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# Exploring Historical Roots and Current Methodologies of Engineering Systems

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Session 3B: Engineering Systems Education—  
Innovations in Curriculum

June 17, 2009  
Second International Engineering Systems Symposium  
Cambridge, Massachusetts



Massachusetts Institute of Technology  
**Engineering Systems Division**

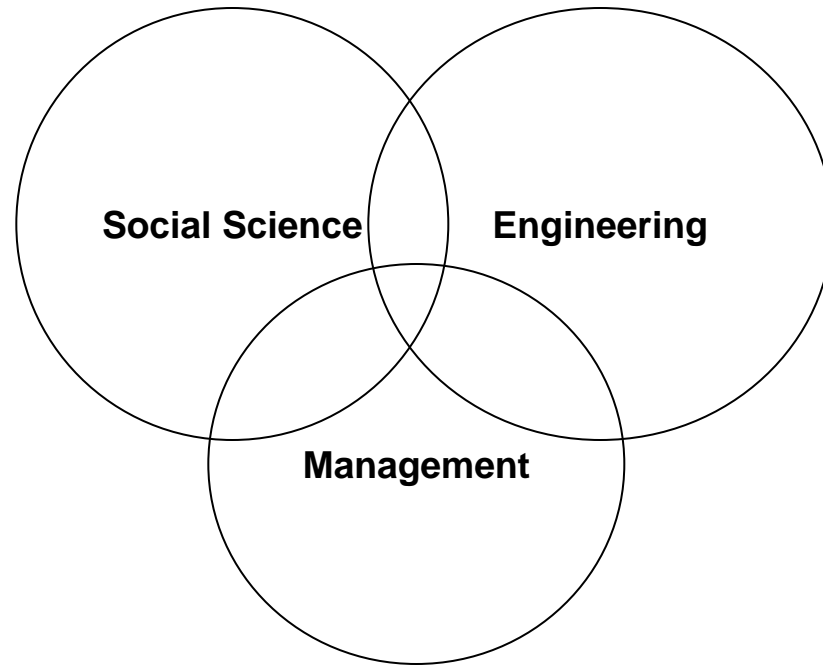


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# Motivation for Historical Analysis

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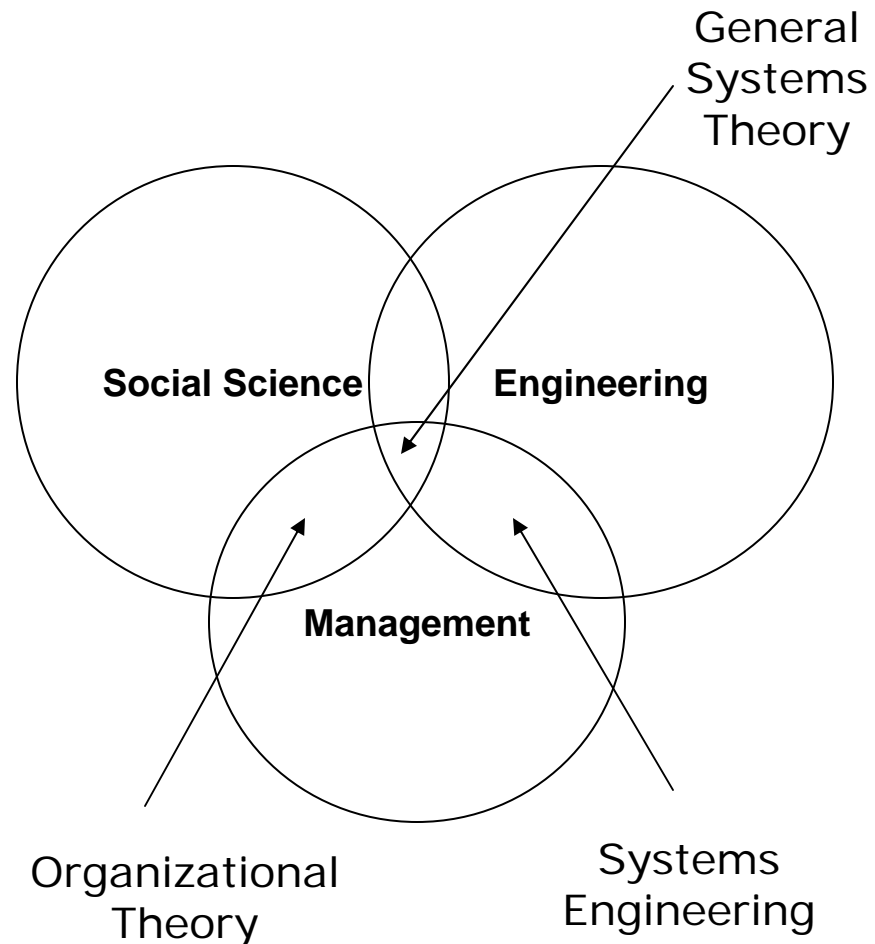


**Main Idea: There is value in ESD researchers understanding the historical context of the methods they use.**

# Historical Roots of Engineering Systems

## Examples of ROOTS

General Systems Theory
Operations Research
Innovation Theory
Systems Engineering
Systems Dynamics
Organizational Theory
Agent Based Modeling



# Historical Roots of Engineering Systems

Examples of  
ROOTS

General Systems Theory
Operations Research
Innovation Theory
Systems Engineering
Systems Dynamics
Organizational Theory
Agent Based Modeling

**Moving from  
deterministic &  
mechanistic to stochastic  
& complex systems...**

# Current Methods of Engineering Systems

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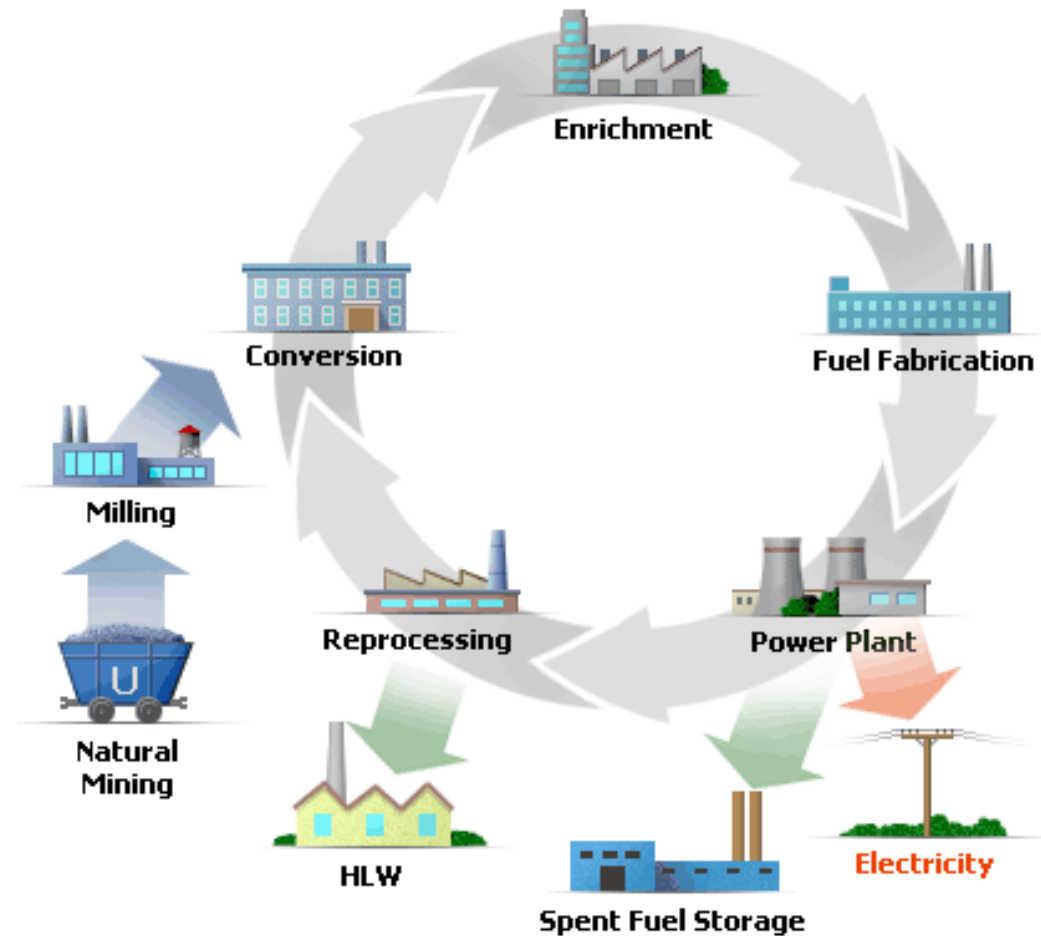
## Examples of METHODS

System Dynamics
Agent Based Modeling
Benefit Cost Analysis for Project Evaluation
Real Options Analysis
Stakeholder Analysis
Strategy Development

# Current Methods of Engineering Systems

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Oil platform (Cardin)

[http://www.nasa.gov/centers/jpl/images/content/256576main\\_platform-browse.jpg](http://www.nasa.gov/centers/jpl/images/content/256576main_platform-browse.jpg)

# Current Methods of Engineering Systems

## Examples of METHODS

System Dynamics

**Agent Based Modeling**

Benefit Cost Analysis for Project Evaluation

Real Options Analysis

Stakeholder Analysis

Strategy Development



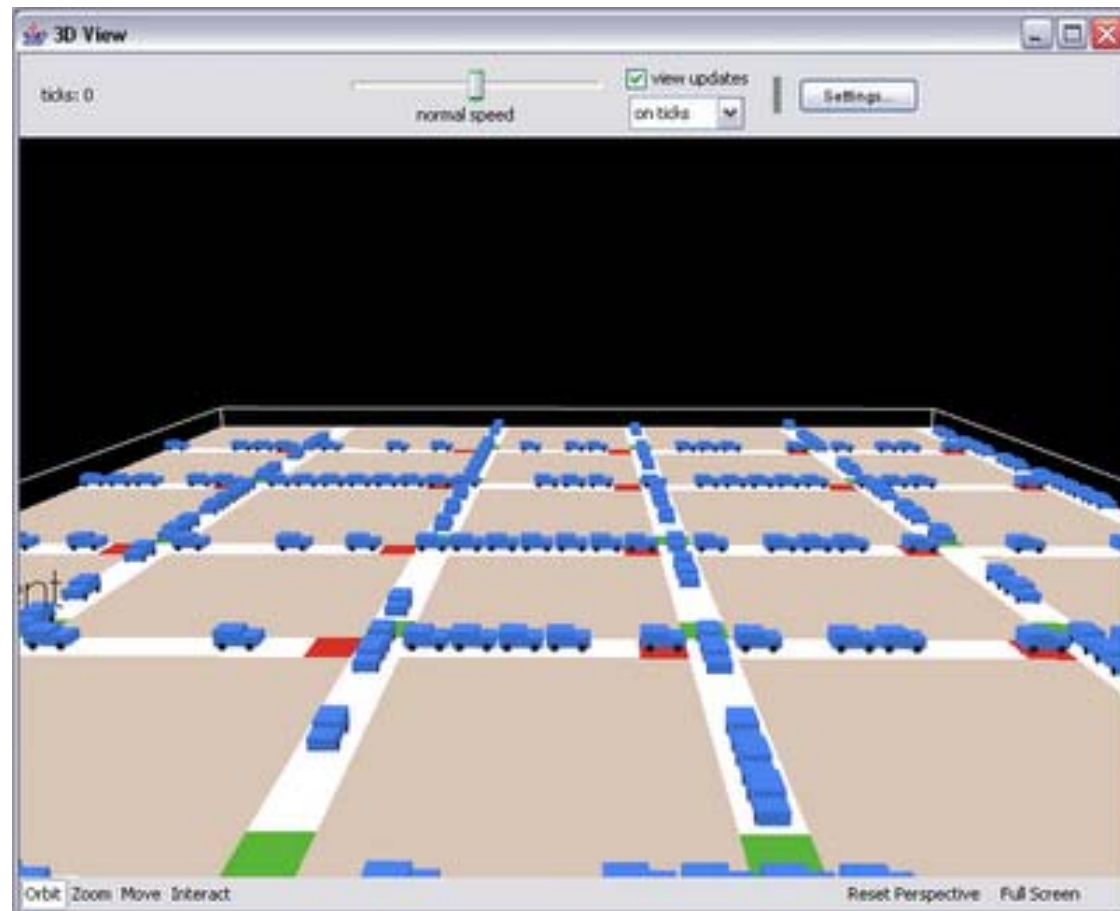
## Traffic

<http://www.iphonematters.com/images/uploads/27862-hi-traffic.jpg>

# Current Methods of Engineering Systems

## Examples of METHODS

System Dynamics
<b>Agent Based Modeling</b>
Benefit Cost Analysis for Project Evaluation
Real Options Analysis
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Strategy Development

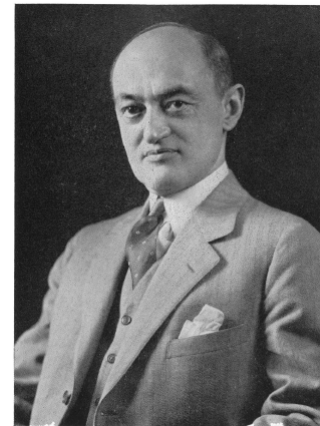


Traffic Simulation

# Choosing a Historical Root: Innovation Theory

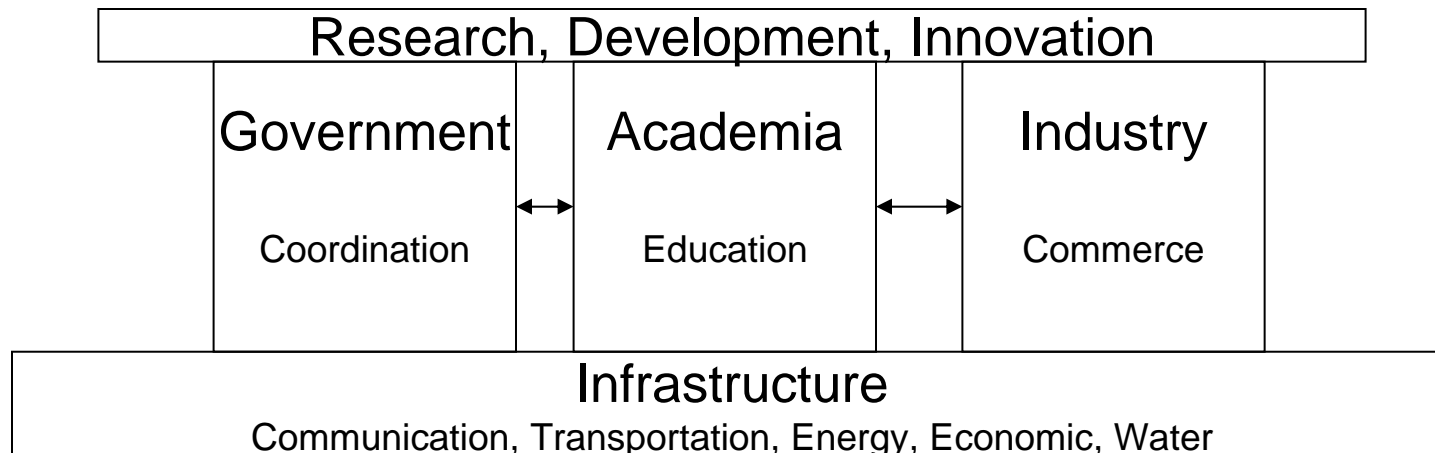
## Root: Innovation Theory

- How does technological change impact the economy?
- Focus on work of Joseph Schumpeter
- Used a forward-looking perspective



**Joseph Schumpeter**

(Haberler, 1950)



**Role of  
Technology in  
International  
Development**

# Choosing a Current Eng Sys Method: Strategy Development

## Method: Strategy Development

- How can firms make plans to compete successfully and maximize profit/increase efficiency?
- Focus on work of Michael Porter and Henry Mintzberg
- Used a backward-looking perspective



**Michael Porter**  
(Source: [www.nndb.com](http://www.nndb.com))



**Henry Mintzberg**  
(Source: [www.people.mcgill.ca](http://www.people.mcgill.ca))

Coal



<http://img.dailymail.co.uk>

Nat. Gas



<http://www.scientificamerican.com>

?



**Climate  
Change  
and Utility  
Planning**

Solar



<http://www.resourceactionprograms.org>

Wind



<http://www.metaefficient.com>

Nuclear



<http://www.florida.sierraclub.org>

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# Overview of Innovation Theory



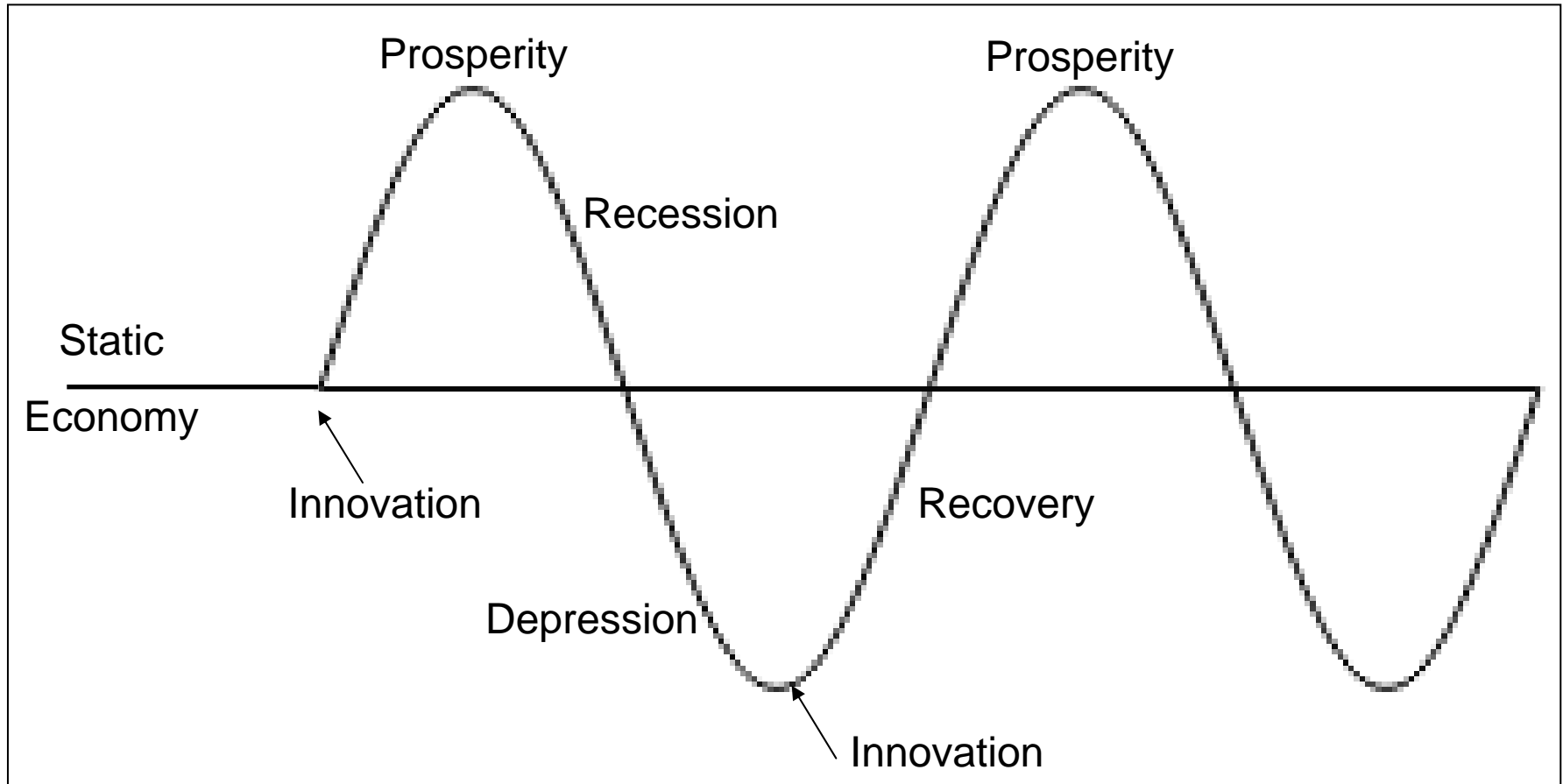
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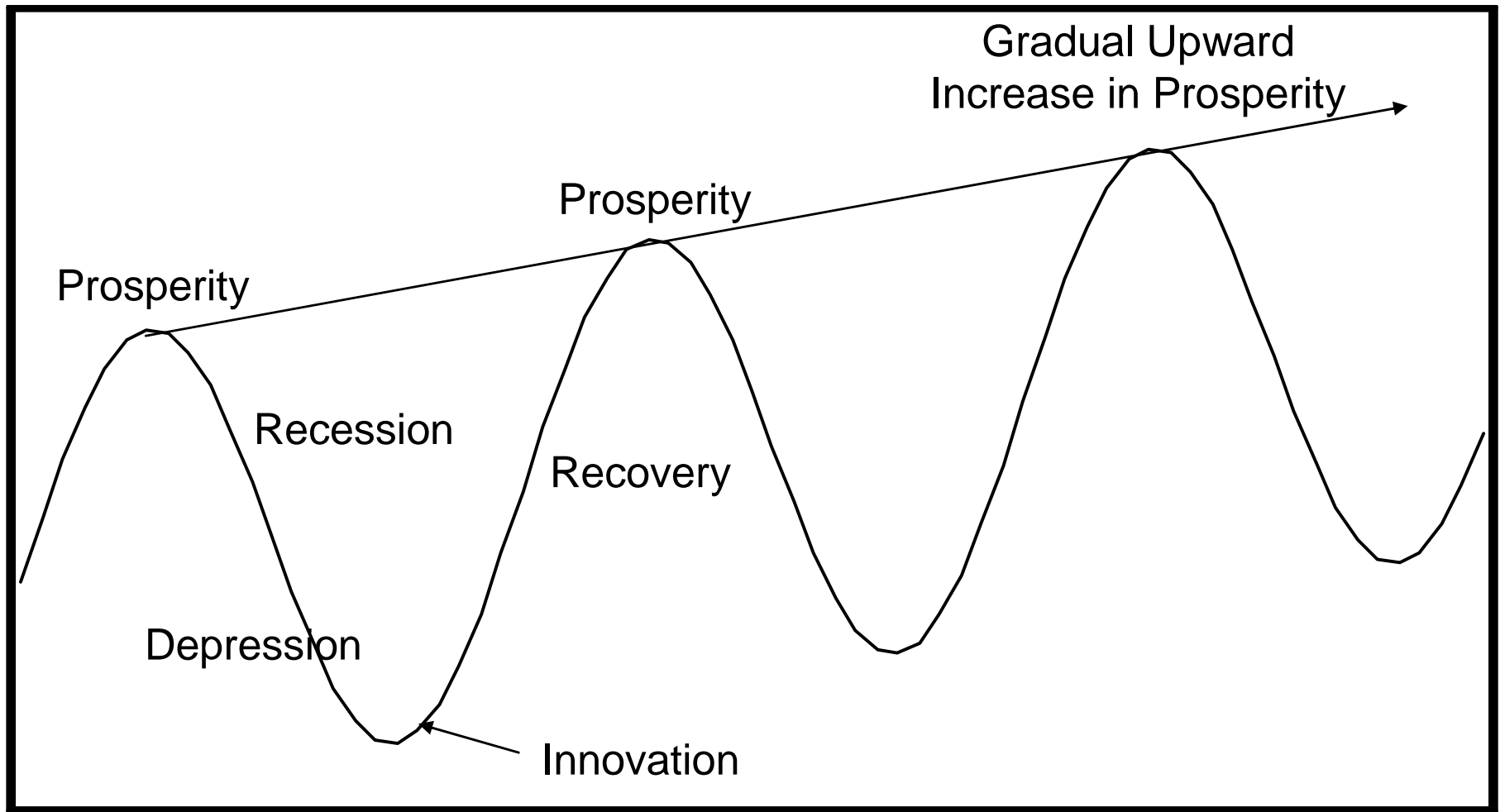
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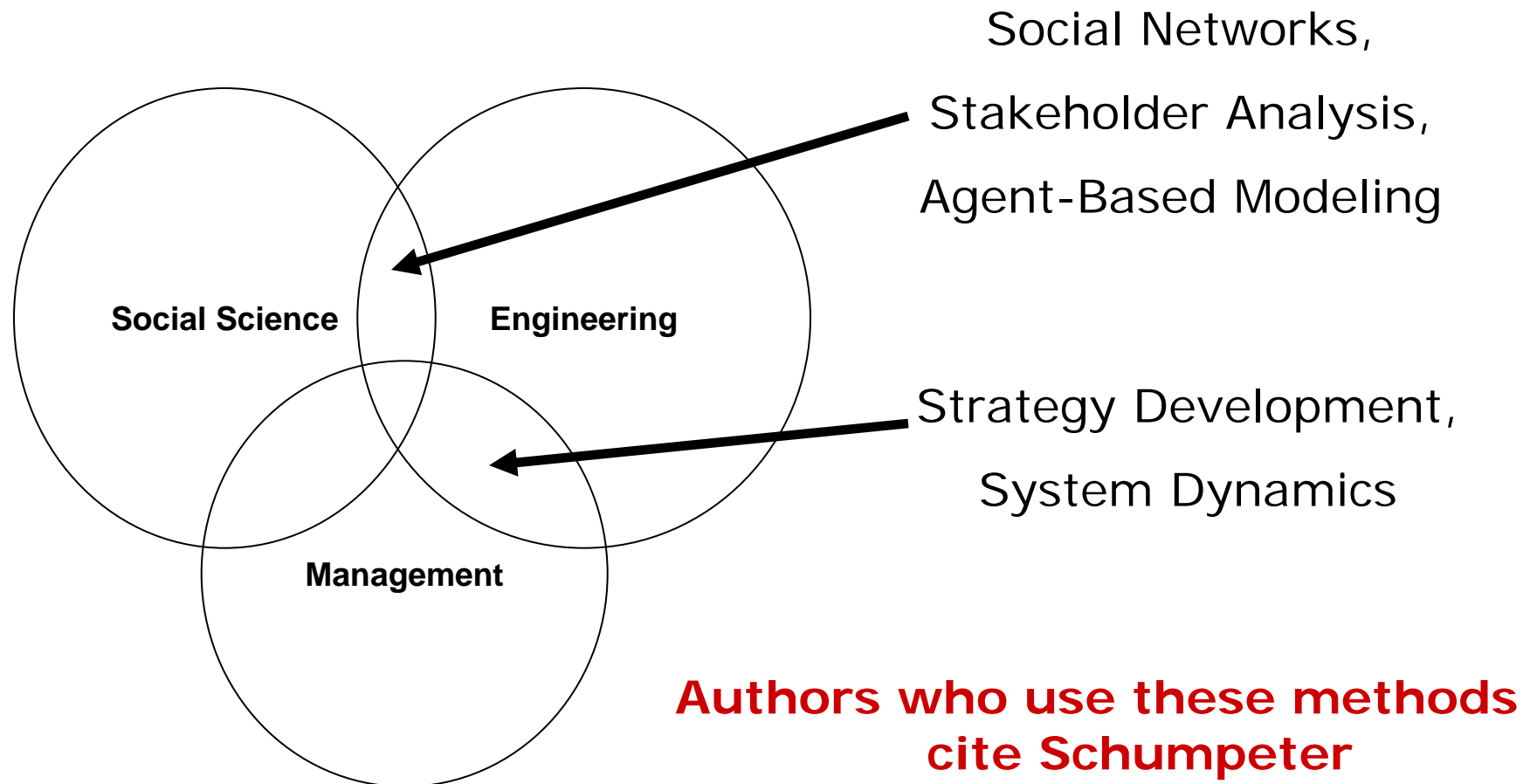
# Overview of Innovation Theory: Schumpeter



# Overview of Innovation Theory: Schumpeter



# Does Schumpeter impact current Engineering Systems methods?



# Example from ES Research: Management of Collaborative Satellite Projects in Developing Countries

- Satellite System Design
- Satellite Project Implementation
- Space Policy
- Systems Architecture

## Space Technology Policy

- Role of Infrastructure in Development
- International Technology Transfer
- Infrastructure Project Management
- Role of Technical Innovation in Economic Development**

## International Development

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# Overview of Strategy Development



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# Overview of Strategy Development

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- Broad Definition of Strategy
  - “Where we are now”
  - “Where do we want to be?”
  - “How do we get there?”
  
- Strategy Development as an Engineering Systems Method
  - ES at the intersection of Engineering, **Management**, and Social Science
  - Facilitates understanding of our complex systems

# Overview of Strategy Development: Porter and Mintzberg

Porter's

## Five Forces Model

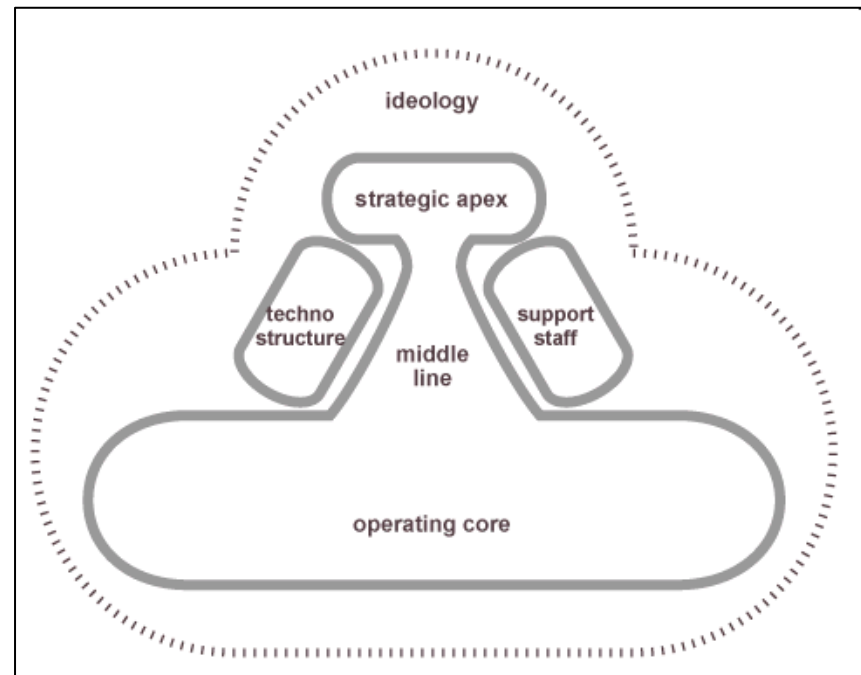
The Five Forces That Shape Industry Competition



(Porter, 2008)

Mintzberg's

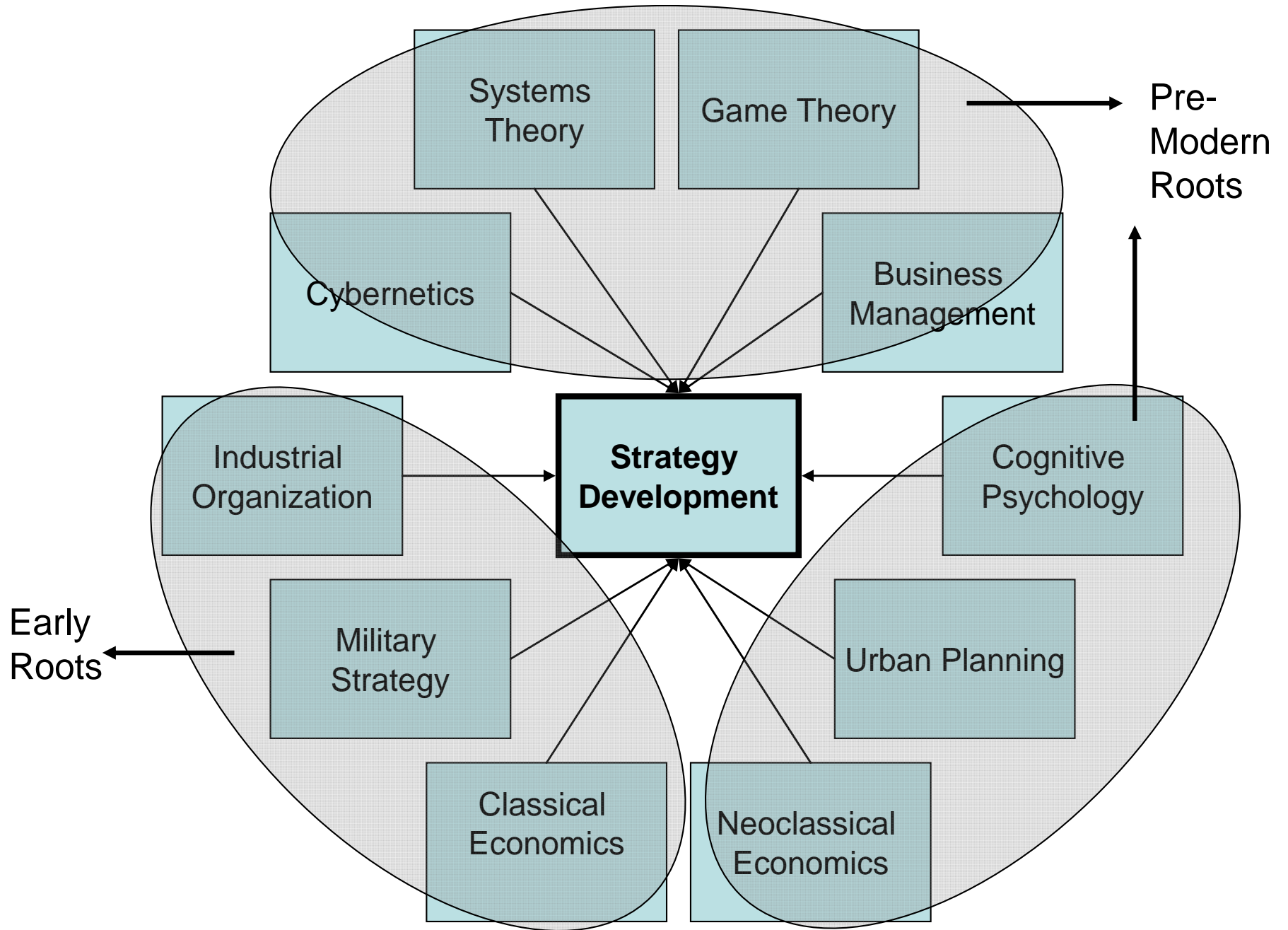
## Emergent Strategy and Organizational Structure in 5's



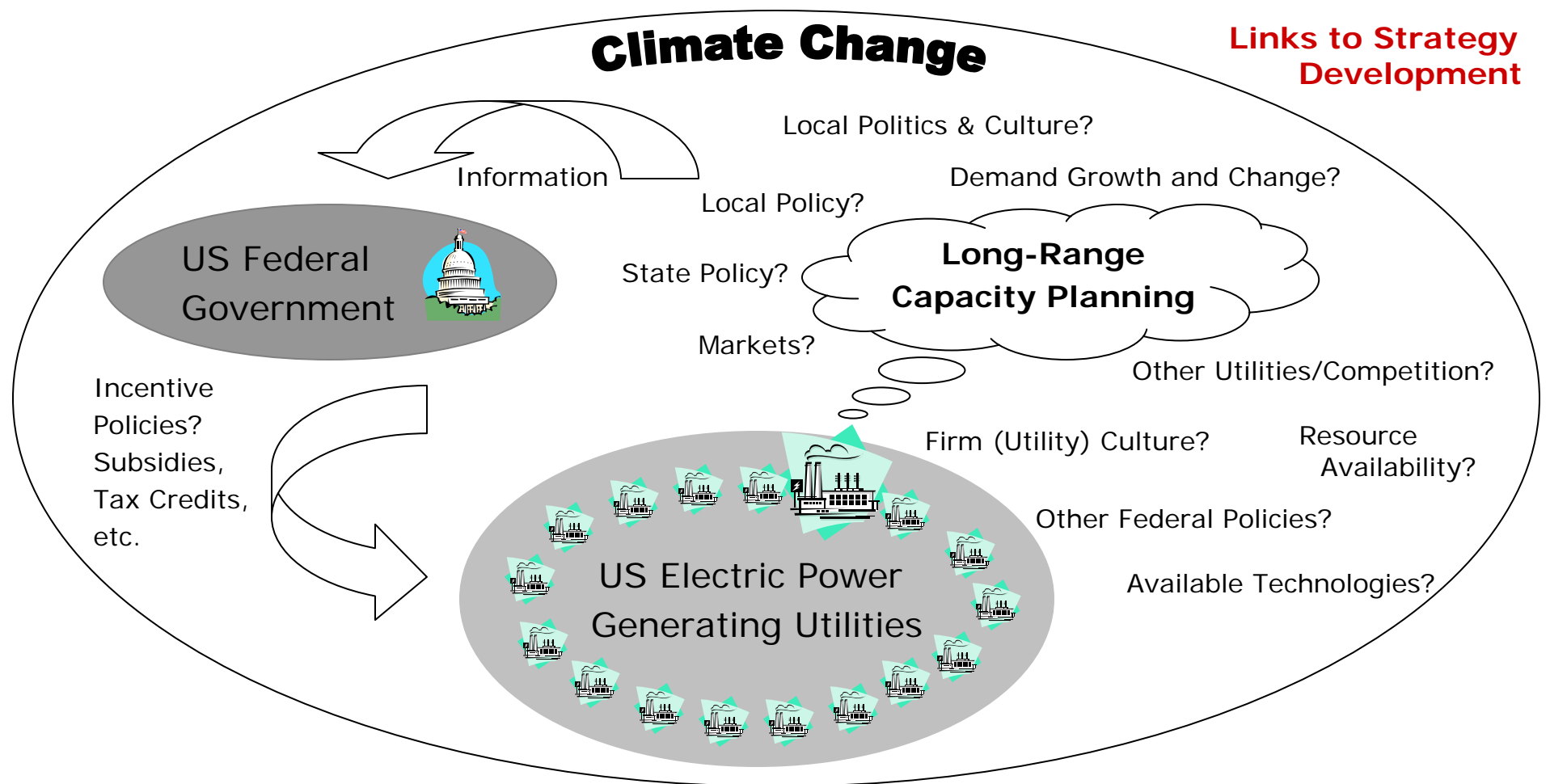
(www.clickok.co.uk)

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Which historical disciplines have impacted Strategy Development?



# Example from ES Research: Climate Change and US Regulatory Incentive Policy for Electric Utilities



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# Finding the Links...



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# Connections between Innovation Theory and Strategy Development

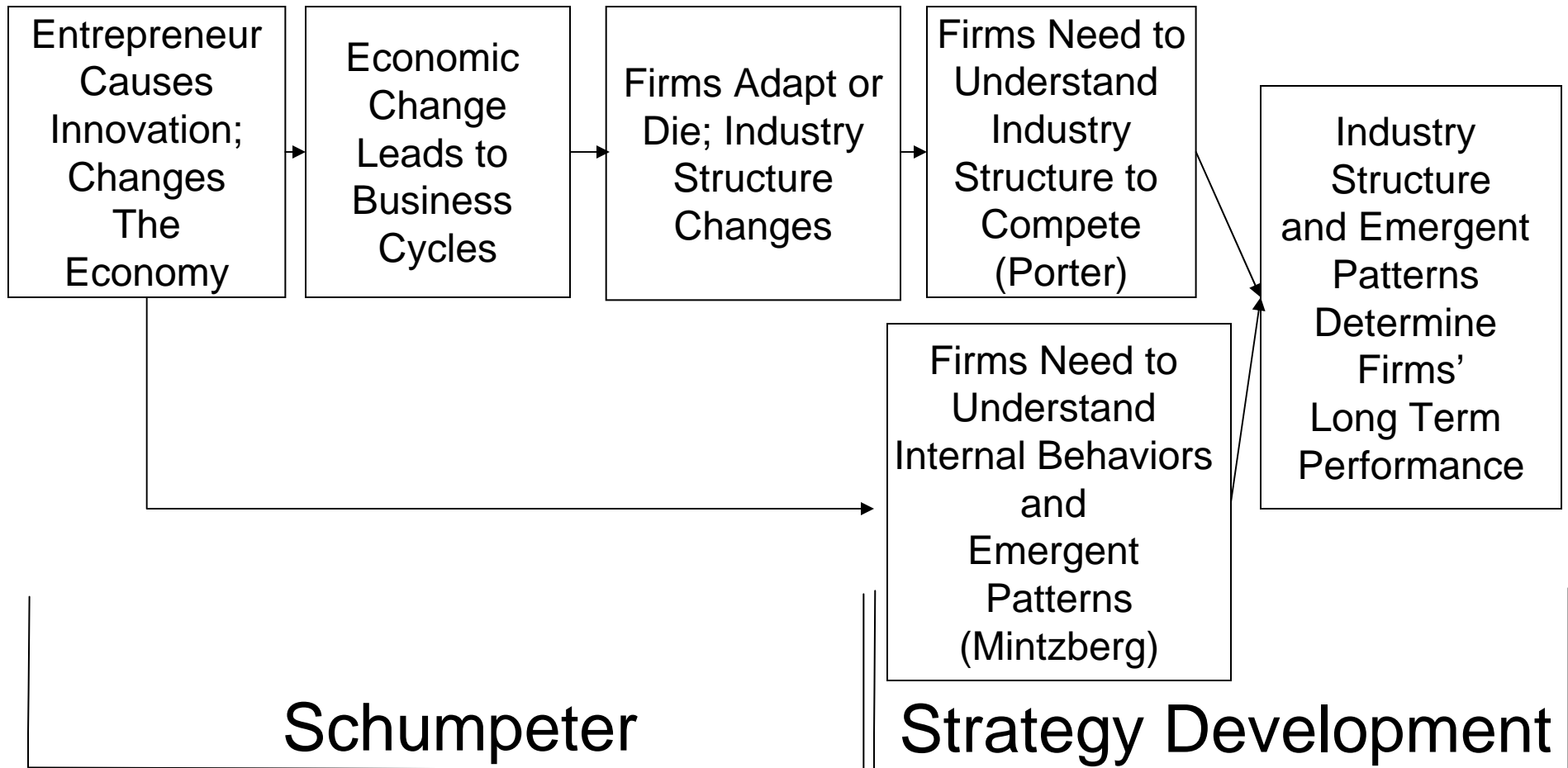
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- A **logical chain** of ideas flows from Schumpeter to the scholars on Strategy Development
- **Parallel evolutions** and change cycles

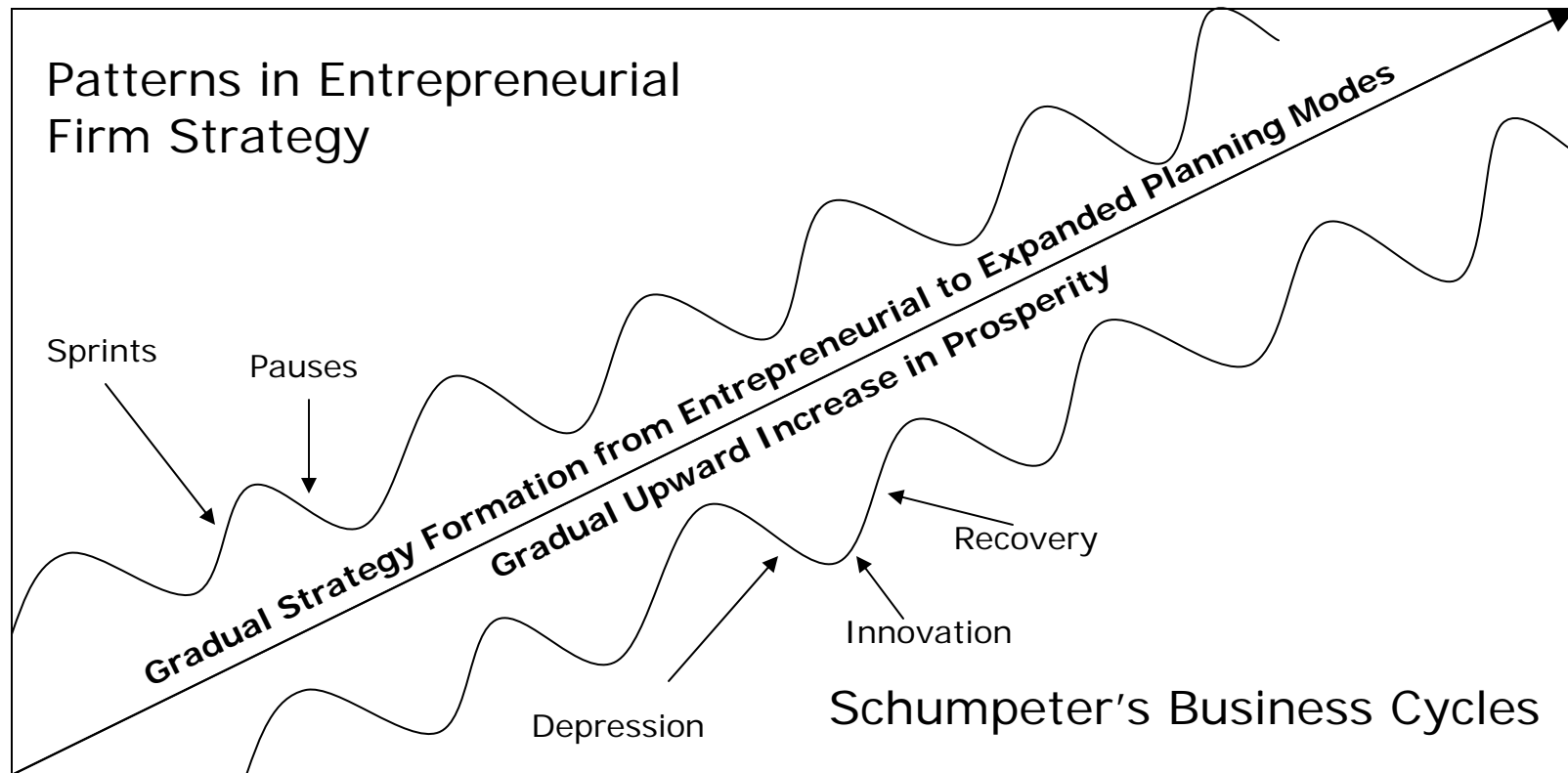
But,

- The link between Schumpeter's theories about innovation and Strategy Development is just one of **many historical links** flowing backward and forward for these fields

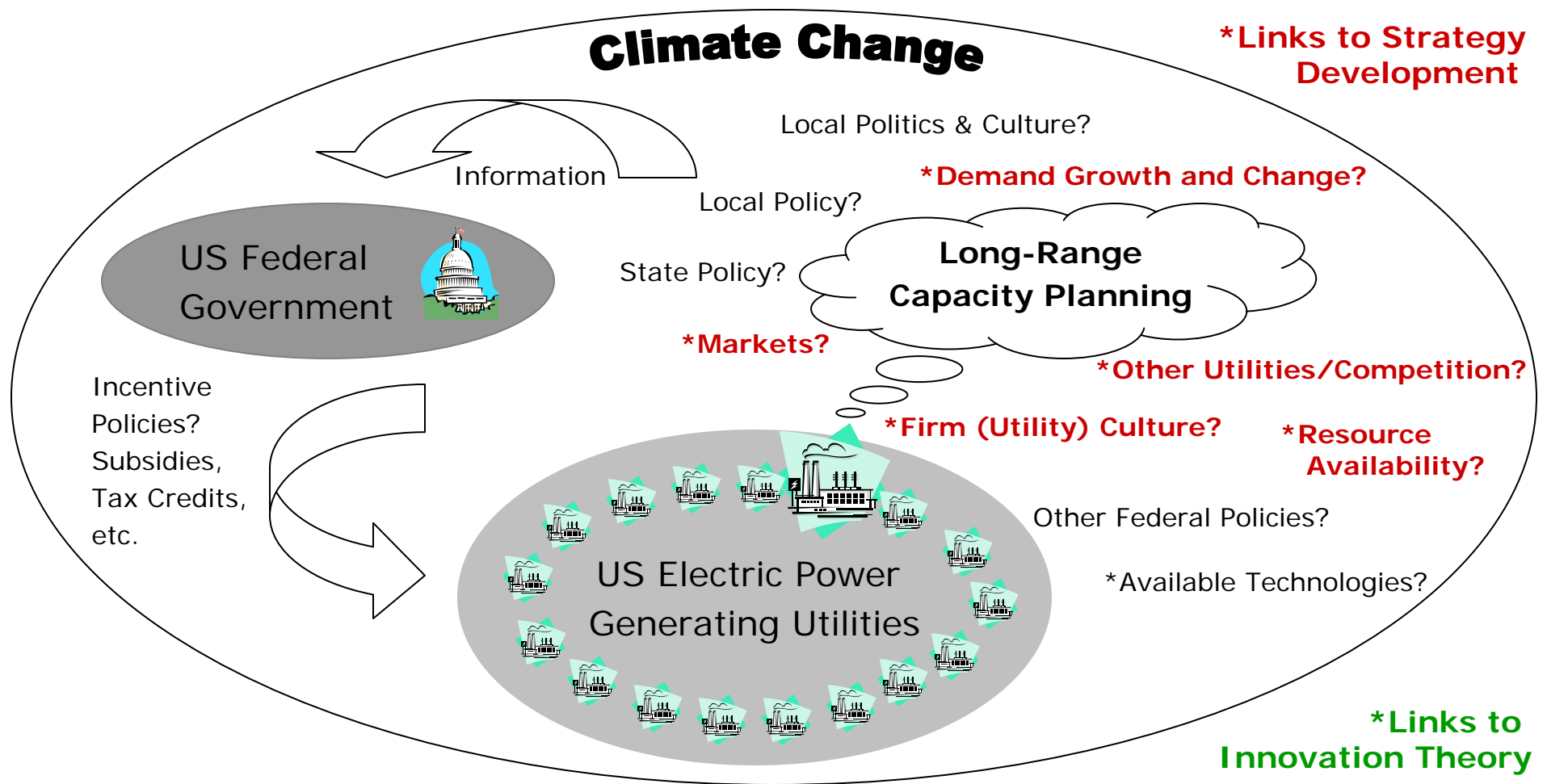
# Connections between Innovation Theory and Strategy Development



# Connections between Innovation Theory and Strategy Development



# Example from ES Research: Using the Links...



# Connections between Innovation Theory and Strategy Development

## Historical Roots of ES

Industrial Organization

Game Theory

**Impact of Technology On Economy**

General Systems Theory

Cybernetics

Economics

Military Strategy

Business Management

Urban Planning

Cognitive Psychology

## Contemporary ES Methods & Fields

System Dynamics

Agent-Based Modeling

Stakeholder Analysis

**Strategy Development**

Social Networks

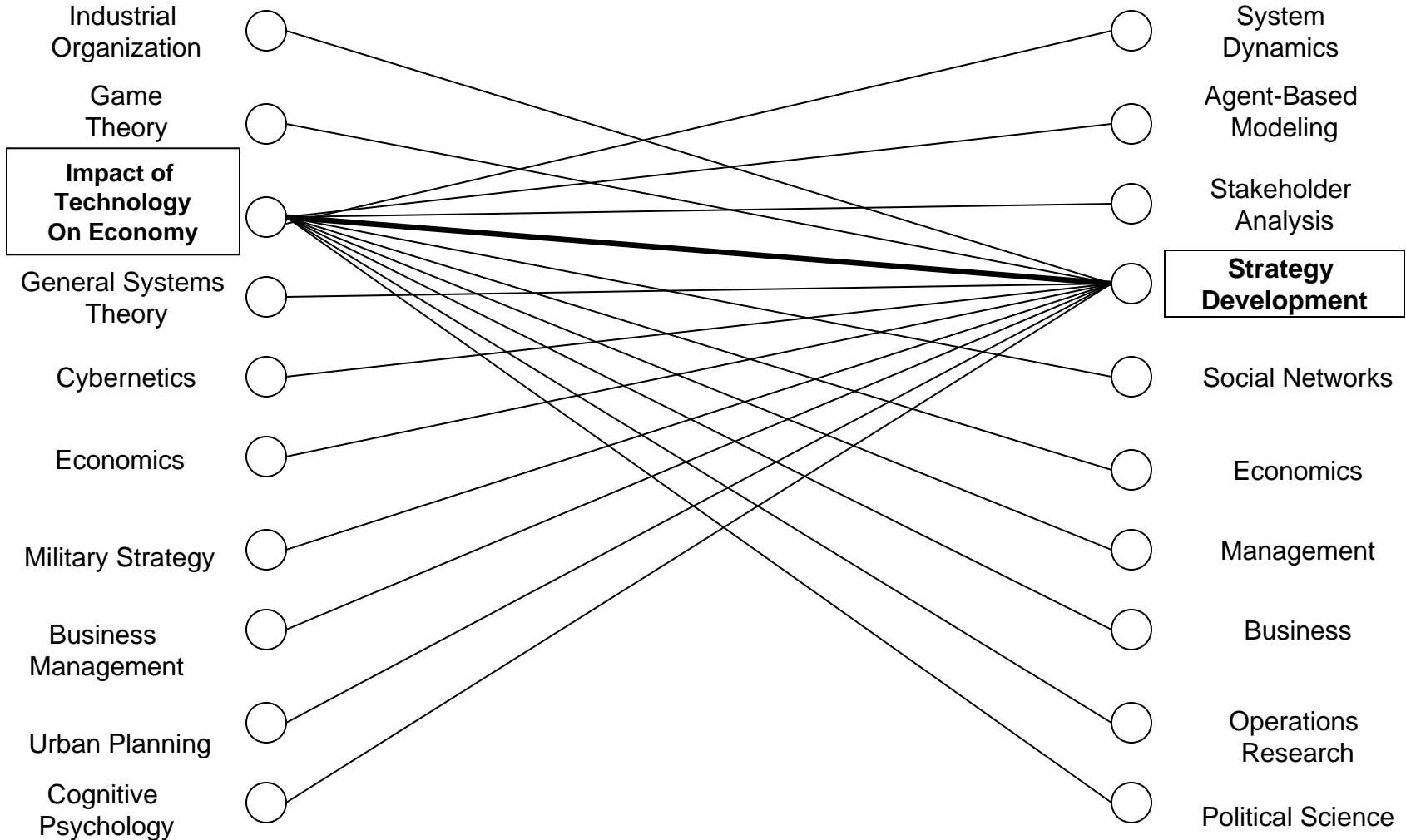
Economics

Management

Business

Operations Research

Political Science



# What Did We Learn?

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- **Connections** between modern Engineering Systems methods and their histories
- **Perspective** gained from historical analysis of a research method
- **Need** for an Engineering Systems methods reference library
- **Reflections** on educational experience

# References

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<http://query.nytimes.com/gst/fullpage.html?res=9E0CE4D61331F937A15754C0A964958260> Accessed November 25, 2008.
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# Questions?

## Thank You

Professor Joe Sussman

Professor Christopher Magee

Christopher Roberts



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# Backup Slides

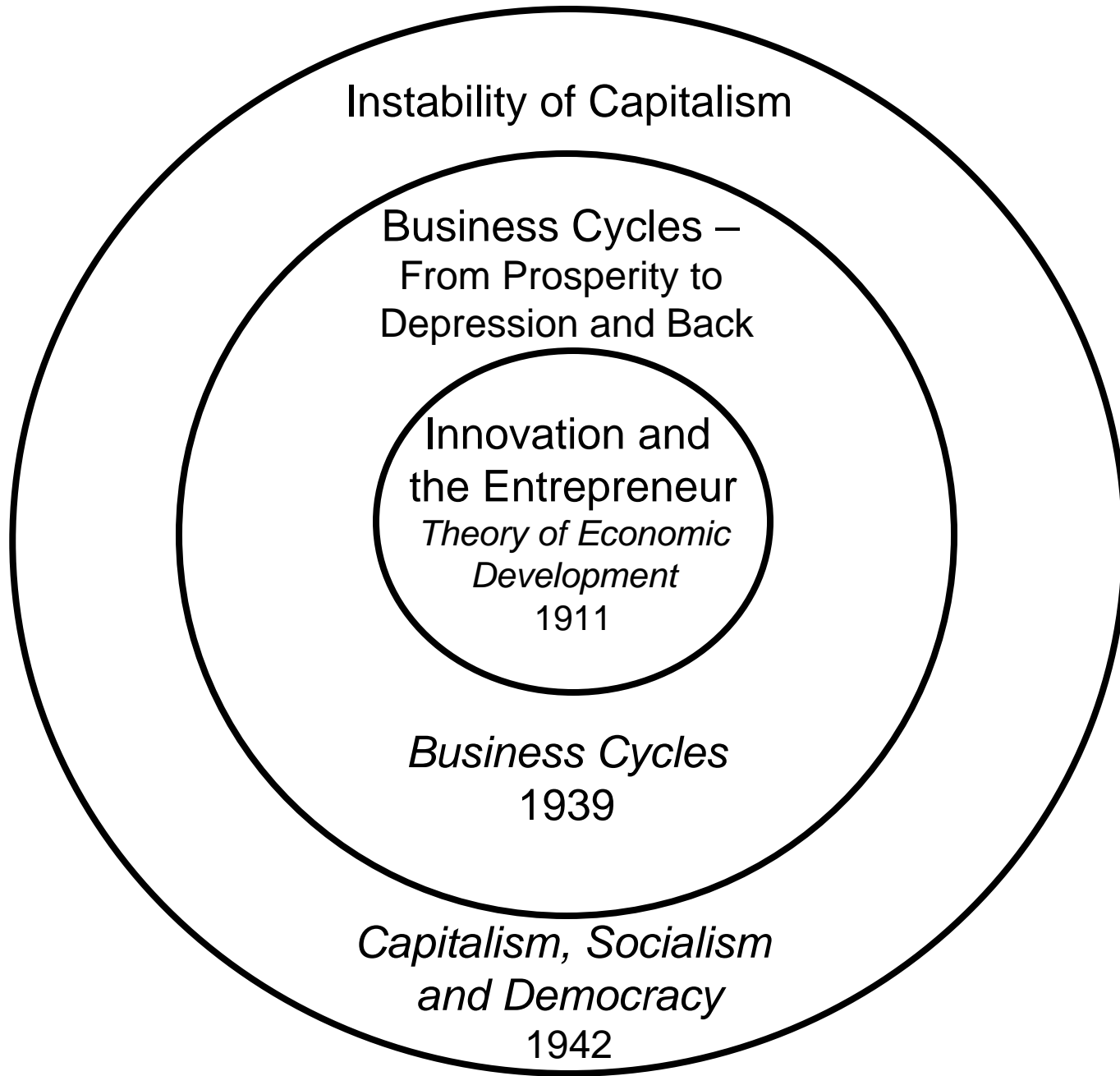


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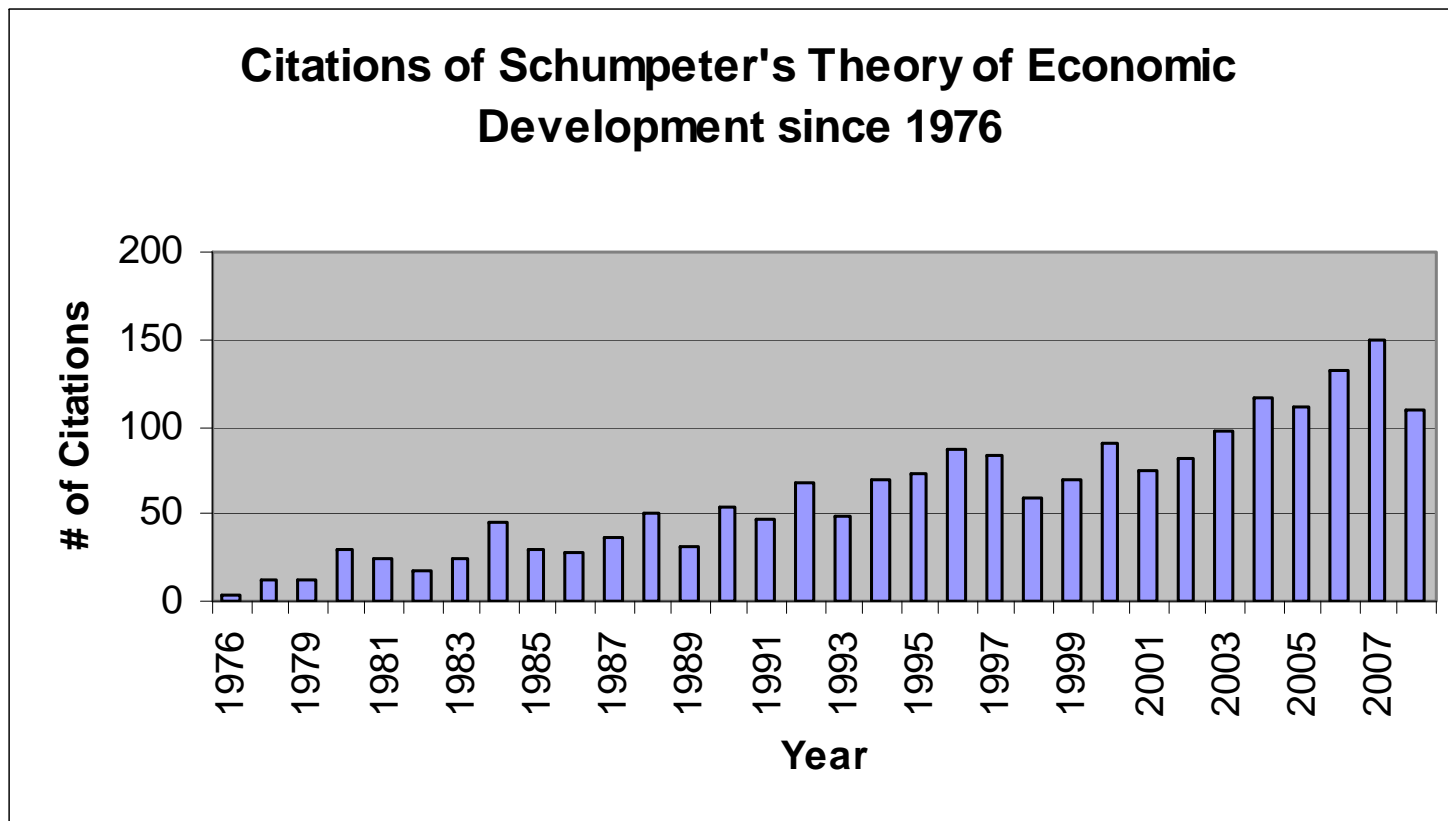


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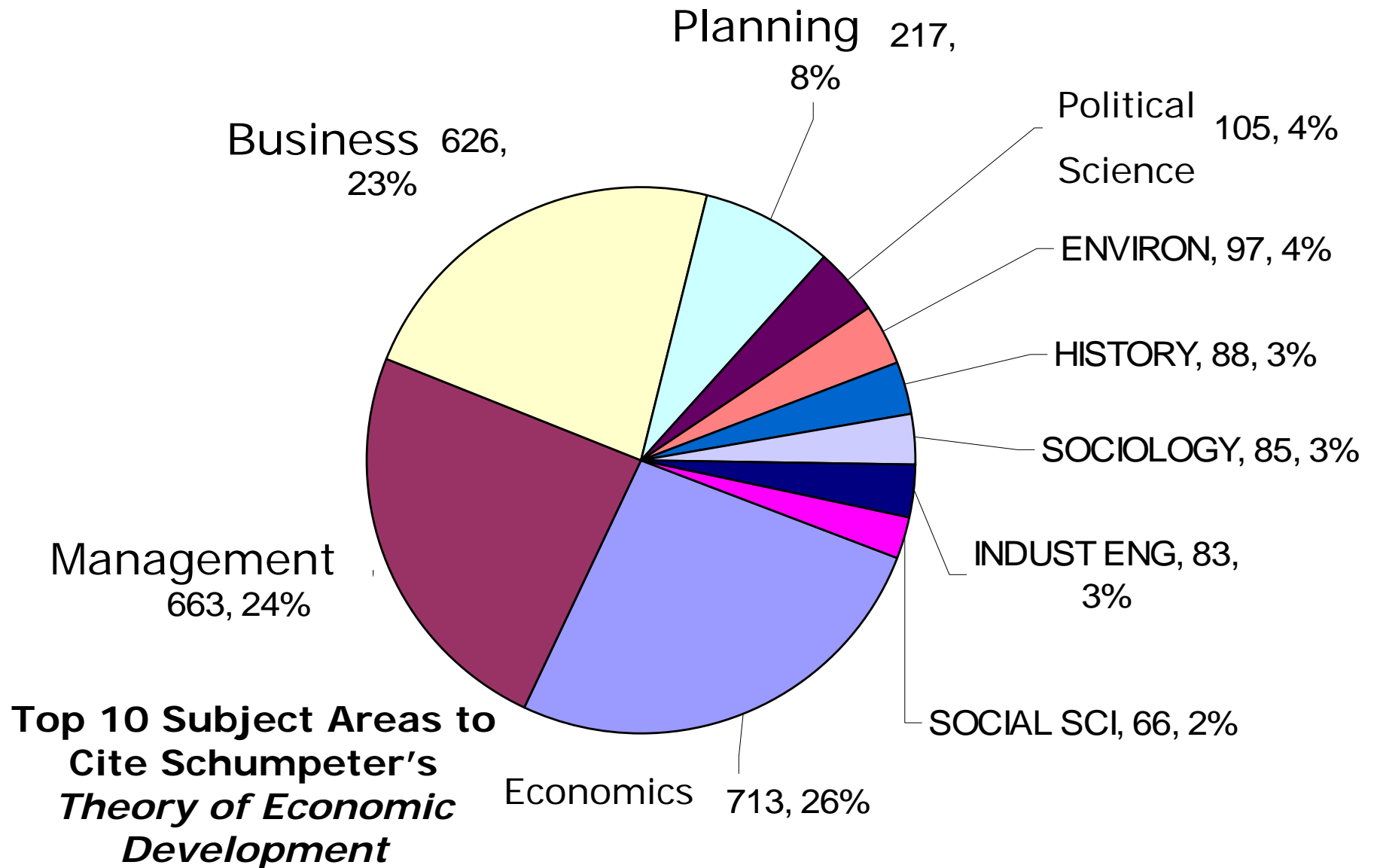


# Schumpeter's Impact over Time

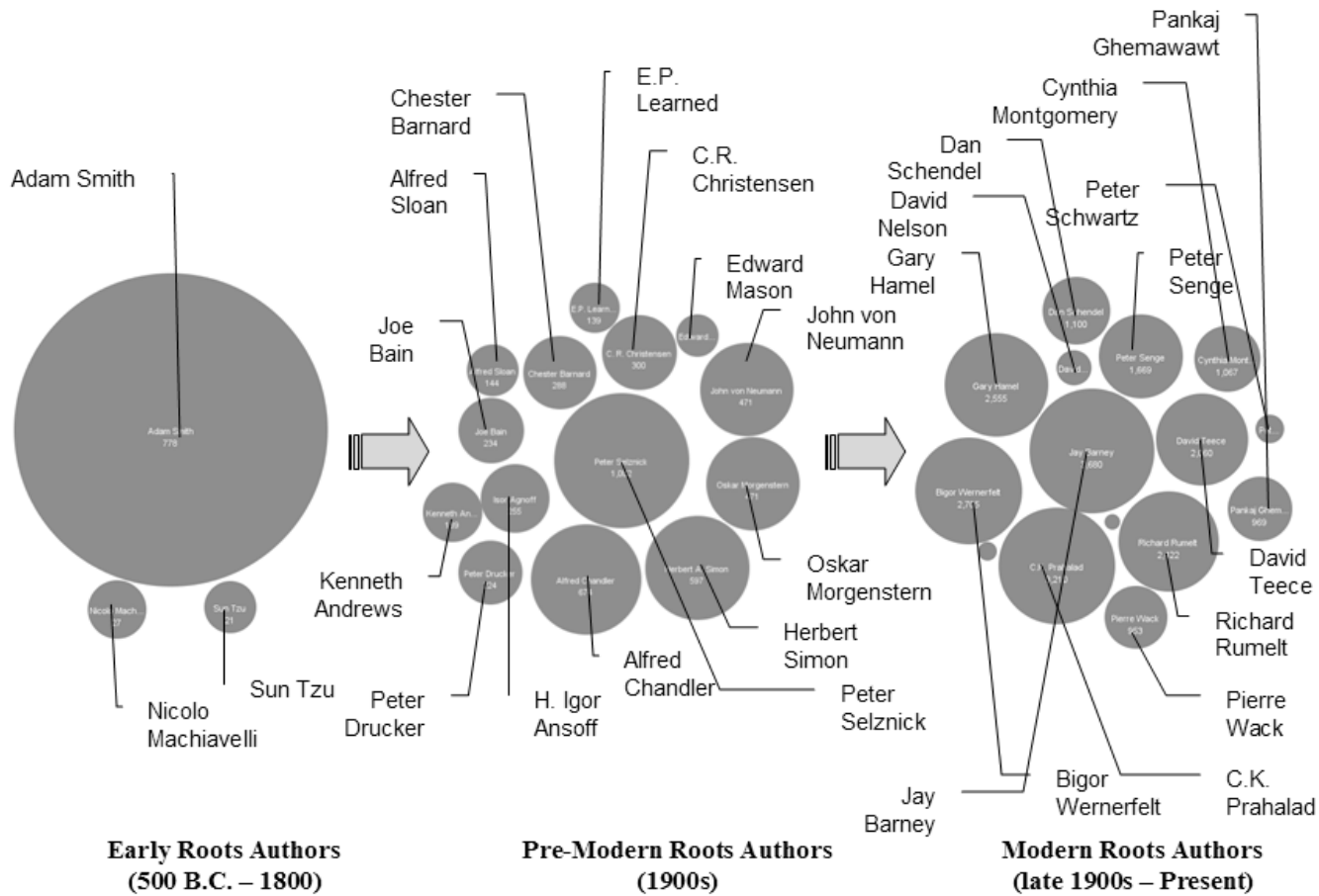


**Time Trend Results from Citation Analysis for One of Schumpeter's Major Books**

# Which modern disciplines are impacted by Schumpeter's work?



# Evolution of Strategy Development



# Schumpeter's Impact

<i>Scholar</i>	<i>Field/Discipline</i>	<i>Methodology</i>
Michael Macy	Sociology	Agent-Based Modeling
Olav Sorenson	Innovation, Management, Entrepreneurship	Social Networks
R. Edward Freeman	Business and Ethics	Stakeholder Analysis
Jeremy Hall	Innovation, Management, Entrepreneurship	Stakeholder Analysis
<b>Ian MacLachlan</b>	<b>Geography</b>	<b>Strategy Development</b>
<b>Nicholas Argyres</b>	<b>Management</b>	<b>Strategy Development</b>
Andreas Groessler	Management	System Dynamics
John Sterman	Management	System Dynamics