From RPI-X to Agentic AI:

The Knowledge Problem and the Scaling of Market Coordination in Electricity

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Presentation Overview

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RPI-X as constitutional design for rivalrous discovery

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4 **Digital Technologies as Scaled Discovery**

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The scale changes. The logic does not.

1

The Big Claim:

Littlechild's Legacy Is Epistemic

The Central Claim

The Core Argument

1. Littlechild's contribution is best understood as a regulatory posture grounded in *epistemic humility*, as well as a set of institutional innovations.

2. RPI-X reframed competition as a rivalrous *discovery process*, and regulation as a framework that must preserve that process, not replace it.

3. This epistemic logic is not historically bounded; it scales into transactive energy platforms, real-time pricing, and AI-mediated coordination.

4. The central challenge then and now: constrain durable monopoly power without extinguishing *decentralized discovery*.

Intellectual Lineage

Hayek (1945)
Dispersed knowledge & prices as surrogates

Kirzner (1973)
Entrepreneurial alertness & error correction

Schumpeter
Creative destruction under uncertainty

Coase (1937)
Transaction costs & institutional boundaries

Joskow
Institutional realism in power systems

Littlechild (1983)
RPI-X as epistemic institutional design

2

Littlechild's Core Insight:

Regulation as a Framework for Rivalrous Discovery

RPI-X as Epistemic Design

Origins & Context

Post-privatization UK: how to discipline monopoly without cost-plus omniscience. Littlechild's 1983 report proposed a forward-looking price-cap regime, later applied under the Electricity Act 1989.

The Mechanism: Constraint + Discretion

$P_t \leq P_{t-1} (1 + \pi_t - X)$. If the firm beats the X-factor, it keeps the gains. If it falls short, it bears the losses. Profit and loss are discovery signals within the regulatory framework.

What RPI-X Does NOT Do

Does not compute efficient costs. Does not continuously recalibrate revenues. Epistemic modesty, not technical sophistication, is the central design feature.

The Multi-Year Commitment Interval

Immediate recalibration upon observing profit would kill the incentive to search for efficiencies. Credible commitment over time protects the return to discovery long enough for learning to occur.

Competition as a Rivalrous Discovery Process — Not an Equilibrium

Hayek (1945)

The Division of Knowledge

The central problem is coordinating knowledge that exists in fragmentary, contextual, or tacit form across individuals. Prices are *knowledge surrogates* — compressed signals that guide action without requiring agents to understand the underlying causes of change.

Kirzner (1973)

Entrepreneurial Alertness

Opportunities exist because prices fail to reflect underlying conditions. Entrepreneurs notice unrecognized discrepancies and act on them. Profits reward *error correction* — the closing of ignorance gaps in the price structure.

Littlechild & Owen (1980)

Formal Expression

The Austrian process view is not merely qualitative. Their model represents market interaction as a *stochastic discovery process*, with testable implications about price dispersion and the conditions under which discovery occurs.

Constitutional vs. Managerial Regulation

Rate-of-Return Regulation

Managerial approach

- Audits costs *ex post*; assumes regulators can observe the firm's cost function
- Recalibrates revenues in response to observed costs
- Blunts cost-reduction incentives (Averch-Johnson effect)
- Substitutes regulatory judgment for the discovery process itself

RPI-X: Constitutional Regulation

Epistemic approach

- Sets a rule-bound price path; does not compute efficient costs *ex ante*
- Firms retain discretion over internal organization and procurement
- Profit retention during the control period rewards successful cost discovery
- Defines the boundaries of discovery — does not direct its content

3

The Knowledge Problem in Regulated Electricity Networks

How Knowledge Is Dispersed, Contextual, and Tacit in Power Systems

Operational Knowledge

Localized and asset-specific

- Generators: plant conditions, fuel contracts, ramping constraints
- Network operators: congestion, contingency risks, voltage constraints
- Customers: interruption costs, thermal inertia, EV charging flexibility
- Much of this is tacit — difficult to codify in regulatory filings

Temporal & Spatial Variation

Continuously evolving

- Marginal costs fluctuate with fuel prices and renewable output
- Locational prices diverge as congestion emerges and dissipates
- Weather shifts supply and demand simultaneously
- No stable equilibrium to calculate once and implement

Investment Decisions

Anticipatory and irreversible

- Expectations about demand growth, technology costs, and policy are dispersed and heterogeneous
- Cannot be centrally aggregated without significant simplification
- Long-lived infrastructure decisions whose consequences unfold over decades

What Price Suppression Actually Destroys

Why Scarcity Pricing Matters Epistemically

Elevated prices during tight supply communicate system stress without requiring agents to know the underlying cause. The price aggregates dispersed conditions into a single actionable signal. When caps bind, that signal weakens: consumers, retail suppliers, and potential entrants all receive attenuated information.

Consequences

- Investment incentives weaken; risk migrates to regulators or taxpayers
- Capacity signals are degraded precisely when most consequential
- The relevant question: not whether prices exceed marginal cost, but whether the pricing regime preserves the communicative function for decentralized coordination

Case: Texas Winter Storm Uri

Gas, power, water, and governance were tightly coupled — a cold snap cascaded into a system-wide catastrophe.

Price suppression had dampened the signals needed for decentralized adaptation. The failure was epistemic, not merely engineering.

"Scarcity must be communicated if decentralized adaptation is to occur."

— Littlechild & Kiesling (2021)

Retail Competition as Decentralized Information Aggregation

Uniform Regulated Tariffs

Presumes regulators can determine the right tradeoff among price level, volatility, duration, and service quality on behalf of all consumers.

Abstracts from heterogeneity in risk tolerance and time preference. Forecloses the discovery of what consumers actually want — substituting administrative judgment for market revelation.

Retail Competition

Suppliers experiment with fixed-price, indexed, time-of-use, and green contracts. Switching behavior communicates what administrative hearings cannot elicit.

The retail market is a decentralized laboratory for contract design — aggregating dispersed demand knowledge through rivalry.

Dynamic pricing extends this aggregation to hours and minutes.

4

Digital Technologies and the Expansion of Discovery

From Passive Demand to Active Participants

The Traditional Model

- Centralized generation, one-way delivery, passive demand
- Customers responded to uniform average-cost tariffs
- Operational knowledge resided almost entirely with generators and system operators
- Demand was a forecast to be served — not a resource to be coordinated

The Digital Era

- DERs, EVs, smart thermostats: end users become active participants
- The 'man on the spot' now sits behind the meter — real-time data on storage, output, and preferences
- Automation reduces transaction costs; loads become flexible resources
- Coasean implication: as coordination costs fall, the boundary between hierarchy and market shifts

Real-Time Pricing as Distributed Control

01

Communicates Localized Scarcity

When distribution constraints bind or reserves thin, elevated prices transmit system stress without requiring agents to observe the underlying physical state. The price encapsulates dispersed operational knowledge into a single actionable signal.

02

Incentivizes Decentralized Response

Flexible loads reduce consumption, storage discharges, distributed generation increases output. Each adjustment reflects private knowledge about costs and preferences. The system operator need not specify which device responds or by how much.

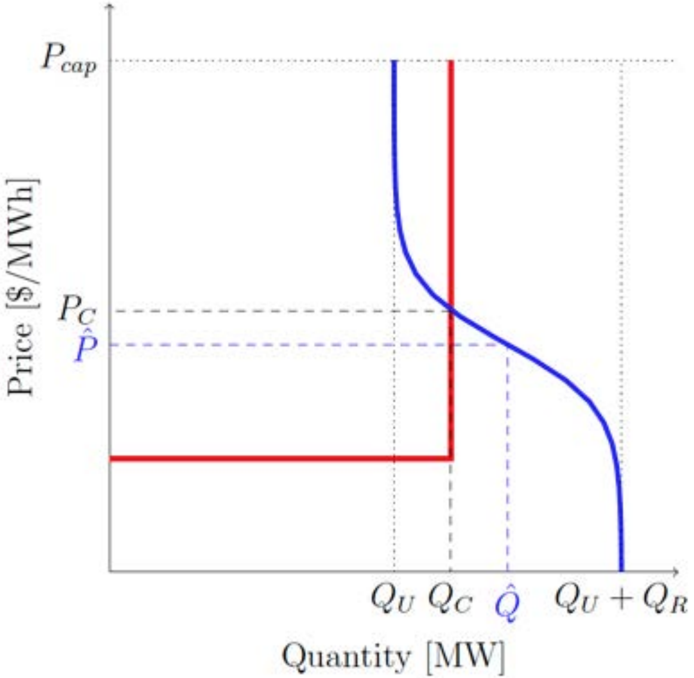
03

Reduces Administrative Coordination

Granular price formation substitutes signal-driven adaptation for instruction-based central control. Instead of directing millions of devices, the operator defines market rules and boundary conditions. Prices are distributed control variables.

Active Automated Market Participants: Transactive Energy

Transactive Energy: Type 1 vs. Type 2 Systems — and TESS



Type 1: Signals Flow to Devices

Economic signals flow from the platform to assets. A price is computed and communicated; devices adjust if it crosses a user-set threshold.

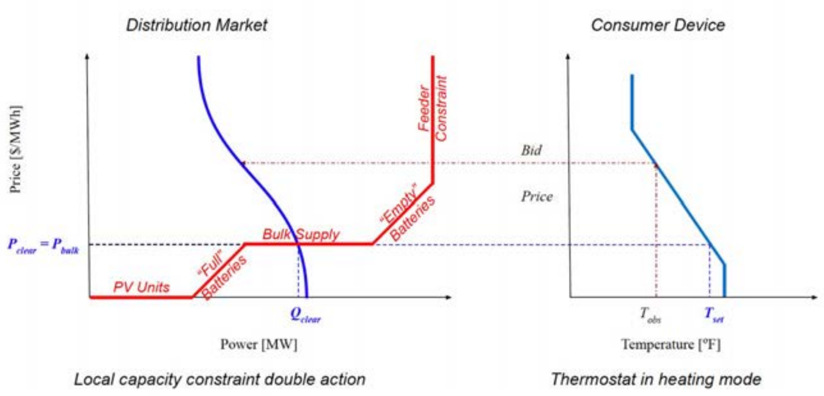
Analogous to posted/administrative pricing — informative, but one-directional. Communicates scarcity to devices.

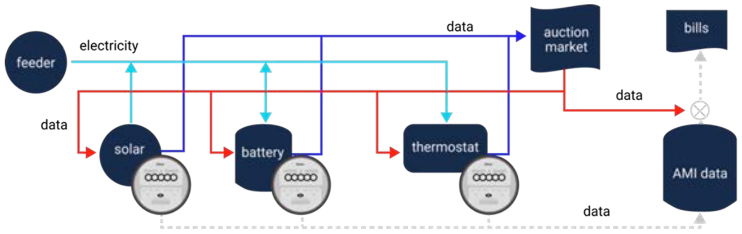
Type 2: Knowledge Flows from Devices

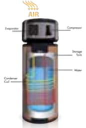
Devices submit bids expressing willingness to produce or consume. A clearing mechanism aggregates bids to form a market-clearing price.

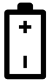
Analogous to a double auction — price emerges from dispersed preferences. Aggregates knowledge from devices. Fully instantiates Hayekian price formation.

Transactive Energy: TESS









TESS: A Type 2 System in Practice

Post Road Foundation, Maine — DOE Connected Communities

Diverse DERs (solar, storage, heat pumps, EVs, smart appliances) submit bids encoding local constraints and preferences. A double-auction clears every five minutes or less; the clearing price is communicated back to devices, which adjust autonomously.

Structural parallel to RPI-X: bounded freedom — prices constrain outcomes while each agent retains discretion over response. The designer need not know the innovations in advance.

AI Super Agents and the Trust Problem

The Super Agent: Human Principal + Algorithmic Agent (McDavid, Kiesling & Chassin, 2026)

A human principal delegates market participation to an AI agent that attends to thermal properties, weather, battery state, and price signals simultaneously — at minute-by-minute resolution no human could manage. This makes high-frequency market participation feasible for ordinary households.

1. Agent-Level Trust

Agents must encode and execute preferences faithfully.

Risk: machine learning models are opaque. The principal's direct knowledge of time and place is replaced by preferences encoded in advance — which may not track evolving circumstances.

2. Platform Governance

Trust that clearing mechanisms, settlement rules, and data access protocols are transparent and manipulation-resistant.

Parallel to RPI-X: credible, predictable rules create the environment in which agents can experiment and invest.

3. Rule Stability

The credible expectation that market rules will not be revised ex post in ways that undermine participation.

Without rule stability, participation thins, liquidity declines, and the discovery process weakens. Trust is an operational requirement.

5

Implications: Layered Regulatory Architecture

The Electricity Stack: A Layered Technological & Institutional Architecture

Layer 3

Competitive Services

Permissive governance

- Retail suppliers, aggregators, storage operators, demand response firms, software providers
- Domain of Kirznerian alertness and Schumpeterian innovation — rivalry reveals what no regulator could specify
- Posture: remove entry barriers, enforce consumer protection, let the market process operate

Layer 2

Coordination Layer

Transparent protocol governance

- Wholesale markets, distribution pricing, data platforms, and clearing processes
- Governance: transparency, nondiscrimination, and rule stability — not cost auditing
- Protocol design shapes whether distributed resources participate on equal terms and price signals propagate without distortion

Layer 1

Physical Network Infrastructure

Targeted incentive regulation

- Transmission and much of distribution retain natural monopoly characteristics
- Performance-based regulation along the lines of RPI-X remains appropriate
- The epistemic logic that justified RPI-X — firms discover efficiencies within a credible constraint — still applies here

Regulation as Architecture, Not Management

Protocol Design

- Interconnection standards, data governance, and settlement rules determine whether distributed resources participate on equal terms
- Poorly designed protocols entrench incumbents and distort price formation even without explicit market power
- Well-designed protocols lower entry barriers and sustain conditions for rivalry

Property Rights over Data

- As metering data and device states gain value, clarity about ownership and access becomes essential
- Ambiguity increases transaction costs, deters innovation, and creates opportunities for incumbent foreclosure

Commitment and Stability

- Credible commitment is necessary to support investment — as with RPI-X
- *Ex post* interventions — suppressing scarcity rents, unpredictable rule revisions, political price caps — cause decentralized actors to discount future returns and thin participation

Scaling the Discovery Process

Complex systems contain knowledge that no central authority can fully possess or process. Institutions that acknowledge this constraint and design rules accordingly — rather than assuming it away through administrative omniscience — are better suited to harness the adaptive capacity of decentralized agents.

The digital electricity system makes that principle newly visible, newly urgent, and newly testable at scales Littlechild could not have anticipated. The scale changes. The logic does not.

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