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Socio & Econophysics

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View on Population Changes in the Industrial Revolution Era

The human population is made up of individuals with inherent self-assembling and feedback interaction tendencies: first 'short-range' in local groups (family, tribes) and then 'long-range' (cities, states, and then even empires). The population develops in a closed Earth system. Nowadays, boundaries (spatial, resource, and ecological) that constitute essential constraints have emerged.

Doesn't this look like a description of a perfect Very Complex Soft Matter system?

The formation of human civilization began around 10 000 BCE, with the onset of the Anthropocene. Since then, the global population permanently risen, finally forming a pattern well beyond the simple exponential Malthus behaviour:

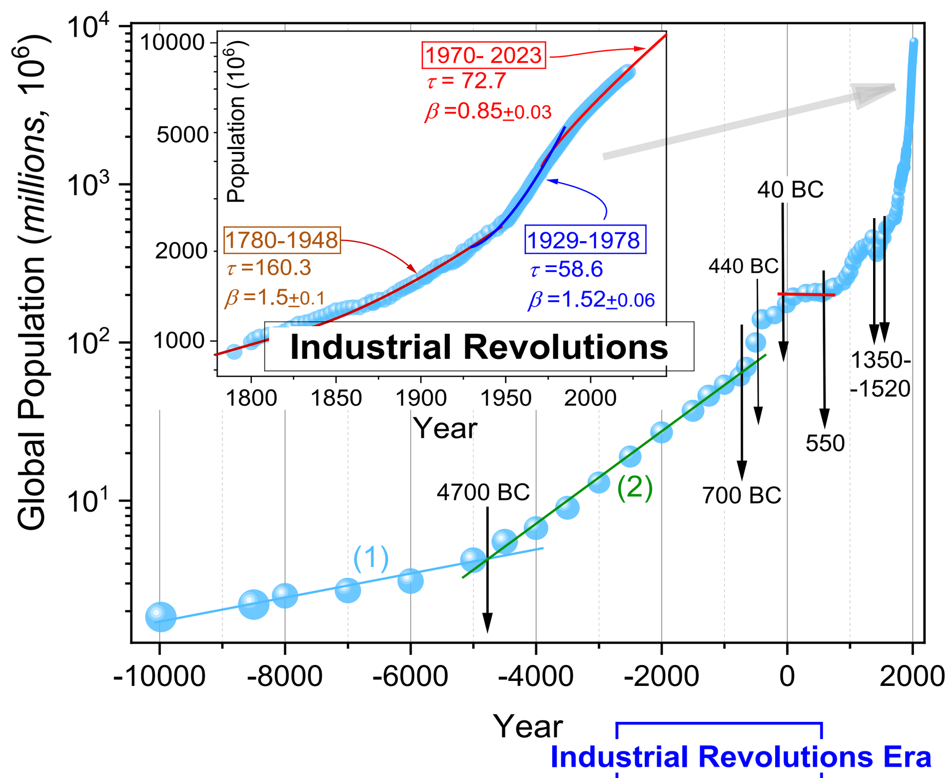
$P(t) = P_0 exp(r \times t) = P_0 exp\left(\frac{t}{\tau}\right)$ where $r = const$ is the Malthus growth rate and $\tau = 1/r$

τ - enabling estimation of the time needed to 50% rise of decrease from the current $P(t)$ value.

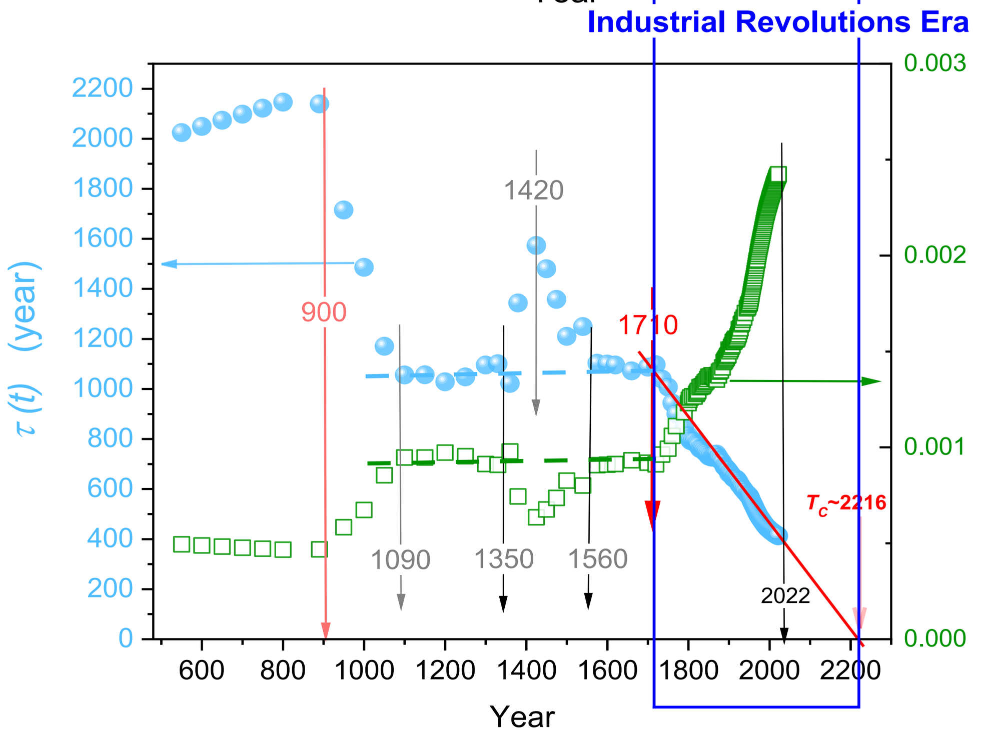
The above behaviour led to the proposal of the Super-Malthus concept behaviour:

$$P(t) = P_0 exp(t/\tau)^{\beta} \Rightarrow lnP(t) = lnP_0 \pm (t/\tau)^{\beta},\ \tau = const \quad (1)$$

$$P(t) = P_0 exp(r(t) \times t) = P_0 exp\left(\frac{t}{\tau(t)}\right) \quad , \tau(t) \neq const \quad (2)$$



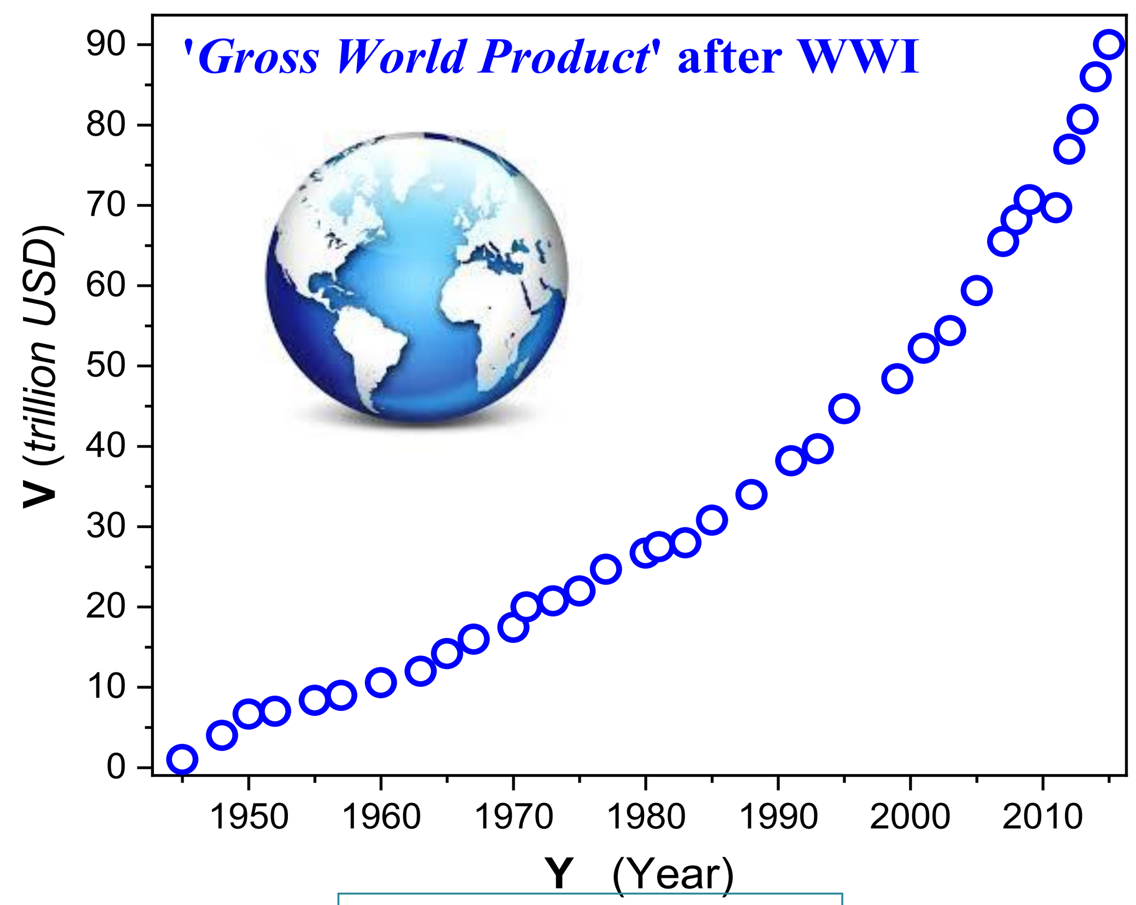
Eq. 1 is commonly in Soft Matter physics, with the exponent indicating the stretched exponential ($\beta < 1$; energy dissipation) or compressed exponential ($\beta > 1$, energy gaining) patterns; for $\beta = 1$, for the basic Malthus behaviour. Eq. 2 is trickier it requires the knowledge of relaxation time $\tau(t)$ in prior. Nevertheless, one can 'reverse' the analysis focusing on relaxation time itself instead of $P(t)$ portrayal: $(t) = 1/r(t) = t \times ln(P_0/P(t))$



The simple linear pattern $\tau(t) = a - bt$ in IR Era yield unique behavior for these times:

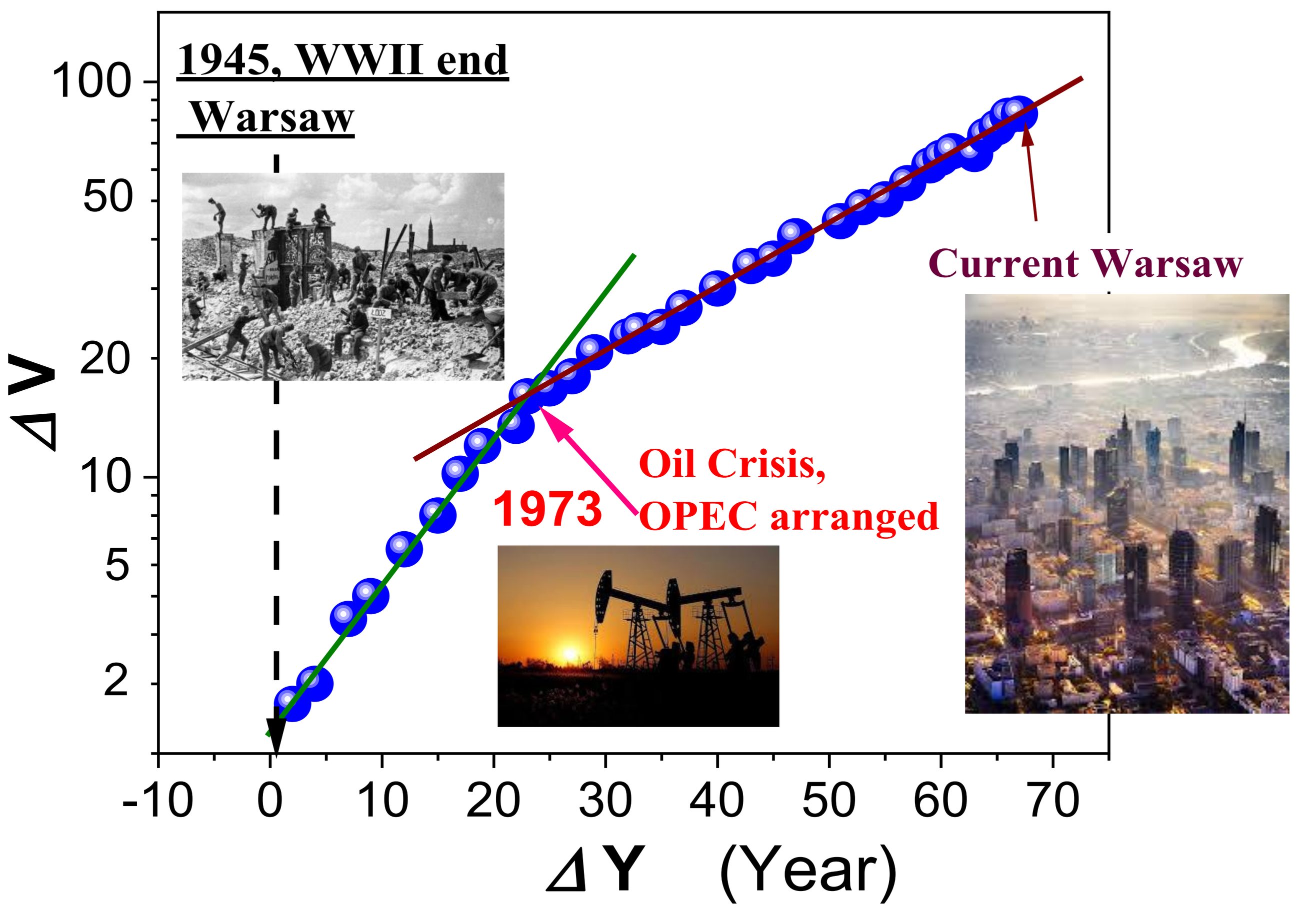
$P(t) = P_0 exp(b't/(T_C - t))$ coincided with the so-called Constrained Criticality pattern. Constrained by planetary Carrying Capacity?

The unique population growth, b after World War II ($P(1945) = 2.3\ billion, P(2025) = 8.2\ billion$), timesof great reconstruction on a qualitatively new socioeconomic basis, led to a previously unknown level of growth in global Gross Domestic Product (GDP).

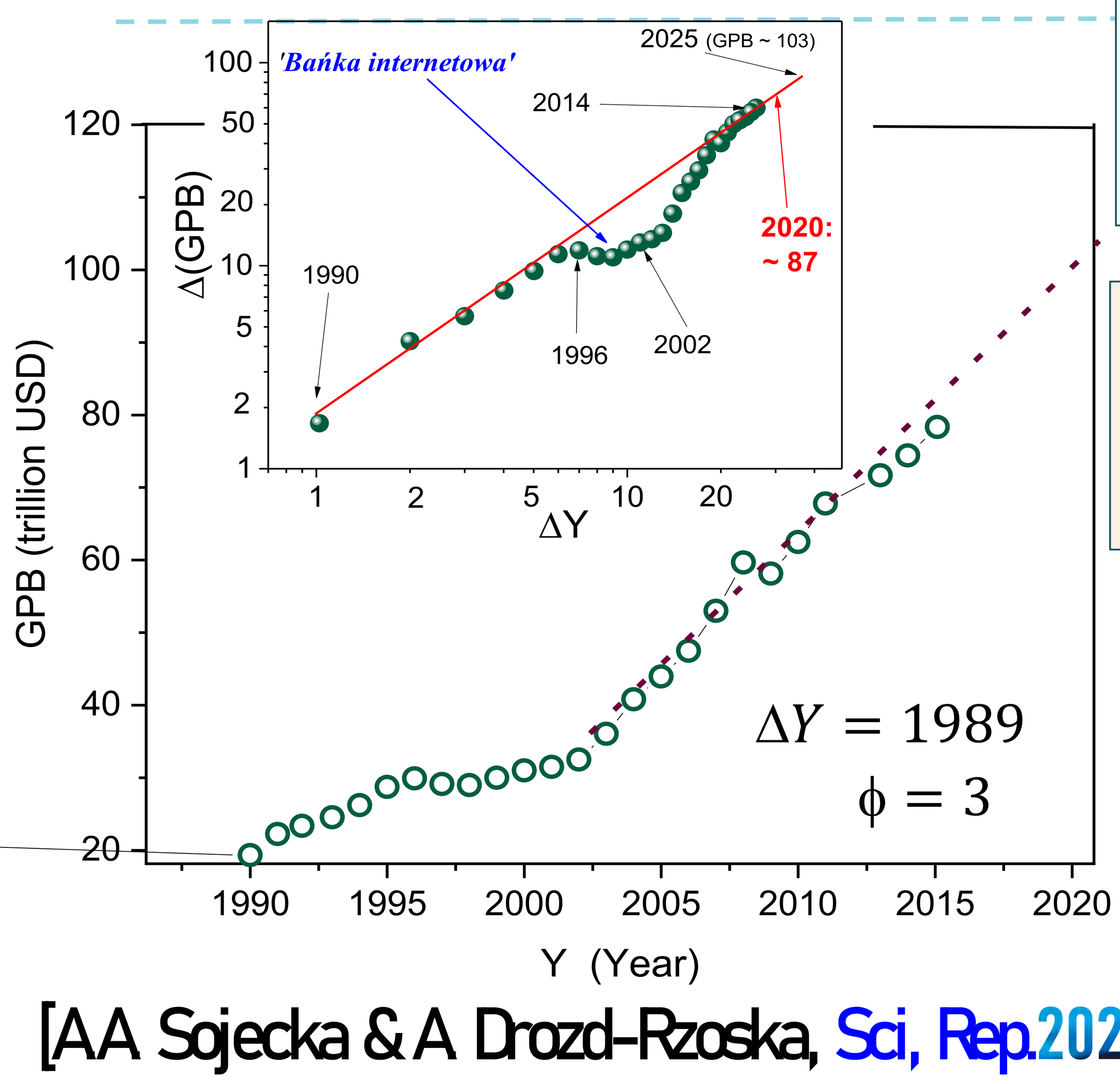


$$\Delta V(\Delta Y) = y_0 \exp(V_{free} \times \Delta Y) \rightarrow$$
$$\ln \Delta V = \ln y_0 + V_{free} \Delta Y = a + b\Delta Y$$

Since 1948 till nowadays the basic semi-log analysis reveals the exponential rise of GDP (the right plot). However, since 1989 (the collapse of the communist system & USSR) the focused insight reveals the super-boost critical-type (the left bottom plot)

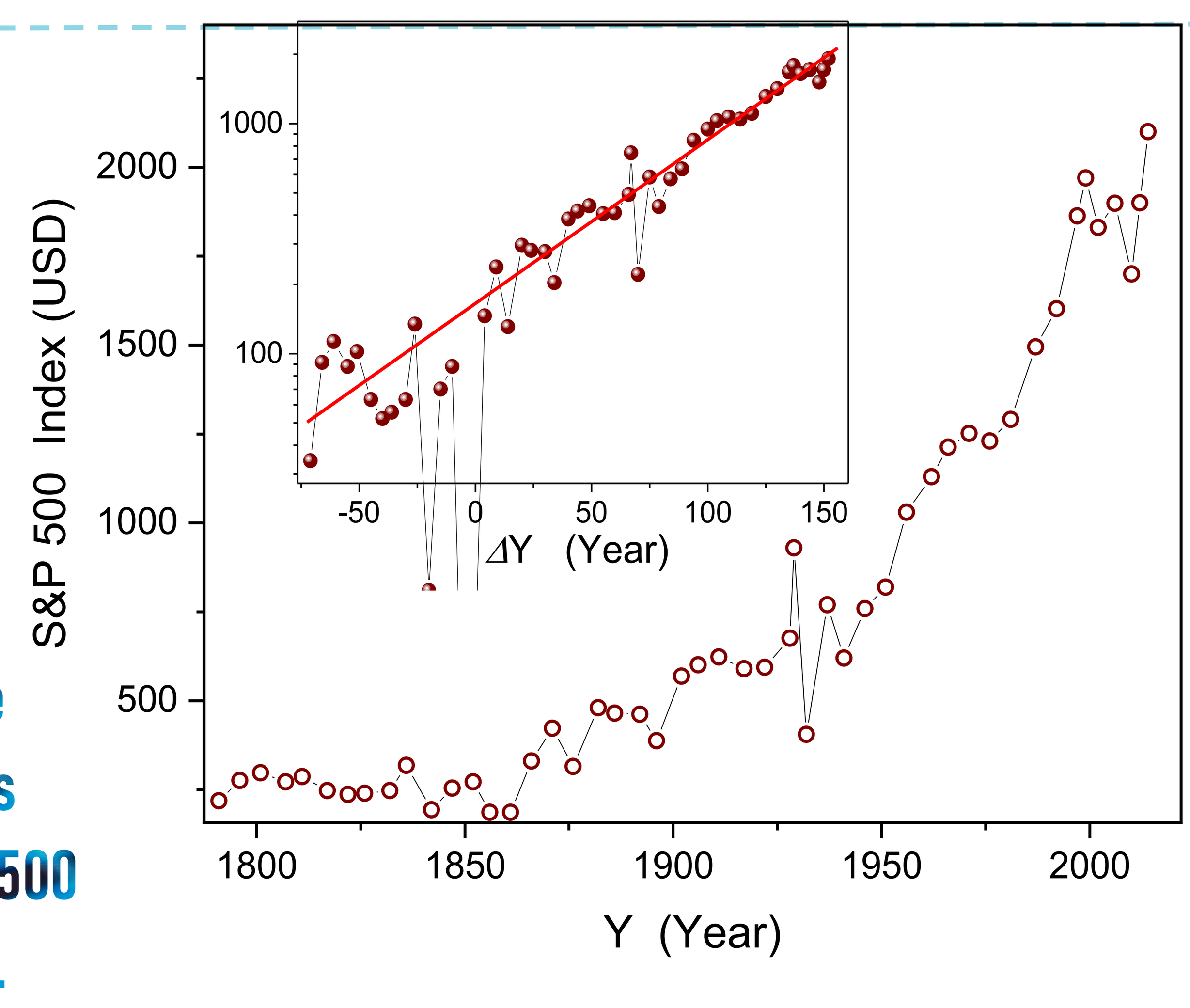


$$\Delta(GPB) = p_{ref} \Delta Y^{\phi} \rightarrow$$
$$\log[\Delta(GPB)] = \log p_{ref} + \log \Delta Y^{\phi} =$$
$$= \log p_{ref} + \phi \log \Delta Y = a + b\Delta Y$$



$$V_{SP}(\Delta Y) = v_0 \exp(V_{free} \Delta Y) \rightarrow$$
$$\ln V_{SP} = \ln v_0 + V_{free} \Delta Y =$$
$$= a + b\Delta Y$$

Data available since 1798 yields the unique possibility of considering Standard & Poor's normalized factor for capitalization of the 500 world-greatest enterprises – corporations.



[AA Sojecka & A Drozd-Rzoska, Sci. Rep.2024, 9, 6816

As shown in the right bottom plot, their 'power' rises continuously for over two centuries exponentially, with no impact of grand disasters that occurred like WWI or WWII.