City-State Interactions in a Resource-Constrained Environment: an Agent-based Model

Andrea Piras,[1] Francesco Bertolotti,[1]

1. School of Industrial Engineering, LIUC Università Cattaneo, Castellanza, 21053, Italy

Understanding city-state dynamics in a resource-constrained environment could shed light on historical entities' decision-making and inform modern policy decisions. This research employs an agent-based model (ABM) [1] to assess the different strategies a city-state can undertake to achieve survival and prosperity over a given time span.

The model includes three kinds of agents: city-states, villages, and soldiers, each with an explicit location on a two-dimensional surface characterized by a heterogeneous level of fertility. City-states possess several behavioural preferences, representing heterogeneity in urban governance and development. These include the likelihood of establishing new villages, investing in military and civil technology or wealth, upgrading fortifications, recruiting new units, and organizing military missions. City-states can recruit soldiers, who follow their orders, engage enemies in battles, and manage their food requirements in villages and open fields. Villages produce food and transfer it to the city-state to which they belong. Also, villages can periodically increase their fortification to withstand attacks.

At the beginning of each simulation, a defined number of cities and villages are established throughout the landscape. The model's core is the city-state's decision-making process, where each city-state has its unique preferences, which influence its behavior, that encodes the risk preference both in offensive and defensive situations. A risk-averse city could have a conservative strategy, defending with higher intensity their villages or recruiting more troops to guard the city. [2][3]

The exploration of the ABM allows us to find the best possible combination of behavioural parameters for a city-state, for a given set of environmental parameters. A sensitivity analysis examines the relationship between city-states and environmental conditions [4].

References

[1] Eric Bonabeau, "Agent-based modeling: Methods and techniques for simulating human systems", 2002
[2] Randall G. Bowdish, "Military Strategy: Theory and Concepts", 2013
[3] Dominic K. Albino, "Military Strategy in a Complex World", 2016
[4] Bertolotti, F., Locoro, A., and Mari, L. (2020). Sensitivity to initial conditions in agent-based models. Multi-Agent Systems and Agreement Technologies: 17th European Conference, EUMAS 2020, 2020, 501–508.

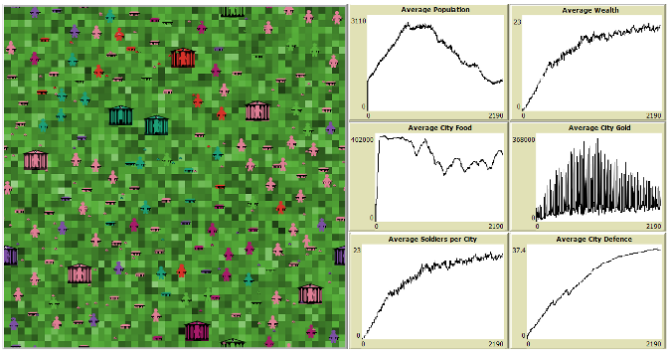

Figure 1: Graphical user interface