

Teaching Systems Thinking with Spreadsheets

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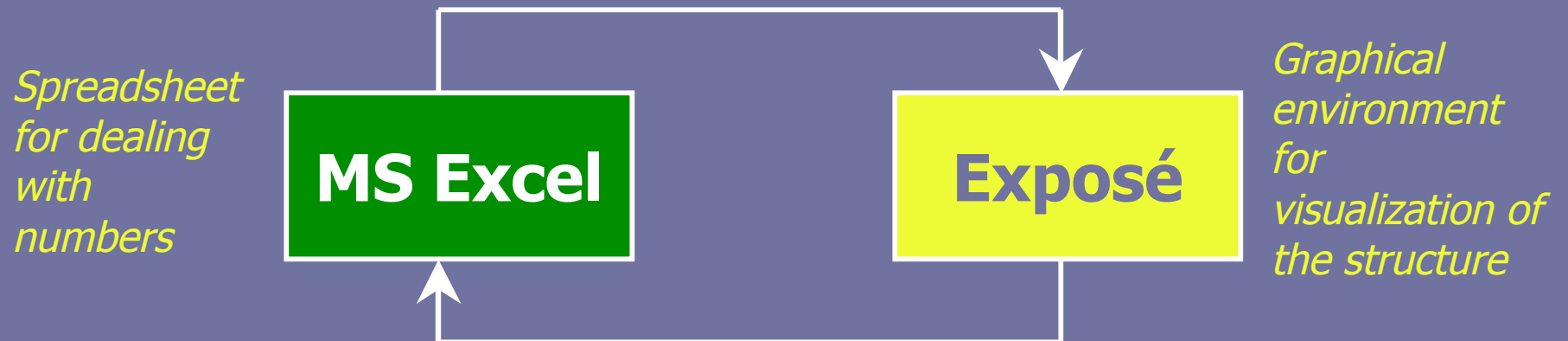
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Outline for this talk:

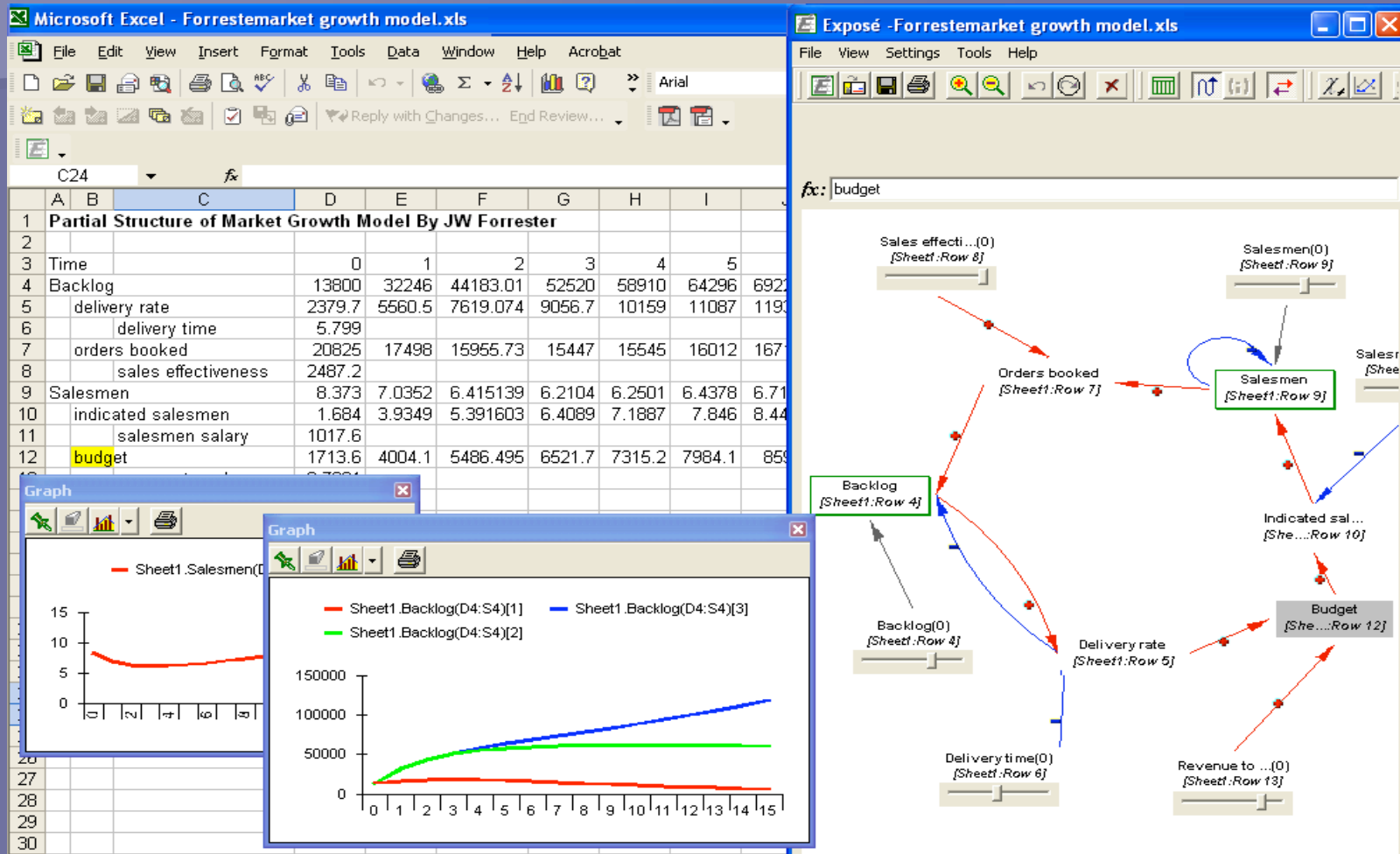
- Introducing Exposé
- The rule of three
- The structural component
- What does Exposé offer

Introducing Exposé

- Exposé is an add-in to Microsoft Excel that brings systems thinking capabilities to the spreadsheet.



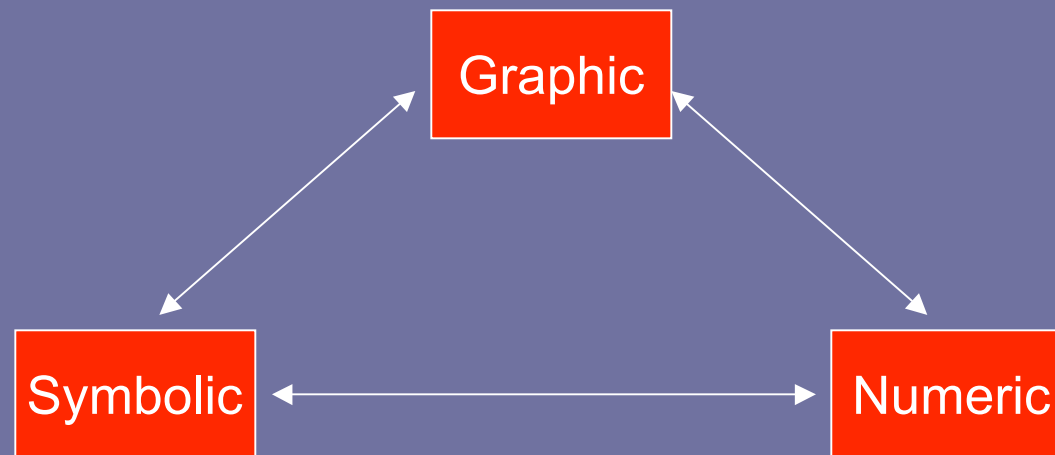
Introducing Exposé



Framework

- **The Rule of Three:**

Every topic should be presented geometrically, numerically, and algebraically



(Hughes-Hallett, Gleason, et al, Harvard Calculus Consortium, [Calculus](#))

Framework

- New emphasis from the calculus reform movement
- Attempt to balance students' abilities to use and interrelate information in numerical, graphical, and symbolic form with similar facility
- Facility with all pathways gives opportunity for fuller understanding of concept studied

Example: Lines

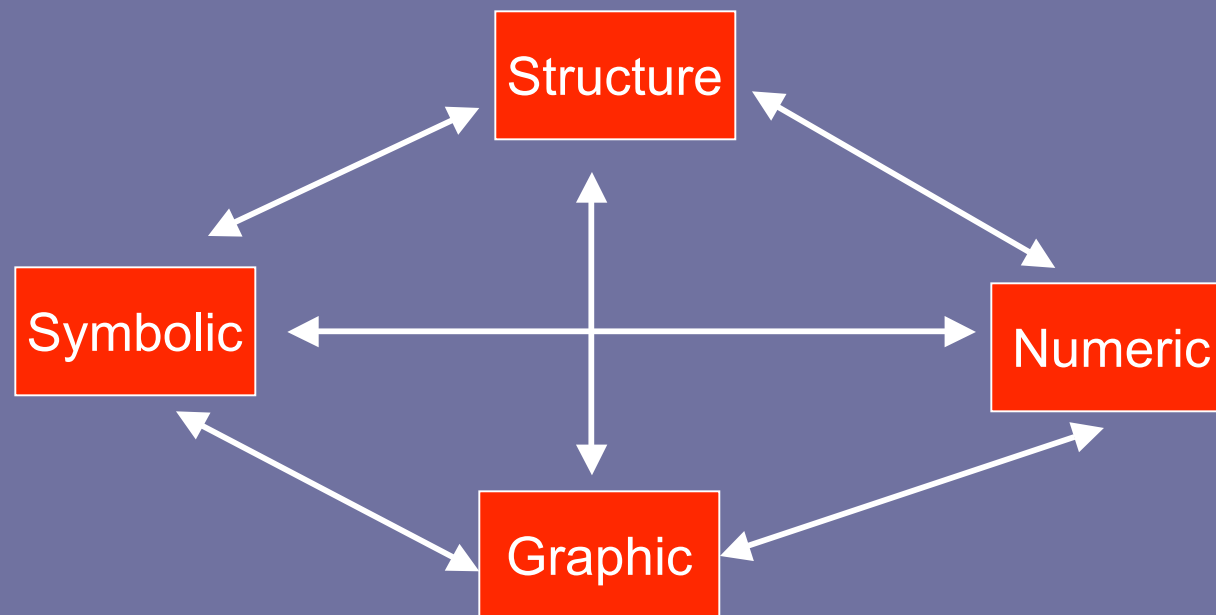
- symbolic \longrightarrow numeric
- Evaluate function for particular values of the variable.
- numeric \longrightarrow symbolic
- Calculate equation of a line from two points.
- graphic \longrightarrow numeric
- Identify coordinates on a graph.

Example: Lines

- numeric \rightarrow graphic
- Plot points to form a graph.
- symbolic \rightarrow graphic
- Graph line.
- graphic \rightarrow symbolic
- Determine equation from graph.

The Hypothesis

- In many cases, it would be useful to use systems thinking to extend the Rule of Three to the Rule of Four: present topics numerically, graphically, symbolically, and structurally.



Rule of Four

- Structure Matters

- Because it influences behavior (Graph)

Example: Saving Account

- Symbolic

$$S(t) = S(t-1) + D(t) - W(t-1)$$

S: Savings

D: Deposits

W: Withdrawals

T: Months

Example: Saving Account

- Numeric

	A	B	C	D
1	Month	Savings	Deposits	Withdrawals
2	1	10	5	3
3	2	12	5	3
4	3	14	5	3
5	4	16	5	3
6	5	18	5	7
7	6	16	5	7
8	7	14	5	7
9	8	12	5	7
10	9	10	5	7
11	10	8	5	7

Example: Saving Account

- Structure



Example: Saving Account

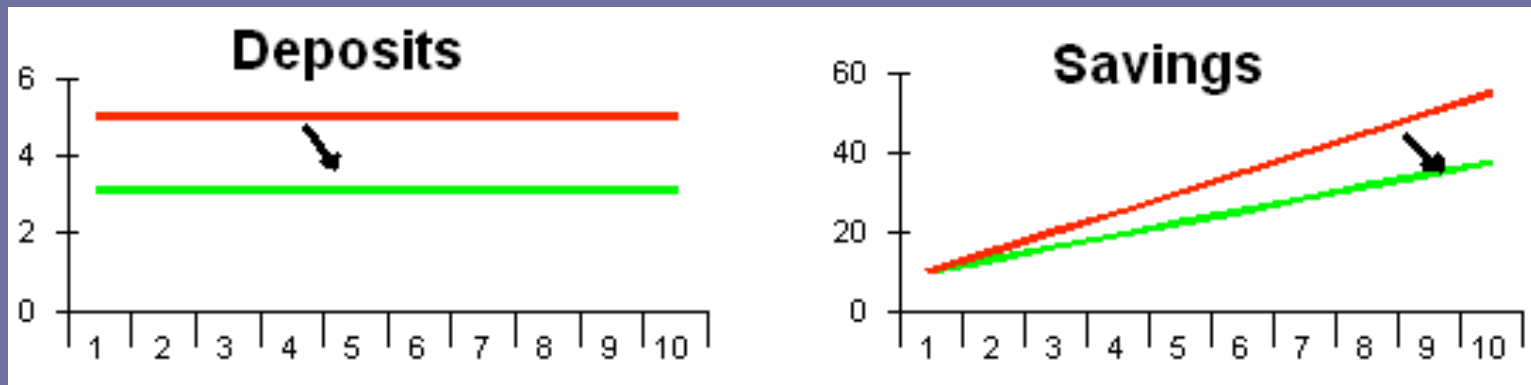
■ Graph



The structural component

can shed light on questions like:

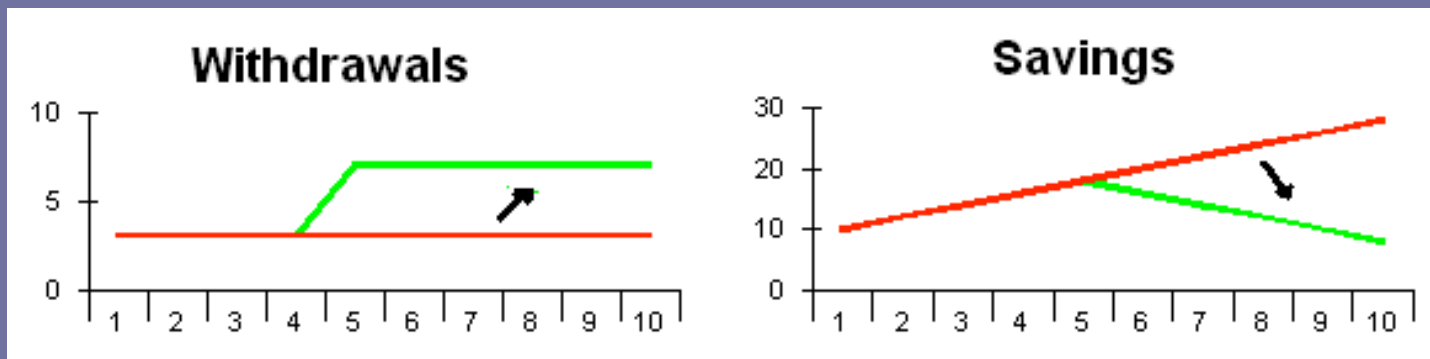
- What would happen to your saving account if your deposits decrease?



The structural component

can shed light on questions like:

- What would happen to your saving account if your withdrawals increases?



The structural component

- Offers an even more robust understanding of the concept as it gives students another way to visualize and understand lines

The Rule of Four

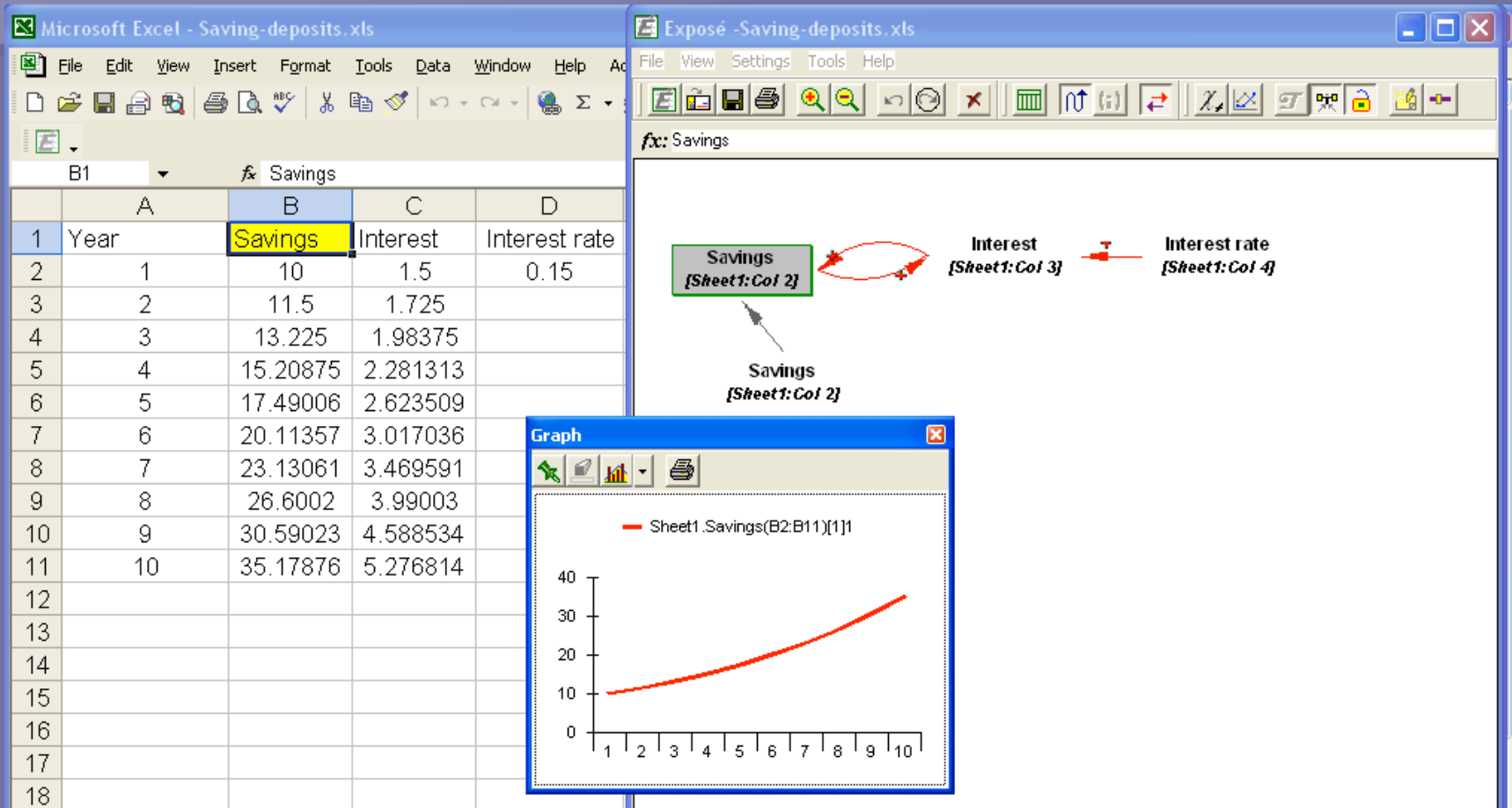
- Can extend this idea to other concepts, for example the study of exponential functions:

Example: Savings and interest

$$S(t) = S(t-1) + \text{Int}(t-1)$$

$$\text{Int}(t) = i * S(t)$$

Example: Savings and interest



What does Exposé offer?

- Tree diagrams of precedence
- Tree diagrams of causal drivers
- Feedback loops
- Intensifying stocks and dynamic variables
- Polarity of the links
- Sliders for sensitivity analysis

The Rule of Four

- Just as computer algebra systems (CAS), graphing calculators, and spreadsheets, have enhanced the richness of the bidirectional pathways of the Rule of Three, Exposé can help to bring the fourth component for better understanding.