Trade and the Spread of Civilizations

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Abstract

There are a limited number of resources in the world, many of which we need to live. Individually, only a few people would be lucky enough to be in a location with enough resources to survive. The majority of the population, however, would be unable to sustain themselves, having access to only a few resources. The only way for these people to survive is to trade with others, exchanging their excess for necessities. Most everyone is willing to trade if they get something they want, but not many will trade for things they don't need. However, people are willing to give away spare resources to help out if they know that the other will do the same if the situation reverses. These friendships eventually form societies, large networks of individuals collaborating together. Survival is much more likely if one is part of a society than living outside of one. Even still, resource management remains key to survival of not just the individual, but also of the society. Cooperation and coordination is necessary to make sure everyone has access to what they need, and is one of the most influential factors that enabled ancient society to reach where we are today. In this study, effective resource management strategies are gauged and tested by four civilizations in a limited world. We found that civilizations that share their wealth more between members have a higher number of surviving members than those who hoarded resources.

Methods

To test the hypothesis that altruistic civilizations would have better survival rates, we created a simple simulation of theoretical ancient civilizations. For our simulation, an agent-based model was chosen as opposed to a mathematical model, as it is better able to simulate the actions of individual agents. The setup for the model is detailed below. All phases are repeated each turn.
In every run of the simulation, the "world" was set up with each civilization given four tiles in the center of a quadrant. The right two civilizations were sharing civilizations, while the left two were selfish.

Initial Setup

1) Tiles were randomly assigned to be a part of a civilization (represented by color)
2) Tiles are assigned modifier values for each of 3 resources. This is how much of each resource will be generated each turn
    a) F = Food
    b) H = Water (Hydration)
    c) W = Wood

Turns

Phase 1 - Resource Distribution

1) All tiles receive a number of each resource determined by the tile resource modifier values

Phase 2 - Trade

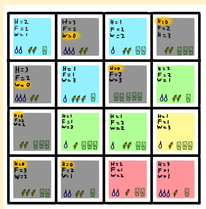
1) Tile actions go in order from top left to bottom right
2) Selected tile looks at its resources and determines what it needs to survive
    a) Tiles need at least 1 of every resource to survive to the next turn
    b) If the tile does not need anything to survive, it will skip this phase
3) The tile will look at a random surrounding tile (in a plus pattern) and offers to trade with one to get the resources it needs
4) The tile initializes the trade with the new tile. It offers one of its unneeded resource for what it needs from the other
5) The other tile will either accept or decline, depending if it needs the resource to survive.
    a) However, if the other tile is of the same territory as the one offering the trade, it will accept as long as trading still allows it to survive
6) Once all the tiles have gone a first time, the trade happens again, for a total of two trade rounds

Phase 3 - Sharing

1) Civilizations are either sharing or selfish. Only the sharing civilizations do this phase
2) If a tile is next to a tile of the same civilization, it checks to see if it has more of a resource than the neighbor
3) If it does, it gifts one of that resource to that neighbour

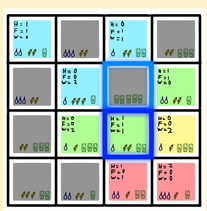
Phase 4 - Death

1) If a tile has not managed to secure enough resources to survive, it dies
2) All surviving tiles consume one of each resource



Phase 5 - Expansion

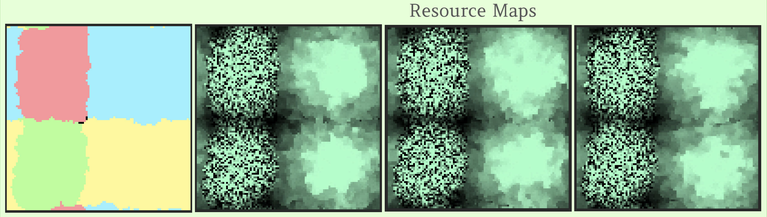
1) If a tile is neighboring a dead tile, the selected tile can attempt to conquer it using one of each resource. Once that is successful, the tile joins the same group as the tile that conquered it



Results

The purpose of this research was to test different trade strategies within civilizations that had limited resources. Since each tile needed resources to survive, trade was crucial to survival and spread of the civilization.
Below are the statistics from the end of simulation outputs from a 100x100 world with 75 turns and a resource carrying cap of 75.

Resource Maps



Civilization map. Each color represents a different civilization. Black tiles are dead (civilization 0)

Food Heatmap | Water Heatmap | Wood Heatmap

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Turn #75
Civilization0: 5
Civilization1: 1946
Civilization2: 3016
Civilization3: 1781
Civilization4: 3252
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(left) Civilization populations at the end of the simulation.
Civilization 0 is dead/unconquered tiles (black space on the Civilization map). Civilizations 1 (centered top left on maps) and 3 (centered bottom left on maps) are selfish, 2 (centered top right on maps) and 4 (centered bottom right on maps) are altruistic.

Survival was highest among the altruistic civilizations. While some individual tiles have higher resource counts in the selfish civilizations, there are fewer live tiles. There is less individual wealth (when there's a higher resource carrying capacity) in altruistic civilizations, but they are better able to spread and survive since every tile has the resources to spread outward.
Further topics could be explored with similar simulations. Specifically, more trade strategies can be explored to find more optimal trading patterns. Natural disasters could also be tested, to see which survival strategy works best when the world isn't constant, especially if there are extended periods of time where certain resources aren't available. Combat could also be added, where civilizations must protect their resources from enemies. These could add further depth to the simulation to learn more optimal survival strategies.

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