Systems Approach Explains a Mysterious Slowdown Effect in Climate Economics

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Mysterious slowdown effect in climate economics: a brief description. Climate disasters – severe droughts, floods, ice storms – have a strong negative effect on the Gross Domestic Product (GDP). It seems reasonable to expect that once this event is over – and thus, all obstacles to eco0nomy growth are gone – the economy will continue to grow at the same rate as before. In reality, however, for quite some time the growth remains much slower [1, 2] – and economists do not know why this happens.

A similar slowdown can be observed after other disasters as well, e.g., after earthquakes, volcanic eruptions, etc. How can we explain this phenomenon?

Our explanation. Let $x_1, \ldots, x_n$ be parameters that describe the state of the economy, e.g., x_1 is GDP, x_2 is unemployment level, etc. In the absence of external disruptions, the rate of change $\dot{x}_i$ of each of these parameters depends on the current state of the economy: $\dot{x}_i = f(x_1, \ldots, x_n)$. The changes in x_i are relatively small. In a small neighborhood, every small surface is well approximated by its tangent plane, i.e., any smooth function $f(x_1, \ldots, x_n)$ is well approximated by a linear expression. Thus, a good description of the economy is provided by the following system of linear differential equations $\dot{x}_i = a_i + \sum\limits_j a_{ij} \cdot x_j$. It is known that a general solution of such a system is a linear combination of the terms $\exp(\lambda_k \cdot t)$, where λ_k are eigenvalues of the matrix a_{ij}:

$$x_i(t) = c_1 \cdot \exp(\lambda_1 \cdot t) + c_2 \cdot \exp(\lambda_2 \cdot t) + \ldots \tag{1}$$

Without losing generality, we can sort the eigenvalues in decreasing order $\lambda_1 > \lambda_2 > \ldots$ The term corresponding to λ_1 grows the fastest, so after a while, the relative contributions of all other term tend to 0, and we get $x_i(t) \approx c.\exp(\lambda_1 \cdot t)$, with growth rate λ_1.

After the disaster is over, the economy is described by the same system of equations, so the new solution also has the form (1). However, in this case, in general, the terms proportional to c_2, c_3, etc. can no longer be neglected. So, after time Δt, while the first term in the right-hand side of the formula (1) still get multiplied by the factor $\exp(\lambda_1 \cdot \Delta t)$ that correspond to growth rate λ_1, all the other terms get multiplied by smaller factors $\exp(\lambda_2 \cdot \Delta t)$, etc. As a result, the overall growth rate is smaller than λ_1 – which is exactly what has been observed.

References

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[2] J. Duncombe, "A new approach to an unresolved mystery in climate economics", *Eos*, Vol. 103, Paper 220417, https://doi.org/10.1029/2022EO220417.