**Economic Wealth & Inequality: What can agent-based model simulations tell us?**

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**Background**

The research project implements an agent-based economic model in which agents gather resources, trade, and make devices that will increase the speed of gathering resources. By controlling the level of social inequality among agents, we can observe the results on economic growth and wealth inequality.

**Objective of this Project**

1. Finish the line-by-line conversion from Python to C++ so it can more quickly and test the converted C++ code to make sure it works the same as the Python version.
2. Add ability to run batches of jobs in which agent groups are heterogeneous in trade power, resource gathering speed, device making speed, and device inventing speed.

**Conversion**

The Python version took several days to run a simulation using 24 agents, 24 resources in 3000 “days” of agent time. The results of the C++ version were verified by running unit tests for all multiple scenarios and comparing the results with the original Python version. After complete conversion, the C++ version took 1.66 hours using the same settings.

**Trade Power**

When unequal trade power is added to the model, more powerful agents skew the bargaining price for resources or devices so they get a larger portion of the gain from trade. Trade power = 1 means all agents are equal. The larger “trade power” the more unequal the gains from trade are split.

**Wealth**

Units held represents the wealth of agents. The graph compares the wealth when Group 1’s trade power is 1, 3, and 1000. The higher the trade power is, the richer Group 1 is and the poorer Group 0 is, which means the difference between the two groups’ wealth gets larger when the difference of trade power between the two groups gets larger. Importantly, even though one group becomes richer, overall wealth for society is lower when one group reaps a larger, unequal portion of the gains from trade. Greater inequality accompanies lower economic growth.

**Time Usage**

The graph shows that the high trade power group uses much more time gathering resources with machines and factories, especially factories, than the low trade power group. That is, more technological sophisticated and less labor intensive devices. A possible explanation is that the unbalanced trade power created two classes: an advanced technology class that produces more higher order devices and a less sophisticated class that spends much less time making higher order devices and does all of the gathering of resources with lower order devices.

**Inequality**

We used our model to study what happens to economic growth and wealth inequality when several parameters of model are adjusted:

-- Agents given less or more “monopoly power” when they first invent a device.
-- Some agents are given unequal power when making trades.
-- Some agents are faster than others at gathering resources, inventing devices, or making devices.

**Inventor Monopoly Power**

Inventor device experience (IDE) is the experience that a device’s inventor immediately gets when it invents the device. It is a measure of how much advantage the inventor has over other agents when it comes to making and selling duplicate devices. The default IDE is 6. The higher IDE is, the more difficult for other non-inventor agents to copy the device.

The graph shows two cases: the default 6 and 40, which gives the inventor maximum power. We found that when IDE is high, devices are discovered (invented) earlier than when IDE is low. The discovery corresponds with the Schumpeterian Hypothesis, which states “Large firms in concentrated markets are more likely to support innovation.” (1).

**Device Making Speed**

After a device is invented, agents need to gain experience by making copies of it. When they have enough experience, they can make copies efficiently. The required amount of experience controls the device making speed, that is, if the minimum experience needed is very high, agents need to spend a long time gaining experience which slows down making speed.

**Inequality and Wealth**

The gini coefficient (2) is used to measure wealth inequality. High gini means high inequality and low gini low inequality. When two groups are the same, the gini over all agents is about 0.073, that is, there is basically no inequality. Even though random chance has benefited some agents more than others, the gain is quickly distributed throughout society by trade. The first graph on right shows the average gini of all agents when one group’s device making speed is faster is about 0.103, which means there is more inequality among agents than when all agents are the same.

Wealth According to the units held graph (the second one on the right), the fast group is also much wealthier than the slow group. It basically creates two classes, a rich technologically sophisticated class and a relatively poorer labor class. More importantly, the average units held of all agents is about 43803, compared with 39897 when no group distinction exists among agents.

**Device Made**

The gini coefficient when Group 1’s device making speed is twice the Group 0’s.

The dark blue line is the average units held for all agents when both groups have trade power 1. The other lines represent the average units held for each group when Group 1’s trade power is 3 or 4000.

The average time that both groups use to gather resources using tools, machines and factories when Group 1’s trade power is 1000 and Group 0’s is 0. (The original 3000 “days” data is deprecated to only include the first 1000 “days” to make it clearer. The trend does not change for the last 2000 “days”)

The total number of each type of devices made when IDE is 6 and 40 up to “today”.

The average units held for both groups and all agents when one Group’s device making speed is twice the Group 0’s. The dark blue line represents the average units held when all agents have the same device making speed.

**Inventing Speed**

Agents have the opportunity to invent and make devices, which help them gather resources faster. Some agents have their invention speed reduced to represent lack of access to resources, capital, or education.

**Future Work**

Limited Resources: The model currently allows agents to gather resources without depleting the environment, which is not true in reality. It would be useful to add functions to control the total amount of resources, the number of resources each agent can extract on any “day”, and the distinction between renewable and nonrenewable resources.

Agent Behavior:

Adding more heterogeneous properties to agents, such as fraud and sickness, would better simulate the real world. Top-down social policies and labor market exchanges are also planned for future implementations.

**References**


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