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Building Confidence in Simulation Models using Automated Analyses

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Departement Wirtschaft

Introduction

- Model validation and documentation is a much discussed topic in SD
- Validation tests often lack details in their formulation and rely on the experience of the modeler (e.g. Sterman 2000, Forrester & Senge 1980)
- Modeling guidelines are often diverse (different variable types, different naming principles)
- Documentation is inconsistent (Rahmandad & Sterman 2012, Groesser & Tschupp 2012)

Introduction

- Model documentation has an excellent tool in SDM-Doc
- This has led to a standardization and improvement of model documentation
- PySD testing battery → Structure oriented behavior tests, not formulation

Objectives of the PySD testing battery

- Provide modelers with effective input for building model confidence
- Provide effective points of inquiry
- Test assumptions

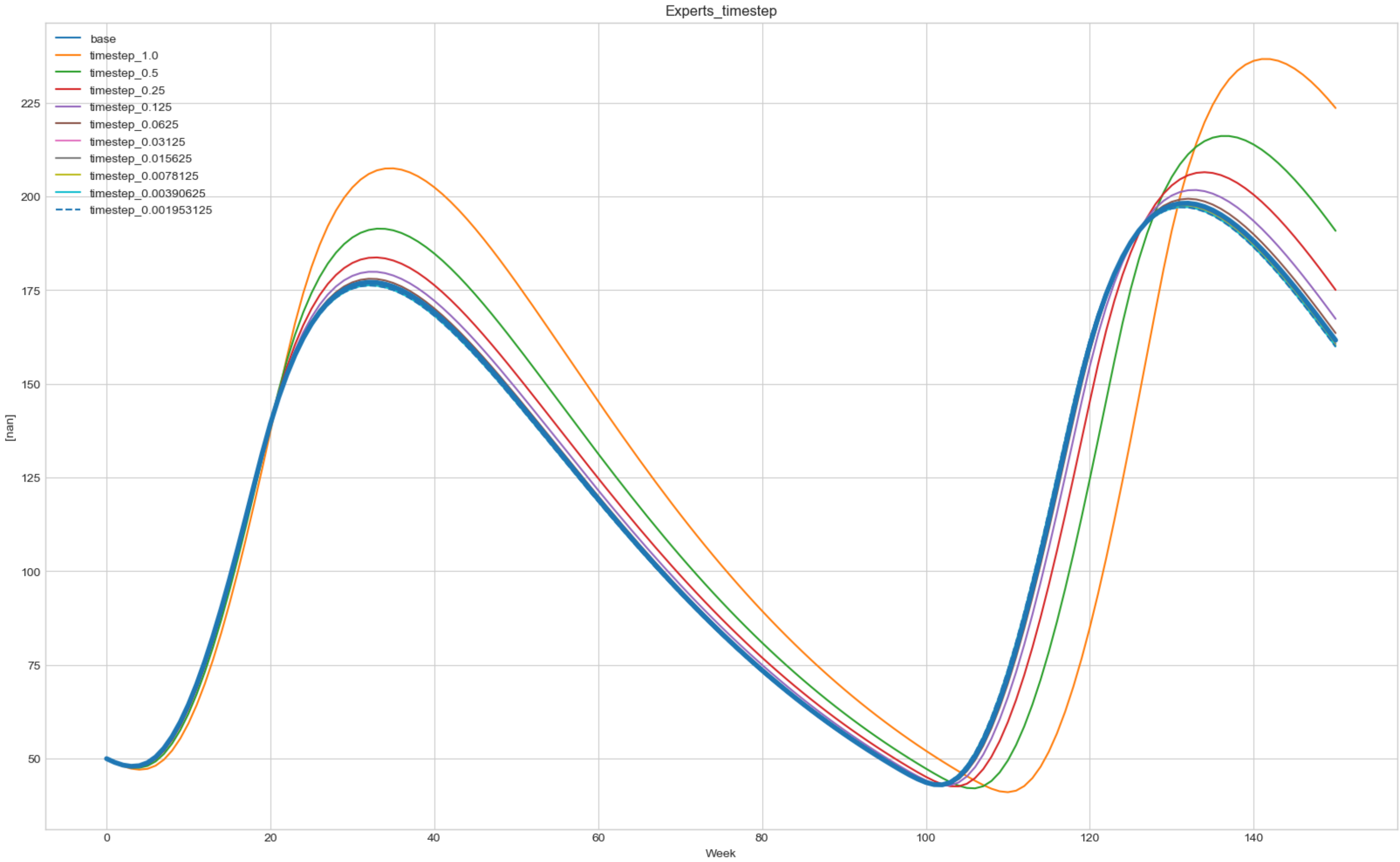
Time Step test

- *"Cut the time step in half and test for changes in behavior."*

- x_{ast}= value of stock s for timestep run with timestep a at timestep t
- x_{bst}= value of stock s for timestep run with timestep b = 2a at timestep t
- t = 1, …, m are integer values for each time step of the model runtime, with m being the final time step calculated as $m = \frac{\text{final time} - \text{initial time}}{\text{timestep}_b}$
- *s* = 1, …, *n* are integer values assigned to all stocks in the model, with *n* being the total number of stocks in the model
- $\frac{1}{m} * \sum_{s=1}^{m} \frac{1}{n} * \sum_{t=1}^{n} \left|\frac{x_{ast} - x_{bst}}{x_{bst}}\right| \leq 0.025$

- Iteratively test for timesteps from $\frac{1}{2^1}$ to $\frac{1}{2^9}$ until condition is met → b is optimal timestep

Time Step test (2)



Extreme Condition test

“Subject model to large shocks and extreme conditions.”

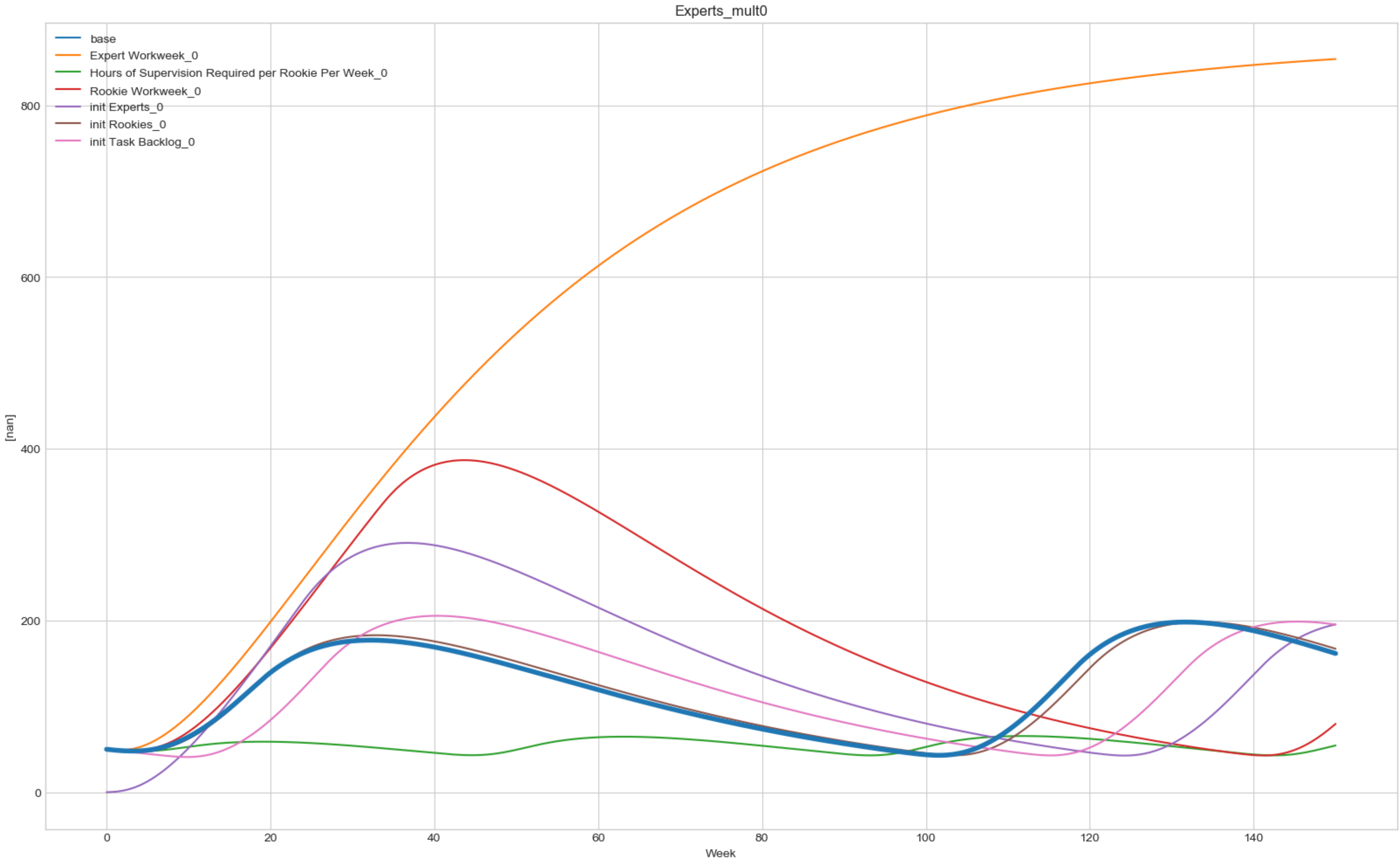
Exogenous variable name	Lower Bound Extreme value	Base Value	Upper Bound Extreme value
Variable a	0*x	x	10*x
Variable b	0*y	y	10*y
…	…	…	…

Extreme Condition test (2)

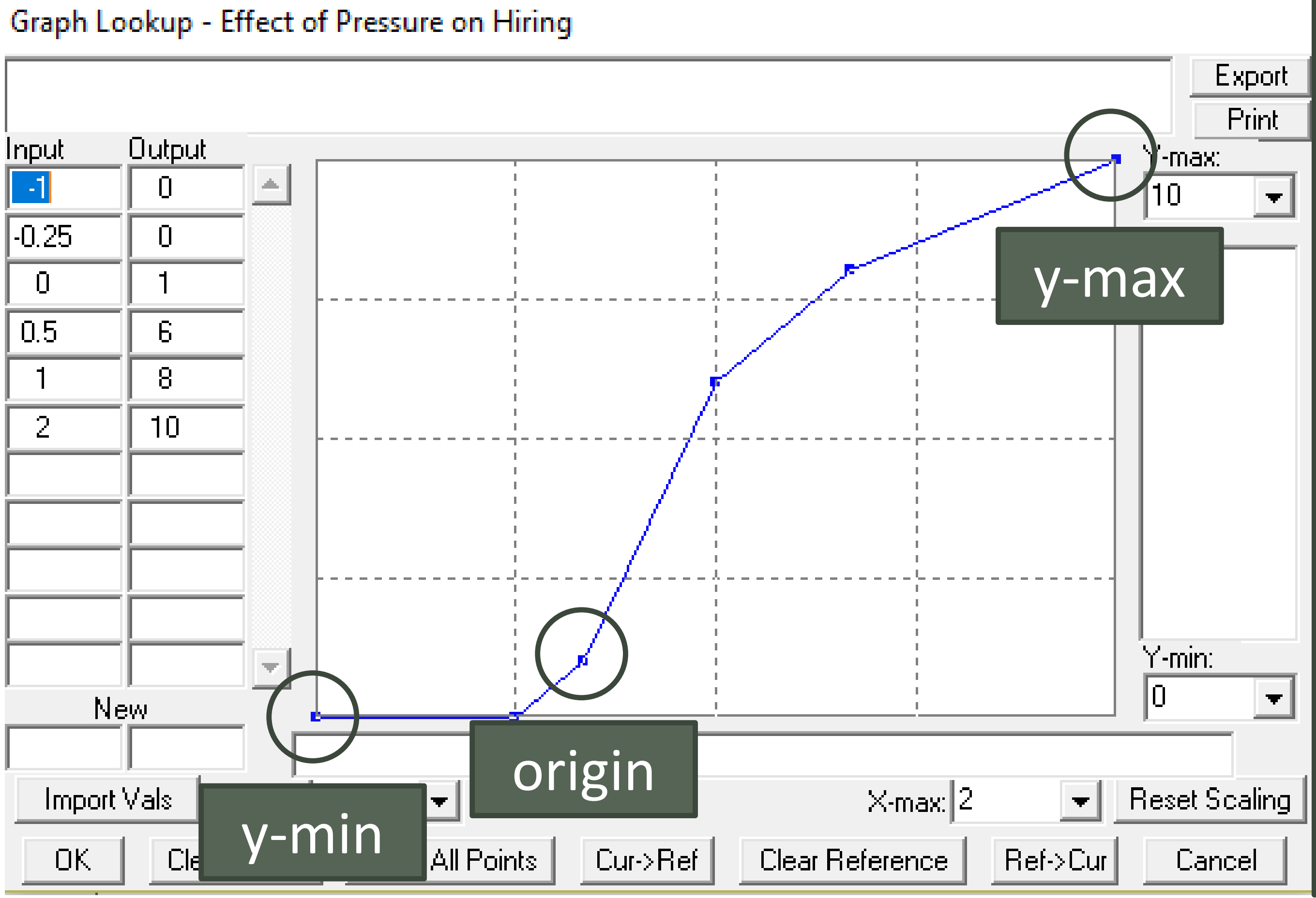
		Extreme run	
		Only positive values	Not only positive values
Base run	Only positive values	Not flagged	Flagged
	Not only positive values	Not flagged	Not flagged

Run	Variable	Flag Description
Exogenousvariable_setting	Variable where the flag occurred	Unexpected negative values

Extreme Condition test (3)



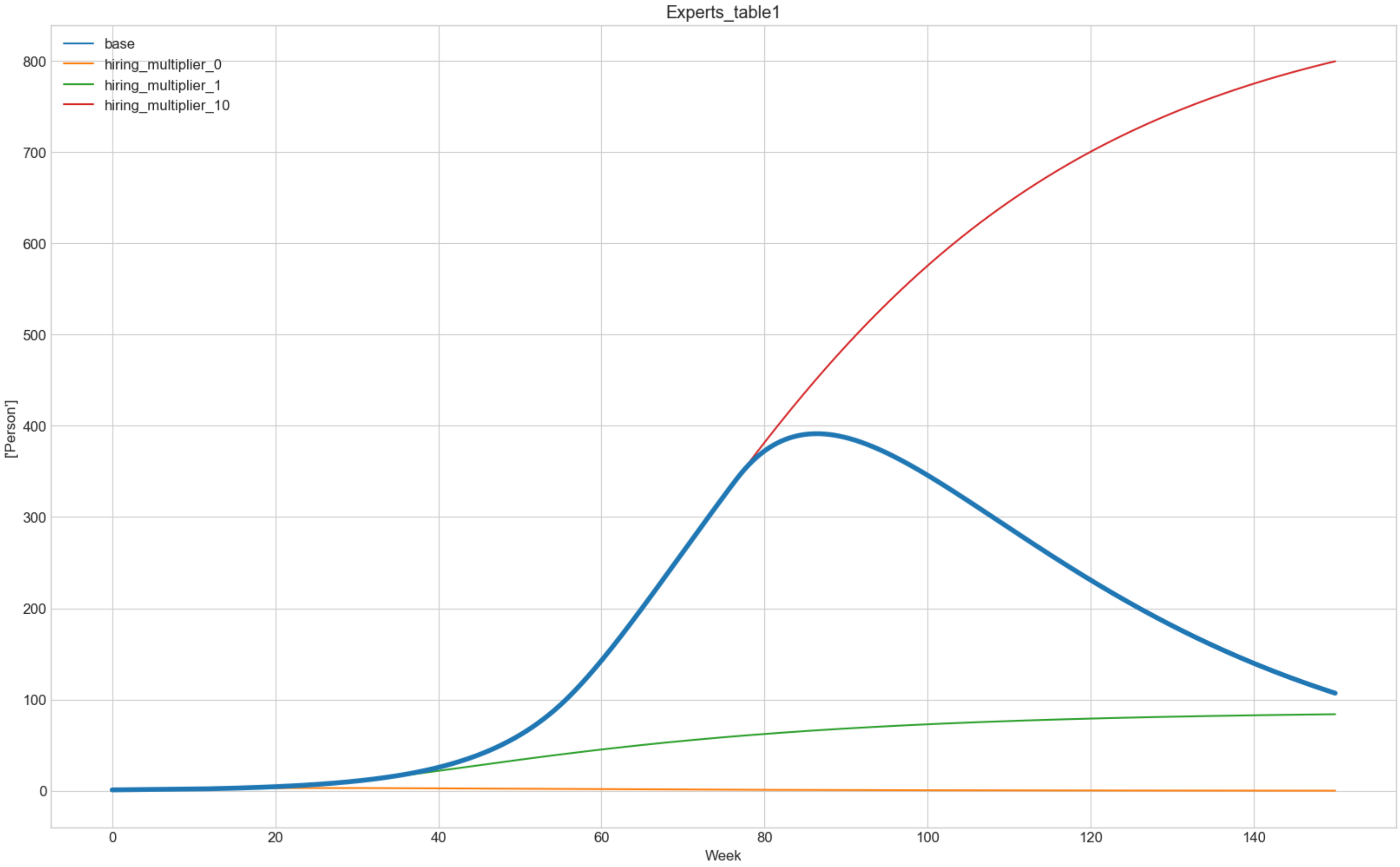
Extreme Condition test (4)



For each table function, three runs are executed:

- table value fixed at y-min
- table value fixed at origin (0 or 1)
- table value fixed at y-max

Extreme Condition test (5)



Error tracking

- Errors are tracked for every run
- Errors tracked are:
  - Division by 0
  - Floating point
  - Negative flows
  - Negative stocks

Discussion

Benefits of using automated analyses

- Time savings
- Comparability of results
- Rigor in formulation
- Rigor in test application

Future research

- Empirical validation of current tests
- Develop “error profiles” and automated interpretation
  - Preselection of output
- Develop model formulation standards driven by evaluation
  - Naming
  - Variable blocks