Toward mapping topographies of qualitative scenarios: An investigation of a comprehensive scenario set

Vanessa Schweizer[1,*], Alastair Jamieson-Lane[2], Nix Barnett[3], Hua Cai[4], Stephan Lehner[5], Matteo Smerlak[6], Melinda Varga[7]

[1]University of Waterloo, Centre for Knowledge Integration, Canada
[2]University of British Columbia, Mathematics, Canada
[3]University of California-Davis, Department of Mathematics and Complexity Sciences Center, USA
[4]University of Michigan, School of Natural Resources and Environment, Department of Civil and Environmental Engineering, USA
[5]German Aerospace Center (DLR), Institute of Air Transportation Systems, Germany
[6]Perimeter Institute for Theoretical Physics, Canada
[7]University of Notre Dame, Department of Physics, USA

*Corresponding author: vanessa.schweizer@uwaterloo.ca

Extended abstract: In policy analysis, investigators may make multiple significant assumptions in order to address a policy question. Even with quantitative integrated assessment (IA) or computable general equilibrium (CGE) models, the application of expert judgment is common for elements of scenarios that are not modeled explicitly. Potential shortcomings with expert judgment include overly optimistic scenarios (wishful thinking) and overconfidence (discounting or overlooking important policy-relevant scenarios). Such problems may be compounded for policy issues with long time horizons, such as forecasts of social and technological change in the face of climate change.

A method for confronting these shortcomings is cross-impact balance (CIB) analysis, where a large number of qualitative scenarios can be assessed systematically for internal consistency. CIB is capable of synthesizing qualitative and quantitative information for elements of a system that may otherwise be difficult to model explicitly. This can be useful for many purposes including linking storylines with quantitative scenarios as well as more comprehensively exploring possible system behavior, which enables uncertainty analysis. For the latter purpose, CIB can return information suggestive of system evolution (in CIB parlance, “scenario succession”). The added benefit of studying system evolution is that plausible yet internally inconsistent scenarios may be indicative of policy-relevant tendencies for a system (i.e. a rough system topography) including potential path dependencies. This is because in CIB, an inconsistent scenario is comprised of an unstable combination of element outcomes, and an inconsistent scenario seeks to update to a more stable combination.

Through this project, we took steps toward developing a method for mapping the topography of a set of qualitative scenarios using CIB. We did this by first enhancing CIB with the development and application of a software tool that can return a full picture of scenario successions as a Markov chain. Additionally, we considered modifications to the deterministic algorithm for classical CIB with multiple cases of stochastic rules for scenario succession. As a starting point, we considered a case of a simple three-variable system (with 27 possible scenarios) and found that the stochastic rules generally replicated the classical findings of final system attractors and their basins of attraction. However, there may be an entropy threshold for

the reliability of stochastic succession rules for CIB. The succession rule that had the highest entropy and entropy production (local arctan) was unable to replicate the classical findings for system attractors. Future work could search for entropy thresholds for stochastic succession rules as well as test the robustness of our findings for more complex systems specified by more than three variables.

In general, a method for mapping the topography of a space of relevant qualitative scenarios could be useful as part of a toolbox for quantitative scenarios in energy and environmental research. Such maps could provide information about the evolution of scenario elements that are not otherwise represented in a quantitative model. Alternatively, the map could provide a rough approximation of results that would be expected from a detailed quantitative scenario analysis. Both of these applications would be improvements to the otherwise ad hoc application of expert judgments for scenario assumptions that are exogenous to a quantitative model.