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Collapse mitigation in a socioeconomic system under a systemic shock

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Systemic shocks inevitably lead to negative socioeconomic outcomes. The COVID-19 pandemic and the war in Ukraine are the prominent examples of such systemic shocks. Shock-initiated spreading processes often have a domino effect on both the social and economic levels. The war in Ukraine, despite its devastating effect on the Ukraine's society and economy, has not led to the full collapse, against all odds. In this work, we make an attempt to provide at least a qualitative illustration of the mechanisms governing the dynamics of a socioeconomic system in the state of collapse from the viewpoint of statistical physics. Surprisingly, we uncover common principles that allow the overall collapsing scenario to be mitigated, with the system's dynamics stabilized.

We consider a response of a socioeconomic system to a systemic shock in a group of economic agents with limited economic resource. To this end, we exploit a simple two-level model of active and passive economic agents with mutual negative feedback between the number of active agents and collective resource acquisition [1]. In this case, economic resource is associated with the average amount of money or income per economic agent and formally corresponds to the effective market temperature, with the income distribution of economic agents obeying the Boltzmann–Gibbs statistics [2]. The coupling between the spreading process and resource in such a system is supposed to be of activation type, with the transition rate between the passive and active populations governed by the activation mechanism (Arrhenius-like law). A characteristic level of resource consumption is associated with activation energy (e.g., corresponding to the minimum level of resource consumption in our particular case).

We show that the phase portrait of the system features a collapse phase, in addition to the shock-free and post-shock phases. The shock intensified by the increasing resource deficit can ultimately drive the system to a collapse at nonzero activation energy because of limited resource – the effect opposite to thermal explosion. In this case, the system can no longer stabilize and return to the stable shock-free state or a poorer post-shock state. We demonstrate that there exists a certain critical point at which the system collapses at any initial conditions. Moreover, social regulations in the case of low economic resource can have a negative effect and provoke the system's collapse. On the other hand, there are simple external measures that can protect the system against the collapse, which make the focus of our investigation. We demonstrate that the system's collapse can partially be mitigated by external subsidies meaning constant resource inflow from some external source or by means of debt interpreted as a negative resource.

It is interesting that a two-level model considered here formally describes the dynamics of cooling of a system of agents due to shock-induced transitions between two discrete inner states of agents. In this case, the crisis state of the financial market can be associated with a Bose condensate-like state at low market temperature [3]. A more complex multi-level system of interacting agents as well as different interacting social groups can also be considered [4].

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Primary authors: GANDZHA, Ivan (Institute of Physics, National Academy of Sciences of Ukraine); KLIUSHNICHENKO, Oleksandr (Institute of Physics, National Academy of Sciences of Ukraine); LUKYANETS, Sergey (Institute of Physics, National Academy of Sciences of Ukraine)

Presenter: LUKYANETS, Sergey (Institute of Physics, National Academy of Sciences of Ukraine)

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