LEARNING TO EVOLVE

Why do social scientists do such a poor job of predicting changing social behaviors and conditions of complex social systems?

- Crime rates (incarceration & violence crime)
- Election outcomes (changes in party control)
- Economic performances (stock markets, growth, unemployment)

But how accurately do natural scientists forecast complex real-world systems?

- Long-range weather patterns & climate trends
- Earthquakes, volcanic eruptions
- Outbreak & spread of epidemics
Indeterminacy in predicting outcomes originates in the nonlinear relations among the key variables of complex dynamic systems.

Nonproportionality, interactions, feedback loops

“Butterfly effect” – small disturbance in initial state produces wide differences in later conditions

Over time, a chaotic system can follow unpredictable paths in its time trajectories, yet exhibit recognizable patterns (cyclical irregularities)

- Fractal geometry
- Strange attractors
ORGANIZATIONAL EVOLUTION

Evolutionary org’s change also assumes indeterminacy

Evolutionary paths are random: no progress toward an end-goal (teleology)
Instead, developments are recurrent, cumulative, probabilistic patterns with unpredictable paths (yet open to post facto understanding)

Roots in Biological Evolution Theory

Chas Darwin & Alfred Wallace

Explanation of continuously emerging novel biological forms or attributes through population interactions with environments

Evolutionary theory describes the historical genealogies of species
THREE KEY CONCEPTS

**Variation:** Form modifications produced by chance via mutations, genetic coding errors of individual organisms

**Natural Selection:** Reproduction & survival of organisms whose heritable traits are better suited to existing environmental conditions (“Survival of the fittest”)

**Retention:** Persistence of a selected variation over successive generations in a population (inertia)

“Descent with modification” (Darwin): parents transfer their genetically altered & selected traits to their offspring

**EX:** Alpha gorillas have more mates than others
Faster cheetahs survive to reproduce more offspring
EVOLVING ORGANIZATIONS

How explain origins, spread of new org’l forms?

• Organizational evolution as metaphor or explanatory theory?

• Darwinian inheritance or Lackmarckian acquired traits?

• What analogs to key concepts: species (form), population, inheritance, generation, gene?

Two sources of variation on which selection operates:

  Organizational genetics focuses on internal routines

  Environmental conditioning emphasizes external technology innovations
Organizational Routines

Organizational genetics approach treats changes in internal everyday activities ("routines") as the source of variations on which evolutionary selection & retention operates.

**Routines**: formal and tacit rules or capabilities determining organizational activities & productivity (Nelson & Winter 1982)

Change in org’l routines is functionally equivalent to genetic mutations in biological evolution

1. **Standard operating routines** governing existing org’l resource stocks
2. **Investment routines** responding to changing profits, growth
3. **Search routines** for innovative technologies (R&D)
Environmental Conditioning

Environmental conditioning approach identifies external constraints on possible forms & changes.

Technology is main driving force creating macro-economic growth (capital intensity, real wages).

Innovations create new niches for new org’l forms to enter & exploit.

- Technologies as evolving units explaining macro-growth patterns.
- Business firms as technology carriers--applied scientific ideas (patents).

Co-evolution of orgs/pops & environments thru mutual influence.

EX: SMO protest repertoires evolve to cope with state supression techniques.
PATH DEPENDENCE

Who will prevail in the Xbox vs. PS2 vs. GameCube competition to dominate computer gaming consoles?

Path dependence: earlier choices & random events constrain an org’s later options (history does matter)

- Once launched down a path, retracing or switching technology standards becomes increasingly difficult
- Dynamic increasing returns & cumulative techs reinforce movement along the initial path

Complementary technological interdependencies:

Software & applications (Apple vs MS)

But the locked-in technologies not always optimal: QWERTY; VHS/Betamax; MS-DOS
ORGANIZED INNOVATION

American myth of heroic lone inventors: Edison, Burbank, Ford

In 20th century, creation of new scientific knowledge & technologies grew increasingly systematized by organizations and governmental policies
THEORETICAL EXPLANATIONS

Org theories explain diverse innovation aspects, from learning processes to organizational survival rates

INNOVATION: Any departure from existing technologies or management practices; changes in routines

- Organizational innovations are major sources of variations for evolutionary selection & retention
- Institutional isomorphism across corporate R&D practices
- Resource dependence inhibits organizations from investing in innovation investigations that yield competitive advantages
- Org cultures may foster or inhibit innovative orientation (3M)
- Inter- & intraorg networks shape innovation dynamics and diffusion rates
National Innovation Systems

In US, “communism and cancer” (military needs since WWII and biomedical demands by 1970s) spurred emergence of an intricate national innovation system

“Hierarchical, multidimensional network of public and private institutions interacting non-linearly in a given historical context”

(Leoncini 1998:75).

R&D expenditures as key indicator of national capacities to solve complex sociotechnical problems

R&D = 2.9% of US and Japan GDP; 1.8% of European GDP

European Union's Sixth Framework Programme (2002-06) sets funding priorities for the EU, but 83% of public funds still decided by each nation

<http://europa.eu.int/comm/research/faq.html>
NSF Research Classification

NSF’s triadic classification tracks annual spending patterns:

**Basic research** on comprehensive knowledge without specific applications: subatomic particles, human genome, global climate change

**Applied research** to meet specific needs: improved battlefield communications, genetically modified crops

**Development** to apply knowledge “directed toward the production of useful materials, devices, systems, or methods,” including prototypes: demonstrate zero-pollution engine; universal verbal-language translation machine

**Decreasing US public sector R&D funding after fall of USSR; similar trends in other capitalist democracies**

US has 44% of world R&D, far ahead of Japan (1995); but other Group of Seven’s nondefense R&D is 118% of US spending
Fig. 10.1. R&D Expenditures

SOURCE: National Science Foundation
(1) increased reliance by US firms on sources of R&D outside their organizational boundaries, through such mechanisms as consortia, collaboration with US universities and federal laboratories, and strategic alliance with other US and foreign firms;

(2) expanded performance of R&D offshore by US firms and increased performance by non-US firms of industrial R&D within the United States [especially by Japanese firms];

(3) increased reliance by US universities on US and foreign industry for research funding and expanded efforts by US universities to license and otherwise realize commercial returns from the results of academic research.

TRIPLE HELIX

“Triple Helix” interdependent clusters of collaborative networks among universities, businesses, and local-regional governments in applied & development projects to transfer knowledge into commercial products & services


Institutionalized conflicts between:

A: university openness norms of peer-reviewed basic research grants & journal publication (payoff in disciplinary prestige)

B: business secrecy norms of patent-protection for commercial developments (payoff in startup firms’ IPO stock options)

Is this system transforming/deforming the universalistic principles of US universities?
INNOVATOR ORGANIZATIONS

Organizational and population learning processes imply continuum from the majority **reproducer organizations** to a minority of **innovator organizations**

Most orgs’ resource limits prevent R&D to create new knowledge and apps; rely on **exploitation** of existing technology to wring competitive advantages

**Innovator orgs** engage in **exploration** of new basic science and technology

(1) small startup entrepreneurs use investors’ capital to pursue high-risk, unproven technologies

(2) large deep-pocket corporations (3M, H-P) maintain units for routinized R&D

**EX New biotech firms & pharmaceuticals**
INCREMENTS vs BREAKTHROUGHS

Most innovation involves minor, incremental “competence enhancing” improvements that fit easily with existing organizational routines and capabilities, enhance their improve performance.

Rarer “competence destroying” breakthroughs by new entrants, threaten the status quo & force all orgs to radically restructure their skills and routines to survive.

EX: railway, airplane, computer, genetic modification.
INNOVATION JOURNEY

Uncovering details of innovation processes inside innovator orgs is crucial for understanding how they contribute to variation in org’s evolution dynamics.

Case studies of innovation within orgs by Minnesota Innovation Research Program refute a linear pathway (life cycle) from ideas to research to commercial products.

Innovation journey is chaotic process that increases organization’s learning capacity: “nonlinear cycle of divergent and convergent activities that may repeat over time and at different organizational levels if resources are obtained to renew the cycle.”

Three Innovation Journey Phases

Appearances are deceiving: Innovation journey’s three activity phases resemble a linear sequence

But actual organizational experiences alternate between:
• unpredictable discoveries made under divergent-chaotic conditions
• systematic testing under more stable-convergent conditions

THE INITIATION PHASE
1. Gestation in extended period lasting several years
2. Shocks from internal & external sources trigger concentrated efforts
3. Plans developed and submitted to controllers for resources to launch development
Three Innovation Journey Phases

THE DEVELOPMENTAL PHASE

4. Proliferation of numerous ideas and activities on divergent, parallel, convergent paths
5. Setbacks and mistakes cause resource and development time lines to diverge
6. Shifting success-failure criteria trigger power struggles between project managers and resource controllers
7. Innovation personnel participate in highly fluid, emotionally charged ways
8. Investors and top management frequently involved as checks-and-balances
9. Relationships with other organizations lock innovation units into specific action courses with unintended consequences
10. Involvement with competitors, trade associations, government agencies to create supportive infrastructure

THE IMPLEMENTATION/TERMINATION PHASE

11. Adoption of innovation by linking, integrating new and old or fitting innovation to local situation
12. Termination by implementing innovations or when resources run out