From **Bounded Rationality** to **Economic Complexity**: **Limits** of **Freedom**, **Democracy** & **Law**

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Limits to **Enlightening** & **Rationality**

- **Freedom** > **global warming** and **environmental crisis**, **poverty**, **wars**
- **Democracy** > **shock therapy** & **transition depression** in EEFSU (East Europe and former Soviet Union) vs. **innovative leadership** in China's reform and transition
- **Rule of law** > **asymmetric power** of **multi-national companies** in EEFSU vs. rise of **competitive firms** in China's **decentralized experiments**

Equilibrium Illusions in **Market Fundamentalism**

- **Frisch** model of **noise-driven cycles**: market stability + external shocks > **self-stabilizing** > **laissez fair market**
- **Friedman** argument for **self-selective efficient market** based on **perfect imitation** of winner's strategy > no room for speculators > **freedom without uncertainty**
- **Lucas** model of **rational expectations** and **microfoundations**: **perfect foresight** against government policy, **rational choice** of unemployment > **democracy without unemployment & government**
- **Coasian world** of **zero transaction costs**: **bilateral bargaining** for conflicting interests > **institutional convergence regardless initial conditions** and legal arrangement > ultimate reductionism = **Ostwald energism** without structure
- **Washington consensus** and **shock therapy**: **liberalization**, **privatization**, stabilization by **credit contraction** policy

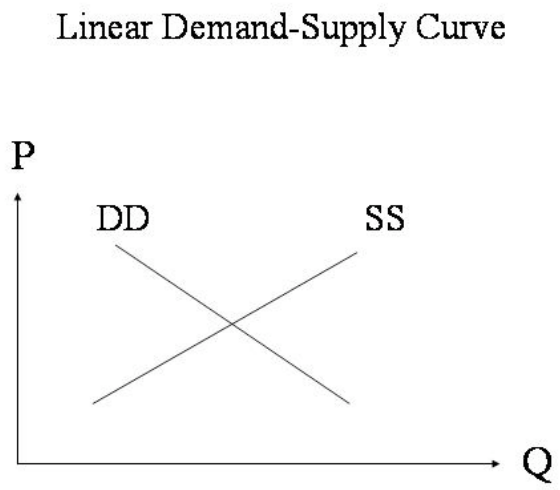
From **Classical (Analytical) Mechanics** to **Nonlinear Non-Equilibrium (Evolutionary) Physics**

- **Frisch noise driven cycles** > challenged by **thermodynamics** & **economic chaos** (**limited predictability** and recurrent crisis)
- **Lucas microfoundations** > against **Principle of Large Numbers** > **meso (financial market)** can be **creative** & **destructive** instability
- **Coasian world** > challenged by **bio-physics laws** and **history of division of labor**

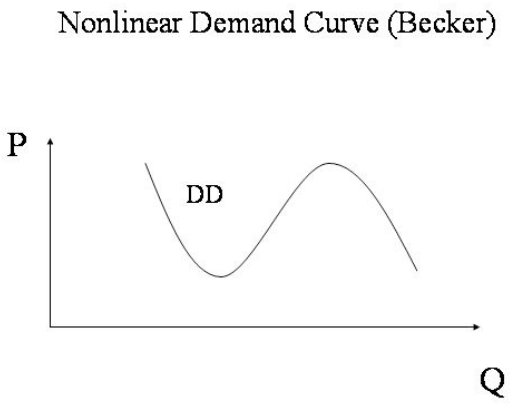
Breakdown of Equilibrium Believes

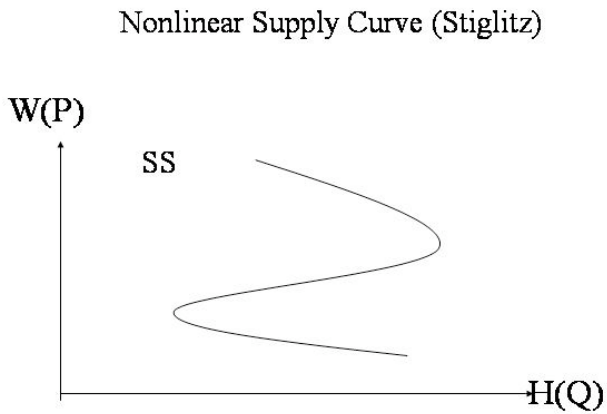
- Human nature is **greedy** (infinite wants) ? > limited wants under **limited life** with bio-ecological constraints > **social animal** in nature > **limit** of **unfettered individualism**
- **Self-stabilizing** market under **linear demand and supply curve** (**unique equilibrium**)? > **nonlinear demand and supply curve** = **multiple equilibrium** and chaos
- **Fair game** under **symmetric information** and **symmetric power** > **symmetry breaking** in division of labor > origin of **market power** and **inequality**

Linear Demand-Supply Curves > Unique Equilibrium

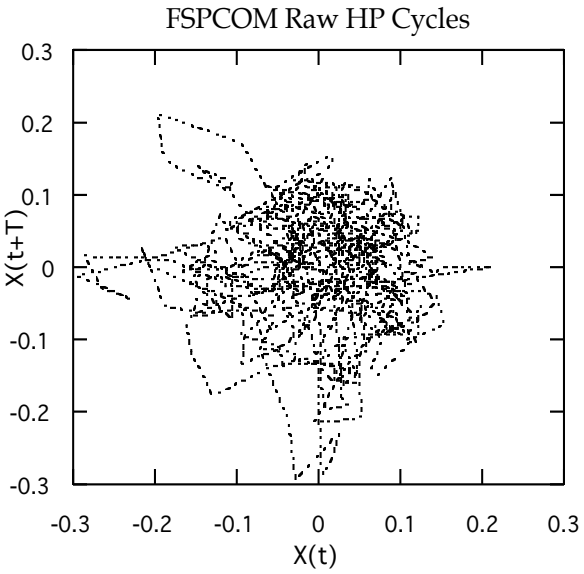


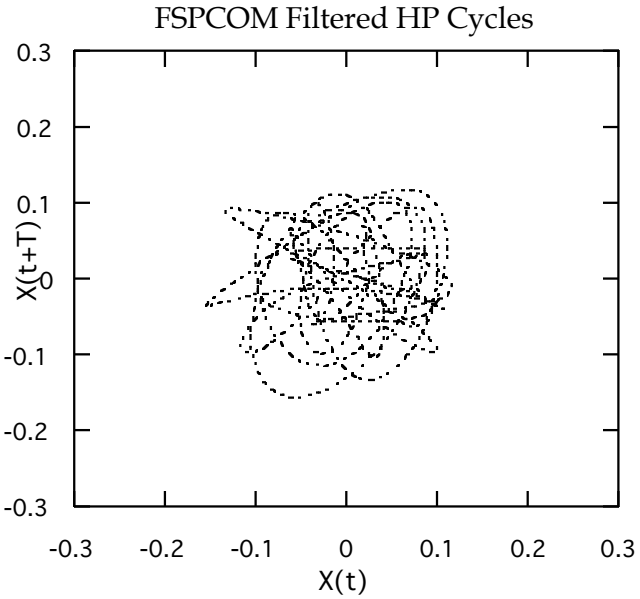
Nonlinear Demand Supply Curves>
Multiple Equilibriums





Phase portraits of **business cycles**
White Noise vs. **Color Chaos**

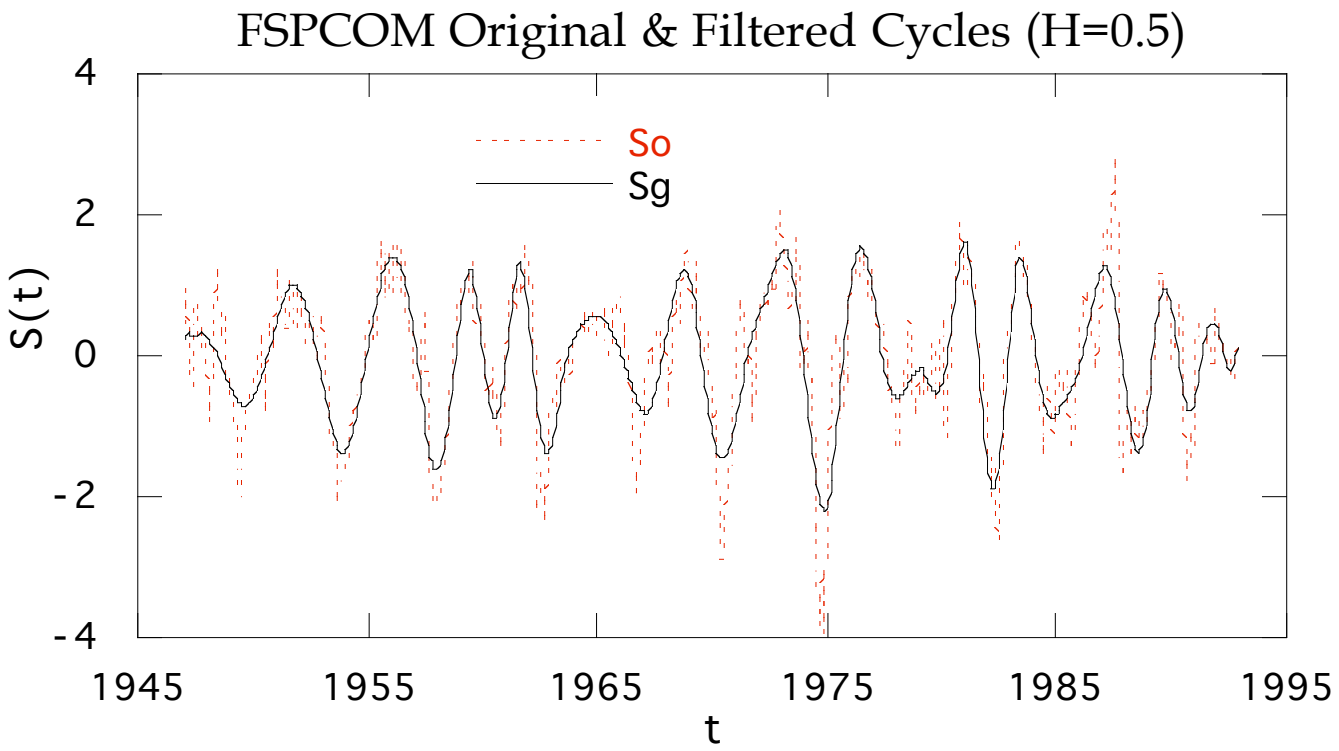




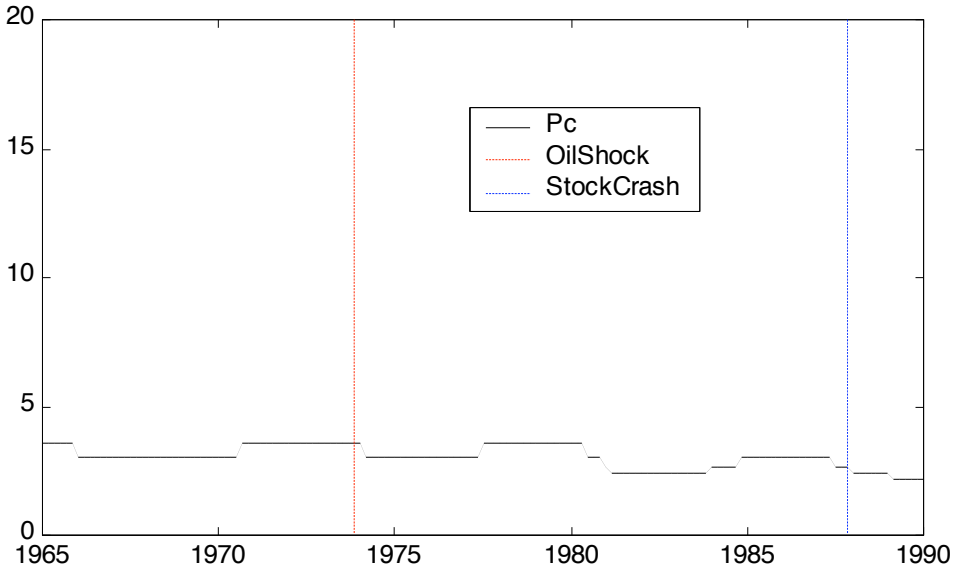
Stock Price Indexes FSPCOM (Standard & Poor 500)

Correlation dimension of color chaos in =**2.5**

Variance of **color chaos** = **69 %**



Economic **Diagnosis**



External shock: frequency moved AFTER the shock
Internal instability: frequency moved BEFORE the shock

Noise-Driven Cycles（Frisch 1933）vs. **Harmonic Brownian Motion**（Unlenbeck & Orstein, 1930）

- Wang & Unlenbeck (1945)

$$\rho(\tau) = \exp(-\frac{\beta\tau}{2})[\cos(\omega_1\tau) + \frac{\beta}{2\omega_1}\sin(\omega_1\tau)]$$

- Frisch model for **American business cycles**, which would be **damped in 5-20 years**（Chen 1999, 2004)!

Frisch model: Perpetual Motion Machine of Second Type?

- **Frisch was not the FIRST**: G.E.**Uhlenbeck** and L.S. **Ornstein**, "**On the Theory of Brownian Motion**," *Physical Review*, 36(3), 823-841 (**1930**).
- **Frisch's Informal conference paper**: R. Frisch, "**Propagation Problems and Impulse Problems in Dynamic Economics**", in *Economic Essays in Honour of Gustav Cassel,* George Allen & Unwin, London (**1933**).
- Frisch's promised paper, "Changing harmonics studied from the point of view of linear operators and erratic shocks," was **advertised three times** under the category "**papers to appear in early issues**" in ***Econometrica***, including Issue No. 2, 3, and 4 of Volume I (April, July, and October **1933**) but **never appeared** in *Econometrica* since 1934.
- Frisch **never mentioned a word** about his prize-winning model in his **Nobel speech in 1969** (Frisch 1981).

Principle of **Large Numbers** for Positive Variables

- $S_N = X_1 + X_2 + \ldots\ldots + X_N$

$$RD = \frac{Std(S_N)}{Mean(S_N)} \approx \frac{1}{\sqrt{N}}$$

Observed relative deviation of **US real GDP** is **20 times larger** than Lucas model could explain（Chen 2002)!

Weak microfoundations in **labor** and **producer market**

The observed implied numbers predicted by the Lucas model is 400~ 500 times smaller (RD is 20 times larger) than in US real economy.

Possible microfoundations

in **financial markets** and **industrial organization**

not in **labor** or **producer market**

Implication >

Three layer structure (micro, meso, macro)

rather than **two layer structure (micro, macro)**

in economies

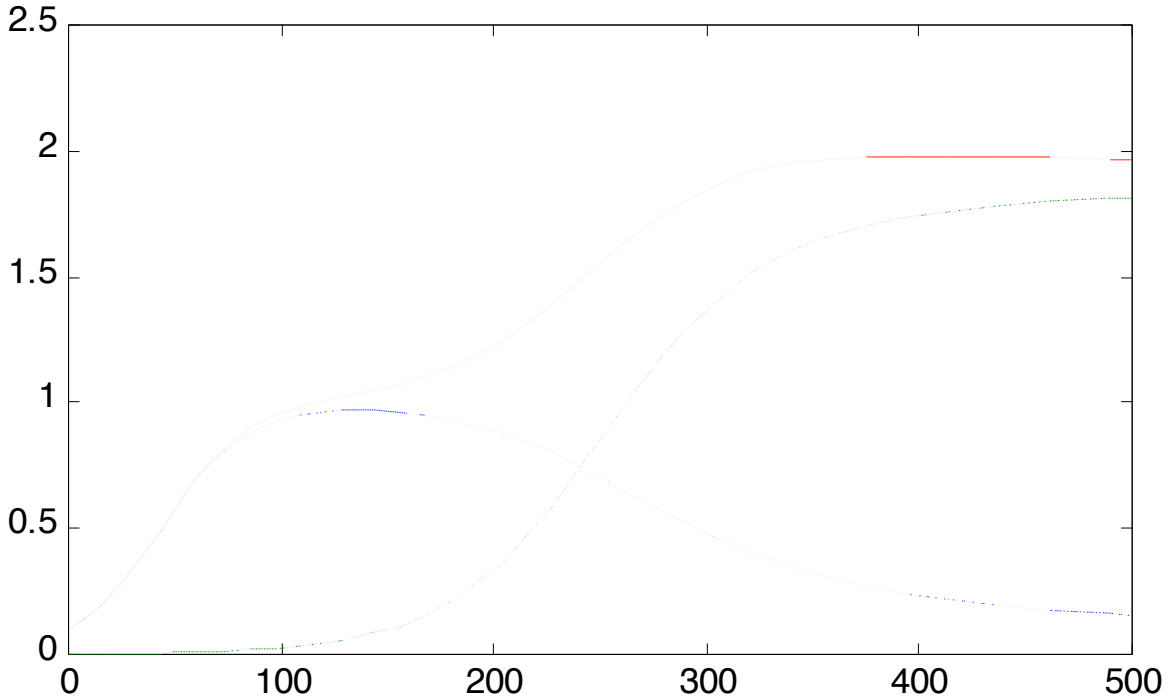
Conflicting Strategies in **Transaction Costs** (T.C.)

- **Cost/price competition** for existing products > **reducing transaction costs**
- **Innovation/marketing competition** for creating new market for new products > **increasing transaction costs**
- General trends in division of labor > **increasing complexity** > **increasing T.C.**
- Wallis and North(1986): **T.C. ratio of GDP** in US: **25%** (1870) > **50%** (1970)

Non-existence of the **Coasian World** with **Zero Transaction Costs**

- **Infinite diffusion speed**: against **Relativity** theory (**light speed limit**)
- **Zero information costs**: against the **Uncertainty Principle of Quantum Mechanics** > **minimum energy** for **information collection** and **transmission**
- **Reducing trend of T.C.** > against the **law** of **Thermodynamics**

From **Long Waves** to **Logistic Wavelets** > **Creative Destruction** under **Species Competition**



Rise of **Complex Economics** and **End** of **Atomic Rationality**

- From **individual freedom** to **social coordination** > rise of **European Union**
- From **partisan democracy** to **public participation** > **Scandinavian model** and **open innovation system** (unix, Wikiepedia etc.)
- From **universal laws** to **decentralized experiments** > **China model** of **regional competition** and **coordination** under **mixed economy**

From **Age of Reason** to **Age of Complexity**

- **Linear** mechanism > **Nonlinear** dynamics (Poincare)
- **Equilibrium** perspective > **Evolutionary** (Non-Equilibrium) Perspective (Prigogine)
- **Predictable** risk (white noise) > unpredictable uncertainty caused by bifurcation and chaos (May)

- **Perfect information & rational choice > top-down design & ownership control**
- **Bounded rationality & creative vision > decentralized experiment & social learning**

Science Community as **Social Model**

- Science has **open competition** but not governed by **majority rule**
- Science has **evolving leadership** but no **private ownership & control**
- Science cares about **procedure & methodology**, but more about **facts & theory**
- Science is critical in analyzing **information** vs. **ignorance**, truth vs. **power**, **dream** vs. **reality**

Vision with a **question**

- Under new **technology innovation** and **ecological constraints**, do we need a disruptive change
- From **invisible hand**
- To **helping hand**, disciplined hand, or **coordinated hand**?

Readings in **Complexity Science**

- **Schrödinger**, E. ***What is Life****?* Cambridge University Press, Cambridge (1948).
- **Prigogine**, I. ***Order Out of Chaos****, Man's New Dialogue with Nature,* Bantam Books, New York (1984).
- **May**, R. M., ***Stability and Complexity in Model Ecosystem****,* Princeton University Press, Princeton (1974).

- Chen, Ping. "**Evolutionary Economic Dynamics**: Persistent Business Cycles, Disruptive Technology, and the Trade-Off between Stability and Complexity," in Kurt Dopfer ed., *The Evolutionary Foundations of Economics,* Chapter 15, pp.472-505, Cambridge University Press, Cambridge (2005).
- Chen, Ping. "**Complexity of Transaction Costs and Evolution of Corporate Governance**," *Kyoto Economic Review*, 76(2),139-153 (2007).