A System Dynamic Approach for Modeling Forced Migration of Refugees

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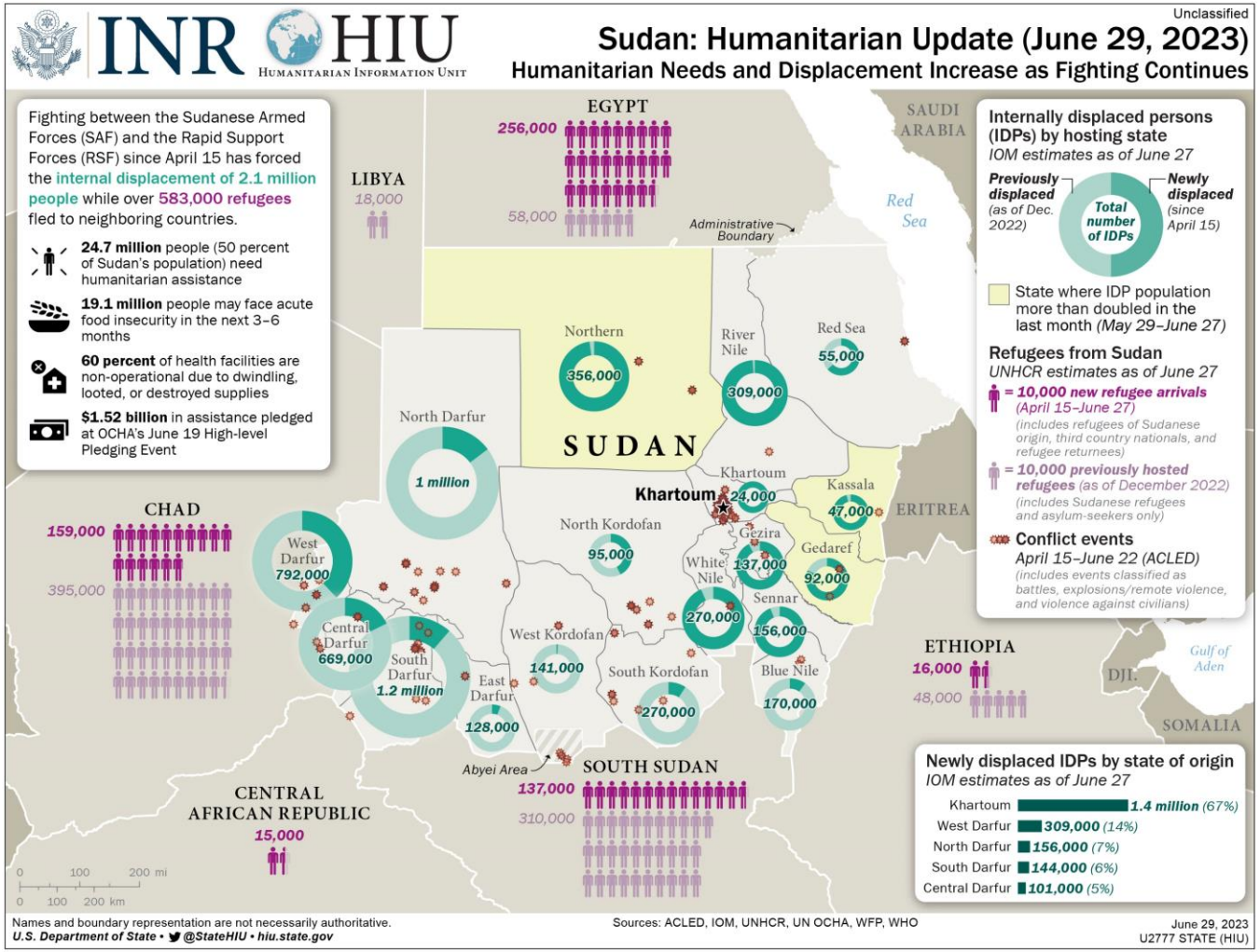
Agenda

- Intro
- Methodology
  - Data sources
  - Model
- Results
- Discussion
- Conclusion



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Intro

- Migration becoming larger demographic component
- Record high numbers since WWII
- Population numbers increasing in migrant prone countries

Syrians and Iraq refugees arrive at Lesvos , Greece (2016)

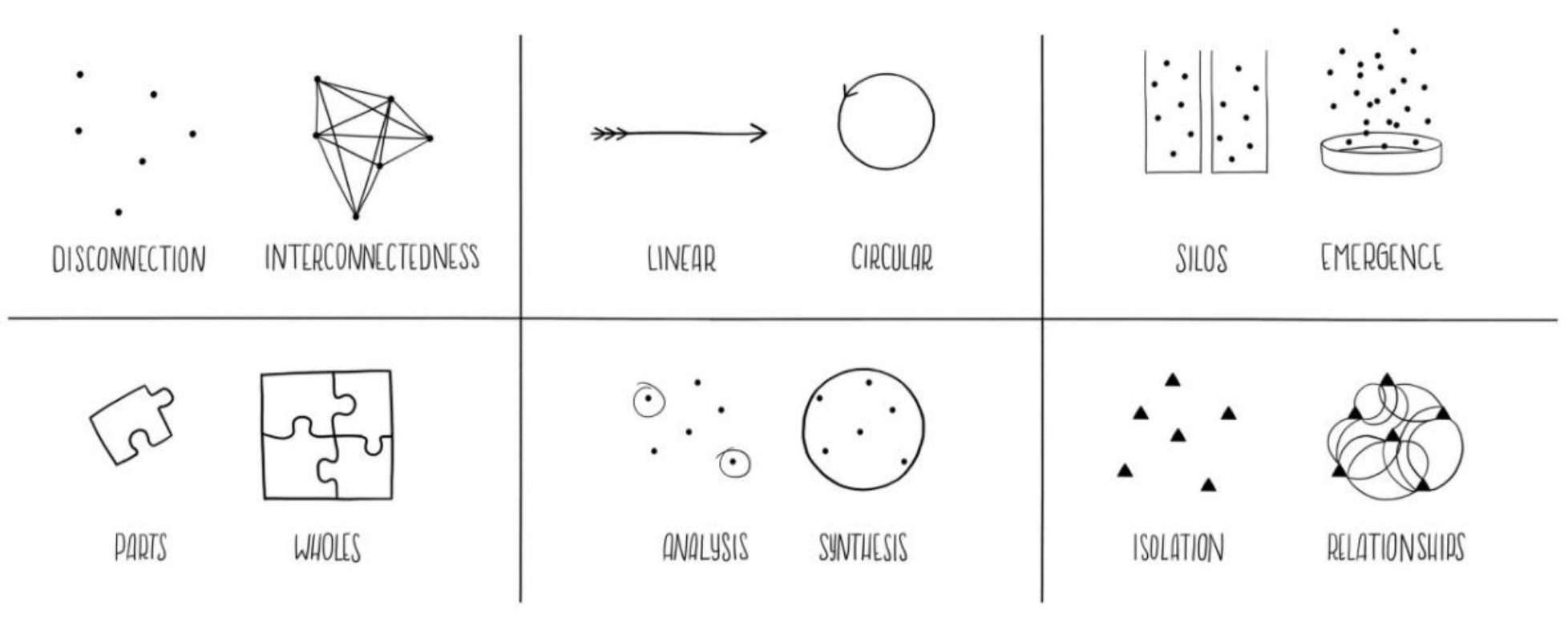
Motivation

- New migration paradigm in digital age
  - Increase in forced migration
  - Emergence of open & crowdsourced data
- Relevance to regional and national security
- Technology developments provide new insight

Refugees charging phones at makeshift charging station (Flickr, 2015)

Refugees using smartphone technologies during migration trajectories (Flickr, 2015)

Systems thinking



Systems thinking (illustrations by Emma Segal , 2021)

Prior work

Quantitative studies on forced migration

- Refugee numbers and magnitude (Schmeidl, 1997)
- Multivariate analysis (Zottarelli, 1998)
- Expanded socioeconomic variables (Melander and Öberg, 2004)
- Binomial Regression (Neumayer, 2005)
- Pooled Regression (Echevarria and Gardeazabal, 2016)
- FLEE model (Suleimenova et al., 2017)

System Dynamics Models

- Flows of migrants (Mabogunje, 1970)
- State instability (Choucri et al., 2007)
- Allocations of aid (Taylor & Masys, 2018)
- Future alternatives (Taylor, 2020)

Parameter values based on authoritative and open-source data used in SDM

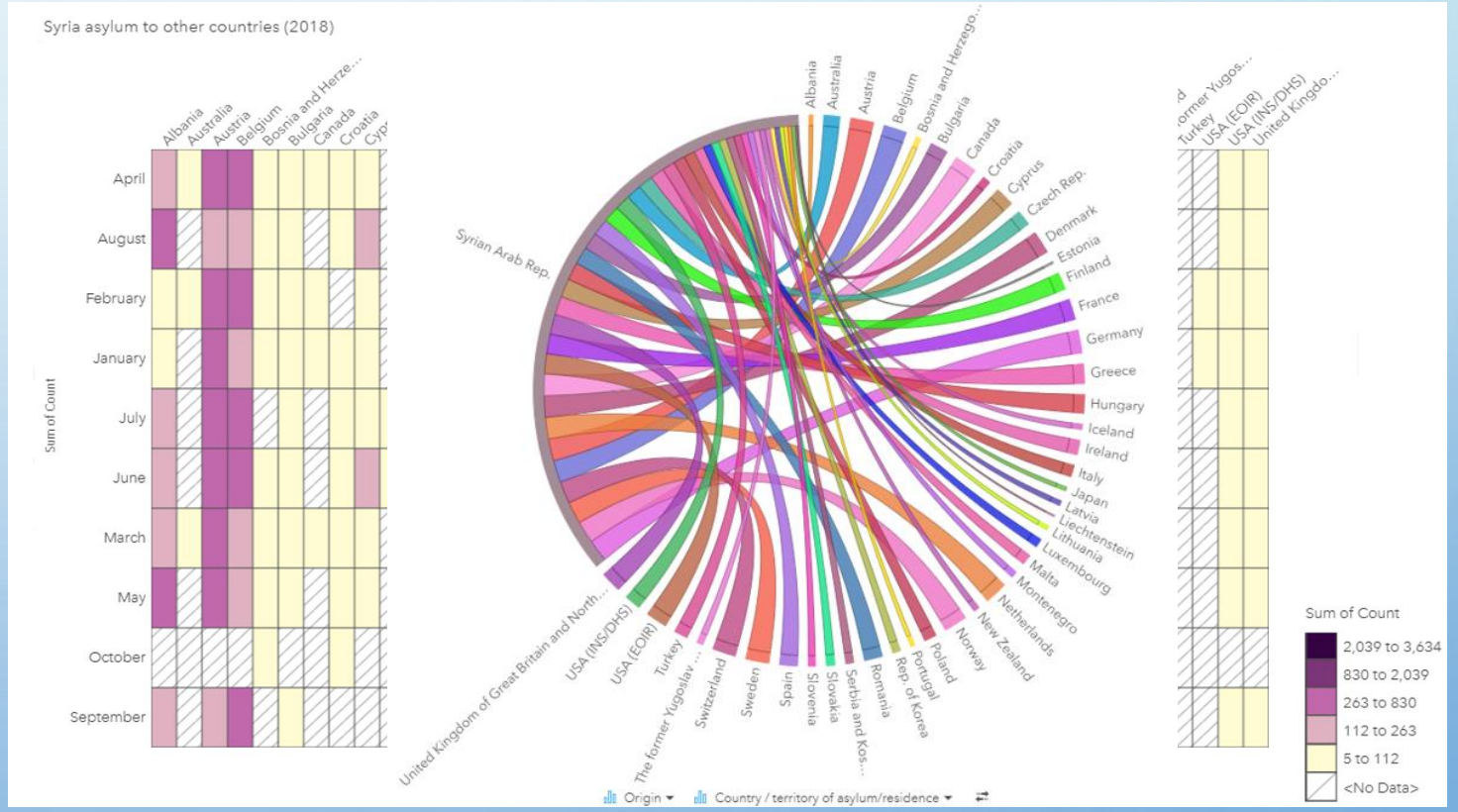
	Name	Range of Values	Default Model Value	Source of Data or Parameter
Stocks	Potential Displaced	0-100x10^6	20,442,541	World Bank, (2019)
	Displaced Persons	0-100x10^6	5,391,603	Model prediction
Parameters	Regime legitimacy	0 - 100	74 - 87	Transparency International (2019)
	Human rights violations	0 - 6298	1164 - 6298	Syrian Revolution Martyr Database (2021)
	Conflict	0 - 10	10	Halkia et al. (2017); Gibney et al. (2020)
	Regime force violence	0 - 10	0 - 10	Al-Maghafi (2018)
	Socio-political mobilization	0 - 100	56	Leenders and Heydemann (2012); Clark and Regan (2019).
	Intervening opportunities	1.1 - 10	1.1 - 10	Weatherspark (2021)
	Contact rate	0 - 100	30	

Table 1: List of parameter values based on authoritative and open-source data used in SDM

Data sources

UNHCR reference data

- Asylum
- Displacement statistics
- Camp estimate



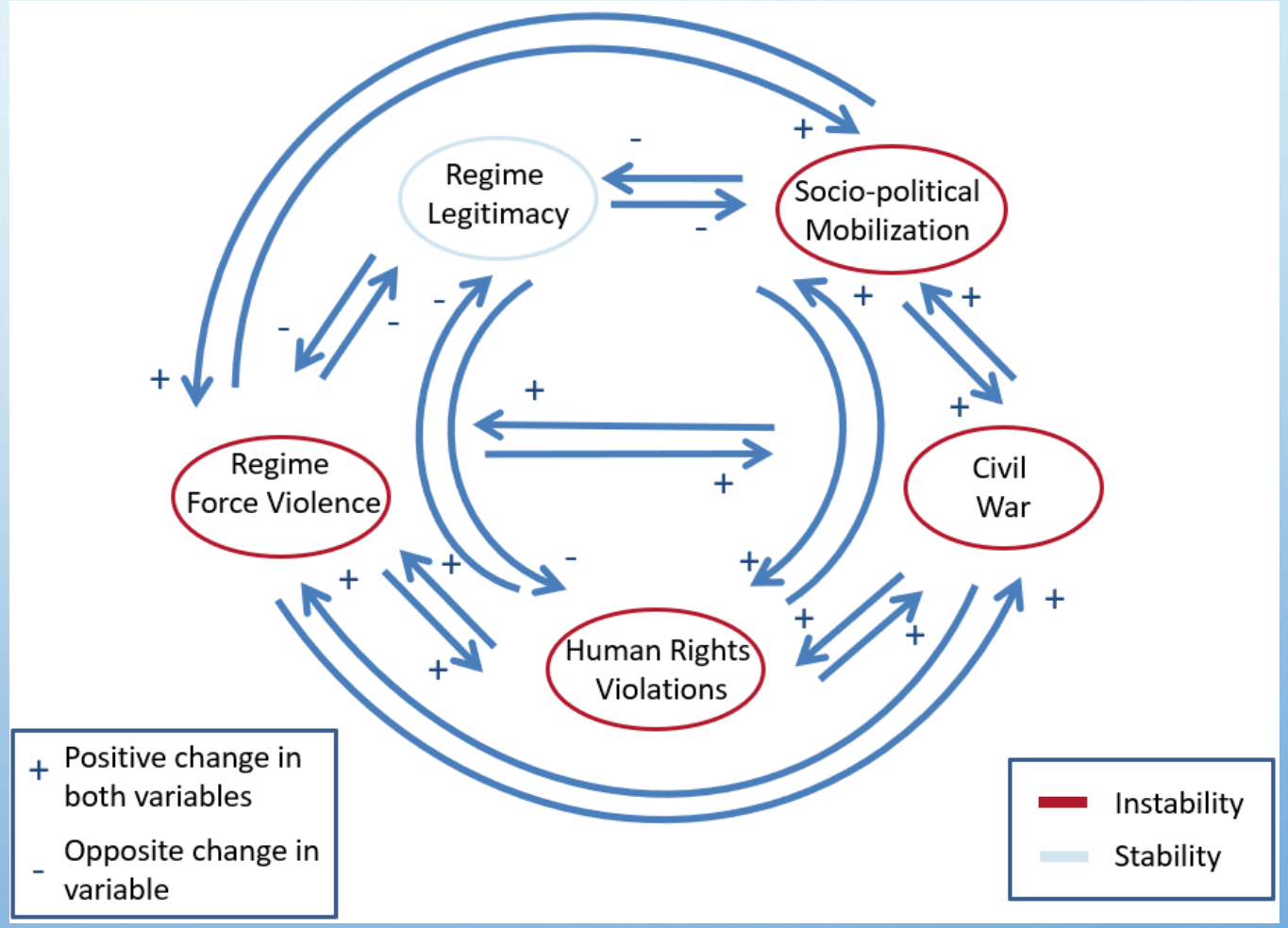
Syrian asylum monthly counts (1999-2018)

Syrian asylum to destination countries (1999-2018)

Model

Conceptual model

- Variables
  - Stability
  - Instability
- Arrows
- Polarity

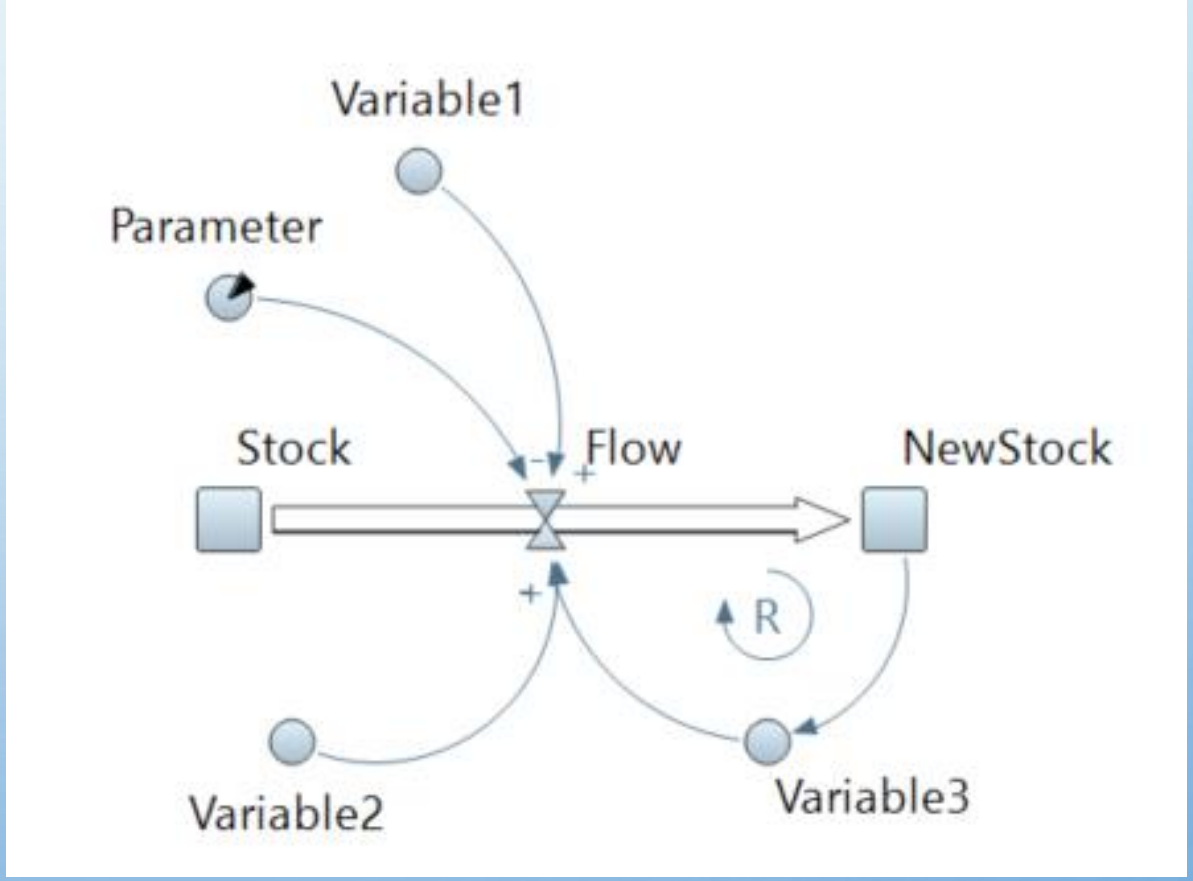


System dynamics conceptual model for forced migration

Model

Model components

- Stock
- Flow
- Variable
- Parameter
- Link
- Polarity
- Loop

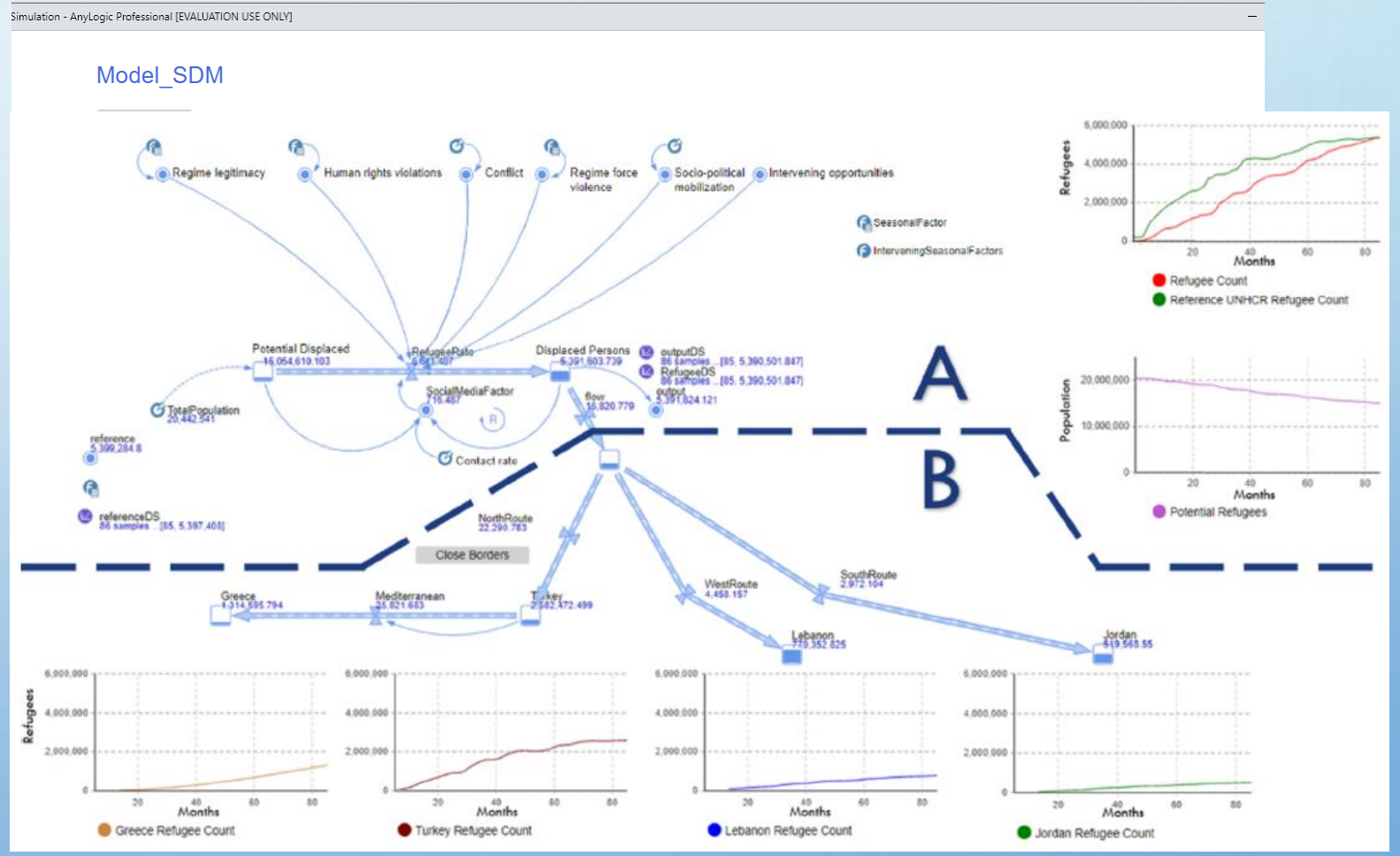


System dynamics model elements

Model

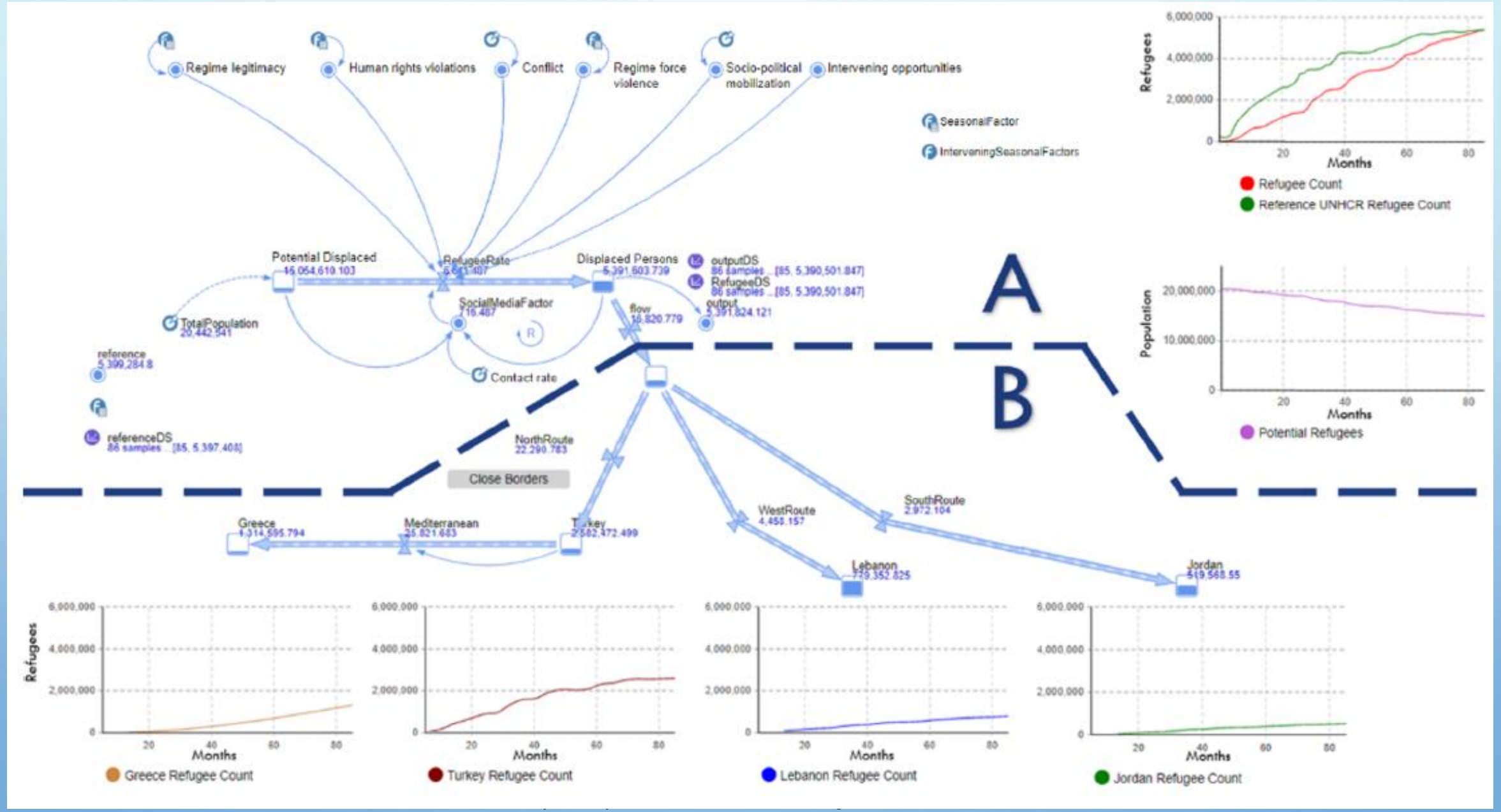
Refugee SDM

- Stocks
- Flow
- Parameters
- Dynamic parameters
- Table functions
- Charts



System dynamics model for forced migration

Model



System dynamics model for forced migration

Methodology

Refugee SDM

- Stock (potential displaced persons) from authoritative source
- Rate of flow based on several variables grounded in forced migration literature
  - Root, proximate cause, or trigger event for refugees
  - Data resides in database tables accessed by model
  - Variables for the model are based on open-source data that varies in temporal resolution.
- Values aggregated into monthly time horizon values

Results

- Produced comparable refugee counts
- Simulation runs January 2012 to December 2018
- Calibration
- Feedback
- Delays
- Events

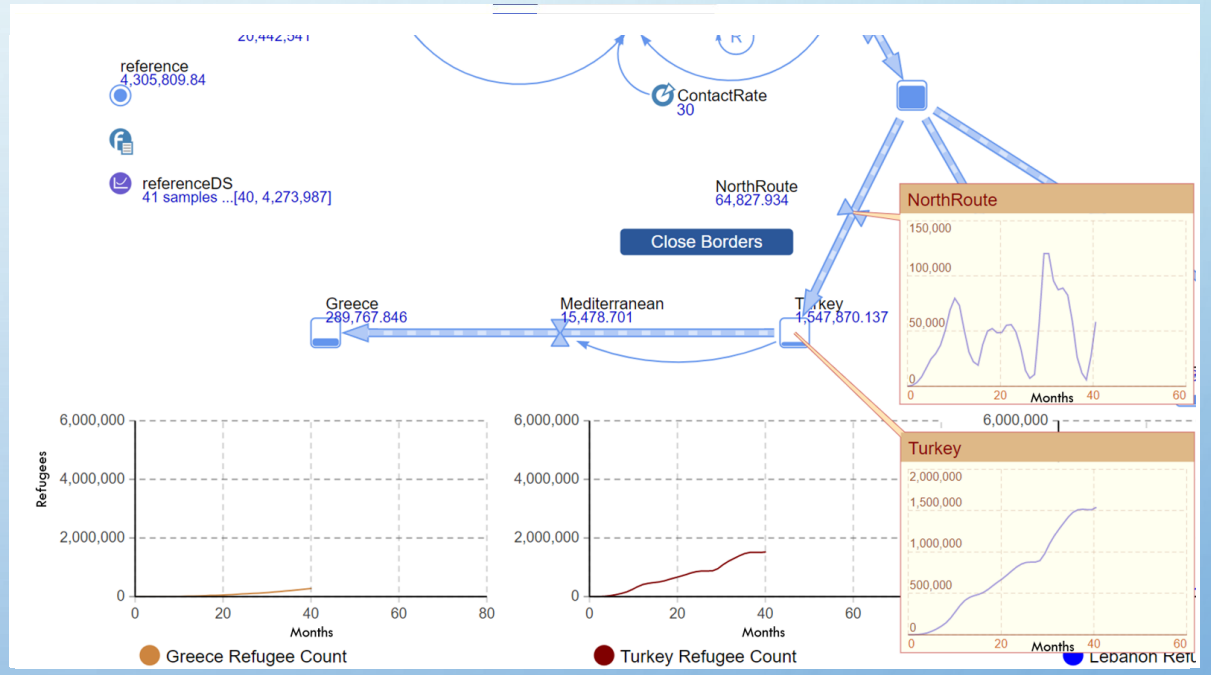
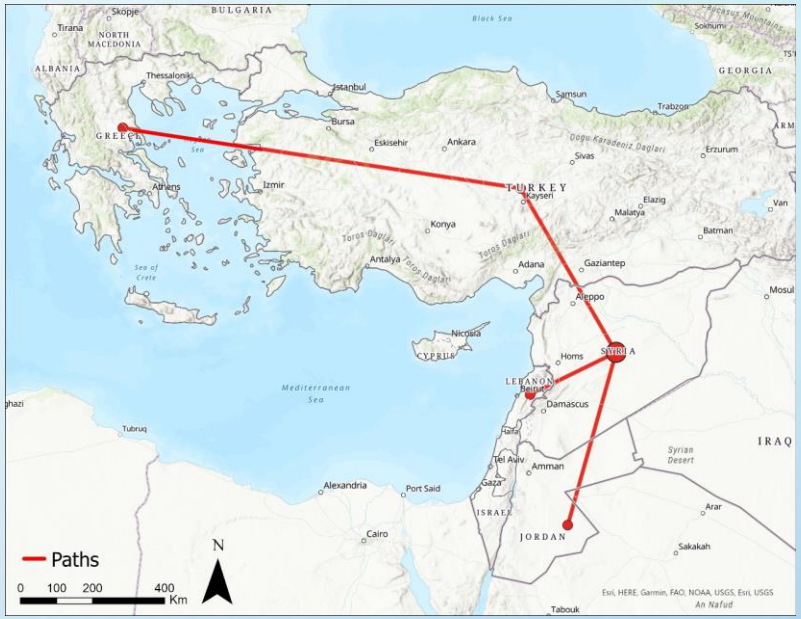


Figure 4: Simulated refugee count plotted with reference UNHCR refugee count

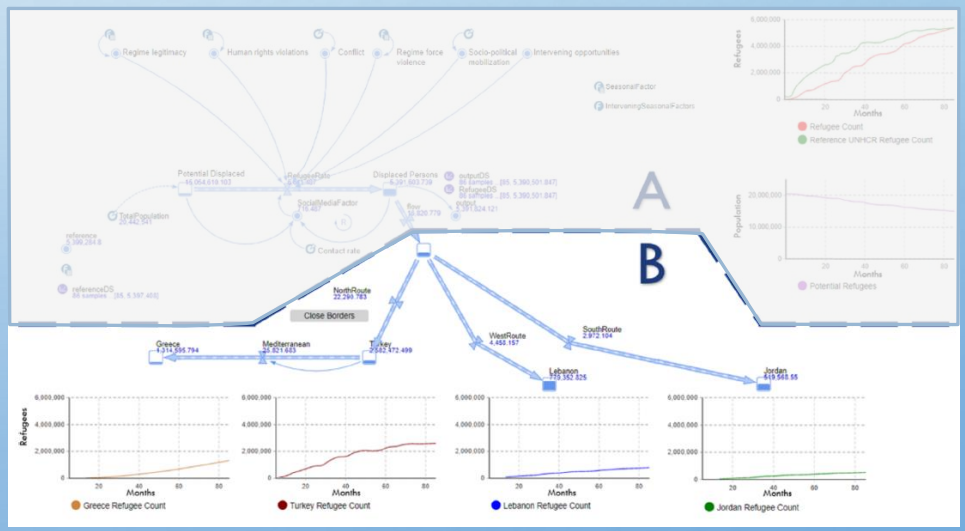
Results

Routes for refugees

- Primary routes identified in literature
- Alternative country distance from origin
- Openness of a country (ease of entering)
- Number of refugees already present in the country (popularity)
- Border closure built into model



Migration routes



System dynamics model for forced migration

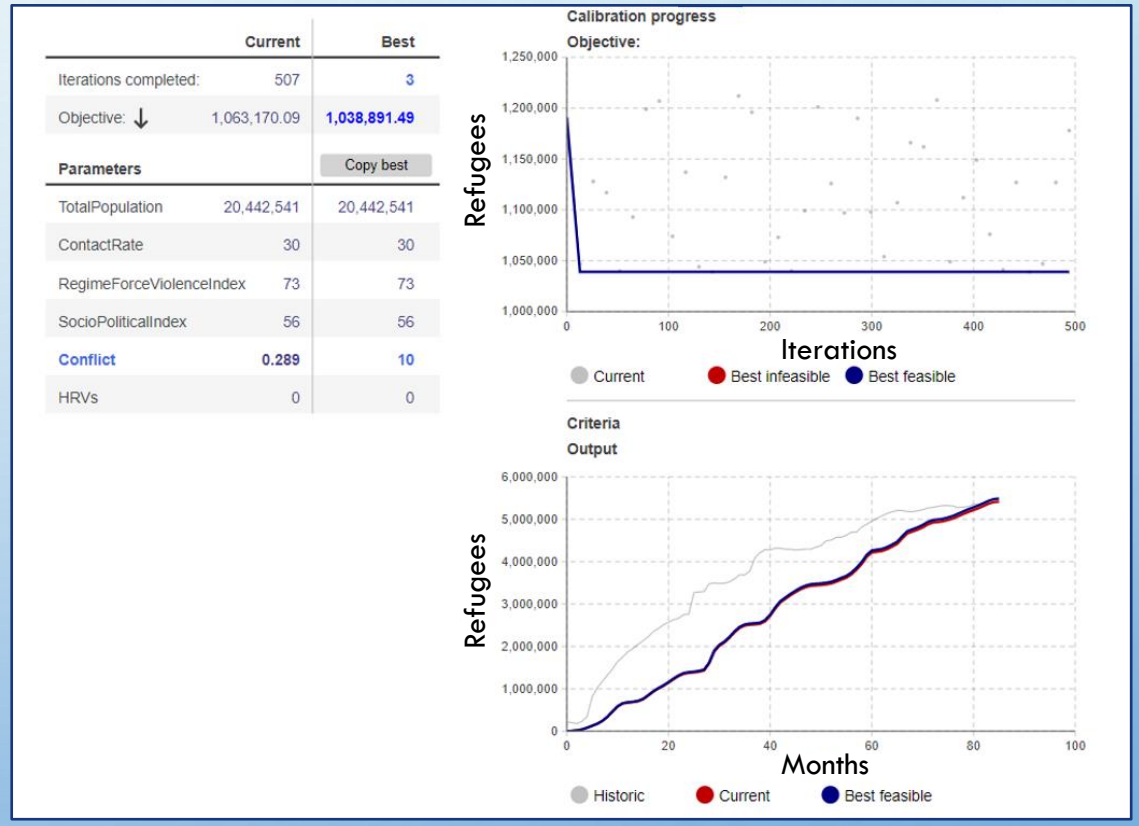
Results

Calibration

- Individual calibration experiments

Parameter	Calibration range	Default value	Calibration recommended value
Regime legitimacy	500–232,000	Varies by month	100
Human rights Violations	25,500–1,000,000+	Varies by month	3,601
Conflict	900–417,000	10	10
Regime force violence	40,003–1,000,000+	Varies by month	Varies by month
Socio–political mobilization	500-232,000	56	100
Contact Rate	2–845,000	30	100

Table 2: Calibration and sensitivity analysis experiments

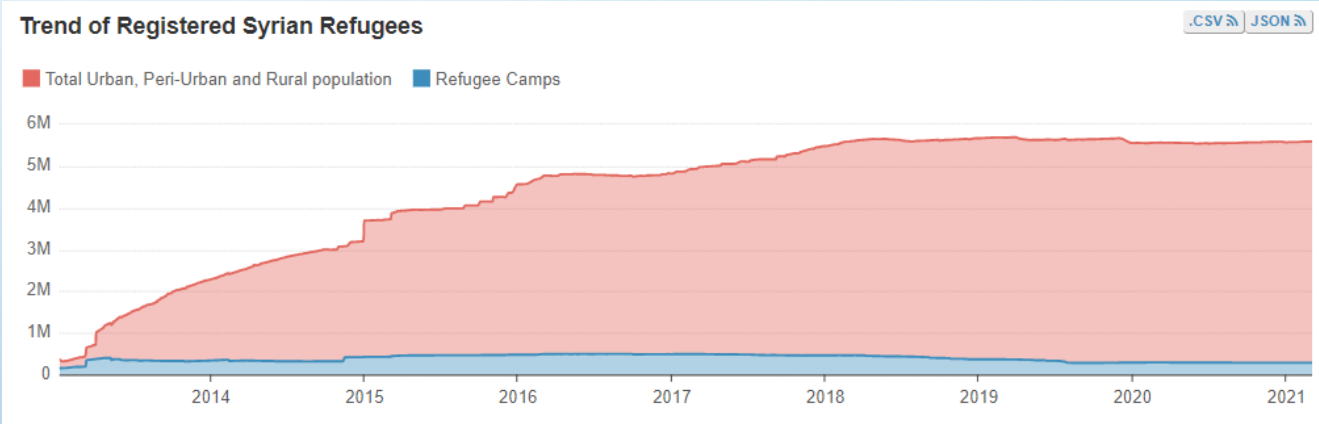


Calibration for SDM conflict parameter

Results

Verification

- Units
- Logical check
- Dependencies & relations



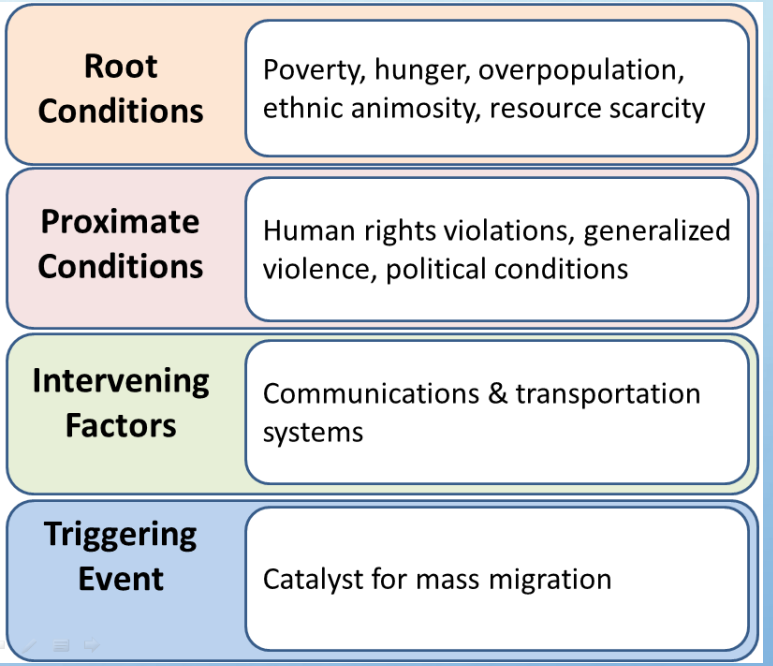
Open data for Syrian refugee counts (UNHCR, 2021)

Validation

- Structural: relevant variables
- Behavioral: Comparing against UNHCR historical reference values

Scientific contribution

- New typology for refugee applications and modeling
- Utilizing diverse data sources to understand forced migration
- Open source and social media show potential for refugee applications and use within System Dynamics Model (SDM)
- Methodology for modeling forced migration
- SDM projects refugee population



Factors in forced migration

Conclusion

- Open source and social media are beneficial to obtaining more recent information for simulation model for refugee applications and use within SDM.
- SDM is applicable for modeling forced migration.

THANK YOU!

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