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 \( \lambda_k \) 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 \( \lambda_1 \) 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 \( \lambda_1 \).
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 \( \Delta t: \)
  - 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 \( \lambda_1, \)
  - 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 \( \lambda_1. \)

- This is exactly what has been observed.
5. References


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