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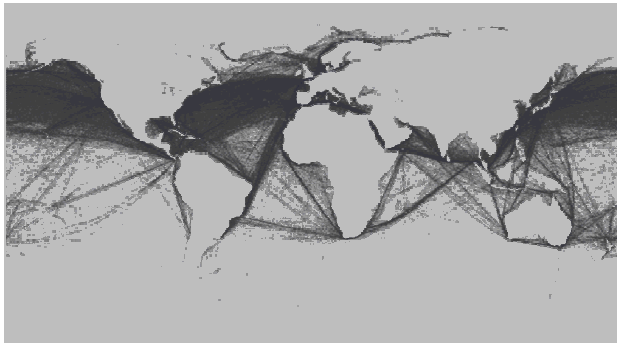

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# Modeling Complex Systems

## - Economic Exchange and Global Finance

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U.S. DEPARTMENT OF ENERGY NNSA

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# Outline

- Introduction
- Background
  - Complex Systems methodology
  - Energy Surety issues
- Two projects:
  - Exchange Model – Marshall Kuypers
    - Background and Motivation
    - California Energy Crisis model
  - Global Finance Project – Asad Khan

Complex Adaptive System of Systems (CASoS) Engineering Initiative
http://www.sandia.gov/CasosEngineering/

# Complex Systems

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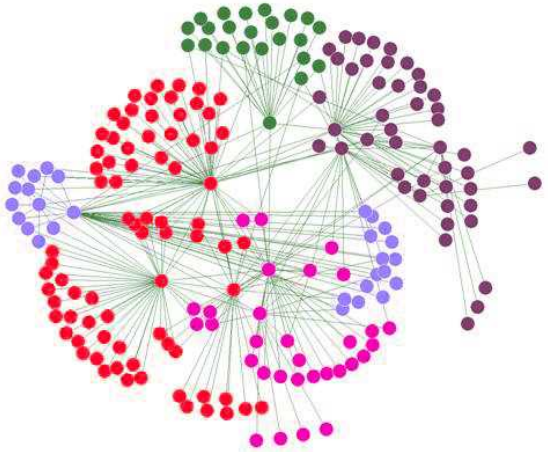
Complex Systems- A collection of interacting parts that produce emergent properties or behavior

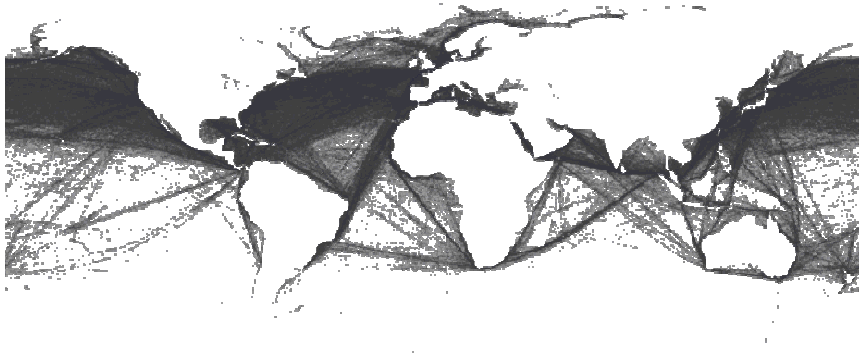
- Why Use them?
  - More accurate (modeling traffic with ODEs versus ABMs)



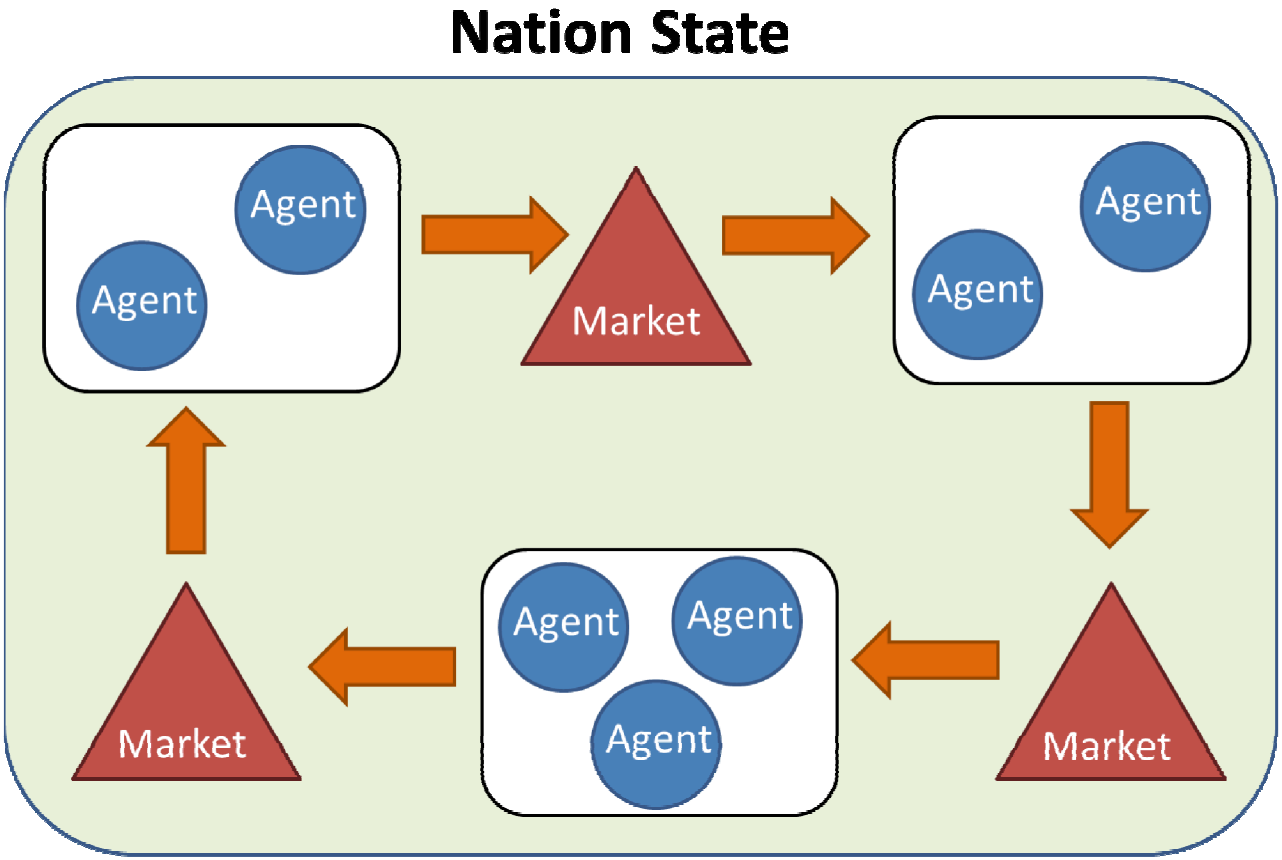
Pictures obtained from Wikipedia Commons: taken by Daniel Tenerife and 'minesweeper'

# Exchange Model - Background

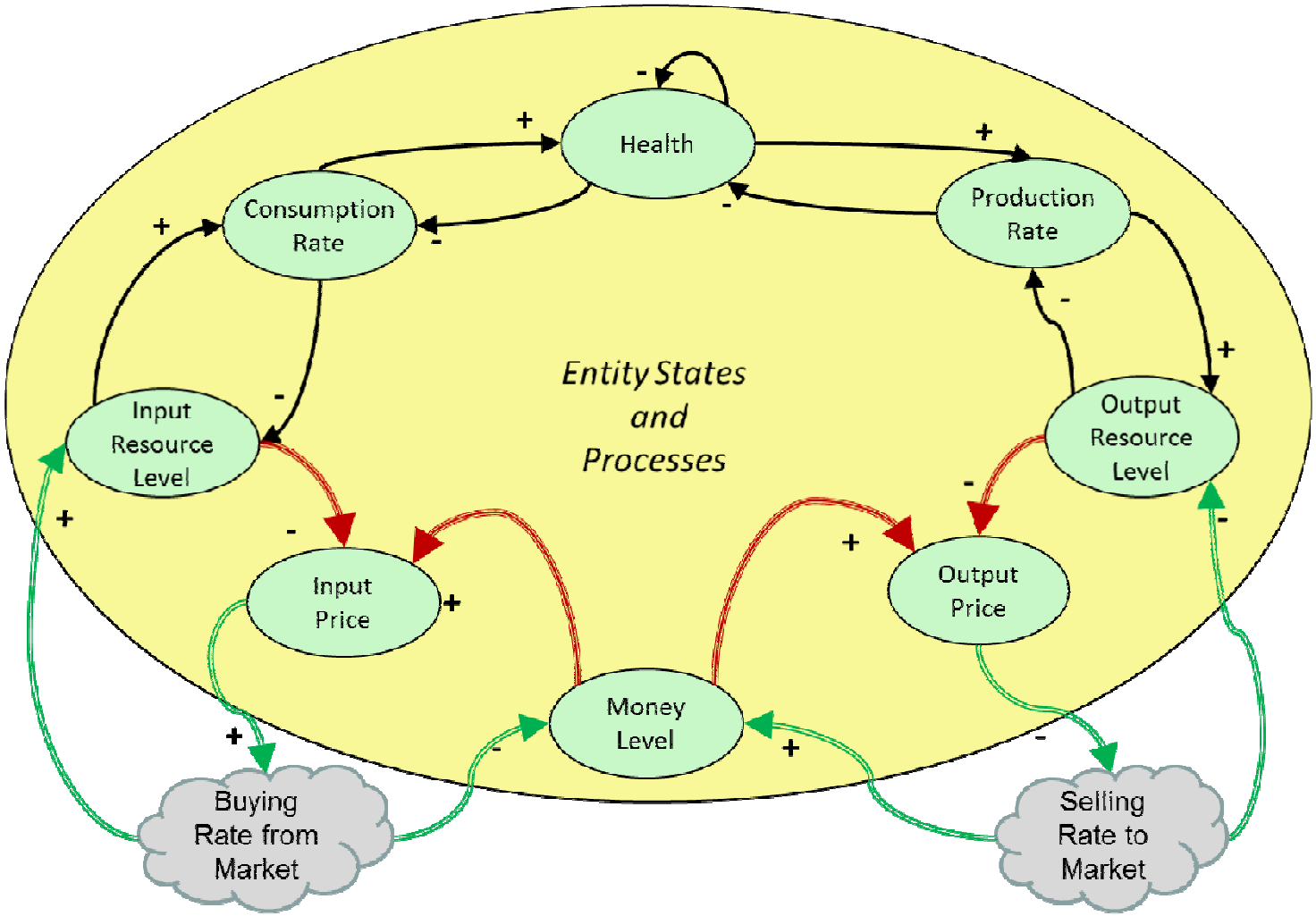

- Needed to help understand complex politico/socio-economic interactions
- World made up of agents interacting through markets to exchange resources
- Energy scarcity is one of the most pressing issues



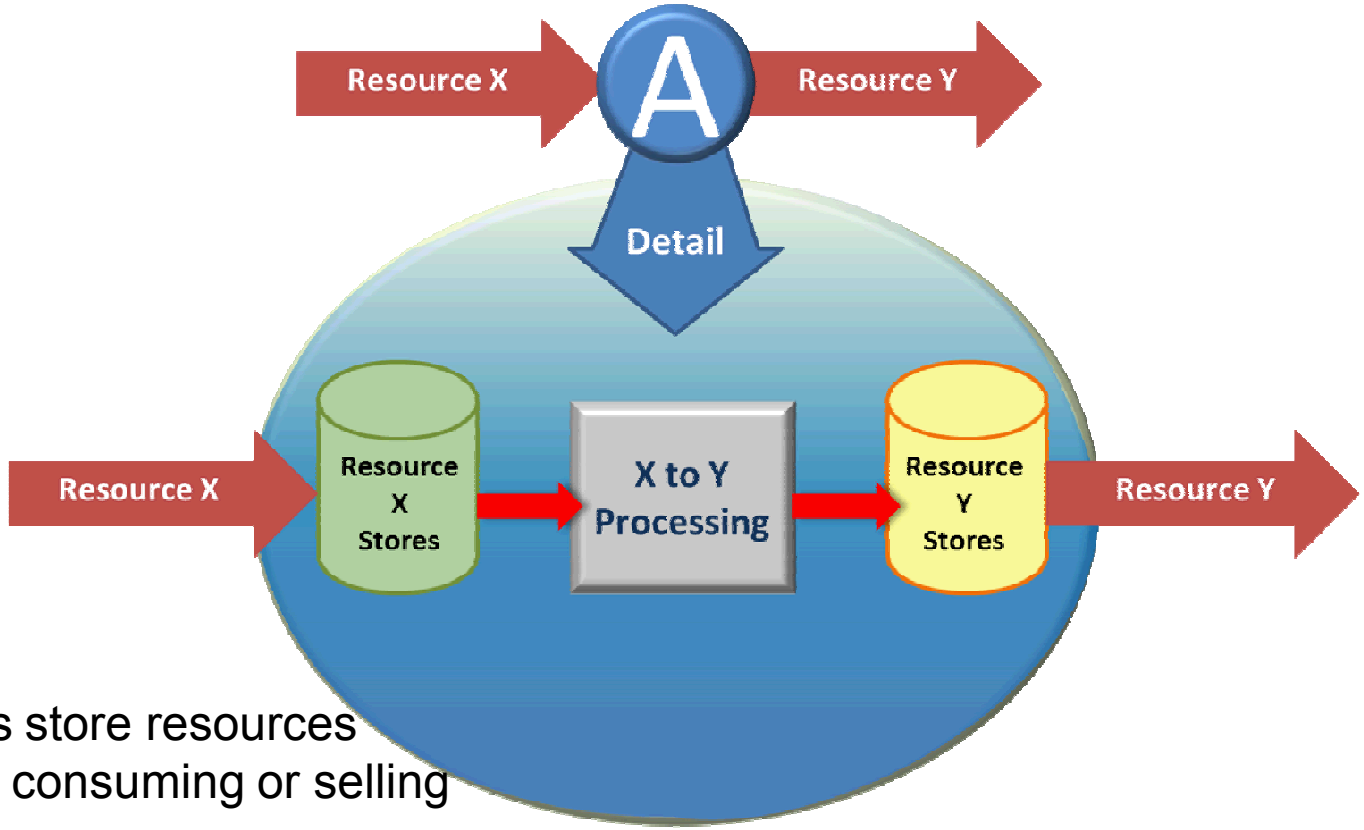
# Exchange Model – Structural view



# Exchange Model – Agent view

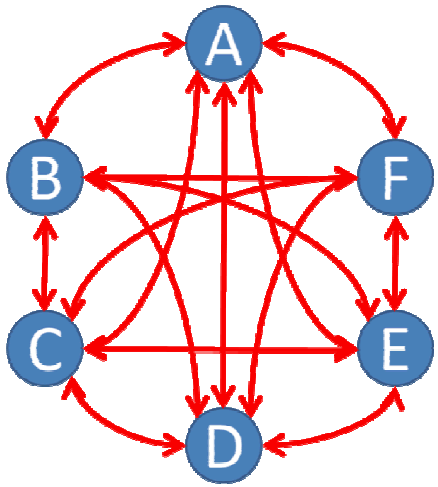


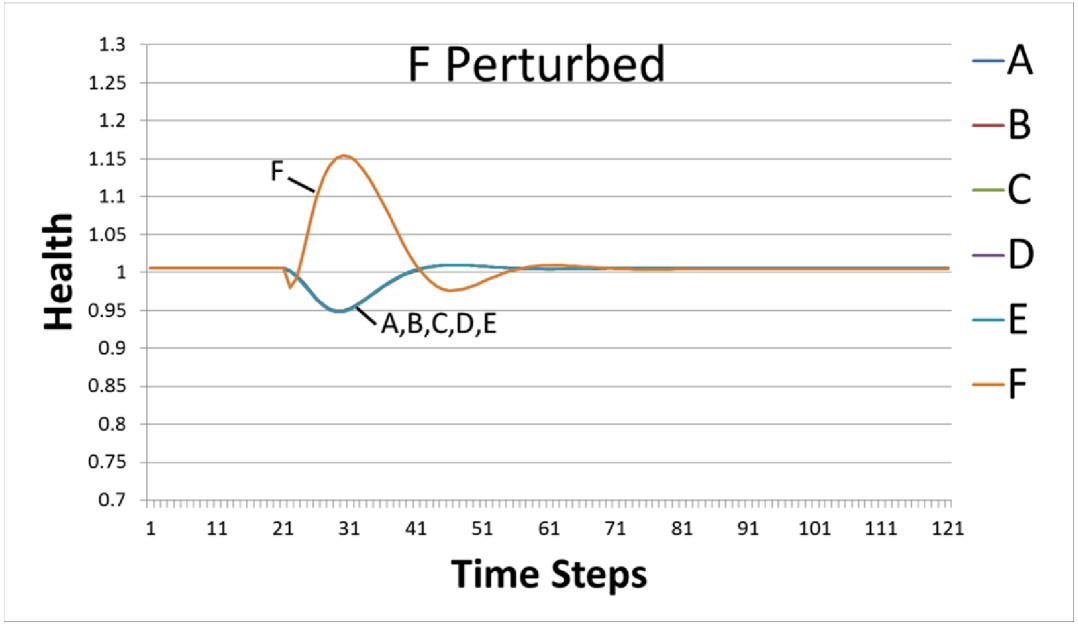
# Exchange Model – Agent Production Process




- Agents store resources before consuming or selling
- This structure allows perturbations to be introduced into the system by changing the storage(s)

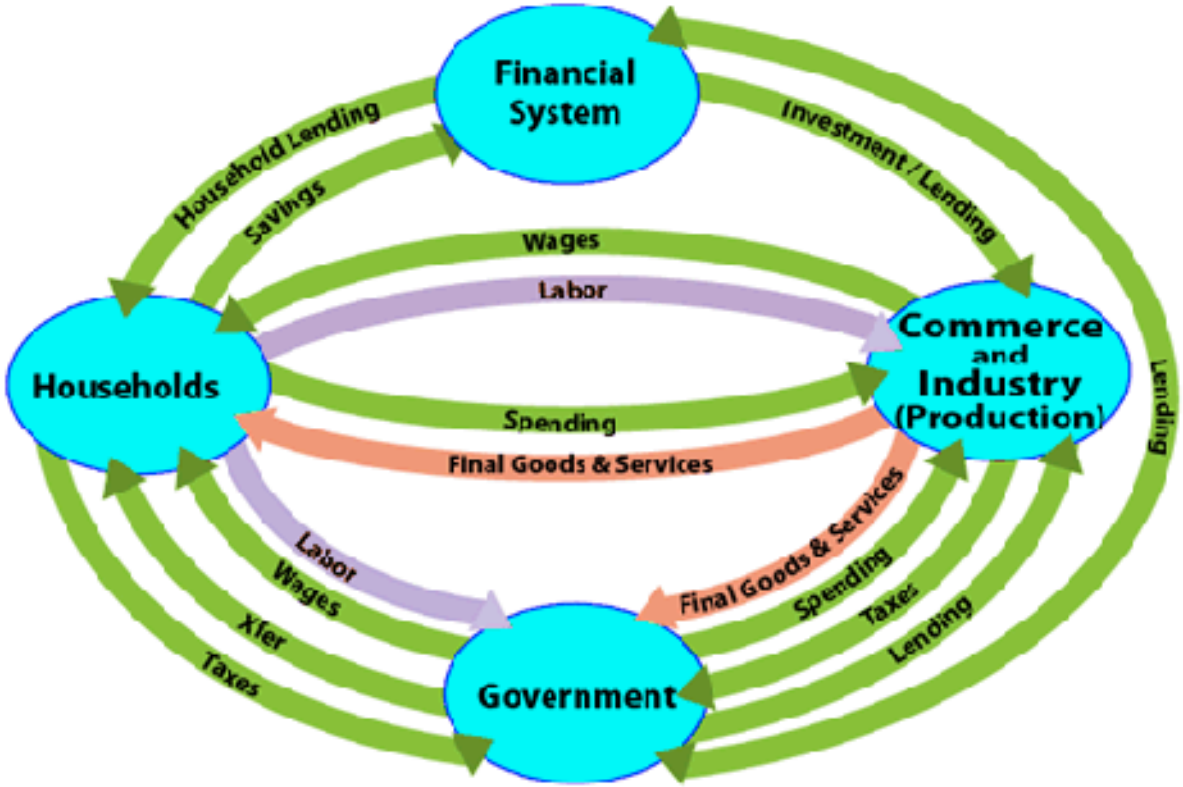
# Exchange Model – Artificial Scarcity




- Perfectly connected network of different productive sectors
- Sector F creates artificial scarcity, profits handsomely
- Increasing storage size (energy storage, SPR), dampens F's profits and – therefore – incentive to cut production

# Global Finance - Background

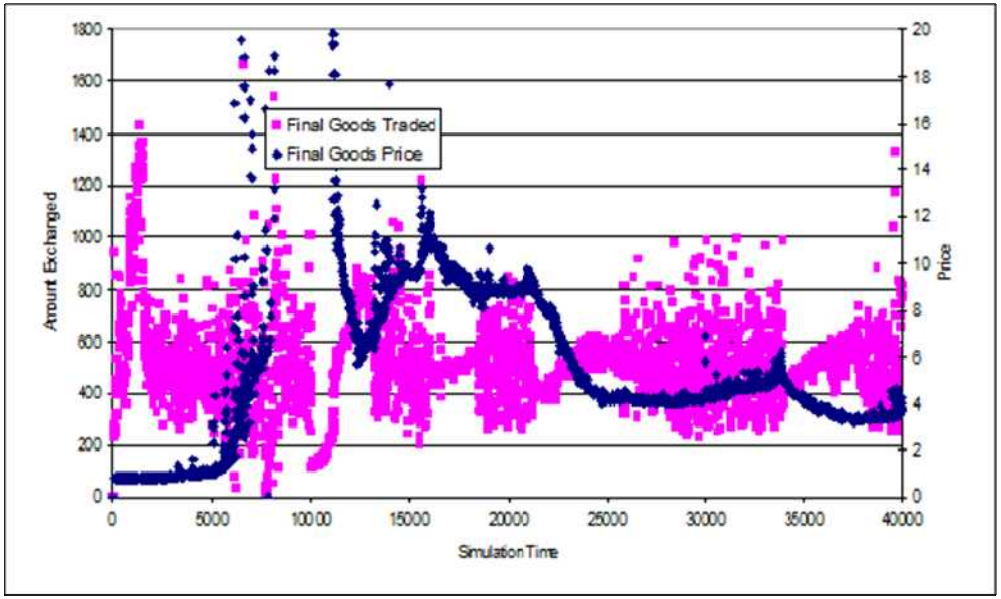



- Motivated initially by need to understand 2008 financial collapse
- Financial Systems crucial to function of economy, including energy markets

# Global Finance – Trader Behavior

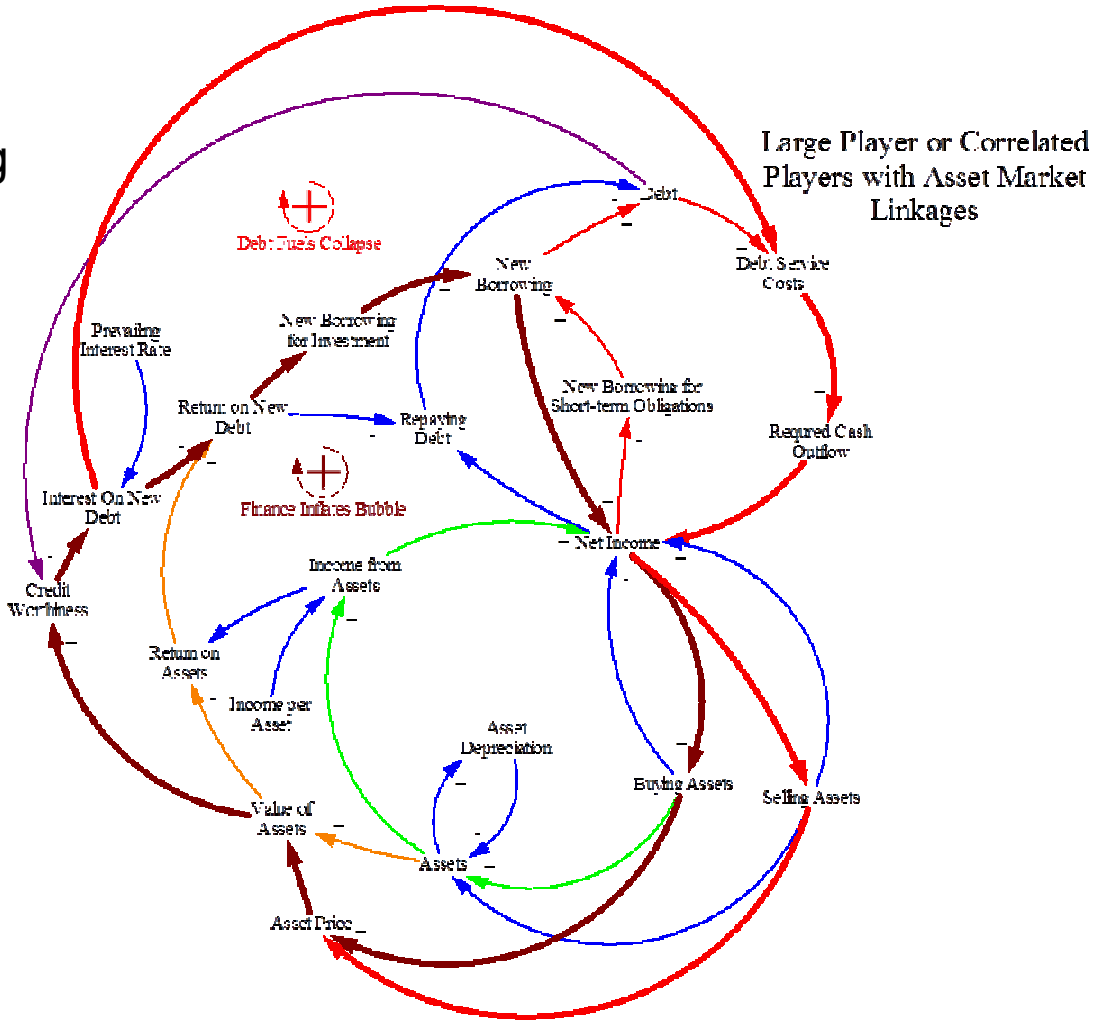

- Positive feedback effects on asset prices can lead to bubbles and crashes

- This market experiences periods of generally declining price and increased volume, alternating with periods of stabilized price and highly variable volume



# Global Finance –
## Innovation and Leverage Cycles

- Financial innovations often allow better allocation of capital among different sectors of the economy and management of risk
- However, this can increase systemic risk as leverage increases (as in 2003-2008)
- Technological innovation (e.g. renewable energy) gives further source for new investment in equity markets and complex financial products



# Global Finance - Energy Markets

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- Short-term investors
  - In 2008, hedge funds purchased supertankers of oil and parked them offshore as part of arbitrage strategy, affecting supply
  - Some politicians attacking speculators for current rising gas prices
- Renewables hot in private equity and venture capital
- New financial developments include:
  - Global Development Bonds (structured like CDOs)
  - Indices and Funds for renewables sector

- Global Finance Model will help us predict effects and test implications of proposed policies (Dodd-Frank Reform, Volcker Rule, curbs on speculation and shorting, etc.)