Systems Approach Explains a Mysterious Slowdown Effect in Climate Economics

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1. 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 economy 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.
- 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?

2. Our explanation

- Let $x_1, \ldots, x_n$ be parameters that describe the state of the economy.
- For example, 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:

$$\dot{x}_i = f_i(x_1, \ldots, x_n).$$

- The changes in x_i are relatively small.
- In a small neighborhood, every smooth surface is well approximated by its tangent plane.
- In other words, any smooth function $f(x_1, \ldots, x_n)$ is well approximated by a linear expression.

3. Our explanation (cont-d)

- Thus, a good description of the economy is provided by the following system of linear differential equations

$$\dot{x}_i = a_i + \sum_j a_{ij} \cdot x_j.$$

- It is known that a general solution of such a system is a linear combination of the terms $\exp(\lambda_k \cdot t)$:

$$x_i(t) = c_1 \cdot \exp(\lambda_1 \cdot t) + c_2 \cdot \exp(\lambda_2 \cdot t) + \ldots$$

- Here λ_k are eigenvalues of the matrix a_{ij}
- 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 terms tend to 0, and we get $x_i(t) \approx c_1 \cdot \exp(\lambda_1 \cdot t)$, with growth rate λ_1.

4. Our explanation (cont-d)

- After the disaster is over, the economy is described by the same system of equations.
- So the new solution also has the form

$$x_i(t) = c_1 \cdot \exp(\lambda_1 \cdot t) + c_2 \cdot \exp(\lambda_2 \cdot t) + \ldots$$

- 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 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.
- This is exactly what has been observed.

5. References

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