# PG-ABM: An Agent-based Model of Politogenesis

## Abstract

Politogenesis concerns about how and why polities are originated. In this study we first discuss a formal theory of politogenesis, and then propose a model (an agent-based simulation) that helps exploring how the most primitive socially complex polities, i.e. chiefdoms, can emerge from simple non-complex societies.

## Introduction

Members of simple, non-complex societies are known to be socially unranked (egalitarian), they do not have any centralized managements, and their social relations are primarily based on kin-relations. On the other hand, even in the simplest complex societies (i.e. chiefdoms) political and economic power is exercised by a single person (chief) who is supported by a group of persons where each rules local communities. Therefore, chiefdoms are socially ranked, have a specialized management, and the social relations are non-kinship based (Cioffi-Revilla 2014).

We first see the discussion on the origins of polities in the social contract theory of Rousseau (Rousseau 1762). Some other narrative and formal social theories of politogenesis have also been introduced since then. In this study we build an agent based simulation model on Cioffi’s formal theory (Cioffi-Revilla 2014).

The core questions in the politogenesis are three:

* How the requirements are met (potential attained) for a simple society to start evolving into an initial social complexity?
* What are the characteristics of these requirements (elements of the potential)?
* Under what circumstances can the potential be realized (and hence the initial social complexity is emerged)?

Based on the theories and thought experiments answering to these questions we build an agent-based model where simple societies can accumulate potential and finally emerge into socially complex chiefdoms. We validate our model by creating a spatially explicit heatmap of these realizations.

### Why agent based modeling and not system dynamics?

The event-based causal structure of Cioffi’s theory captures the ontology of politogenesis in a way that is closer to agent simulation than the systems dynamics of differential equation-based systems. Although it is a mathematical theory based on probability theory, the social aspect of the problem with many interrelated dynamics and causal relations, occurrence and emergence of events makes the system more suitable for an agent-based model.

In system dynamics we describe a target system with its properties and dynamics by using a system of equations, and derive its future state from its current state. In a system dynamics model individuals (or other discrete entities such as products, events, etc.) are represented by their quantities so they lose any individual properties, histories or dynamics (System Dynamics — AnyLogic Simulation Software n.d.).

As stated by Gilbert and Troitzsch (2005) system dynamics is based upon differential equations and restricted to the macro level. Therefore, the properties of undifferentiated whole are represented by the states of stock/flow and changes in level/rate variables in these equations. Figure 1 is given as an example of stock/flow diagram, which is a specific graphical description language of system dynamics models.

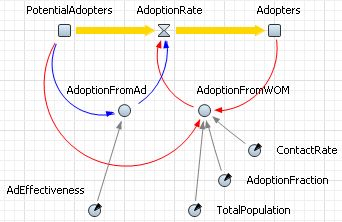


Figure 1 System dynamics stock and flow diagram

On the other hand, as a much more natural way than describing stocks and flows, in agent-based modeling one can model individuals’ (i.e. agents’) attributes, motives (intensives), perceptions (senses), cognitive (decision making and learning) skills, actions, reactions and interactions in object oriented programming (OOP). This object oriented programming approach became popular in computer science in the early nineties and has allowed computational social scientist researchers create such models in a very easy and natural way. Unlike other modeling approaches based on equations where one has to define the phenomena precisely, ABMs are not meant to be precise, hence do not lack of flexibility in exploring phenomena.

Moreover, modeler can create an environment for the agents to dwell on and interact, spatial or abstract; where connections can be on neighborhood basis only, or at social network level. Then the modeler can run his model and observe the emergent behavior at a higher level. ABMs therefore can be extremely flexible as the modeler can freely decide what kind of constraints she would like to put on her model. Therefore, we model this theory using agent based simulation techniques and implement in MASON toolkit (Luke et al. 2003).

Additionally, ABMs are complete (and in this manner precise) because every perception, decision, and action of an agent (and its interactions with other agents and the environment) has to be decided precisely and implemented in the model. Another advantage of agent-based models in exploring social or complex phenomena is the extent of heterogeneity in the model. Every single individual in the model might have different set of features (as in the case of human societies).

## History of Eurasia

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## Cioffi’s Formal Theory

This study is primarily based on Cioffi’s formal theory of politogenesis. Cioffi in his article makes thought experiments and comes up with nine required features (components of potentials) that a simple society has to possess to become chiefdom (Cioffi-Revilla 2014). In the next chapter we describe and synthesize these requirements, and we further discuss how to model them in our simulation. Potentials:

* Kinship knowledge
* Communicative ability
* Normative sociality
* Social identification ability
* Environmental knowledge
* Knowledge of normal vs. rare events
* Food procurement ability
* Homicidal ability
* Collective action ability

### Definitions and Concepts

#### Kinship knowledge

Definition goes here…

## Model Description

The environment consists of a biophysical landscape inhabited by a kin-based society. The initial agent rules are based exclusively on knowledge and skills such as those specified by conditions 1–9. Situational changes activate agent decision-making and produce decisions, behaviors, and emergent patterns that generate politogenesis.

Theory can be employed to predict precise locations for politogenesis, based on prior causal potentials, and can be tested: Locations with highest potentials should coincide with the four politogenic regions known from archaeology (the Levant, China, Peru, Mesoamerica) as well as related areas that may not have generated states until relatively recent times but did generate chiefdoms (e.g., North America, Amazonia, subsaharan Africa, south Asia, and Europe).

### Assumptions

## Model Outline

### Agents

#### Attributes of Agents

### Environment

#### Attributes of Environment

## Conclusion

## References

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