# The Complexity of Canadian Clusters Operating in Global Science

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# Introduction

- **Purpose: Explore a complexity theory (Kauffman) as a conceptual and formal framework**
  - **Understanding the different structures produced by different historical circumstances (path dependence) that all seem to produce successful agglomerations with strong growth potential**
- **Consequences of such complexity analysis have significant policy implications:**
  - **The popular concept of “best practices” is fraught with subtle traps when exploited simplistically**

# The Western Canadian Cases

- Wireless telecommunication
  - Calgary
- Wireless telecommunication
  - Vancouver
- Global Positioning Systems (GPS)
  - Calgary
- Canola biotechnology
  - Saskatoon

# Framing the problem

- **Herbert Simon's "bounded rationality"**
  - **In complex contexts, it is unrealistic to seek optimal solutions.**
  - **Limited time, resources, information because of**
    - **Uncertainty (known variables)**
    - **Ambiguity (unknown variables)**
  - **Best available goal is a satisfactory solution**
    - **"*Satisficing*" rather than optimizing**

# Objectives

- **Identify the structural constraints in a satisficing search for success in a regional industrial system**
  - **How do structural constraints make desirable outcomes differ significantly?**
- **Counter to popular public policy belief, “best practices” are fraught with subtle traps when exploited simplistically**
  - **Perhaps this is a confounding factor in the implementation of best practice?**
  - **Failure to appreciate path dependence?**
  - **Differences matter (Nelson and Winter, RBV, etc)**

# A Formal Model

**N,K theory (Kauffman,1993, “The origins of order”, Rivkin, 2000, “Imitation of complex strategies”)**

| | N=1<br>N=1 | N=2<br>N=2 | N=3<br>N =3 |
|---|---|---|---|
| W1 | X | | |
| W2 | | X | |
| W3 | | | X |

# Complexity…

## K not zero

| | N1 | N2 | N3 |
|---|---|---|---|
| W1 | X | x | x |
| W2 | x | X | x |
| W3 | x | x | X |

# Partial decomposition…

| | N1 | N2 | N3 | N4 | N5 | N6 | N7 | N8 | N9 |
|---|---|---|---|---|---|---|---|---|---|
| W1 | X | X | X | | | | | | X |
| W2 | X | X | X | | | | | | |
| W3 | | X | X | | | | | | |
| W4 | | | | X | | X | | X | |
| W5 | | | | X | X | X | | | |
| W6 | | X | | X | X | X | | | |
| W7 | | | | | | | X | X | |
| W8 | | | | | | | | X | |
| W9 | | | | X | | | X | | X |

# Preliminary Findings:
# *Groups of features (modules)*

- Initiating stimuli
- Recruiting practices
- Quality of life
- Costs and tax
- Educational and training
- Networking features
- Research institutions
- etc

| | **Frenken (2001)** | **Rivkin (2000)** | **Langford et al (2003)** |
|---|---|---|---|
| **Approach** | Empirical case studies (PCs, aerospace, motorcycles) | Formal modeling | Application of formal model to clusters (wireless, GPS, biotech) |
| **Decision-making** | Centralized | Centralized | Decentralized |
| **Constraints** | - Imperfect info.<br>- Complexity<br>- Path dependent | - Imperfect info.<br>- Complexity<br>- Path dependent | - Imperfect info.<br>- Complexity (more stakeholders)<br>- Path dependent<br>- Greater stochastic influences |
| **Problem focus** | Technical/ Engineering | Strategic: Managing scarce resources, uncertainty | Policy: Economic and social development/ improvement |

| | **Frenken (2001)** | **Rivkin (2000)** | **Langford et al (2003)** |
|---|---|---|---|
| **Species** | Product range (e.g. Boeing 777, Airbus) | Industry | Innovation system (e.g. int. science-base, industry players, infrastructure, institutions, etc) |
| **Organism (Unit of analysis)** | Product (e.g. aircraft) | Firm | Cluster (e.g. Calgary wireless firms, local knowledge support and infrastructure) |
| **Genes (features)** | Selected component (e.g. wing) | Selected strategy | Selected policies (e.g. initiating stimuli; recruiting practices) |
| **Alleles (options)** | Component variations (e.g. swept versus straight) | Strategic options | Policy variations and options (e.g. gov.'t action, local demand, investment characteristics; local grads, experienced externals) |

# Barriers to imitation

- Incremental
  - **K = N-1, the “elevations” of adjacent strategies are fully uncorrelated. Of $2^N$ possible strategies - $2^N/(N+1)$ local peaks**
  - **N = 20 system can have 50,000 local peaks**
  - **N = 12 and K = 3, 100 firms find approximately 20 local maxima.**
  - **As K increases, the height of local optima fall toward the mean fitness of the space**

# Barriers to imitation 2

- **Follow the leader**
  - If a leap is to be a success, it must land in the “basin of attraction” lying below the benchmark peak and accessible by tweaking – improbable.
  - The problem of landing in the basin of attraction would not be so serious if peaks tended to cluster on the fitness landscape,
  - BUT…

# Implications

- Epistatic relationships must always be kept in mind.
- From both theoretical and policy perspectives, cluster analysis cannot simply create list of choices (‘alleles’)
  - Path dependence; unique interactions
  - “Best practice lists” are fraught with dangers from both analytic and policy perspectives
- The most readily transferable practices are embedded and relatively isolated in an identifiable subsystem
- Policy recommendations come down to no more than general guidelines articulated for managing complex adaptive systems