



Vensim® Software

Linking systems thinking to powerful dynamic models

Introduction to System Dynamics using Vensim

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Agenda

- **Logistics**
 - File contents
 - Installing Vensim
- **Introduction**
- **A question – balance of SD vs. Vensim?**
- **Interface tour**
- **Building & running simple models**

Setup

- **Get one of the USB drives, containing**
 - Vensim installers – [Mac, Win] x [PLE, DSS, Reader]
 - 1 – Intro
 - 2 – Calibration
- **If you don't already have Vensim DSS or Pro, install a copy**
 - Use the evaluation license key in the text file if you don't have a license
 - You'll want the latest (6.3) for MCMC and payoff features – you can install to a separate folder if you want to keep your existing version
- **Copy the model folders to an easy-to-find location on your local hard drive**

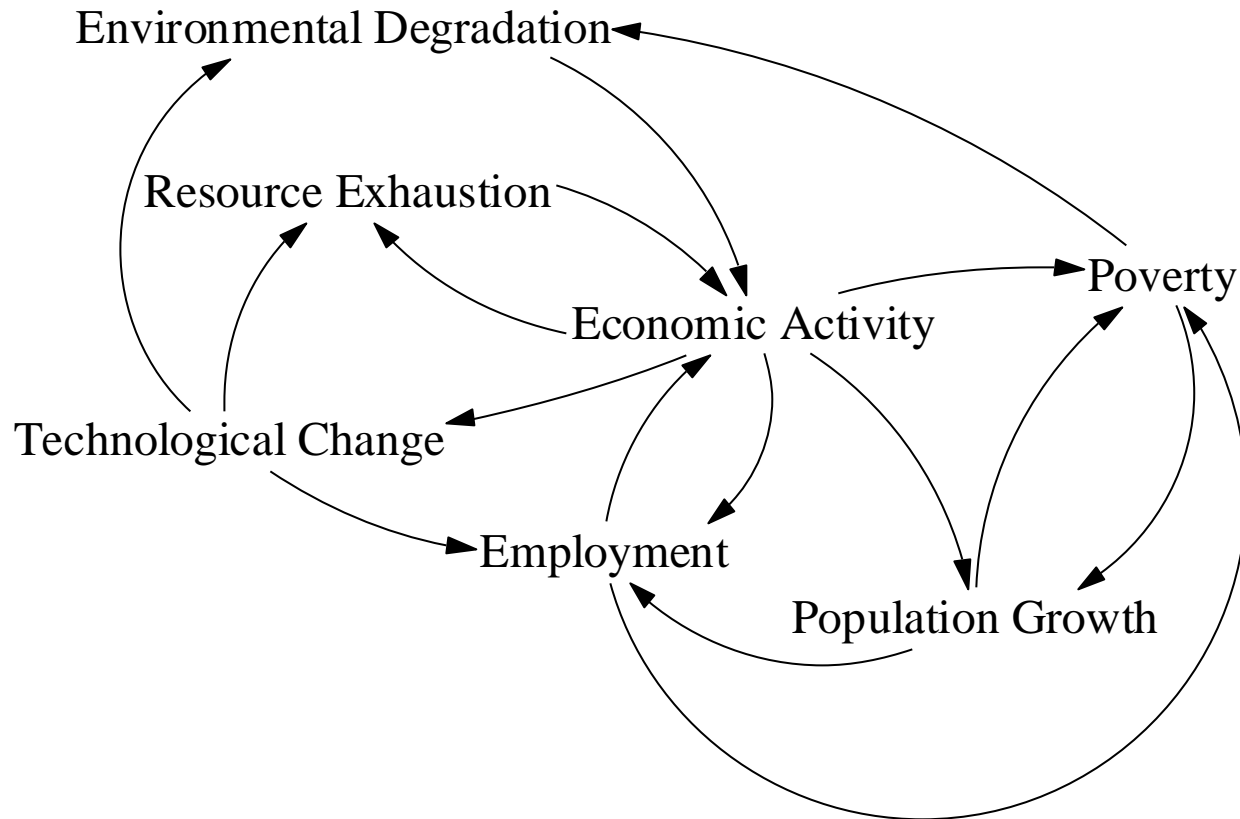
Road Map

| Vensim Mechanics | System Dynamics | Modeling Process |
|--------------------|---------------------------|------------------------|
| Diagramming | Stocks & flows | Choosing a method |
| Equations | Feedback loops | Conceptualization |
| Units | Behavior modes | Debugging |
| Runs | Nonlinearity | Model testing |
| Managing constants | Representing behavior | Validation |
| Data I/O | Equilibrium | Learning from surprise |
| Interfaces | Archetypes | Presenting |
| Synthesim® | Molecules | Change management |
| Lookups | Policy resistance | |
| Causal tracing | Events-Behavior-Structure | |

Motivation - Life is Complicated

- **Global**
 - Climate change
 - Terrorism
 - Nuclear proliferation
- **National**
 - Campaign finance
 - Social security
 - Education
- **Business**
 - Economic crisis
 - IT revolutions
- **Personal**
 - Retirement savings
 - Addiction
 - Love

Problems are coupled

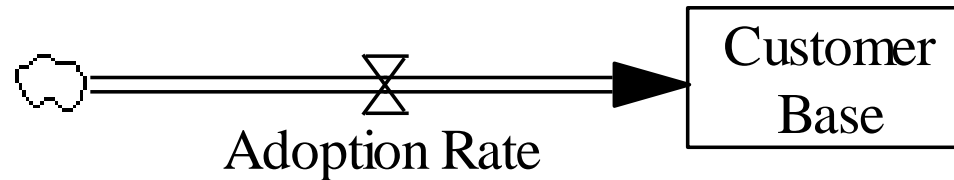


Structures & Their Possible Behaviors (continuous time)

System Order (# of independent Levels)

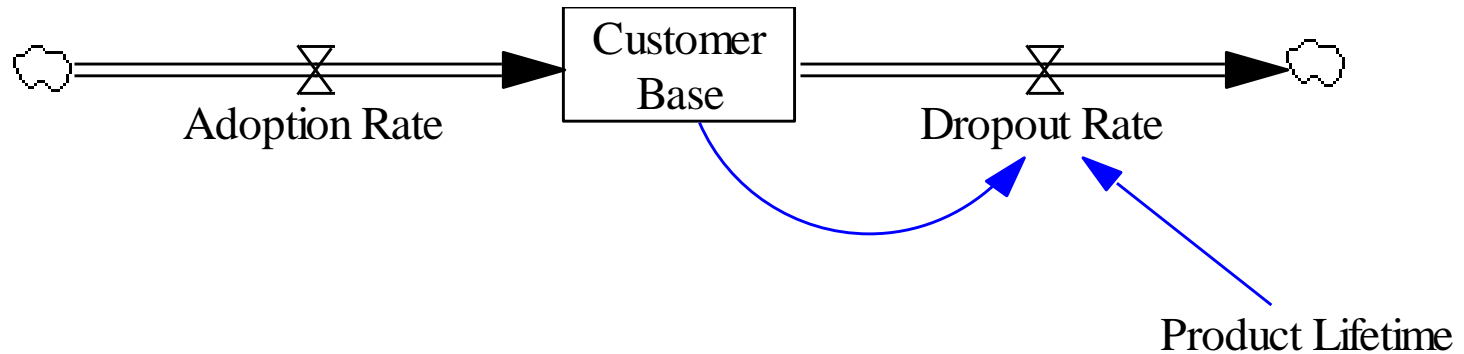
| | 1 | 2 | 3+ |
|---------------------------------|---|--|-------------------------|
| Linear | Accumulation, Growth, Decay, Equilibrium | ◀ Same, plus Oscillation | ◀ Same |
| Nonlinear (typical examples) | ▲ Same, plus S-shaped (logistic) growth | ◀ ▲ Same, plus Overshoot & Collapse, Limit Cycles | ◀ ▲ Same, plus Chaos |

Model 0



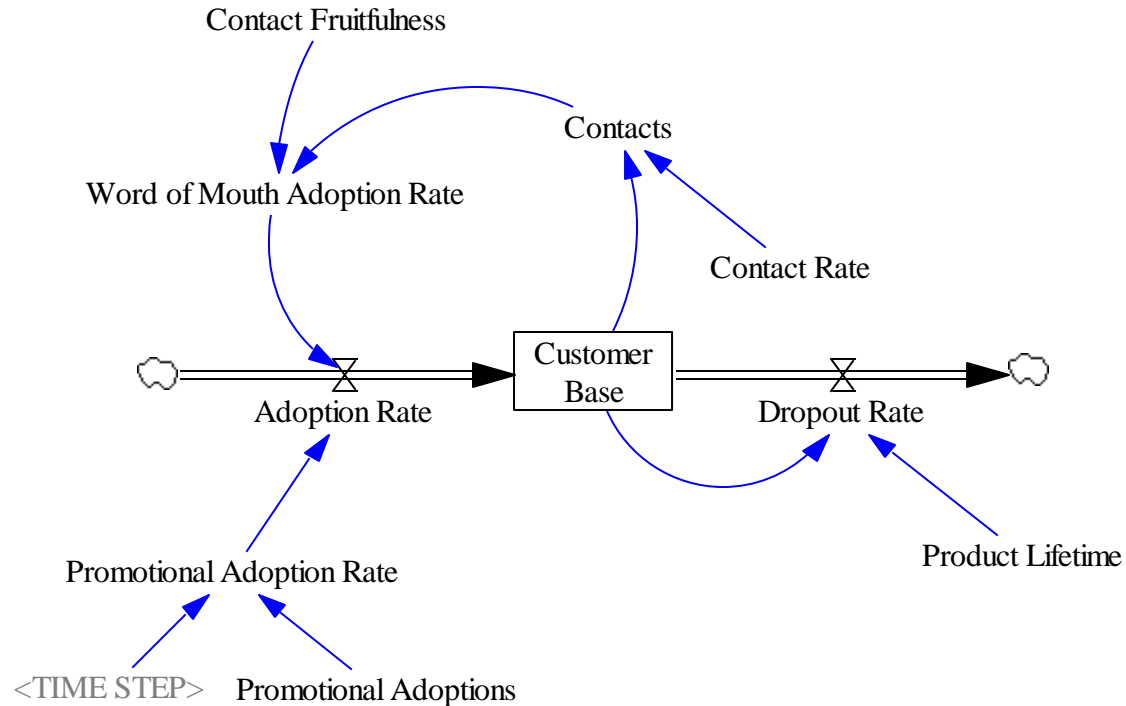
- **Pure accumulation**
- **Diagramming**
- **Writing equations**
- **Units**
- **STEP test input**
- **Ordinary simulation**
- **Seeing output**

Model A



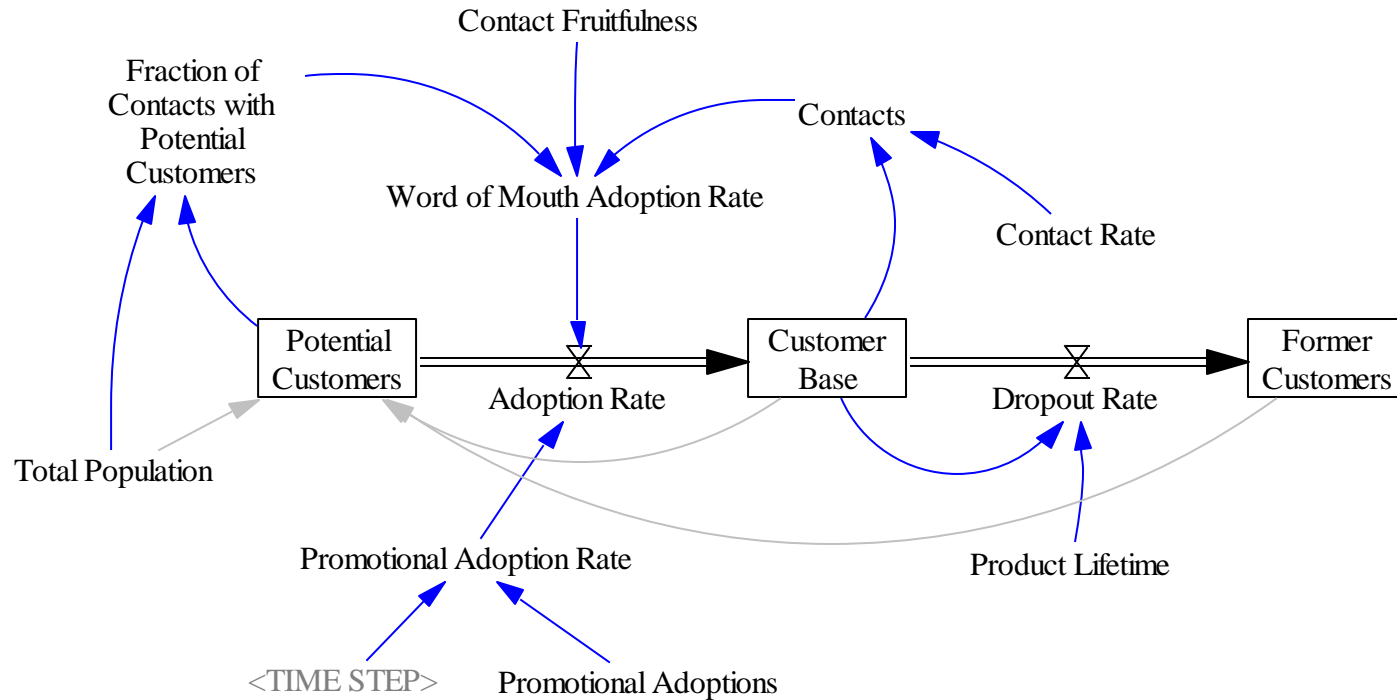
- **Outflow & feedback**
- **Running in Synthesim**
- **Naming runs**
- **Managing datasets**

Model B



- **Growth loop**
- **A discrete event**
- **Causal Tracing**

Model C



- Custom graphs
- A mini control panel

Time & Interest Permitting ...

- **Lookups**
- **Data I/O**
- **Managing constant changes**
- **Q&A**



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Rules of Thumb

Negative feedback (goal seeking, exponential decay)

- **Decay**
 - $\text{Stock} = \text{INTEG}(-\text{Outflow})$
 - $\text{Outflow} = \text{Stock} * \text{Decay Rate}$
- **Smoothing**
 - $\text{Stock} = \text{INTEG}(\text{Change})$
 - $\text{Change} = (\text{Goal} - \text{Stock}) / \text{Time Constant}$
- **Time constant = 1/decay rate**
- **Half life = 0.7 * time constant (because $\text{Log}(2) \sim 0.7$)**
- **$\sim 2/3$ of adjustment at 1 time constant**
- **$\sim 95\%$ at 3 time constants**

- **Example: my perception of the price of gasoline adjusts 20% of the way toward reality per day. After a step change in prices, my expectations have adjusted 95% of the way to reality after $3 * (1/.2) = 15$ days or about two weeks.**

Positive feedback (exponential growth)

- **Stock = INTEG(Inflow); Inflow = Stock*Growth Rate**
- **Time constant = $1/\text{growth rate}$**
- **Doubling time = $(70\%)/(\% \text{ growth rate})$**
- **Example: a city's population grows at 5% per year. It will double in $70/5 = 14$ years, and quadruple in 28 years.**

Initializing in Equilibrium

- **Definition of equilibrium: stocks aren't changing;**
 $\Sigma(\text{flows}) = 0$
- **Little's Law:**
(average value of a stock)
= (average inflow) * (average residence time)
- **Typical strategy:**
 - Initial stock = Initial inflow * residence time, where
residence time = mean time constant of outflows, which is a
harmonic mean, e.g., $\tau_{mean} = 1 / \left(\frac{1}{\tau_1} + \frac{1}{\tau_2} \right)$



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Resources

Vensim Resources

- **The Vensim forum:**
 - <http://www.ventanasystems.co.uk/forum/viewforum.php?f=2>
- **The SD society & forum:**
 - <http://www.systemdynamics.org>
 - <http://www.systemdynamics.org/forum/>
- **My model library:**
 - <http://models.metasd.com>
- **Books**
 - Business Dynamics (Sterman)
 - Strategy Dynamics (Warren)
 - Modeling the Environment (Ford)
 - Industrial Dynamics (Forrester – the classic)