

# *Things Fall Apart*

Some thoughts on complexity, supply chains, infrastructure & collapse dynamics

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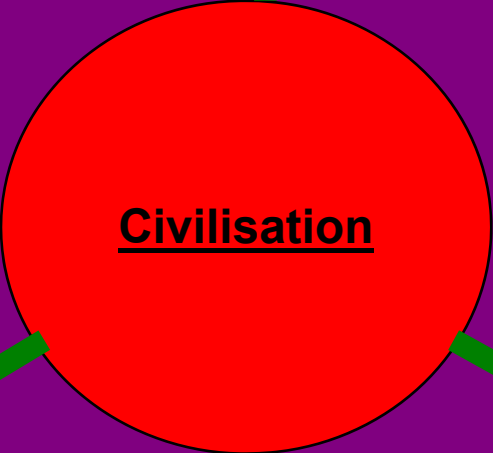
*Turning and turning in the widening gyre  
The falcon cannot hear the falconer:  
Things fall apart: the centre cannot hold:  
Mere anarchy is loosed upon the world*

*from The Second Coming  
W B Yeats*

## 16 Thousand Years: What's Changed?



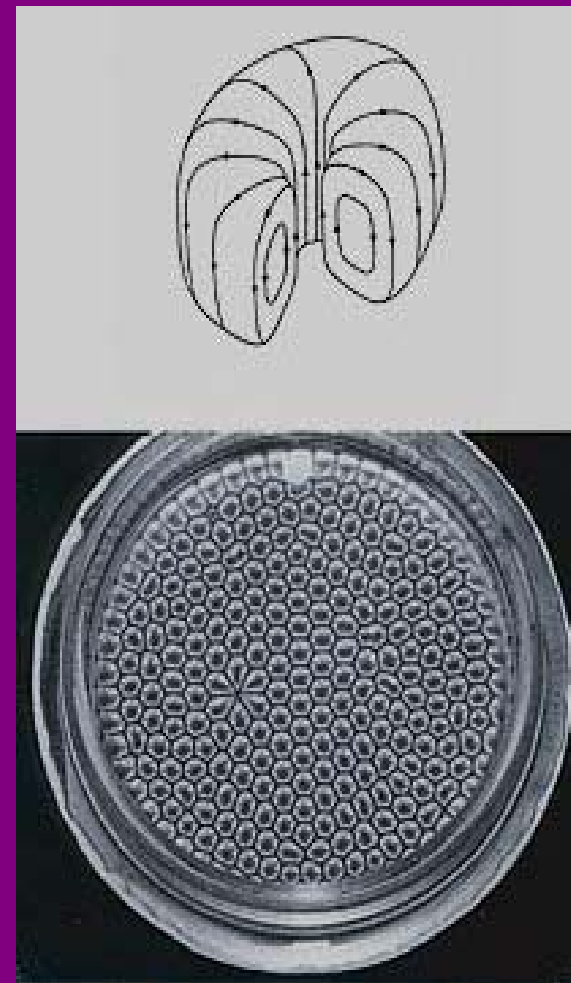
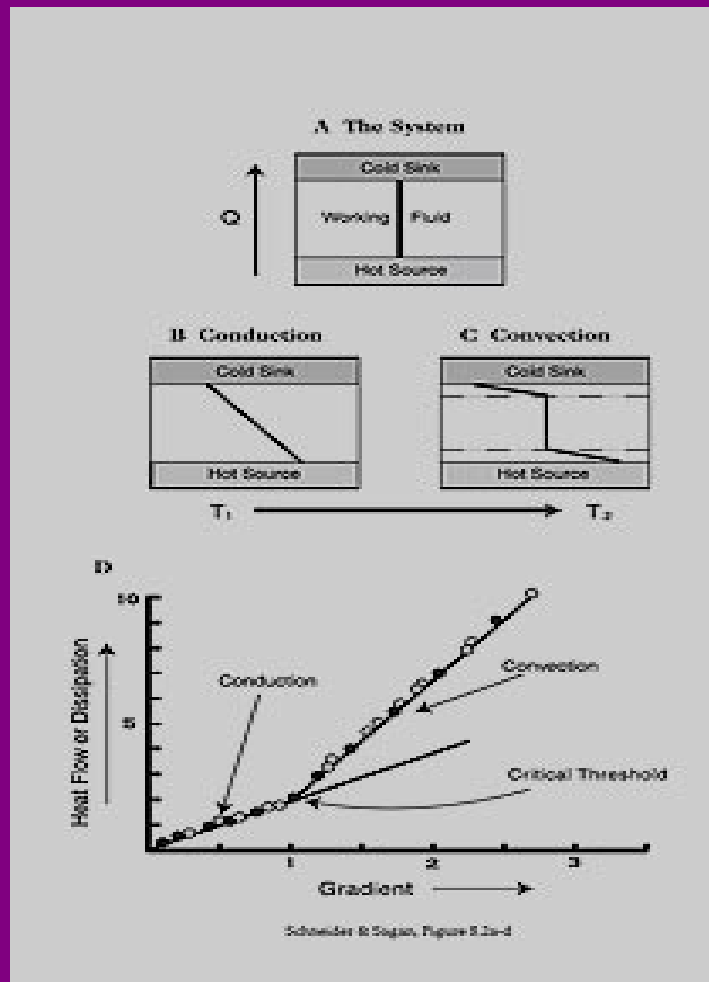
Lascaux cave complex SW France



# Thermodynamics of Civilisation

# Far from equilibrium thermodynamics & Bernard cells

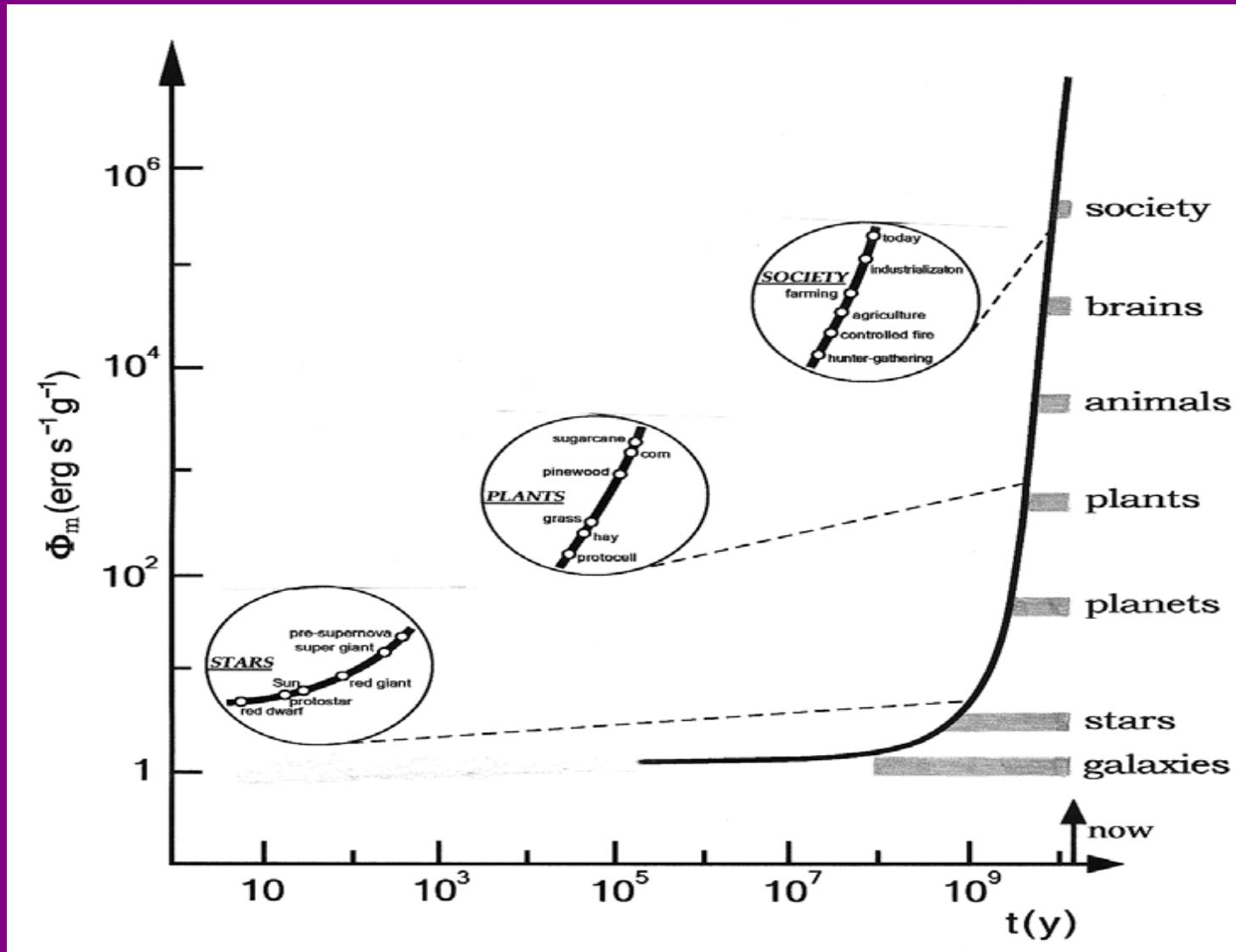
- Flow of free energy allows structure to form.
- Locally, entropy is reduced. Globally entropy increases.
- Thermodynamic properties: phase transitions; MEP; sensitive dependence on initial conditions



(Pictures: [www.intothecool.com](http://www.intothecool.com))

# Energy Rate Density: A Cosmic View

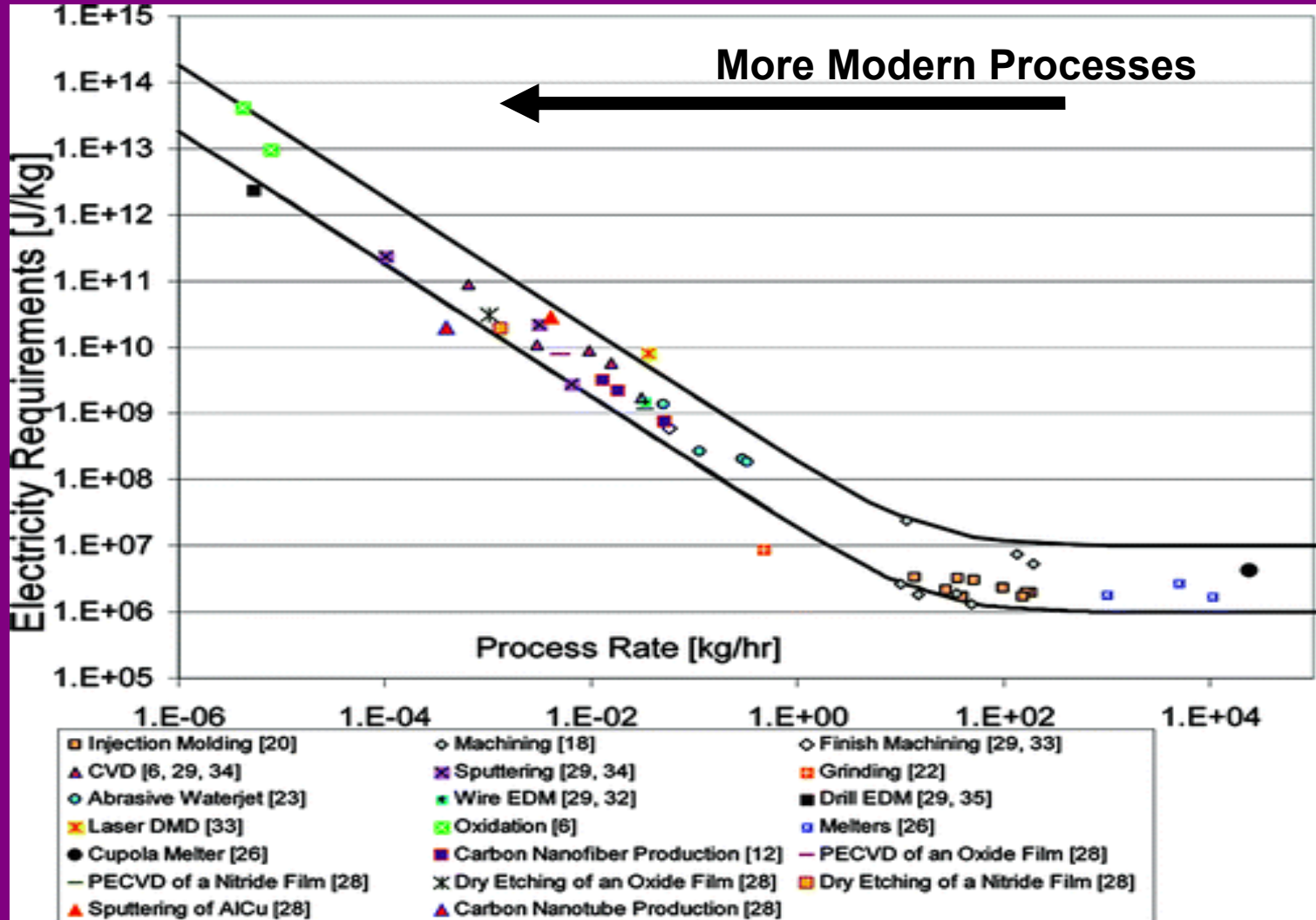
- Trend of greater complexity with evolving sources of free energy
- Complexity is not a goal- teleological explanations not valid



(Chaisson, Eric. *Cosmic Evolution: The rise of Complexity in Nature*, 2002)

## Resources used in manufacturing process

- Growing complexity of modern processes.
- Semiconductor technologies most obvious example.
- 2g 32MB DRAM chip requires 1700 g input. Silicon wafers from quartz uses 160 times energy for normal silicon. (Williams, E.D., Ayres, R.U., Heller, M. *Environ. Sci. Technol.* 2002, 36)



(Gutowski et al. *Environ. Sci. Technol.*, 2009, 43(5))



# Complexity & the Global Economy

## Complexity

Number and depth of interactions; product number; product complexity; institutional complexity

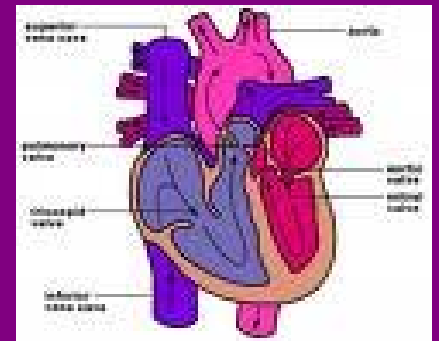
## Self-Organising

The Blind Watchmaker; local control- globally uncontrollable



## Supply-Chains

Resource allocation and distribution; information processing; & infrastructure maintenance



## Growth Tendency in a Finite World

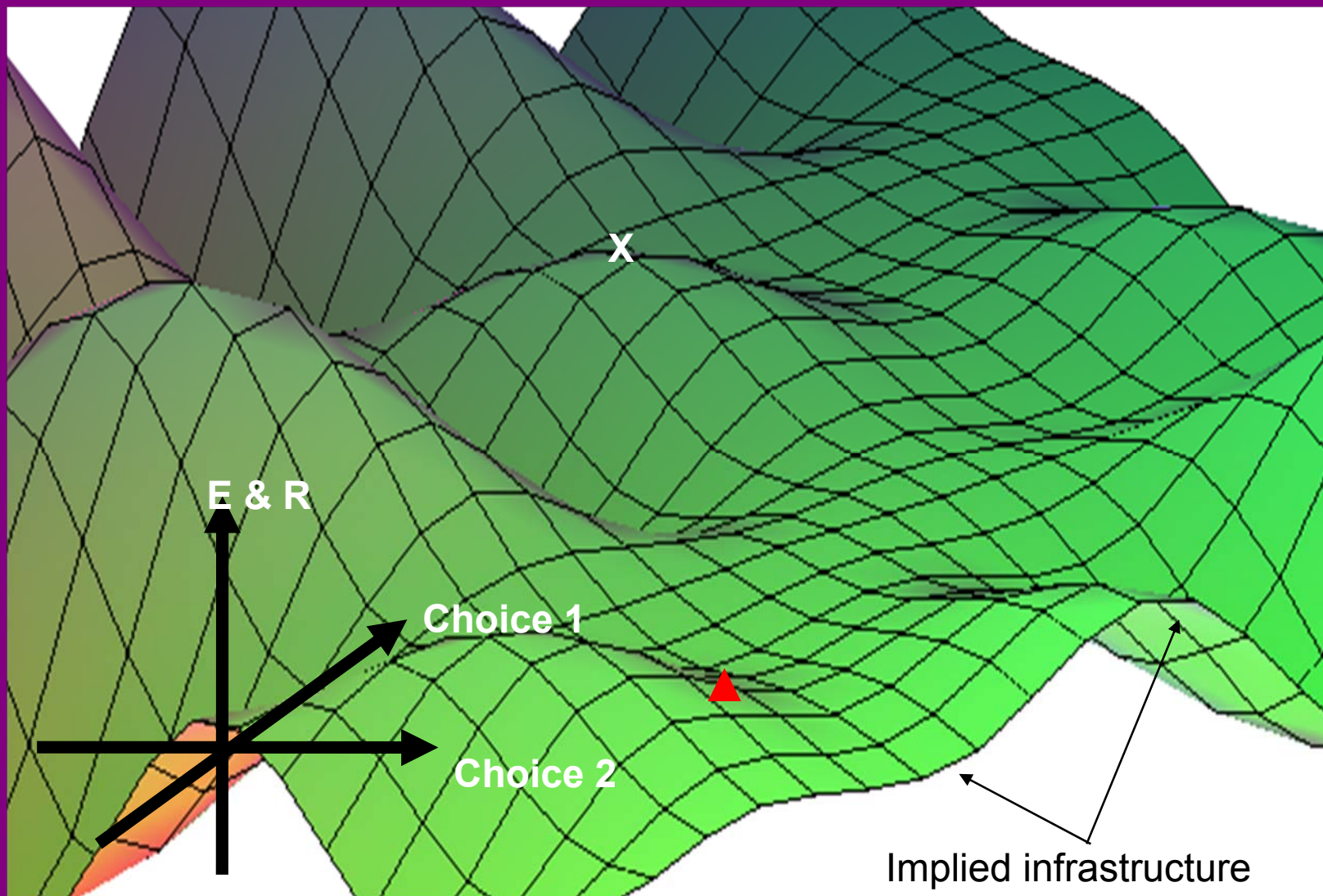
Problem solving is resource intensive;  $I = P \times A \times T$



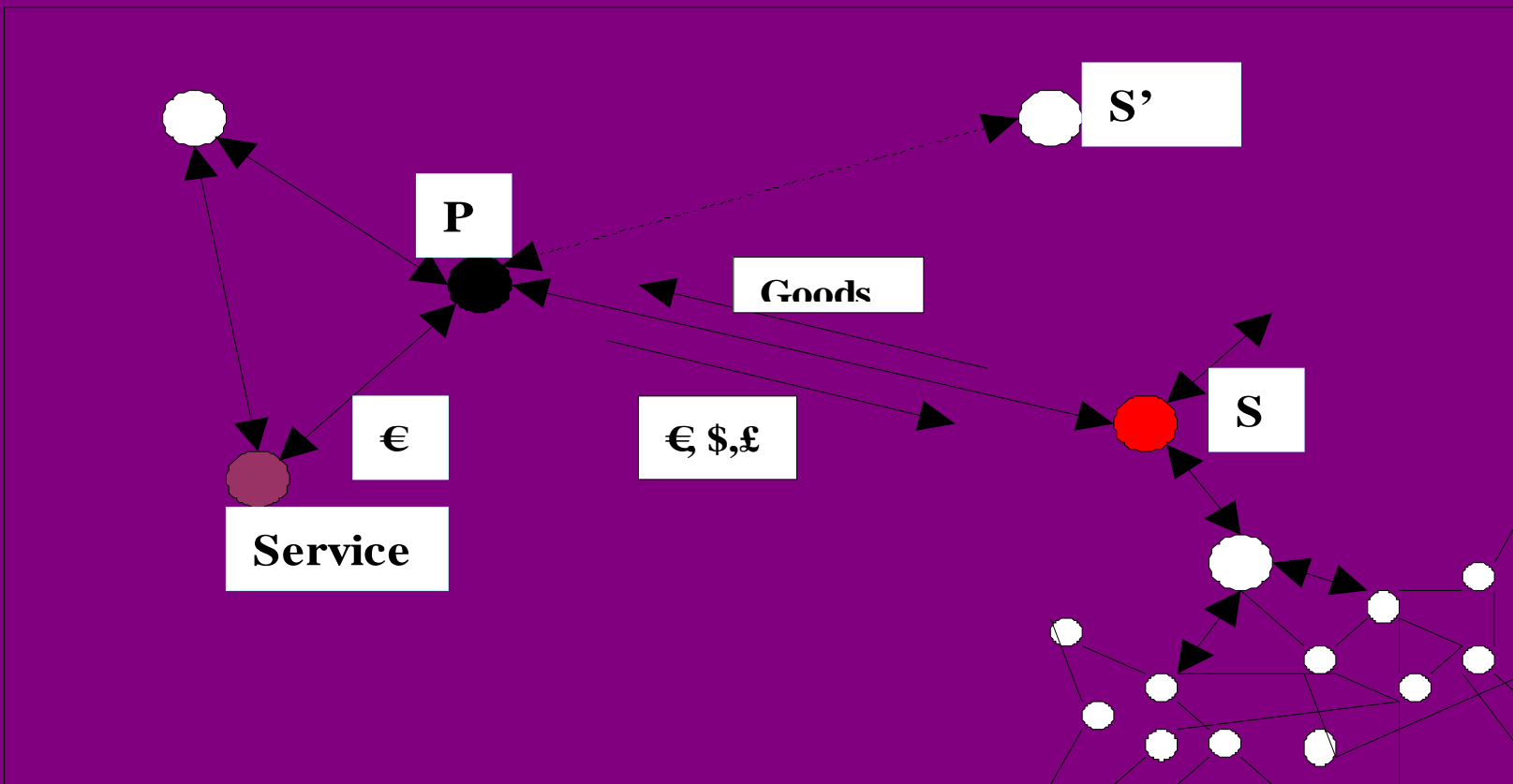
## Evolution of Complexity

- Problem solving-constrained by social, cultural attitudes & structures, implied infrastructure, and resource availability
- Easiest problems/ lowest cost first
- Sub-systems become more interdependent: Can help to manage risk
- As new technologies/ business models emerge, adoption and spread through wider networks dependent upon efficiencies they provide, lower costs, new markets
- New technology and system to which it is introduced co-adapt & co-evolve
- Efficiency gain by letting individual parts of system share transaction costs by integrating common platforms such as IT networks, financial systems, and supply chains
- Growing complexity provides basis for solving more complex problems
- Declining Marginal Returns: Civilisation; EROEI; Material Resources; R&D;Agricultural Productivity
- Lost resilience, can no longer adapt to perturbations (Tainter)

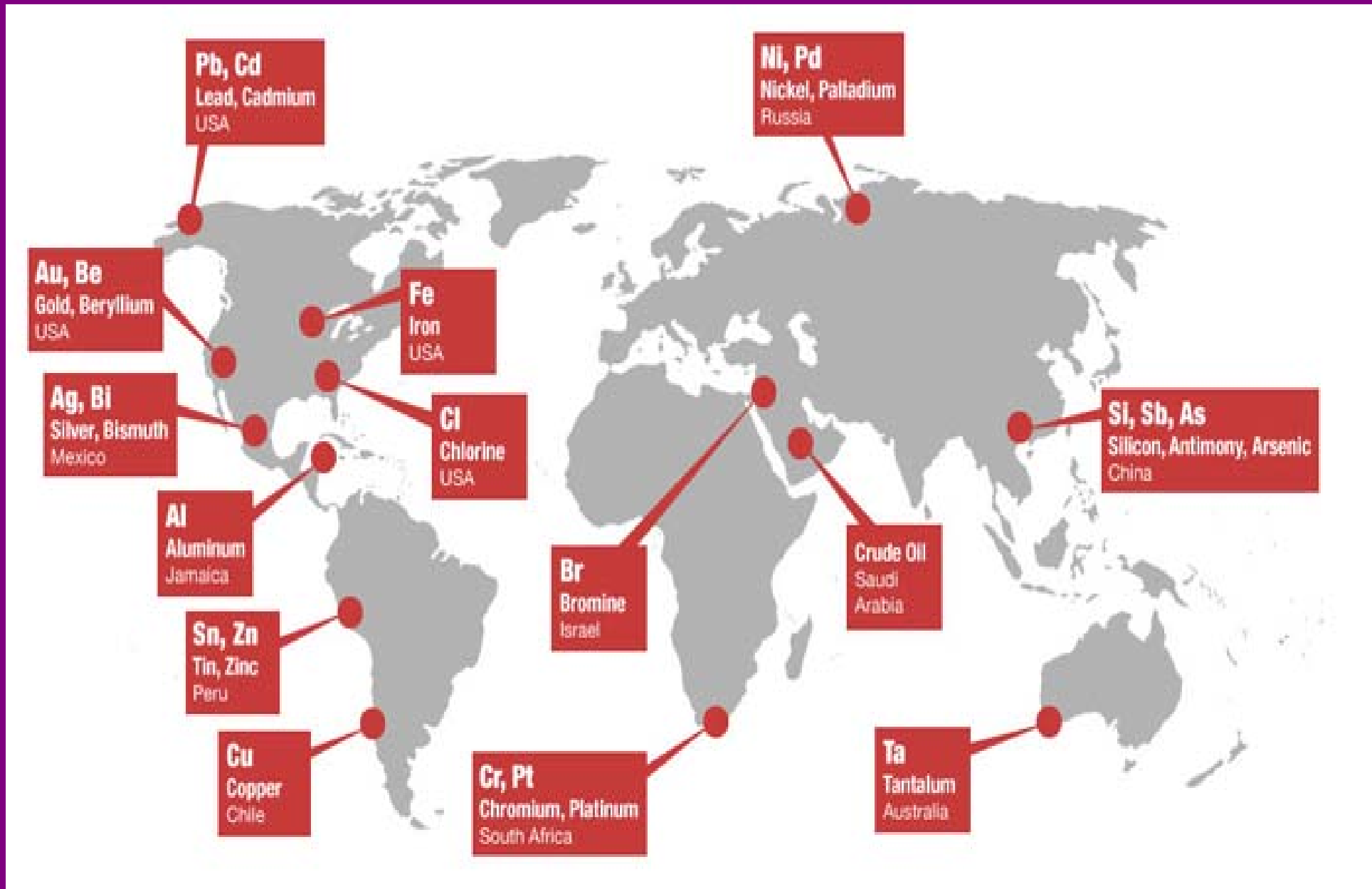
# Analogy: An adaptive landscape for a choice, at a time



# Supply-Chains & Infrastructure



**More complex things-longer/more complex supply-chains**  
**-More un-substitutable components**  
**-More energy/resource dependent**  
**-More implied infrastructure dependent**



# Infrastructure

## Story

- Deep Integration
- Tightly Coupled
- Each part of economy cross-subsidises every other part
- Economies of scale
- Constructed by a growth economy
- Up-grading *is* maintenance



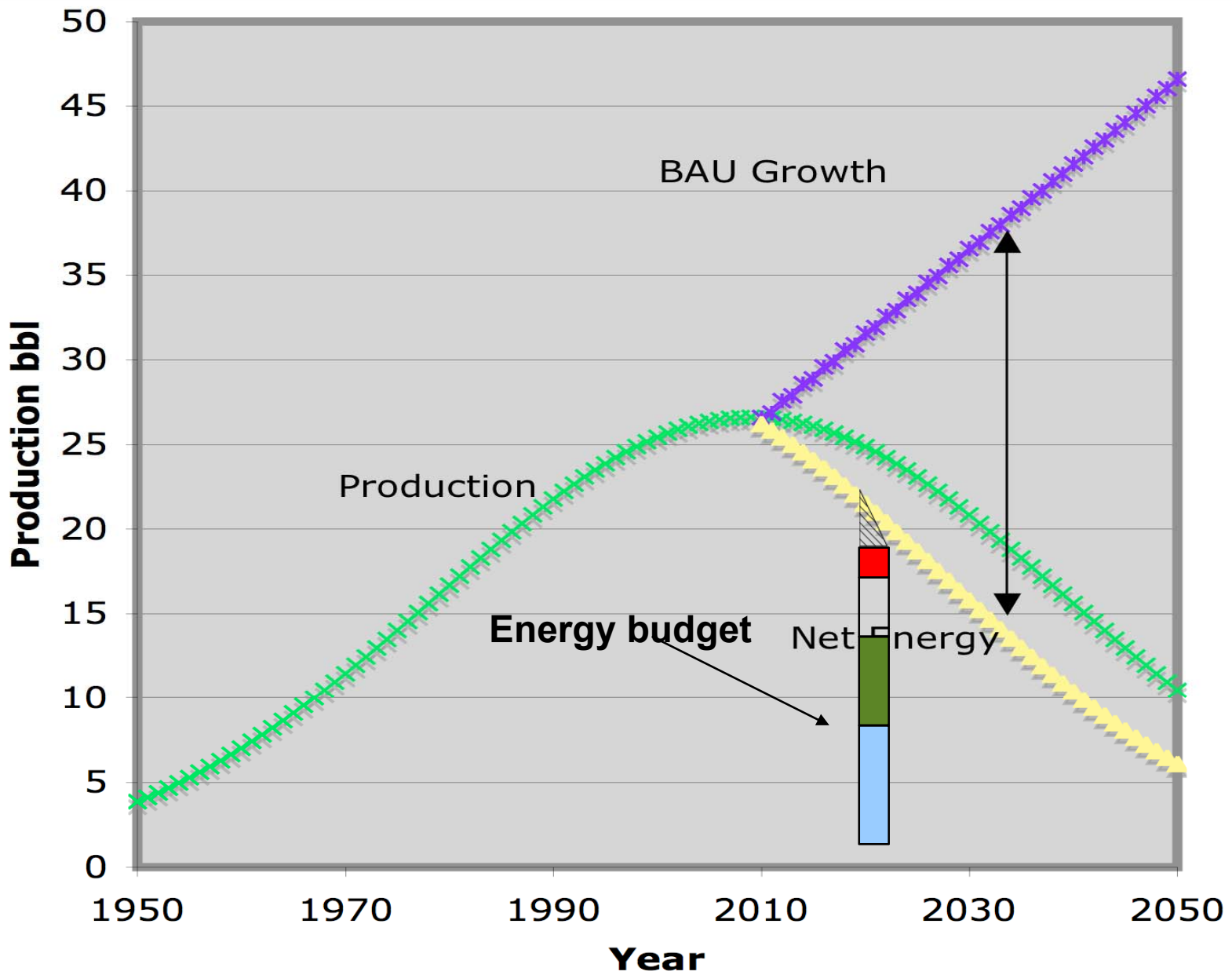
## *Collapse*

**A sudden decrease in complexity**

**OR**

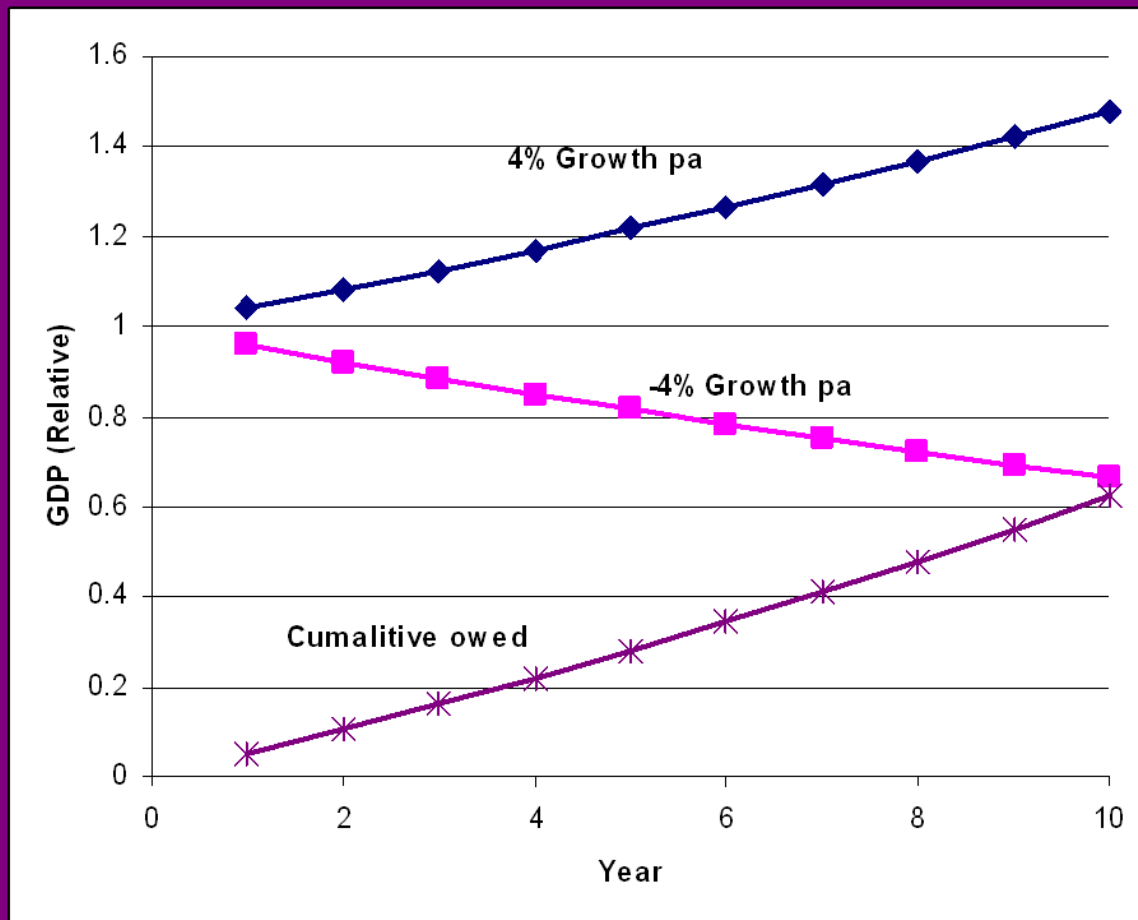
**A phase transition, driven by a series of mutually re-enforcing positive feedbacks**





## Debt & Opaque money

- Monetary System Collapse
- Deflation/ Inflation/ Hyperinflation
- Exchange rate uncertainty
- Uncertainty (thermodynamics)
- Balance of trade
- Investment



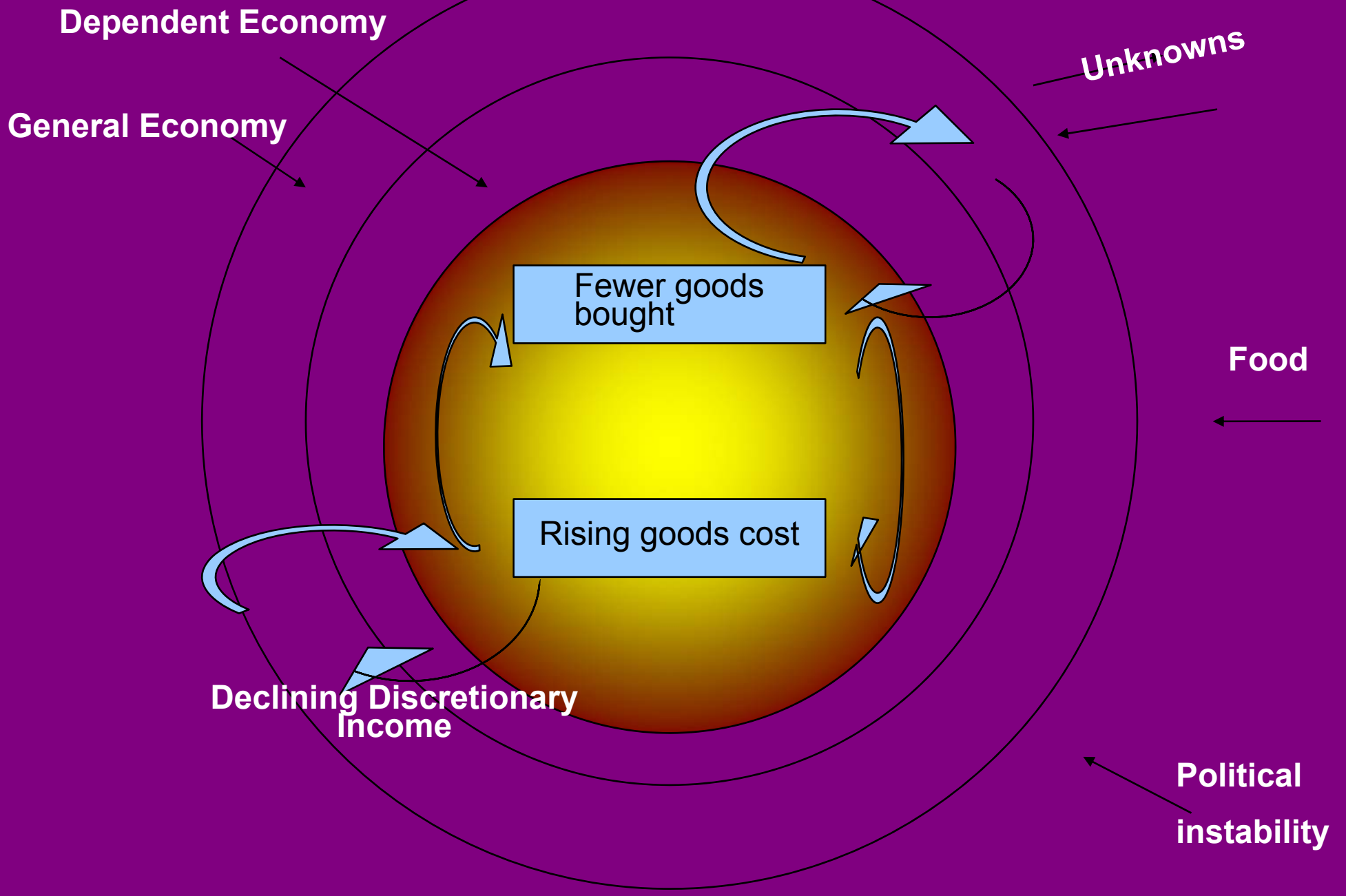
Annual investment accruing 4% interest per annum.  
In a growing economy, that's fine.  
In a contracting economy, principle+interest owed begins  
to swamp the productive economy

## Supply-Chain Creeping Collapse

**Self-re-enforcing interactions between:**

- **Declining discretionary income**
  - **Inability to pay for goods/ inability to run trade deficits**
  - **Opaque money**
  - **Higher input costs**
  - **Plant degradation**
  - **Infrastructure degradation**
  - **Dis-economies of Scale**
- 
- **Creeping Collapse re-enforces creeping collapse**

# Dis-Economies of Scale



# Infrastructure Creeping Collapse

Tightly Coupled

Complex resource intensive supply chains

Expensive to maintain

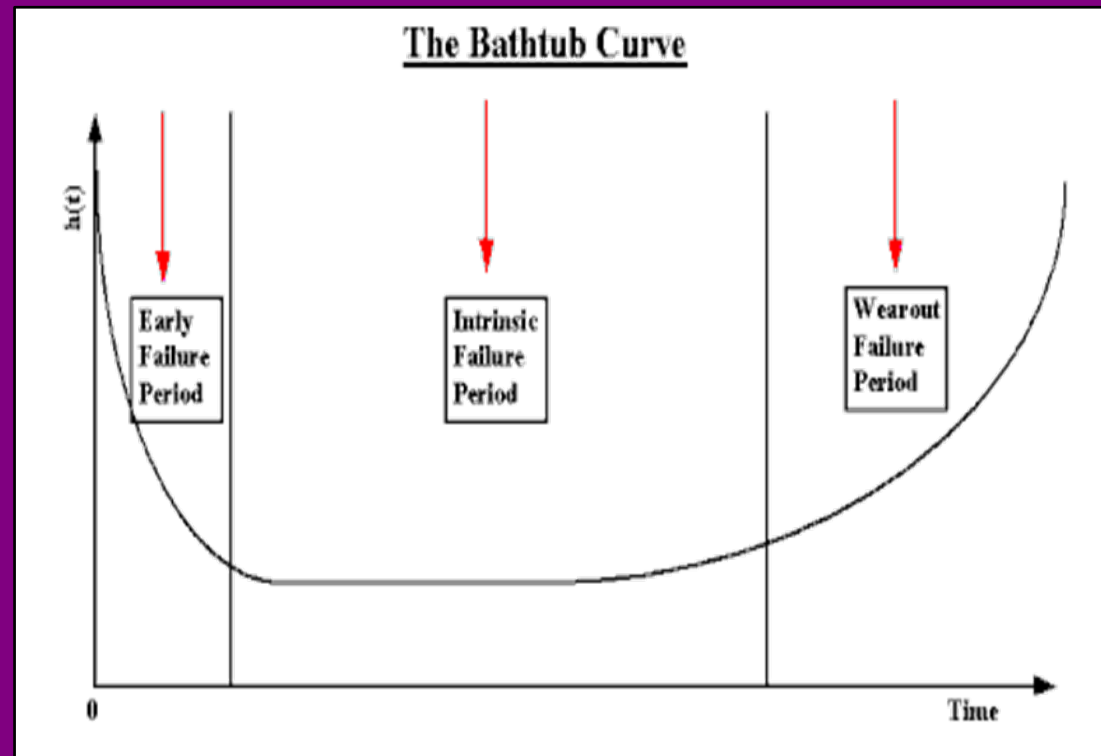
Highly cross-subsidised

Economic stress

Supply-chain creeping collapse

Short-component lifetimes

Complexity and interconnected make cascading failure hard to predict



# Scenario: Fast Supply Chain-Collapse

**ASPO/ Oil Drumers  
ignored/dumb**

**Sovereign/ Debt defaults**

**Energy/food prices inhibit  
growth**

**Sovereign/ Debt defaults**

**Maybe they are correct?**

**Bastards are collapsing the economy!**

**Herd begins to PANIC!**

**Bank Assets collapse**

**Debt cannot be repaid**

**All hell breaks loose!**

**All banks insolvent**

**Supply-chain collapse**



## Conclusions

Fast Collapse

Massive Dis-orientation

Emergency Measures