Midterm 1 Written Report

1 Research Question

How does technological innovation and its monopolization by one group impact social inequality?

2 Tentative Hypothesis

The monopolization of innovation systematically leads to greater social inequality as the innovating group systematically outcompetes the other due to resource efficiency and survival capability.

3 Modification

3.1 Github Repository

Please follow this link to access the Github Repository for modified model.

3.2 Motivation

The goal of this modification is to examine how technological advancement and its monopolization within one group can influence inequality within an artificial society. This setup offers an abstract representation of how technology sanctions targeting a specific group can trap them in a structurally disadvantaged position. A real-world parallel is the technology containment strategy adopted by the United States toward China, which aims to slow China's military development and modernization efforts. This has included expanded export controls and stricter visa screening for students and scholars in sensitive fields, limiting access to advanced technologies and knowledge networks.

3.3 Impact

In the simulation, multiple technology levels are introduced to more accurately reflect the gradual and cumulative nature of innovation. The benefits of advancing to higher levels are designed to diminish over time, modeled through customizable base reduction scales. This feature captures the idea that while technological progress can lead to increased efficiency and resource use, each successive leap may offer smaller marginal gains, reflecting diminishing returns.

3.4 Details

3.4.1 The Agents

In `agent.py`, two new attributes are added during agent initialization. The affiliation attribute assigns agents to one of two groups: group 0 (innovating) and group 1 (sanctioned). Innovating agents can innovate and advance their technology levels up to a maximum of five. In contrast, sanctioned agents remain at technology level one throughout the simulation.
A function `update_tech_level` is introduced to handle technology advancement. When an agent upgrades, their technology level increases by one, and their metabolism is updated based on a fixed percentage of their current level, reflecting greater resource efficiency.
An `innovate` function governs whether an agent can attempt innovation. This process requires the agent to meet four conditions: (1) sufficient sugar to survive another round, (2) membership in the innovating group, (3) a success probability exceeding a random number between 0 and 1, and (4) not having already reached the maximum technology level. The probability of successful innovation is determined by multiplying the agent's sugar level by a predefined innovation difficulty factor. This reflects the idea that innovation is resource-dependent and more likely with greater resource availability.
The `share` function allows innovation diffusion. An innovating agent selects a neighbor within vision range who shares the same affiliation. If the neighbor has a lower technology level, their level is increased by one using the `update_tech_level` function.

3.4.2 The Model

In `model.py`, two new functions are added: one calculates the proportion of innovating agents, and the other computes their average technology level. The model's initialization also includes parameters for minimum and maximum technology levels, innovation difficulty, and a reduction scale. The reduction scale (e.g., 0.9) indicates how metabolism adjusts with innovation. If an agent with metabolism 3 innovates, it becomes 2.7, implying improved efficiency under harsher conditions. The innovate and share functions are incorporated into the model's step function.

3.4.3 The Visualization

Finally, `app.py` is updated for better visualization. Innovating agents appear in yellow and sanctioned agents in purple. The interface includes two additional plots and options to modify variables.

4 Speculative Results

4.1 Imbalanced Survival

The ratio of innovating agents relative to the total population initially rises and then levels off, indicating an uneven survival rate between the innovating and sanctioned groups. Over time, more innovating agents survive and benefit from technological progress, while sanctioned agents remain stagnant and are systematically outcompeted.

4.2 Rise, Decline, and Leveling off of Gini Coefficient

The Gini coefficient rises steadily until the average technology level among innovating agents approaches the maximum of five, signaling that their innovation potential has been exhausted. Then, the Gini coefficient trend starts declining and flattens out, mirroring the stabilization in the ratio of innovating agents. The initial spike in inequality is largely due to random starting positions, where agents placed closer to sugar-rich areas gain early advantages. However, the continued increase in Gini coefficient afterwards reflects how innovation boosts resource efficiency for innovating agents, and the benefits from innovations compound as they converge towards the sugar-rich region and have more chances of contact with agents of the same affiliation.

4.3 Few Inhabitants on Resource-Rich Land

Setting a low innovation difficulty provides a clearer view of how innovation spreads step-by-step. Although this leads to a sharper rise in the Gini coefficient, it does not significantly affect survival differences between affiliations, as many weaker agents are already eliminated during the initial convergence phase. We observe fast wealth accumulation on a resource-rich land with few inhabitants.