Contents

1 Is Urban Future Predictable? ............................................. 1
  1.1 Emergence ......................................................... 4
  1.2 Generic Dynamic Features of Systems of Cities ............... 6
    1.2.1 The Hierarchical Differentiation of City Sizes .......... 6
    1.2.2 The Meta-Stability of Urban Hierarchies ............... 7
    1.2.3 A Regular Quasi-stochastic Process of Growth .......... 8
    1.2.4 Hierarchical Diffusion of Innovation Waves and
          Functional Specializations .......................... 9
  1.3 Variety in the Evolution of Urban Systems ................... 10
    1.3.1 A Simplified Typology of Systems of Cities ......... 12
    1.3.2 Systematic Variations in the Rhythm
          of Urban Growth .................................... 13
  1.4 Urban Future: Models and Scenarios .......................... 14
    1.4.1 Challenges in Building Scenarios About Urban
          Evolution .......................................... 14
    1.4.2 Challenges in Model Validation ........................ 16
References ........................................................................ 17

2 The SimpopLocal Model .................................................... 21
  2.1 Introduction ....................................................... 21
  2.2 Purpose of SimpopLocal ......................................... 21
  2.3 Entities, State Variables and Scales ............................ 22
  2.4 Processes Overview and Scheduling ............................. 23
    2.4.1 Population Growth Mechanism .......................... 23
    2.4.2 Apply Innovation Mechanism ............................. 24
    2.4.3 Create and Diffuse Innovation Mechanisms .......... 25
  2.5 Initial Conditions ................................................ 28
  2.6 Input .................................................................... 29
  2.7 Running the Model for Parameter Estimates: Calibration ... 31
2.8 Simulation Results and Return on Observations
References

3 Evaluation of the SimpopLocal Model
3.1 Quantitative Evaluation
3.1.1 Stopping Criterion
3.1.2 Expectations
3.1.3 Handling the Stochasticity
3.2 Automated Calibration
3.2.1 Optimization Heuristic
3.2.2 Adaptation of NSGA2 to a Stochastic Model
3.2.3 Experimental Setup
3.2.4 Results
3.3 Calibration Profiles
3.3.1 Algorithm
3.3.2 Guide of Interpretation
3.3.3 Result Analysis
3.4 Conclusion

References

4 An Incremental Multi-Modelling Method to Simulate Systems of Cities’ Evolution
4.1 Introduction
4.2 Methodological and Technical Framework
4.2.1 Complementary and Competing Theories
4.2.2 A Methodology for Implementing Multi-models
4.2.3 Exploiting the Results of a Family of Models
4.3 A Family of Models of (Post-) Soviet Cities: MARIUS
4.3.1 Ordering Possible Causes of Evolution from the Most Generic to the Most Specific
4.3.2 Implementing Modular Mechanisms
4.4 Geographical Insights on (Post-) Soviet City Growth from Multi-modelling
4.4.1 Mechanisms’ Performance
4.4.2 Parameter Values
4.4.3 Residual Trajectories
4.5 VARIUS: A Visual Aid to Model Composition and Interpretation
4.5.1 Building the Model Online
4.5.2 Running the Model Online
4.5.3 Analyzing Results Online or ‘How Close Are We?’
4.6 Conclusion

References
## 5 Using Models to Explore Possible Futures

*(Contingency and Complexity)*

5.1 Models as Artefacts of Historically Contingent Complex Systems ............................................ 82

5.2 A Method to Foster Diversity in a Model Outcomes ........ 84

5.2.1 The Pattern Space Exploration Algorithm:

Principles and Implementation ............................. 84

5.2.2 Evolutionary Methods for Parameter Space Exploration ........................................... 85

5.2.3 Novelty Search ........................................ 86

5.2.4 PSE Algorithm ........................................ 86

5.3 Application to Systems of Cities ......................... 88

5.3.1 Order Parameters from Empirical Observation of Urban Systems Evolution Over Time .......... 89

5.3.2 Parameter Space and Pattern Space ................... 90

5.3.3 Results ............................................. 91

5.4 Conclusion: Acknowledging Historical Contingency for the Prediction of Potential Urban Futures ........ 93

References. ................................................ 94

## 6 An Innovative and Open Toolbox

6.1 Introduction .......................................... 97

6.2 The Ant Model ......................................... 98

6.3 Embed the Model in OpenMOLE. ......................... 99

6.4 Do Repetitions ......................................... 102

6.5 Automatic Workload Distribution .......................... 103

6.6 Expose the Variability of the Model ....................... 103

6.7 Aggregate the Results ................................... 104

6.8 Explore the Space of Parameters ......................... 106

6.9 Optimization with Genetic Algorithms ..................... 110

6.10 Sensitivity Analysis with the Profiles Method ........... 112

6.11 Validation, Testing Output Diversity .................... 115

References. ................................................ 117

Erratum to: Urban Dynamics and Simulation Models ................. E1

Knowledge Accelerator’ in Geography and Social Sciences:

Further and Faster, but Also Deeper .......................... 119
Urban Dynamics and Simulation Models
Pumain, D.; Reuillon, R.
2017, XXII, 123 p. 40 illus., 27 illus. in color., Hardcover
ISBN: 978-3-319-46495-4