Using System Dynamics to Understand Disruption:
A General Model for Technology and Industry Disruption

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Steps in the System Dynamics Modeling Process

- Problem Articulation
  - What is the problem?
  - Key Variables
  - Time Horizon

- Formulating Dynamic Hypotheses

- Formulation of a Simulation Model
  - Causal Loops, Stocks and Flows
  - Estimation

- Testing and Validation
  - Consistency with the purpose and boundaries
  - Comparison with Expected Behavior
  - Robustness of the Model
  - Sensitivities and other tests

- Policy Evaluations
Problem/Research Question

How can we improve decision making amidst technology and industry disruption?
Model Formulation, Testing, and Validation
Innovation and competition emerge from the interaction of five gears…

Telecommunications System
Emergent (system-level) behavior

Subsystems
Subsystem-level behavior

Model formulations rest upon:
1. Theories of adoption, tech strategy, and innovation
2. Unstructured interviews with stakeholders
Example: Model based on Theory

Christensen’s Conditions for Disruptive Technology (Christensen 1997)

<table>
<thead>
<tr>
<th>Firm</th>
<th>Price</th>
<th>Primary Performance (Quality)</th>
<th>Ancillary Performance (Innovation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incumbent (e.g. AT&amp;T)</td>
<td>High</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Entrant (e.g. Skype)</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
</tr>
</tbody>
</table>

Assumptions:
- 2 Firms – Incumbent, Entrant
- Each firm represents a typical firm in their industry
Example: Model based on Unstructured Interviews

Assumption:
• Features of each service are separable into (identifiable as) primary performance (quality) and ancillary performance (innovation)

\[
\frac{dI_i}{dt} = I_i^g - I_i^l
\]

Where, \(I_i^g\) = Innovation gain, and \(I_i^l\) = Innovation loss.

\[
I_i^g = R_i \left( \frac{I_i^{\text{max}} - I_i}{I_i^{\text{max}}} \right), \quad (I_i^{\text{max}} > I_i)
\]

\[
I_i^l = \left( \frac{I_i - I_i^{\text{max}}}{I_i^{\text{max}}} \right), \quad (I_i > I_i^{\text{max}})
\]

\[
I_i^g = I_i^l = 0, \quad (I_i = I_i^{\text{max}})
\]
Example: Model based on Unstructured Interviews (Contd.)
(making Firm’s Strategy endogenous)

Assumption:
Both firms endowed with equal total attention (resources)

“\textit{The only strategy was that of a monopolist. Incumbent A did not care what other features you want!}” Director, CTO Organization, Incumbent A
Example: Model based on Unstructured Interviews (Contd.) (making Firm’s Strategy endogenous)

Assumption: Both firms endowed with equal total attention (resources)

"Incumbent cares about ancillary performance only with: the entry of the non-traditional competitor, and the growth of its market share."
Director, CTO Organization, Incumbent A
Example: Model based on Unstructured Interviews (Contd.)

"First [when the entrant enters] the question is whether this is a price game or a performance game. Then, you realize that the future is ancillary."

Chief Strategist and Architect, Incumbent B
Model Testing and Analysis

Model Verification, Validation

1. Calibration with real-world trends
2. Expert Opinion: Regulators (FCC, MIAC-Japan), Industry Architects and Strategy Experts (Motorola, BT, Nokia, Cisco, Comcast, Verizon), Academics (Primary Sources)

Testing

1. Sensitivity of each exogenous parameter (including those that were made endogenous later)
2. Analysis of a unit model to understand structural forces and incentives
3. Analysis of calibrated model to understand timing and magnitude of the forces
4. Industry Structure Scenarios
   - Integrated Incumbent Remains Dominant
   - Niche Entrant, modular in technology and industry structure, displaces the Incumbent
   - Erstwhile Entrant (new Incumbent in the modular structure) remains dominant with a new modular entrant present
Model Validation

Through calibration with data, agreement with shared mental models of stakeholders, and expert opinion

PSTN Calibration

% Households

PSTN Penetration: Model

PSTN Penetration: Data

Source: FCC NECA & USAC Data (2008)
Results
Base Case Behavior
Passive Base Case - Incumbent does not respond to threat
Active Base Case - Incumbent responds to threat
Market Uncertainty: Network Effect Phase Plot

Strength of Network Effect
Sensitivity of Attractiveness to Compatibility ($\epsilon_n$)

Max. Market Share (Entrant)

No Network Effect (Services Interoperate)

Winner Takes All (WTA) outcome less probable

Winner Takes All (WTA) outcome more probable

Network Effect Helps Entrants

Network Effect Helps Incumbents

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Market Uncertainty: Switching Cost Phase Plot

- Time of Disruption (Years)
- % of Incumbent's Consumers Considering Switching Relative to % of Entrant's Consumers

$\gamma_1 < \gamma_2$

$\gamma_1 > \gamma_2$

Time at which Entrant's Market Share Crosses Incumbent's Market Share
Market Uncertainty: Consumer Choice Phase Plot

- Consumers Do Not Value the Attribute
- Consumers Value the Attribute as much as Other Attributes
- Consumers Value the Attribute Twice as much as the Other Attributes
- Consumers Value the Attribute Thrice As much as the Other Attributes

Sensitivity of Attractiveness of Attribute under Consideration

Sensitivity of Attractiveness of Any Other Attribute

Max. Market Share (Entrant)
### Limits to Technology and Industry Disruption

<table>
<thead>
<tr>
<th>Technology Disruption</th>
<th>Industry Disruption</th>
<th>No Industry Disruption</th>
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<tbody>
<tr>
<td></td>
<td>• Weak Network Effect</td>
<td>• Incumbents can affect switching behavior heavily</td>
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<tr>
<td></td>
<td>• Consumer highly price sensitive</td>
<td>• Incumbents innovate while maintaining quality</td>
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<tr>
<td></td>
<td>and willing to risk adopting</td>
<td>• Entrants struggle to offer quality due to lack of</td>
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<tr>
<td></td>
<td>innovative service with low quality</td>
<td>functional control or market power</td>
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<tr>
<td></td>
<td>and compatibility</td>
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</tr>
<tr>
<td></td>
<td><strong>Quadrant Not Studied</strong></td>
<td><strong>Strong Network Effect</strong></td>
</tr>
<tr>
<td></td>
<td>• General double helix dynamics</td>
<td>• Consumer value quality and compatibility over</td>
</tr>
<tr>
<td></td>
<td>without technology disruption</td>
<td>innovation and low price</td>
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<td></td>
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<tr>
<td>No Technology Disruption</td>
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THANK YOU