**Model description: Fission-fusion cycles in *polis* formation**

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1. **Research context and questions**

Communities form the backbone of society and provide crucial loci of social life. One of the most important forms of community in antiquity was the *polis*, characterised as a civic and urban community. One important model of *polis* formation was developed by John Bintliff for the region of Boeotia (Greece) from Iron Age to Hellenistic times (ca. 1000-31 BCE). The model showed how larger *polis* communities emerged out of village communities through fission-fusion dynamics (Bintliff, 2012). Driven by a moderate process of population growth, a small number of small-scale communities developed into sizeable villages in Iron Age times. As communities grew, they reached scalar thresholds in community sizes imposed by cognitive limits to information processing (Wobst, 1974). In order to overcome these thresholds, communities had to develop additional social structures to regulate social life and transpose individual information processing to collective processing through social organisation. This development eventually initiated a pathway towards *polis* formation, where communities obtained an urban and political character.

A different body of work developed in settlement scaling studies, has shown that communities can be considered as social reactors, meaning that they amplify the increasing returns of social interaction through energized crowding (Bettencourt, 2013; Bettencourt, Lobo, & Strumsky, 2007). The effects of these interactions can be both positive and negative, resulting in community formation and socio-economic growth (growing communities) on the one hand, and scalar stress (splitting communities) on the other (Smith, 2019). This field therefore provides a micro-level (intra-community) explanation of meso-level (inter-community) effects characterised by fission-fusion cycles (Crema, 2014; Griffin, 2011).

The original goal of this model was to investigate the manifestation of energized crowding processes in settlement patterns through fission-fusion dynamics. By simulating processes of interaction within communities and the effects of information transmission on a community level, through the implementation of innovation and scalar stress, it would explore the underlying drivers of community fission and fusion. In the end, within the framework of this exercise, this turned out to be too much to include all at once. I therefore decided to focus on the modelling of fission-fusion cycles in settlement patterns, as well providing a potential implementation of an interaction module. However, these two components are not yet integrated in the current version. That is, interactions, information transmission and innovation do not directly drive the patterns of community fission and fusion. A tentative scheme for integration was tried, but considered too artificial. I therefore decided to leave this part out and reserve the integration for a later stage as I continue the development of the model beyond this course.

In the current model, it is interesting to explore how different thresholds for fission and fusion probability, as well as smaller or larger community territories have an effect on fission-fusion cycles and the manifestation of settlement patterns. It is moreover interesting to explore the interplay between villages and *poleis* and their respective impact on the settlement network, and the impact of different scalar thresholds on settlement size distributions.

1. **Description of experiment design**

For description of experiment, see BehaviorSpace experiment “*Submission-experiment*”.

1. **Discussion simulation results**

Due to time constraints, no systematic model analysis could be conducted. However, during coding and testing of the code, interesting behaviour could be observed in the interactions between villages and polis communities, and the interplay between settlements. It is my intention to continue working on this model in the future beyond this course, and I promise that as soon as I am able to properly analyse the results, I will share these with the instructors.