Review of: "Gamification of the overexploitation of natural resources. An operational game based on System Dynamics"

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Review of *Gamification of the overexploitation of natural resources. An operational game based on System Dynamics*, by Ugo Bardi and Ilaria Perissi

This is an outstandingly well-written, clear and succinct paper that accomplishes two important and complementary goals. It explains in simple but rigorous terms the Lotke-Volterra system of differential equations and it develops a lively board game that is suitable to implementing the equation system with variable degrees of complication. It is a game that should also appeal to a wide range of ages and interests, and that, as the authors correctly point out ".... is not intended as a tool to indoctrinate players to accept a specific view. The game only shows that, given certain conditions, human actions directed to maximize profits may lead to overexploit and destroy natural resources……".

The paper is so well written, and the game so well designed, that I have very little to suggest with regards to what *is* in the paper. As a geologist who has worried for many decades about the exhaustion of mineral resources, I do have some suggestions about possible *variants* of the game. They all focus on a simple mathematical fact that should be obvious but appears not to be, or perhaps to be easily swept under the rug in the pursuit of economic growth. This is the fact that a finite planet cannot sustain indefinite economic growth, and the indefinite population growth that provides the necessary scaffolding for economic growth. I realize that this is the goal of the Moby Dick game, but perhaps coming up with variants that address some urgent present day situations might be warranted. In particular, I would suggest addressing the catastrophically diminishing supply of fresh water and the critical scarcity of most of the metals required for decarbonation of the economy, including not only metals such as lithium required in batteries, but also copper for transmission lines.

The "Water Game" could be tied directly to human population. Freshwater would be replenished at a constant rate in each game round. Human population could grow at some rate that is a function of the supply of food, which in turn requires freshwater to grow. It might be possible to add a conflict aspect, whereby when human population exceeds the supply of

water, and thus food, it does not simply decrease by “natural” means, but rather different countries, represented by different players, enter into direct conflict with one another. The relative strengths of the countries, and their ability to cause population decline in their opponents (a euphemism for war, or course), might be based not only on their population sizes but also on such things as technological development and availability of other resources, which could be allotted at random at the beginning of the game (at random but independently, e.g., technology does not necessarily go together with resources, witness for instance Germany at the outbreak of World War I). Perhaps a game along these lines could open eyes about the more humane alternative of enforcing one child policies, compared to the unimaginable suffering of famine and war.

The “Lithium Game” might appear simply to be a variant of the “Oil Game”, but there are important differences that it might be possible to incorporate into the game. First, the situation as we approach the first third of the twenty-first century is one in which we wish to convert, seemingly overnight, an already highly developed and energy hungry world economy into an electricity-based economy. This is radically different from the situation a century and a half ago, when economic growth was a gradual process that imposed rising but gradual demands on the supply of fossil fuels. The second crucial difference is in the scarcity of the natural raw materials needed for this transformation, compared to the relative abundance of fossil fuels. To put it simply, there is not enough recoverable lithium in the Earth’s crust to electrify the world’s transportation system, let alone to, in addition, build battery stations to store electrical energy generated by renewables such as wind, solar and tides. And this is just to replace what is already there, it does not consider what would be required to foolishly sustain the chimera of “growth”. The same arguments apply to cobalt, nickel and even copper - we are already exploiting very marginal copper ore bodies, and it is not clear what the cost (economic and environmental) would be to supply the astronomical amounts of copper required for a fully electrified economy, not even whether the required amount of copper exists in recoverable mineral deposits. Incorporating all of this into a board game is almost certainly not easy, but I would urge the authors to give it some thought, as it might help to open minds to the fact that slogans such as “Net Zero” are just that - slogans. And that no way out of our predicament is possible unless we renounce the idea of indefinite economic and population growth.

In any event, I congratulate the authors on a magnificent effort and offer these suggestions as little more than food for thought.

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