificial intelligence fundamentally differs from both traditional physical capital and conventional software, making standard economic models ill-suited to capture its dynamics. Unlike physical capital, AI systems are non-rival in use yet subject to hard capacity constraints in inference compute; unlike software, they require massive upfront investment in data–compute synthesis and exhibit rapid economic obsolescence. We conceptualize large language models as **Digital Intelligence Capital**—a distinct asset class whose value is inherently *relative* rather than absolute, depending on capability differences across competing models and the moving technological frontier. This relative valuation, combined with strong scale effects in training and deployment and binding capacity constraints in inference, generates endogenous depreciation, persistent innovation pressure, and non-standard demand responses that cannot be explained by existing capital accumulation or software platform frameworks.

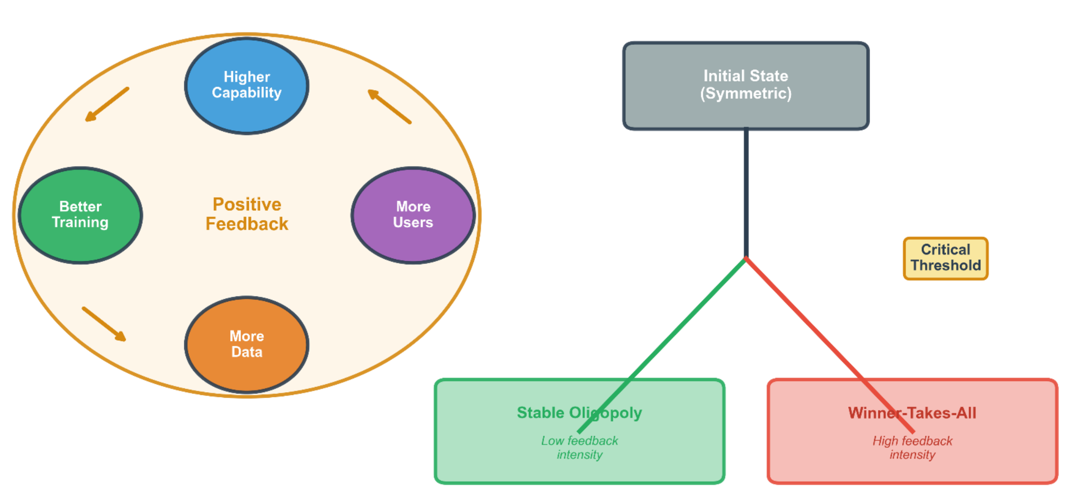
Core Modelling Framework

- The AI economy is organized as a **two-tier production stack**. Upstream, a small set of foundation model providers invest in large-scale compute and data to produce general-purpose intelligence, which is supplied as an intermediate input through capacity-constrained API markets. Downstream, a continuum of agent developers and application firms combine this intelligence with domain-specific orchestration and architectural design to produce differentiated services. Crucially, usage at the downstream layer generates interaction and feedback data that flow back upstream, improving model capabilities and reshaping competitive advantage. The interaction between compute constraints, data accumulation, and feedback loops tightly couples supply and demand, creating dynamic amplification effects that govern innovation incentives, market concentration, and the evolution of the AI industry
- We model foundation models as accumulating a distinct stock of **Digital Intelligence Capital**, produced through a data–compute synthesis technology that exhibits strong complementarities and increasing returns to scale. This capital functions as a non-rival intermediate input but is constrained by physical inference capacity, shaping pricing and downstream adoption. Crucially, the economic value of Digital Intelligence Capital is *relative*: a model's profitability depends on its capability advantage over competitors and the moving technological frontier. As a result, investment by one firm endogenously depreciates the value of rivals' existing capital, generating **endogenous economic depreciation** even in the absence of physical decay. This framework links capital accumulation, competition, and depreciation into a unified dynamic system that departs fundamentally from standard capital accumulation models.



Mechanism III: Data Flywheel & Market Bifurcation

Feedback-Driven Winner-Takes-All Dynamics

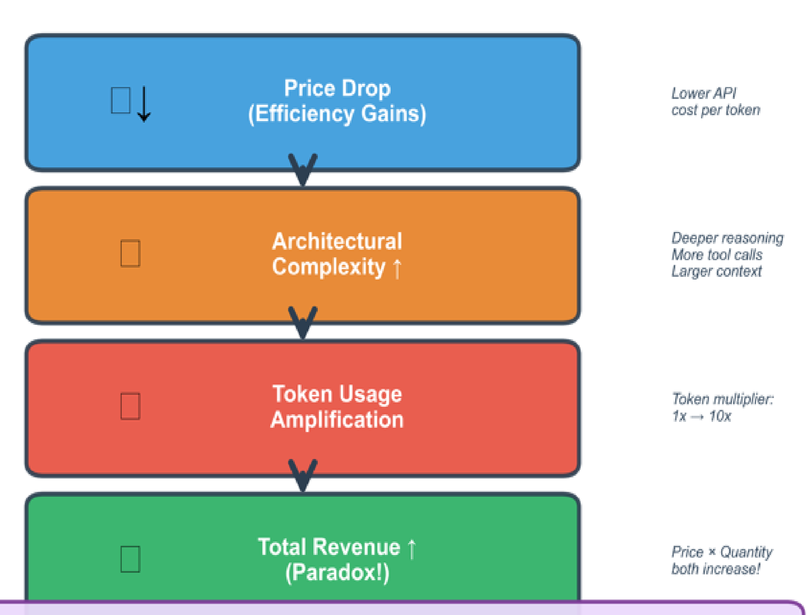


Key Insight

- Better models attract more users → generate more data → become even better
- Market outcome depends on feedback intensity (data learning vs. decay)
- Above threshold: Monopoly is structural outcome, not strategic choice

Mechanism II: Structural Jevons Paradox

Demand-Side Architectural Response

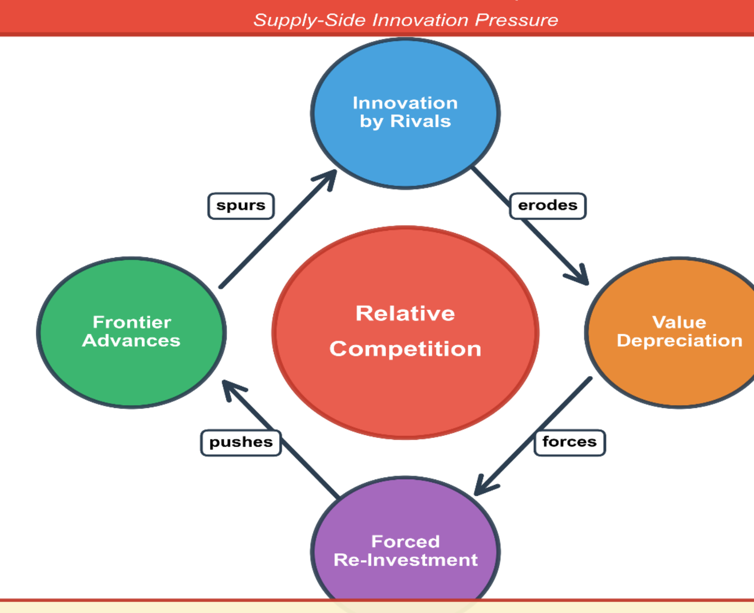


Key Insight

- Demand is NOT fixed – architecture choice is endogenous
- Cheaper intelligence → More complex workflows → More compute consumed
- Efficiency gains lead to INCREASED total resource usage (paradox)

Mechanism I: The Red Queen Effect

Supply-Side Innovation Pressure



Key Insight

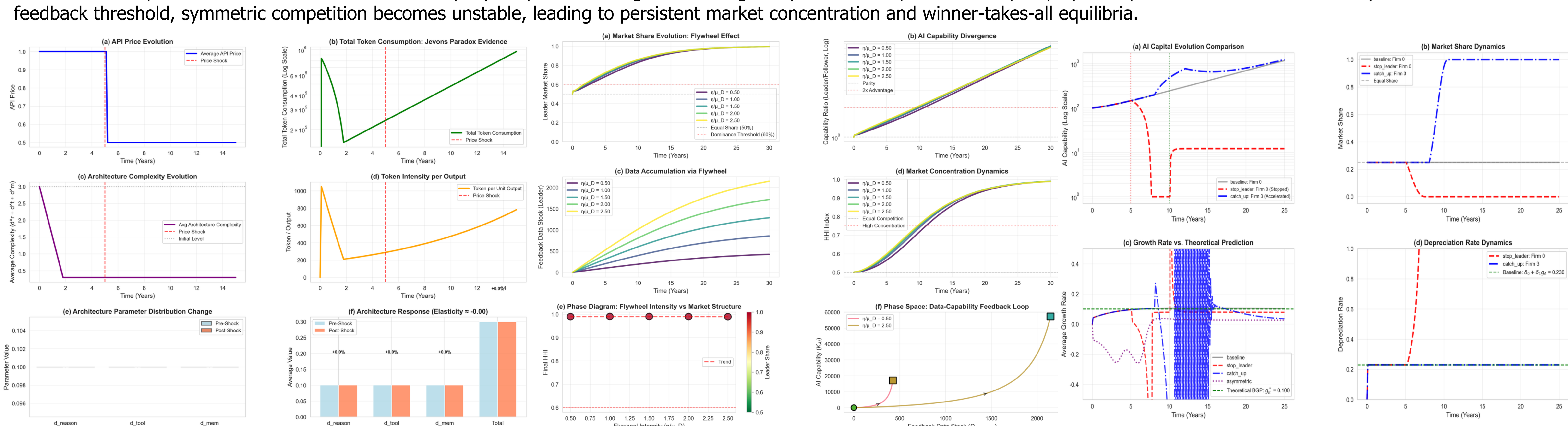
- Asset value depends on RELATIVE capability, not absolute
- Innovation by one firm depreciates rivals' capital
- "Running to stay in place" – continuous innovation required

Quantitative Evidence

Quantitative Evidence.

We validate the theoretical mechanisms **using large-scale agent-based simulations** that jointly model foundation model providers, downstream agent developers, and heterogeneous users interacting over compute- and data-constrained markets. The simulations endogenize investment, architectural choice, pricing, and usage, allowing Digital Intelligence Capital to evolve dynamically under competition. This framework reproduces the co-evolution of supply and demand implied by the model, generating rich transitional dynamics that cannot be captured by static or representative-agent approaches.

The simulation outcomes confirm three core predictions of the theory. First, Digital Intelligence Capital exhibits substantial **endogenous depreciation**, with lagging firms experiencing rapid economic value erosion driven by frontier expansion and rival investment rather than physical decay. Second, demand for compute becomes **super-elastic** as prices fall, reflecting architectural amplification and the transition from simple prompt-based usage to multi-agent systems. Third, the economy displays sharp **bifurcation behavior**: beyond a critical feedback threshold, symmetric competition becomes unstable, leading to persistent market concentration and winner-takes-all equilibria.



Policy Implication And Conlusion

- Our results highlight fundamental limits of price-based antitrust in the AI economy. When the marginal cost of intelligence falls rapidly and prices naturally approach zero, low prices no longer signal competitive health, nor do they prevent market concentration driven by data feedback and relative capability dynamics. Effective regulation must therefore target the *structure* of the production system rather than its prices. Policies such as mandatory data interoperability, portability of feedback data, and standards for interface openness can weaken self-reinforcing data flywheels, restore competitive stability, and preserve downstream ecosystem viability without undermining the scale efficiencies inherent in foundation model development.