Toward mapping topographies of qualitative scenarios

Investigation of a comprehensive scenario set

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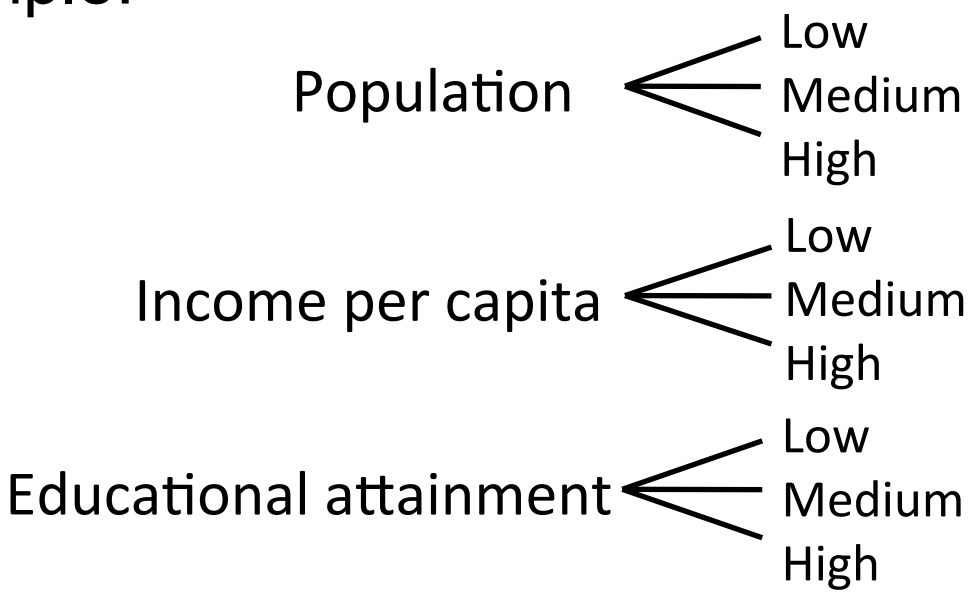
Inspiration and the project team

- **Alastair Jamieson-Lane**, University of British Columbia, Mathematics
- **Nix Barnett**, University of California-Davis, Mathematics and Complexity Sciences Center
- **Hua Cai**, University of Michigan, School of Natural Resources and Environment, Civil and Environmental Engineering
- **Stephan Lehner**, German Aerospace Center (DLR), Institute of Air Transportation Systems
- **Matteo Smerlak**, Perimeter Institute for Theoretical Physics
- **Melinda Varga**, University of Notre Dame, Physics

A primer on cross-impact balances (CIB; Weimer-Jehle 2006)

Step 1: Define scenario elements

Simple example:



CIB step 2: Record judgments (statements of interrelationships)

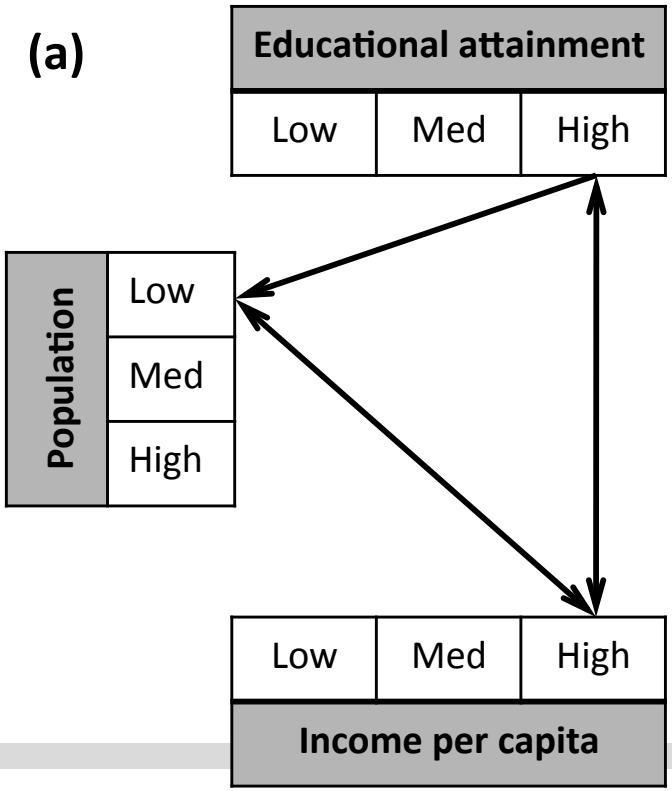
		(1) Population L	M	H	(2) Income/cap L	M	H	(3) Education L	M	H
(1) Population	Given: Low				-2	-2	4			
	Medium									
	High									
(2) Income per capita	Given: Low									
	Medium									
	High									
(3) Educational attainment	Given: Low									
	Medium									
	High									

$C_{X,Y}(x,y) = C_{1,2}(L,H)$

$C_{X,Y} = C_{1,2}$

CIB step 3: Scenario as set of conditions and assessment of internal consistency

Internal consistency determined by **self-consistency**



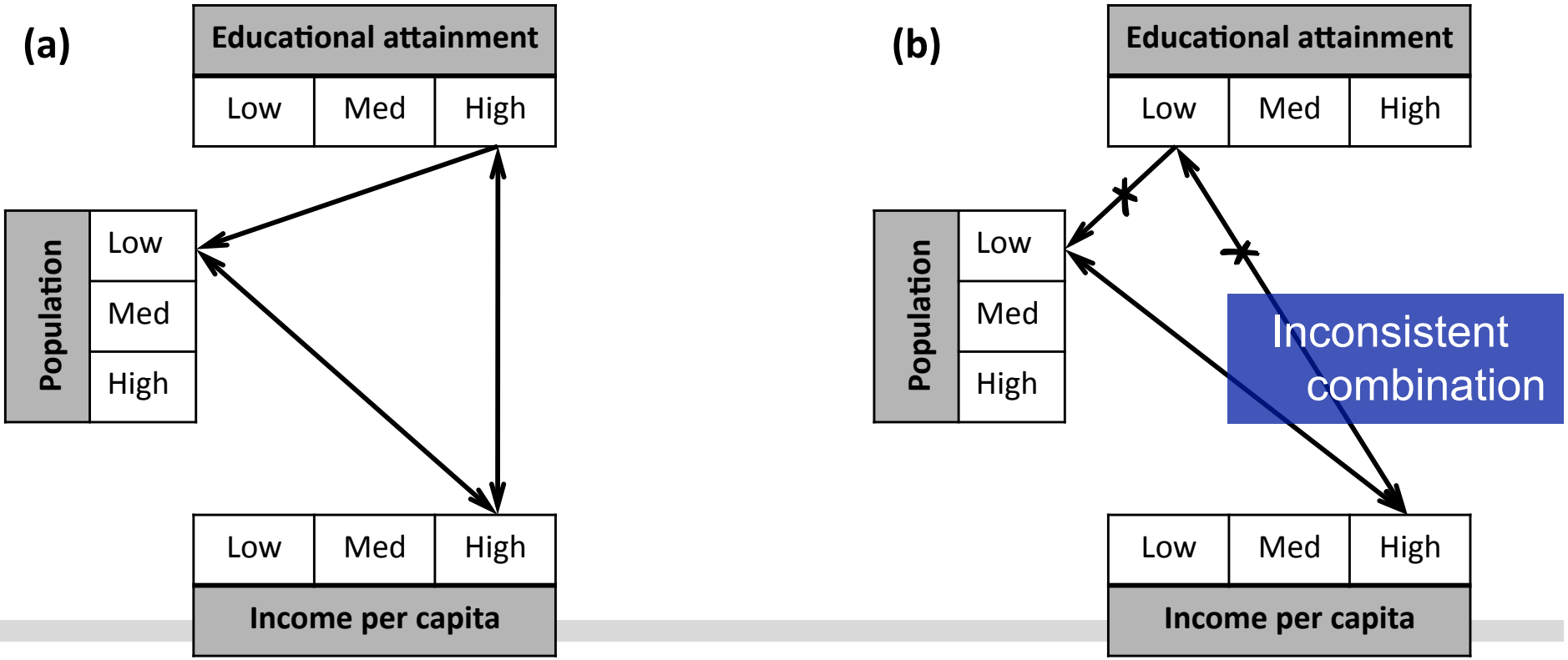
Direct influences among these outcomes well understood at highly aggregated scales

(e.g. demographic transition)

Schweizer & O'Neill (2014)

CIB step 3: Internal consistency check

Internal consistency determined by **self-consistency**



CIB step 3: Internal consistency check

		(1) Population			(2) Income/cap			(3) Education		
		L	M	H	L	M	H	L	M	H
(1) Population	Given:									
	Low				-2	-2	4	-9	3	6
	Medium				0	0	0	-7	-1	8
	High				2	2	-4	7	4	-11
(2) Income per capita	Given:									
	Low	-3	0	3				7	4	-11
	Medium	0	0	0				-9	3	6
	High	3	0	-3				-11	4	7
(3) Educational attainment	Given:									
	Low	-3	0	3	11	-4	-7			
	Medium	0	0	0	-5	10	-5			
	High	3	0	-3	-7	-4	11			
Target outcomes according to self-consistency:		↓					↓	↓		
Impact balances (sum highlighted values):		0	0	0	9	-6	-3	-20	7	13
Target outcomes according to impact balances:		↑			↑					↑

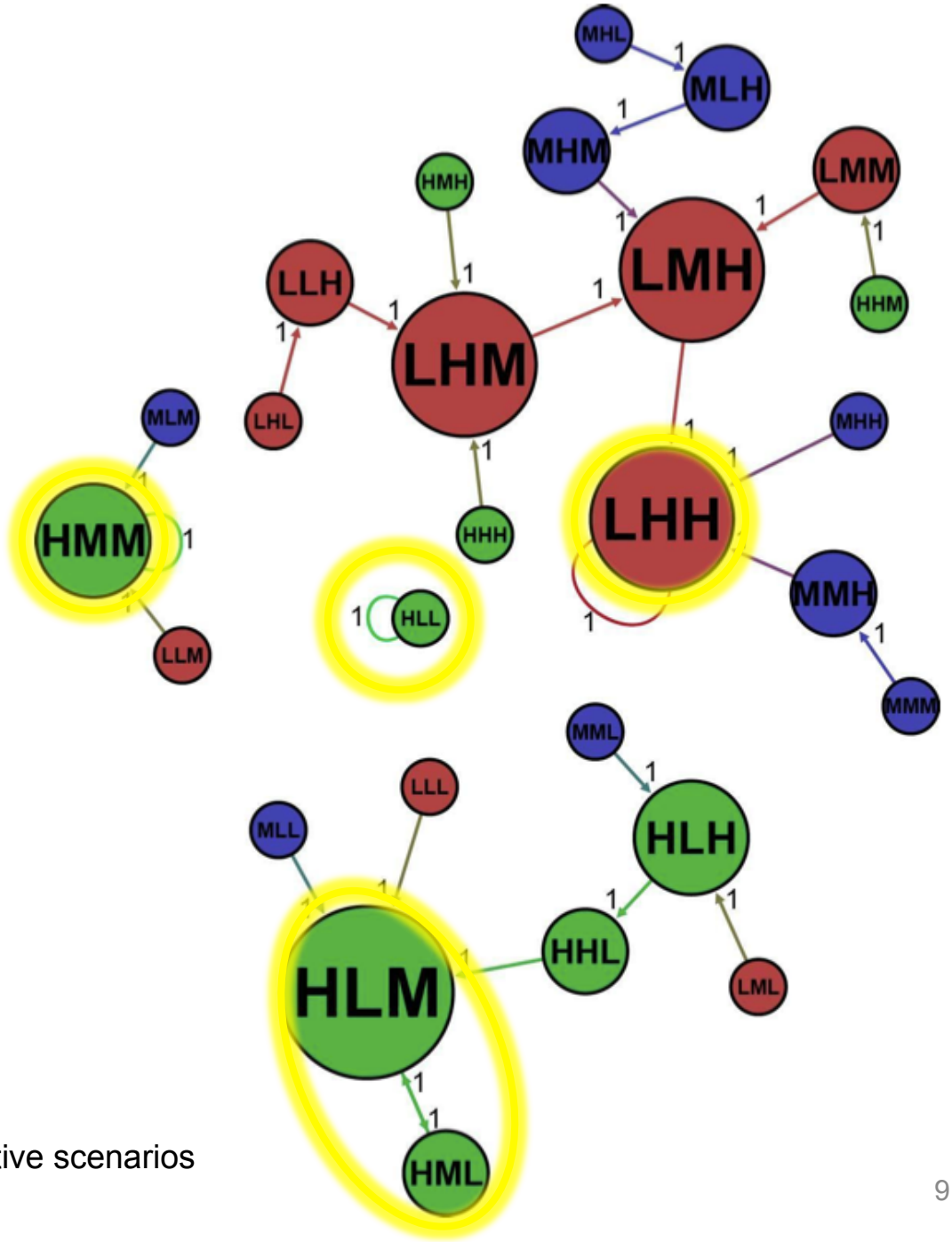
Potentially much more can be done with CIB

Table 6 (Weimer-Jehle 2006)
Solution table for the system example "oil price"

	Scenario A	Scenario B		Scenario C
		Variant B1	Variant B2	
	"Conflict and economic disappointment"	"Calm steps ahead"		"Dynamic in a restless environment"
Scenario weight	186	1	1	136
World GDP growth	<2%/year	2–3%/year	2–3%/year	>3%/year
Borrowing industrial countries	High	Medium	Medium	Low
World tensions	Strong	Moderate	Moderate	Weak
Cohesion of OPEC	Strong	Strong	Moderate	Unstable
Oil price	35–50$	35–50$	35–50$	Unstable

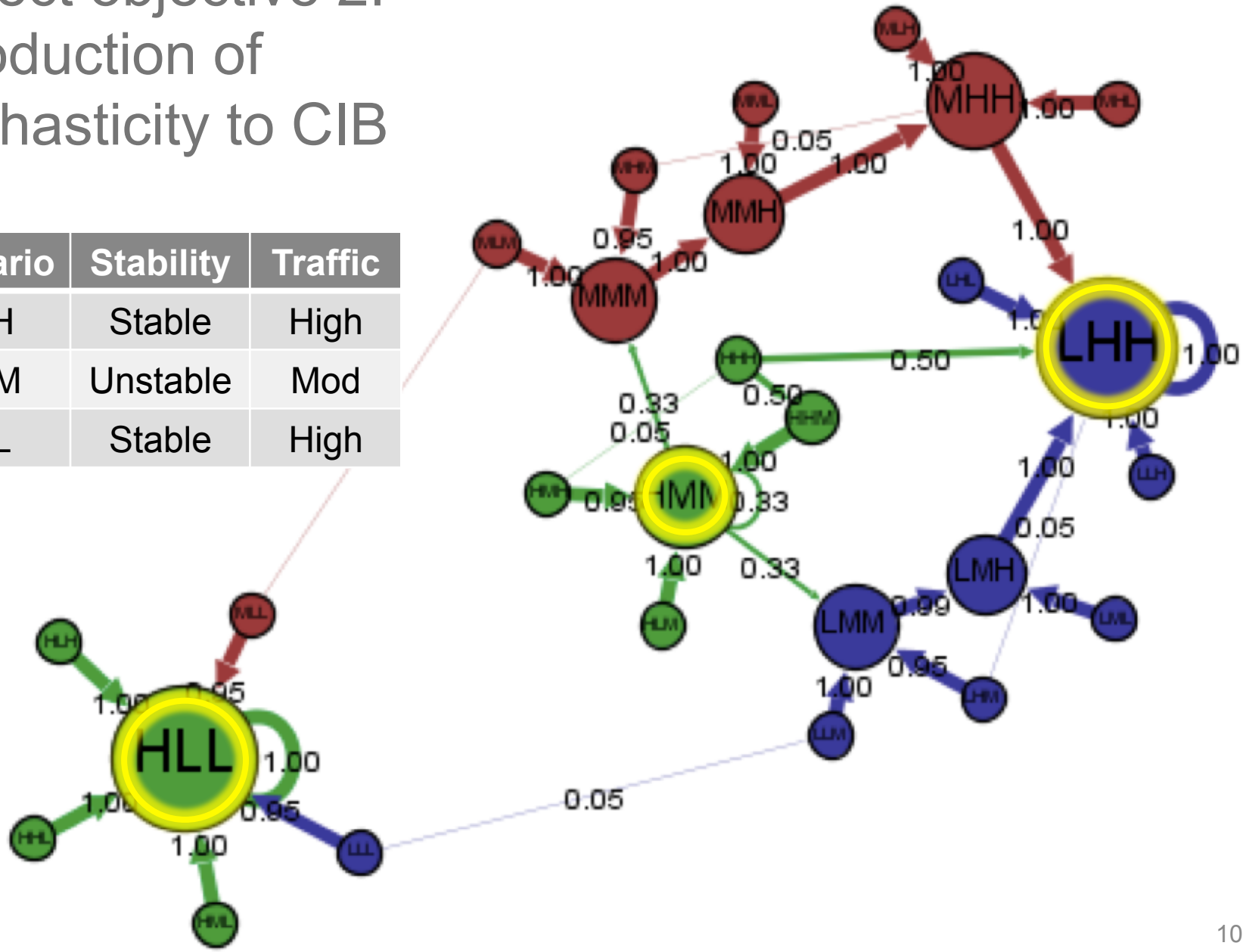
Project objective 1: Visualization of scenario succession

Scenario	Scenario weight
LHH	15
HLM ←→ HML	8
HMM	3
HLL	1

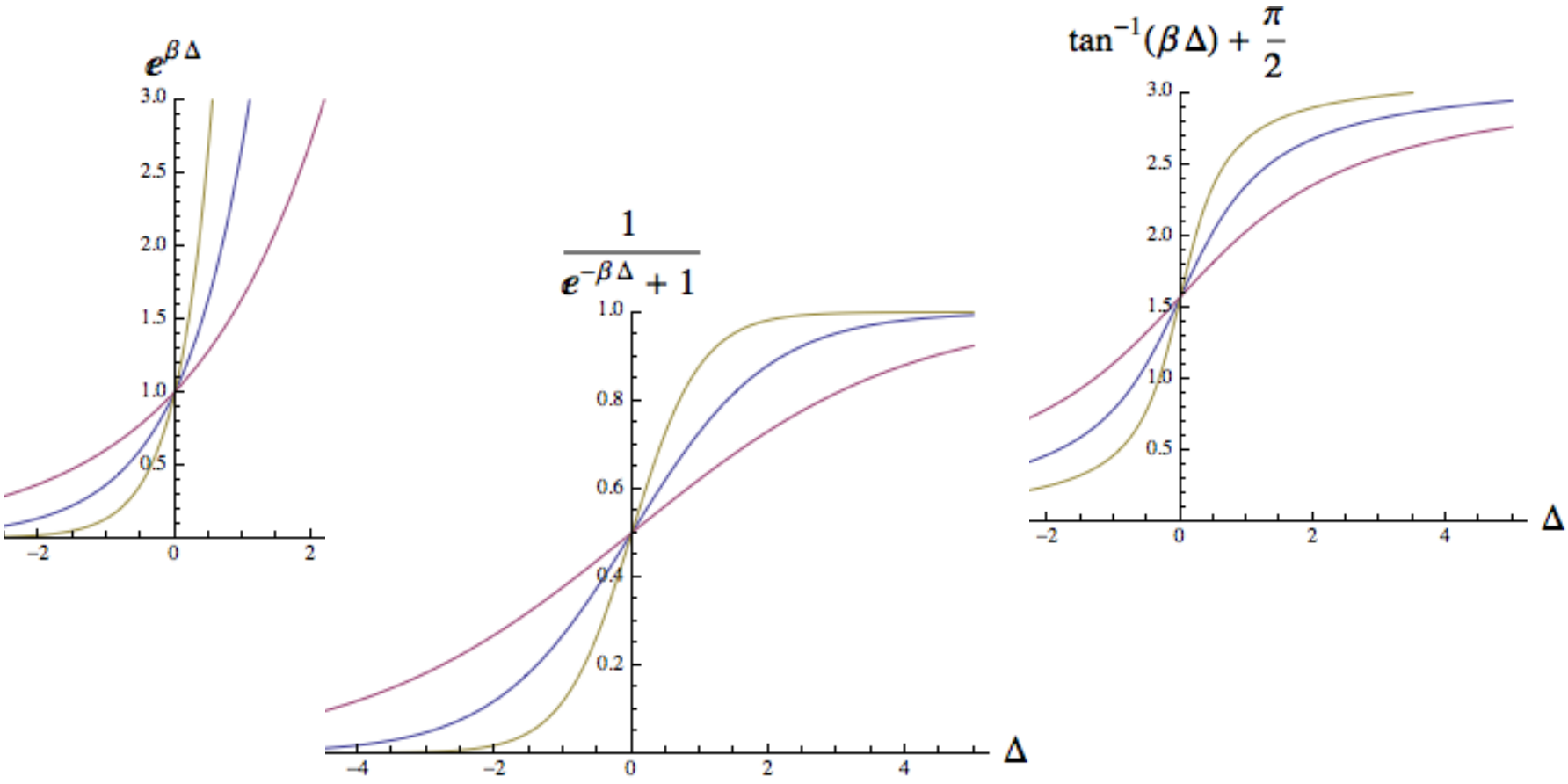


Project objective 2: Introduction of stochasticity to CIB

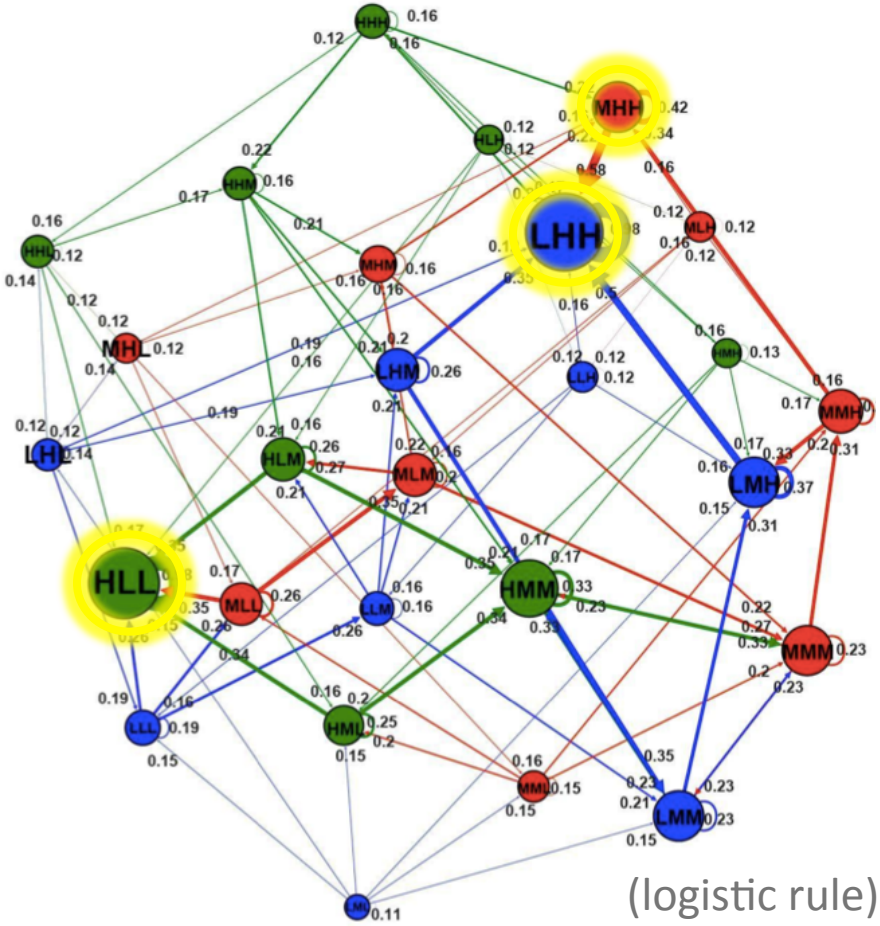
Scenario	Stability	Traffic
LHH	Stable	High
HMM	Unstable	Mod
HLL	Stable	High



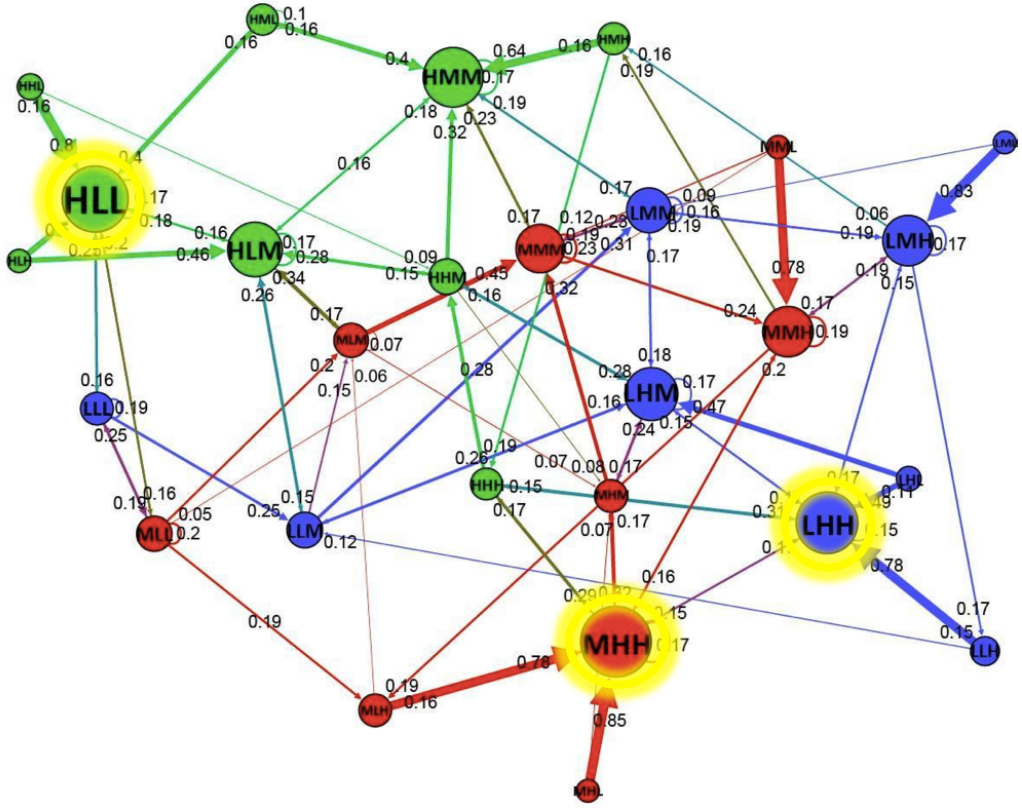
Experimentation with alternative stochastic succession rules



Objective 3: Succession rule comparison



(logistic rule)



(arctan rule)

Summary of progress and future work

- CIB scenario succession can be visualized as a network (a Markov chain)
- With stochastic succession rules, salient features of system 'topography' can be verified, investigated
- Future work
  - » Details of system topography: Are particular scenarios important 'pathways' from one system attractor to another?
  - » Visualization of larger network

References

Schweizer V, Jamieson-Lane A, Barnett N, Cai H, Lehner S, Smerlak M, Varga M (2013) Complexity (Trans-)Science: A Project on Forecasting Social Change. Project report for the Santa Fe Institute Complex Systems Summer School, Santa Fe, NM, September 2013

Schweizer VJ and O'Neill BC (2014) Systematic construction of global socioeconomic pathways using internally consistent element combinations. *Climatic Change* 122:431-445

Weimer-Jehle W (2006) Cross-impact balances: A system theoretical approach to cross-impact analysis. *Technological Forecasting & Social Change* 73:334-361