Modeling is Dead: Long Live Modeling!

Regime change in model construction

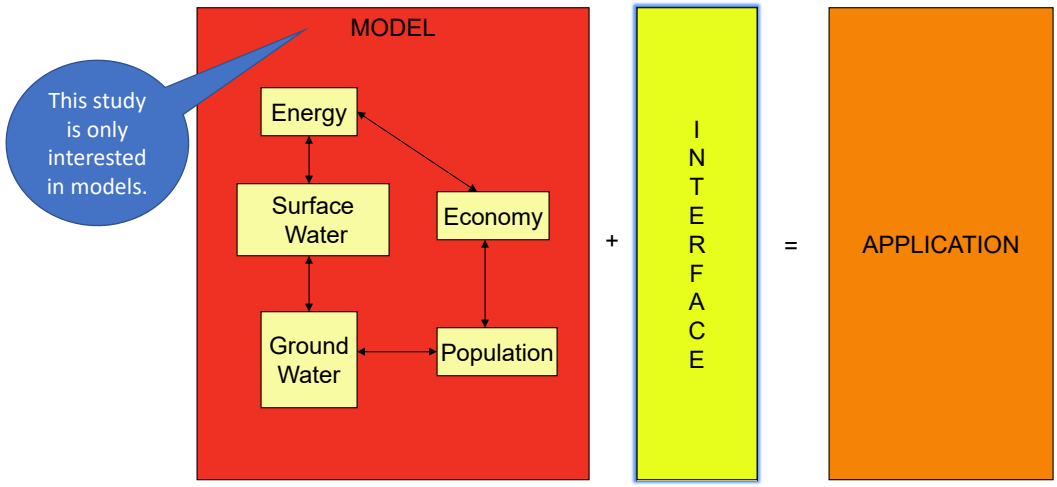
International Conference of the System Dynamics Society
Reykjavik, Iceland 2018

The Setting

- The System Dynamics Society provides access to models submitted as Supporting Material to their annual conference.
- These models are free to anyone*
- These models *may* represent the Society and the System Dynamics field.
  - Model quality (as defined by units, layout, naming, logic, interface, etc.) varies
  - Conclusions (about the methodology, field, and Society) may be drawn from model quality
  - Learning may be enabled or hampered by theses models

*In fact, system dynamics models are available on many public websites.

Terminology: Module, model, interface, application



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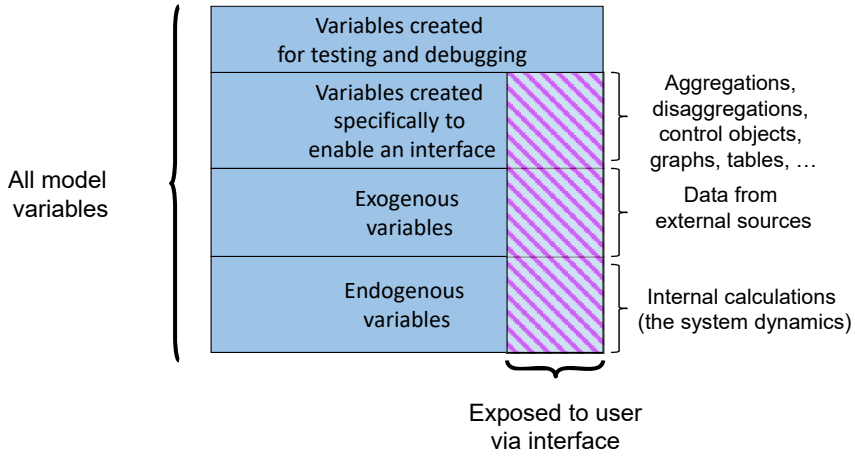
Typical system dynamics *application* variable classes



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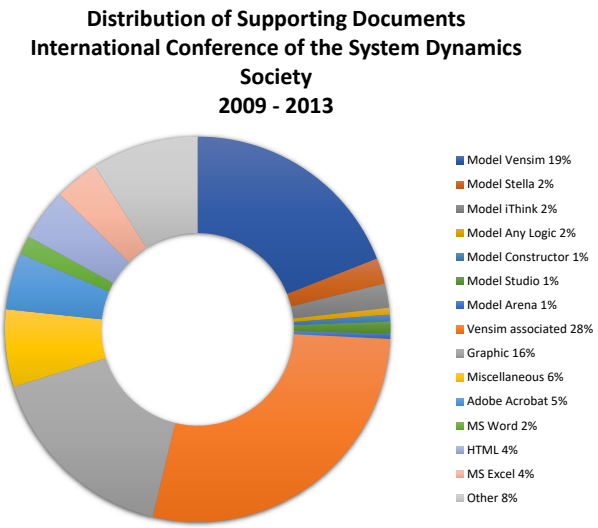


The Method

- The list of all papers from the International Conference of the System Dynamics Society years 2009-2017 were loaded into a file and parsed for the word 'Supporting'.
- The supporting files were downloaded and individually examined.
- Models using Vensim, and Studio were selected and examined using objective and subjective criteria.

The Evidence

- 329 models were downloaded (Vensim and Studio)
- 35 had a sufficient number of problems that they could not be simulated
- 294 were of sufficient quality to run.
- The number of models by year is 33, 13, 19, 40, 40, 40, 39, 29, 35 for 2009-2017 respectively.

Variables captured

- Variables / Module
- Variables / Unit error
- Unit errors / Variable
- (Levels + Constants) / Total variables
- Levels / Total variables

Results

- A cursory view of some of these models shows considerable poor quality in almost all (but not all) of them.
- A pessimistic conclusion might be that no model, other than very small models, models much smaller than the average number of variables in the models sampled (71.8 levels, 313.9 auxiliaries, 47.9 constants) can be examined for model construction quality in a tractable manner and period of time.
- As a model passes each stage of construction quality the time required to test it increases (Wakeland and Hoarfrost 2005). In the extreme, no model can be verified but confidence in a model can be raised.
- There is little, if any, indication in the model files of how the model was built, how long it took, who were the authors, how many persons participated, what was its purpose, etc.

Note: Wakeland and Hoarfrost performed no model construction quality tests.

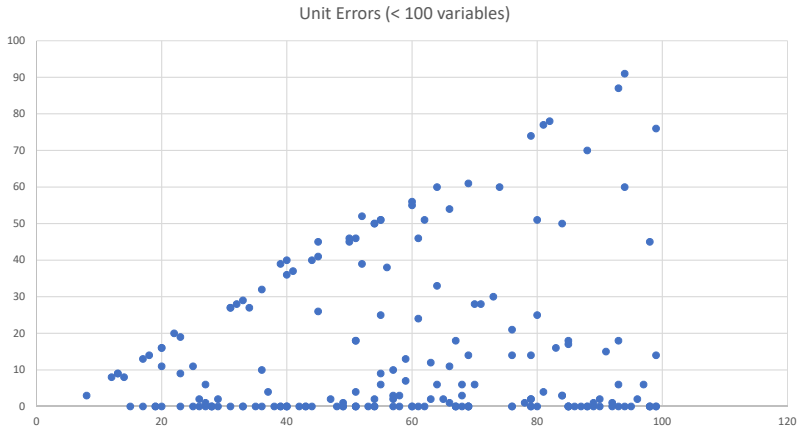
Data

Table 3 Descriptive statistics of all models 2009-2017

	Levels	Auxiliaries	Constants	Unit Errors	Modules
Maximum	5005	30006	972	201	54
Minimum	0	3	3	0	1
Average	71.8	313.9	47.9	17.1	3.3

Large numbers are a result of Vensim's way of counting variables.
Studio for example, considers a 'subscripted' variable to be one variable.

Data



Shall we go on?

***De gustibus non disputandem est* – About matters of taste there is no point in arguing.**

***De veritate disputandum est* – About matters of truth, dispute is fruitful.**

Are we discussing taste or truth?

What can we do?

- Adopt a personal modeling process
  - Develop worksheets
  - Develop checklists
  - Develop habits based on routine use of checklists
  - Model, model, model – practice makes perfect
  - Convert models from accessible languages (DYNAMO, Vensim) to your preferred language
  - Join a user group
- Develop and use standards

Objective criteria

Objective criteria	Description
Variable count	The total number of variables includes exogenous inputs, endogenous model calculations and variables for the interface.
Element count	This represents the number of model values. An arrayed-variable counts as one variable and as many elements as its dimension.
Element/Variable ratio	This ratio is in some sense a measure of model leverage. Variables represent dynamics, elements represent details.
Relative model size	Model size in variables divided by the average model size in variables. This is useful for groups that have an archive of models.
Ranges	A range is a variable's dimension, e.g. a range called 'States' would have 50 elements, one for each state.
Defined units count	Either atomic units or SI units..
Adequate units	A binary decision: all variables have units or not all variables have units.
Modularity	The model is logically divided into relatively self-contained sections if necessary.
Model	Decomposition of a large problem into modules is accomplished with tabs. The number of model tabs signals the degree of model decomposition and re-usability.
Interface	The number of interface elements or views.
Other	Other model decompositions

Objective criteria

Objective criteria	Description
Stocks	Stocks or levels are the model variables that accumulate material, information, persons, etc.
Auxiliaries/Flows	Auxiliaries are composed of rates (flow into stocks per unit of time) and variables used for any purpose other than stock or rate.
Constants	Constants signal the degree to which the model output is controlled by external variables and not by causal relationships in the model itself.
Data quality: constants have documentation	Are all constants documented?
Modeling conventions	These conventions were developed by modelers with input from many sources. If followed, they improve the understandability and reusability of the model.
Naming	Is a well-defined naming convention used?
Embedded constants	Are there auxiliaries with embedded and undefined constants?
Variable names well defined	Are the variables named using the naming convention?

Subjective criteria

Subjective criteria – applied as experience in modeling is gained
Organization score*
Sufficient documentation exists: to undertake improvement by original author(s)
Sufficient documentation exists: to reproduce results by non-authors
Percent of constants documented and documented sufficiently
*Subjective score with values Awful, Poor, Good, Very Good and Excellent

Problems with this research

- Samples versus population: is this the right 'geography'
  - Is the sample/population representative?
  - What about other software?
- Objective versus subjective measures of quality
  - Ease of measurement
  - Binary or scaled performance?
- No causality or correlation examined
  - Does experience matter?
  - Does institution matter?
  - Does the software matter?

Finally – close your eyes, please

- Think of a realistic goal for your models.
- Picture a future where you have achieved that goal.
- Picture the obstacles between you and that goal.

- Overcome them and don't stop until your are proud of your work!