Production and distribution of wealth on a dynamic complex network

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Substantial increases in global wealth and income inequalities since the beginning of the 21st century [1] have drawn the attention of researchers beyond traditional economic theory. Agent-based models allow us to define the rules of interaction between economic agents and analyze the complex emergent phenomena. These types of models are generally applied in mean-field fashion, where agents are randomly selected to perform pairwise interactions. Moreover, they are typically restricted to a conservative market. While this approach has proven to be very useful, further improvements are needed to better reflect real-world systems. Introducing a growing economy, beyond the usual conservative market, appears to be a natural extension for agent-based models. Another interesting aspect is the topological connections among agents. In this work, we investigate a recently proposed dynamic complex network agent-based model [2] within a growing economic scenario. The model evolves through three alternating processes: independent wealth growth of each agent, exchange of wealth between connected agents, and rewiring of connections. For the growing, we consider Brownian motion with two parameters: a drift μ, representing the growth, and the volatility σ, representing the heterogeneity in productivity. For the exchange of wealth we use the Yard-sale model, where the wealth exchanged between agents i and j is defined as $\Delta\omega(t) = \min[\alpha_i\omega_i(t), \alpha_j\omega_j(t)]$, where $\omega_i(t)$ is the wealth and α_i is a risk factor. We assume a probability of the poorest agent winning the transaction given by $p_{i,j} = \frac{1}{2} + f \times \frac{|\omega_i(t)-\omega_j(t)|}{\omega_i(t)+\omega_j(t)}$, where f is the social protection factor, which varies from 0 to 1/2. At every time step of the simulation each agent will make a transaction with all its first neighbors, satisfying all the edges of the network. Therefore, the wealth of an agent i after a time step of the simulation is $\omega_i(t+1) = \omega_i(t)(\mu + \sigma dW) + \Delta_i\omega(t)$ where dW represents a Wiener process and Δ_i is the net amount of wealth traded. The rewiring process starts by randomly selecting a pair i, j of agents, if this pair is disconnected the probability of creating a new connection follows $P_{i,j} = \frac{\omega_i(t)+\omega_j(t)}{\sum_l \omega_l(t)}$ where the sum in l is only on agents with at least one connection. If the selected pair is already connected, the link breaks with the complementary probability $Q_{i,j} = 1 - P_{i,j}$. In the case of $f = 0$, our results show condensation of wealth and connections in a few agents, independent of μ and σ. A very small value of social protection ($f = 0.01$) favors agents from the middle and upper classes, leading to the formation of hubs in the network [2]. However, for a sufficiently large value of σ the condensate state is recovered. For larger values of f, the effect of production is much more significant, while an increase in μ is able to reduce the inequality, increasing σ has the opposite effect. In short, the increase in production benefits poorest agents only in a strong social protection scenario.

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References

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