## A population dynamics model on the social damage by negative information spread

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Spread of information is attracting much concern in modern society where the advance in the internet communication serves the easier and faster spread of any information. The spread of a rumor could have some negative impact on people's behavior for a social occasion, for example, an election, a pandemic situation, etc. In some cases, an information believed once by people becomes revealed later as "fake" or "rumor". In such a case, the government or community may release an official information to let people know that the spreading information is a rumor/fake news, and suppress the negative influence on the social activity. However, actually many rumors and fake news spread and fade out with an autonomous purging by some counter-information given by people themselves without such an official one.

In this work, we consider a population dynamic model on the reaction of a spreading negative information and its counter-information to discuss how effectively the latter could contribute to suppress the social damage by the former. We focus on the role of people who release the counter-information to purge the negative one from the community. We analyze the following population dynamics model:

$$\begin{split} \frac{dU}{dt} &= -\beta BU - \sigma \{R + (1+\epsilon)D\}U; \qquad \frac{dS}{dt} = -\rho(B+R+D)S; \\ \frac{dB}{dt} &= \beta BU - \alpha \{R + (1+\epsilon)D\}B - \gamma B; \\ \frac{dR}{dt} &= \rho(B+R+D)S + \sigma \{R + (1+\epsilon)D\}U - \delta R; \\ \frac{dD}{dt} &= \alpha \{R + (1+\epsilon)D\}B - \delta D; \\ \frac{dX}{dt} &= \gamma B + \delta D; \qquad \frac{dY}{dt} = \delta R, \end{split}$$

where U and S are the population sizes of "unsophisticated" and "sophisticated" people who have not received yet the negative information. People of U potentially believe the negative information, while those of S have the capacity to recognize its harm and release the counter-information once they receive it. B is the population size of "believers" who are the unsophisticated people believing and spreading the negative information. R is that of "rejecters" who consist of the sophisticated people identifying the negative information and the unsophisticated people finding the counter-information. They release the counter-information. D is that of "deniers" who are the unsophisticated people releasing the counter-information after being reformed by the counter-information. They believed once the negative information, that is, belonged to B. X is the population size of those who experienced a period as the believers and have become unrelated to the dynamics of the information spread. Y is that of those who have become unrelated to the dynamics too without believing the negative information. All parameters are positive.

The total population size is assumed constant, N, and the proportion of sophisticated people is given as p, a positive constant characterizing the community. Focusing on the p-dependence of the final size of X as  $t \to \infty$ , which can be regarded as an index to reflect the level of social damage by the negative information, we will try to discuss how such a social nature could be relevant to the community's vulnerability to the negative information.