15.871 Recitation #4

Modeling Product Adoption & Diffusion

Fall 2013
Agenda

• Adoption/Diffusion Models
  – Modified Bass Diffusion Model (starting Vensim model)

• Delays
  – Response of a Delay (Ch 11.1-11.2, more in H2)

• Stock Management
  – Beer Game Stock Management Example

• Learning Curve (Ch 10, BD pg 337-8)

• Partial Model Tests

• Robustness under Extreme Conditions
Historical Data: Upload vdf

VCR Sales, US
Modified Bass Diffusion Model

- **Price**
  - Switch for Exogenous Price
  - Exogenous Price for Testing
- **Fraction Willing to Adopt**
- **Population Willing to Adopt M**
  - Reference Price
  - Initial Population N0
  - Net Population Increase
- **Total Population N**
  - Adoption from Advertising AA
    - Advertising Effectiveness a
    - Social Contacts SC
    - Contact Rate c
  - Market Saturation
  - Word of Mouth
  - Adoption from Word of Mouth AW
  - Probability of Contact with Adopters PCA
- **Initial Adopters A0**
  - Adoption Rate AR
Total Population, \( N \)

\[
\begin{align*}
\text{Population Not Willing to Adopt, } N - PWA & = PNWA \\
\text{Potential Adopters } P & \\
\text{Adopters } A & \\
\text{Population Willing to Adopt } & = PWA
\end{align*}
\]

\[
N = \text{INTEGRAL(Net Population Increase, } N_0)\\
\text{Adopters} = \text{INTEGRAL(Adoption Rate, Initial Adopters)}\\
\text{Potential Adopters} = \text{MAX}(0, \text{Population Willing to Adopt } - \text{Adopters})
\]
PART A INTERACTIVE : BEER GAME STOCK MANAGEMENT EXAMPLE

Draw the causal loop diagram (CLD) and write the equation for the “order rate” according to assumptions that will be presented.

Please note that your CLD and equation for the “order rate” should be “dimensionally consistent”.

\[ \text{order rate} = ? \]
PART A INTERACTIVE: MAPPING OF A SIMPLE STOCK-MANAGEMENT STRUCTURE

Draw the causal loop diagram (CLD) and write the equation for the “orders” according to the assumptions below. Please note that your CLD and equation for the “orders” should be “dimensionally consistent”.

ASSUMPTIONS:

• No delays in deliveries
• No returns
• Shipments are exogenous
• Firm adjusts orders to bring inventory in line with “desired inventory”
• Seeks to close any inventory gaps over a 2-week period.

• HINT: What should go into the “orders” variable?
Response of a Delay

Product Retirement = DELAY N(Purchase Rate, Useful Life of Product, 0, 6)
PART B INTERACTIVE : PULSE RESPONSE OF A DELAY

Please sketch your best estimate of “retirements” after a pulse of purchases:

How does the Retirements flow look like?

<table>
<thead>
<tr>
<th>Purchase Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Units/Year</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
</tbody>
</table>

10/4/2013
Basic Learning Curve Formulation

\[ c_t = f(E_t) \]
\[ c_t = c_0 \left( \frac{E_t}{E_0} \right)^\lambda \]
\[ (1 - f)c_0 = c_0 \left( \frac{2E_0}{E_0} \right)^\lambda \]

or
\[ \lambda = \ln(1 - f) / \ln(2) = \log_2 (1 - f) \]

- \( c_0, E_0 = \) initial unit costs and cumulative experience
- \( E_t = \int_0^t e_s ds \)
- \( \lambda = \) learning curve strength
- Example: For a learning curve with \( f=0.3, \lambda=0.5146 \)
- \( f=0.3 \) implies a 30\% cost reduction for every doubling of cumulative experience (\( \lambda \approx 0.51 \))
15.871 Introduction to System Dynamics
Fall 2013

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