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Mathematical and computer modeling of political conflict resolution

Abstract: The paper examines mathematical and computer modeling of the process of resolving political conflict through economic cooperation between two politically mutually opposing sides (possibly a country or country and its subject). Cases of both zero and variable demographic factor are considered. Factors of aggressiveness, cooperation are variable functions. In the Matlab software environment, numerical calculations were made, appropriate graphs were obtained, and conditions for model parameters were found accordingly, under which conflicts could be resolved.

Keywords: conflict resolution, mathematical model, variable coefficients, numerical solution

In recent years, mathematical modeling has become widespread in the social sphere, in sociology, in particular, in describing information warefares, predicting the results of political elections, processes of training scientific personnel, assimilation of peoples, globalization, etc. [1-3].

As is known, mathematicians Robert Aumann and Thomas Schelling received the Nobel Prize in Economics in 2005 for their cycle of scientific papers "Understanding Conflict and Cooperation Problems through Analysis within Game Theory". Robert Aumann, in his lecture when receiving the prize on 8 December 2005, noted that: "Wars and other conflicts are a major source of human suffering. So, it is appropriate to dedicate this lecture to one of the most pressing and profound issues facing humanity: war and peace", and Thomas Schelling stressed that:" The most exciting event of the last half century is one that has not happened. We enjoyed six years without nuclear weapons blown up in anger".

One of the authors of Singapore "economic miracle" Lee Kuan Yu is sure that "If you need economic growth, it is better not to fight with neighbors, but to trade."

In works [4-6] the new nonlinear mathematical model of economic cooperation between two politically mutually warring sides (perhaps the countries or the country and its subject) which considers economic or other type the cooperation between parts of the population of the sides

directed to rapprochement of the sides and peaceful resolution of the conflict is considered. In model it is meant that process of economic cooperation is free from political pressure, i.e. the governments of the sides and the third external side doesn't interfere with this process.

The work carried out numerical solutions to the Cauchy problem for a two-dimensional nonlinear dynamic system describing the process of economic cooperation of politically opposing sides:

$$\begin{cases} \dfrac{dN_1(t)}{dt} = -\alpha_1(t)(a(t) - N_1(t))(b(t) - N_2(t)) + \beta_1(t)N_1(t)N_2(t) \\ \dfrac{dN_2(t)}{dt} = -\alpha_2(t)(a(t) - N_1(t))(b(t) - N_2(t)) + \beta_2(t)N_1(t)N_2(t) \end{cases} \quad (1)$$

$$N_1(0) = N_{10},\ N_2(0) = N_{20}, \quad (2)$$

when $N_1(t)$ - number of citizens of the first side at the time t, wishing economic cooperation and prone to a subsequent peaceful resolution of the conflict, $N_2(t)-$ number of citizens of the second side at the time t, wishing economic cooperation and prone to a subsequent peaceful resolution of the conflict, $\alpha_1(t),\ \alpha_2(t)-$ factors of aggressiveness (alienation) of the sides, $\beta_1(t),\ \beta_2(t)-$ coefficients of cooperation of the sides, $a(t),\ b(t)-$ the populations of the first and second sides.

We will also use exponential functions:

$$a(t) = a_0 e^{n_1 \frac{t}{T}},\ b(t) = b_0 e^{n_2 \frac{t}{T}},$$

$$\alpha_1(t) = \alpha_{10} e^{n_3 \frac{t}{T}},\ \alpha_2(t) = \alpha_{20} e^{n_4 \frac{t}{T}},$$

$$\beta_1(t) = \beta_{10} e^{n_5 \frac{t}{T}},\ \beta_2(t) = \beta_{20} e^{n_6 \frac{t}{T}}$$

The conflict resolution condition is as follows

$$\begin{cases} \dfrac{a(t)}{2} < N_1(t) \le a(t) \\ \dfrac{b(t)}{2} < N_2(t) \le b(t) \end{cases} \quad t \ge t_* \quad (3)$$

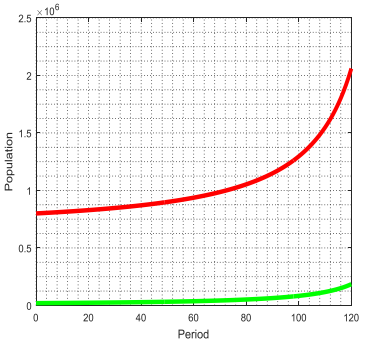
Some numerical results are shown in the figures:

Case 1:

$a_0 = 2 \cdot 10^5,\ b_0 = 4 \cdot 10^6,\ N_{10} = 2 \cdot 10^4,\ N_{20} = 8 \cdot 10^5$

$\alpha_{10} = 4 \cdot 10^{-11},\ \alpha_{20} = 1 \cdot 10^{-11},\ \beta_{10} = 1 \cdot 10^{-8},\ \beta_{20} = 7.5 \cdot 10^{-8}$

$n_1 = 0,\ n_2 = 0,\ n_3 = 1,\ n_4 = 1,\ n_5 = 1,\ n_6 = 1$



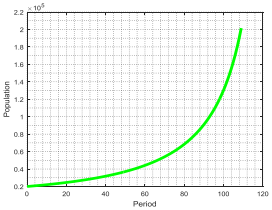
The conflict is resolved: $N_1(120) = 184\,677,\ N_2(120) = 2\,059\,715.$

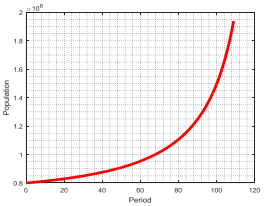
Case 2:

$a_0 = 2 \cdot 10^5,\ b_0 = 4 \cdot 10^6,\ N_{10} = 2 \cdot 10^4,\ N_{20} = 8 \cdot 10^5$

$\alpha_{10} = 4 \cdot 10^{-11},\ \alpha_{20} = 1 \cdot 10^{-11},\ \beta_{10} = 1.2 \cdot 10^{-8},\ \beta_{20} = 7.5 \cdot 10^{-8}$

$n_1 = 0,\ n_2 = 0,\ n_3 = 1,\ n_4 = 1,\ n_5 = 1,\ n_6 = 1$





$N_1(109) = 201\,518$ $N_2(109) = 1\,938\,227$

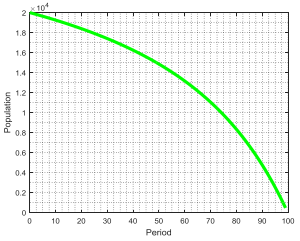
The conflict was not resolved.

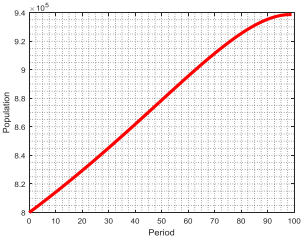
Case 3:

$a_0 = 2 \cdot 10^5,\ b_0 = 4 \cdot 10^6,\ N_{10} = 2 \cdot 10^4,\ N_{20} = 8 \cdot 10^5$

$\alpha_{10} = 4 \cdot 10^{-10},\ \alpha_{20} = 1 \cdot 10^{-10},\ \beta_{10} = 1 \cdot 10^{-8},\ \beta_{20} = 9 \cdot 10^{-8}$

$n_1 = 0,\ n_2 = 0,\ n_3 = 1,\ n_4 = 1,\ n_5 = 1,\ n_6 = 1$





$N_1(99) = 454$ $N_2(109) = 938\,654$

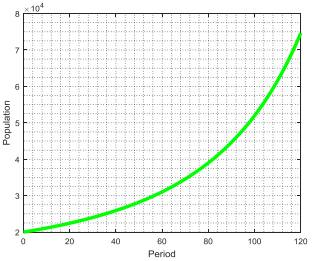
The conflict was not resolved.

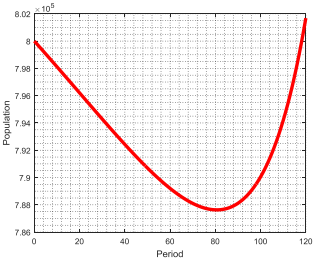
Case 4:

$a_0 = 2 \cdot 10^5,\ b_0 = 4 \cdot 10^6,\ N_{10} = 2 \cdot 10^4,\ N_{20} = 8 \cdot 10^5$

$\alpha_{10} = 1 \cdot 10^{-10},\ \alpha_{20} = 6 \cdot 10^{-10},\ \beta_{10} = 1 \cdot 10^{-8},\ \beta_{20} = 1 \cdot 10^{-8}$

$n_1 = 0,\ n_2 = 0,\ n_3 = 1,\ n_4 = 1,\ n_5 = 1,\ n_6 = 1$





$N_1(120) = 74\,627$ $N_2(120) = 801\,685$

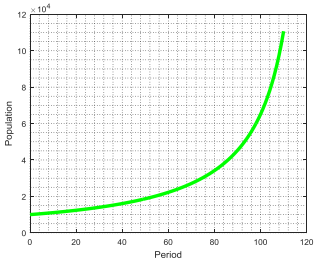
The conflict was not resolved.

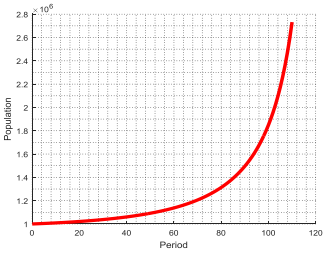
Case 5:

$a_0 = 2 \cdot 10^5,\ b_0 = 4 \cdot 10^6,\ N_{10} = 1 \cdot 10^4,\ N_{20} = 1 \cdot 10^6$

$\alpha_{10} = 5.5 \cdot 10^{-11},\ \alpha_{20} = 2 \cdot 10^{-11},\ \beta_{10} = 1 \cdot 10^{-8},\ \beta_{20} = 8 \cdot 10^{-8}$

$n_1 = 0,\ n_2 = 0,\ n_3 = 2,\ n_4 = 1,\ n_5 = 1,\ n_6 = 2$





$N_1(109) = 103\,576$ $N_2(109) = 2\,589\,820$

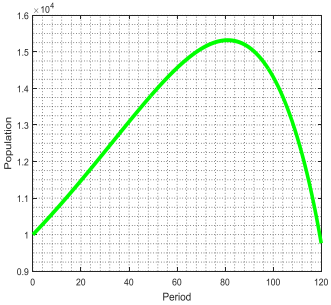
The conflict was not resolved.

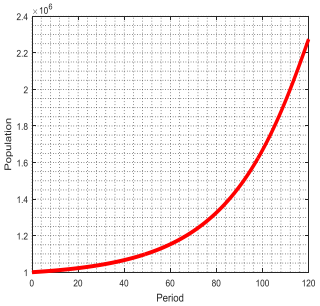
Case 6:

$a_0 = 2 \cdot 10^5,\ b_0 = 4 \cdot 10^6,\ N_{10} = 1 \cdot 10^4,\ N_{20} = 1 \cdot 10^6$

$\alpha_{10} = 5.5 \cdot 10^{-11},\ \alpha_{20} = 2 \cdot 10^{-11},\ \beta_{10} = 1 \cdot 10^{-8},\ \beta_{20} = 8 \cdot 10^{-8}$

$n_1 = 0,\ n_2 = 0,\ n_3 = 4,\ n_4 = 1,\ n_5 = 1,\ n_6 = 3$





$N_1(120) = 9\,765$ $N_2(120) = 2\,274\,891$

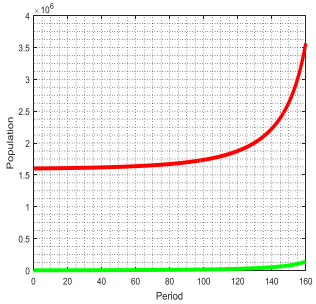
The conflict was not resolved.

Case 7:

$a_0 = 2 \cdot 10^5,\ b_0 = 4 \cdot 10^6,\ N_{10} = 2 \cdot 10^3,\ N_{20} = 16 \cdot 10^5$

$\alpha_{10} = 4 \cdot 10^{-12},\ \alpha_{20} = 2 \cdot 10^{-12},\ \beta_{10} = 1 \cdot 10^{-8},\ \beta_{20} = 8 \cdot 10^{-8}$

$n_1 = 0.1,\ n_2 = 0.05,\ n_3 = 2.5,\ n_4 = 1,\ n_5 = 1,\ n_6 = 2$



The conflict is resolved: $N_1(157) = 114\,304,\ N_2(157) = 3183\,297.$

References:

1. *Temur Chilachava, Tsira Gvinjilia* Research of the dynamic systems describing mathematical models of training of the diplomaed scientists. Seminar of I.Vekua Institute of Applied Mathematics, Reports, 2017, vol. 43, pp. 17 – 29.

2. *Temur Chilachava, Tsira Gvinjilia* Research of three and two-dimensional nonlinear dynamical systems describing the training of scientists. Applied Mathematics, Informatics and Mechanics, 2017,Vol. 22, No.1, pp. 3–20.

3. *Temur Chilachava,* Research Of The Dynamic System Describing Globalization Process. Springer Proceedings in Mathematics & Statistics, Mathematics, Informaticsand their Applications in Natural Sciences and Engineering - AMINSE 2017, v.276, pp. 67-78, 2019.

4. *Temur Chilachava, George Pochkhua* Research of the dynamic system describing mathematical model of settlement of the conflicts by means of economic cooperation, GESJ: Computer Science and Telecommunications, 2018, No. 3 (55), pp. 18–26.

5. *Temur Chilachava, George Pochkhua* About a possibility of resolution of conflict by means of economic cooperation. Problems of management of safety of difficult systems. The XXVI International Conference. Moscow, 2018, pp. 69–74.

6. *Temur Chilachava, George Pochkhua* Research of the nonlinear dynamic system describing mathematical model of settlement of the conflicts by means of economic cooperation. 8th International Conference on Applied Analysis and Mathematical Modeling, ICAAMM 2019, Proceedings Book, 2019, pp. 183–187.