COMPUTER MODELING OF POLITICAL CONFLICT RESOLUTION THROUGH ECONOMIC COOPERATION

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Abstract

Earlier, prof. T.Chilachava proposed mathematical models for resolving political conflicts through economic cooperation between two politically mutually opposing sides (possibly a country or country and its legal subject). We have previously theoretically investigated cases with constant model coefficients. In this work, a computer simulation has been carried out in the Matlab software environment in the case variable coefficients of model. Numerical solutions have been obtained, appropriate graphs have been built and the conflict resolution cases have been found (conditions for model parameters).

Keywords: *Computer modeling, mathematical models of resolution of conflict, variable coefficients of model.*

Introduction

Mathematical modeling of physical processes has a long history [1–13]. Mathematical modeling of physical processes involves the model adequacy, which is validated by Newton's non-relative five laws of classical mechanics: mass conservation law; law of conservation of impulse; the law of conservation the momentum of impulse; the first law of thermodynamics, i.e. energy conservation law; the second law of thermodynamics, i.e. entropy conservation law.

As it is known, there is a very large history of mathematical modeling in biology, ecology, chemistry, medicine and especially in epidemiology.

Synergetics gave a powerful push using of mathematical models in social sciences: sociology, history, demography, political science, conflicting science, etc.

Creation of mathematical models is more original in **social sphere**, because, they are more difficult to substantiate [14, 15].

In the works [16–21] the authors proposed a new direction of mathematical modeling "Mathematical modeling of information warfares".

The works [22–32] propose nonlinear mathematical models of two and three-party elections.

Taking into consideration the important tendencies in the world, it is important to study demographic and assimilation social processes through mathematical modeling.

Nonlinear mathematical models of bilateral and two-level assimilation are considered in [33–36].

The dynamics of innovative processes are one of the promising and fast developing techniques of using mathematical modeling.

The works [37–42] propose new mathematical models of some social processes: interaction of fundamental, applied research, development and innovative projects, two and three-stage training of scientists, competition between the universities.

In 2005, Mathematicians Robert Aumann and Thomas Schelling won the Nobel Prize in Economics for the scientific work cycle “Understanding of the problems of the conflict and cooperation through the game theory”.

At the awarding lecture, on December 8, Robert Aumann pointed out that “Wars and other conflicts are among the main sources of human misery. So it is appropriate to devote this lecture to one of the most pressing and profound issues that confront humanity: that of War and Peace”.

Regarding to the conflict between Israel and Palestine, the “repeated game" principle presents another important methodological aspect of mathematical modeling (game theory). According to this principle: the long-term relationship of subjects in competition can generate cooperation between them, for which, there can not be found a sufficient basis in case of one time relationship (contact). In other words, long-term relationship generates common interests and preconditions for cooperation.

At the awarding lecture, Thomas Schelling noted: "The most spectacular event of the past half century is one that did not occur. We have enjoyed sixty years without nuclear weapons exploded in anger“.

Lee Kuan Yew, author of the Singaporean "Economic Miracle", noted: "If you want economic growth, do not break out the war with neighbors, establish trade relations with them, instead”. He also noted: "I had two paths. The first is to steal and withdraw friends and relatives on the lists of "Forbes", while leaving their people on the naked land. The second is to serve your people and take the country to the top ten countries in the world. I chose the second..."

Considering the existing conflict regions in the world, we consider this kind of mathematical models are very perspective and innovative, including computer simulation that can determine conditions (dependence between model parameters) for which conflict can be solved.

Prof. T.Chilachava proposed to create new nonlinear mathematical models of economic cooperation between two politically (not military opposition) inter conflicting sides (possible states or country and its legal entities), which envisages economic or other type of cooperation between the part of population of the sides, direction towards the rapprochement of the sides and the peaceful resolution of the conflict [43]. Further, in the theoretical sense, the research of these mathematical models, are considered in the works [44 – 52].

The nonlinear mathematical model (the dynamic system) of economic cooperation between two political warring sides offered by us has an appearance:

$$\begin{cases} \dfrac{dN_1(t)}{dt} = -\alpha_1(t)[a(t)-N_1(t)][b(t)-N_2(t)] + \beta_1(t)N_1(t)N_2(t) + F_1(t,N_1(t)) \\ \dfrac{dN_2(t)}{dt} = -\alpha_2(t)[a(t)-N_1(t)][b(t)-N_2(t)] + \beta_2(t)N_1(t)N_2(t) + F_2(t,N_2(t)) \end{cases}$$

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

where

- $N_1(t)$ - number of the citizens of the first side in time-point t, wishing or already being in economic cooperation and inclined to the subsequent peaceful resolution of the conflict;
- $N_2(t)$ - number of the citizens of the second side in time-point t, wishing or already being in economic cooperation and inclined to the subsequent peaceful resolution of the conflict;
- $\alpha_1(t), \alpha_2(t)$ - coefficients of aggression (alienation) of the sides;
- $\beta_1(t), \beta_2(t)$ - coefficients of cooperation of the sides;
- $\gamma_1(t), \gamma_2(t)$ - appeal coefficients to peaceful economic cooperation of the sides of the third external side (coercion coefficients to cooperation) (Model 3);
- $a(t), b(t)$ - the population according to the first and second sides in time-point t;
- $N_1, N_2 \in C^1[0,T]$;
- T - time interval for model (conflict) consideration.

We assume that rather weak condition of resolution of conflict are:

$$\begin{cases} \dfrac{a(t)}{2} < N_1(t) \le a(t) \\ \dfrac{b(t)}{2} < N_2(t) \le b(t) \end{cases}, \qquad t \ge T_1.$$

In the general case of the model the exponential functions are taken as variable coefficients and computer modeling are performed $t \in [0, T]$.

The calculations are performed during the model review period.

By computer calculations two different images are obtained:

- There exists time $T_1 : 0 < T_1 \leq T$, for which system is completed;
- The system is not completed with $t \in [0, T]$ segment:

Below we use following exponential functions:

$$a(t) = a_0 e^{n_1 \frac{t}{T}}, \quad b(t) = b_0 e^{n_2 \frac{t}{T}}, \qquad \alpha_1(t) = \alpha_{10} e^{n_3 \frac{t}{T}}, \quad \alpha_2(t) = \alpha_{20} e^{n_4 \frac{t}{T}},$$

$$\beta_1(t) = \beta_{10} e^{n_5 \frac{t}{T}}, \quad \beta_2(t) = \beta_{20} e^{n_6 \frac{t}{T}}, \qquad \gamma_1(t) = \gamma_{10} e^{n_7 \frac{t}{T}}, \quad \gamma_2(t) = \gamma_{20} e^{n_8 \frac{t}{T}},$$

where

- $a_0 = 2 \cdot 10^5$ - the population of first side;
- $b_0 = 4 \cdot 10^6$ - the population of second side;
- $N_{10} = 2 \cdot 10^4$ - 10% of the population of first side;
- $N_{20} = 8 \cdot 10^5$ - 20% of the population of second side;
- $n_1, \ n_2$ - the coefficients of demographic factors;
- $n_3, \ n_4$ - the coefficients of aggression;
- $n_5, \ n_6$ - the coefficients of cooperation;
- $n_7, \ n_8$ - the coercion coefficients to cooperation.

For clarity we allow that $T = 120$ or $T = 240$ months.

Model 1:

$F_1(t, N_1(t)) \equiv 0$

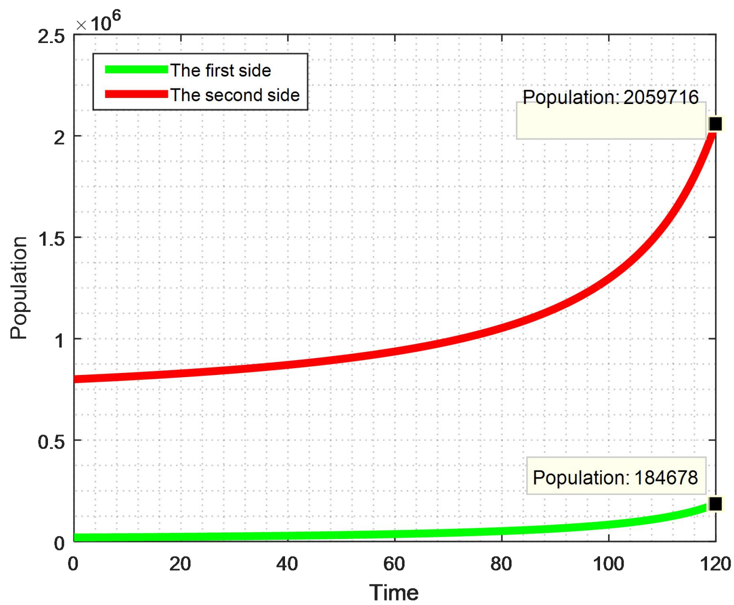
$F_2(t, N_2(t)) \equiv 0$

Case 1.1:

The conflict is resolved $(t = T_1 = 120)$ when

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

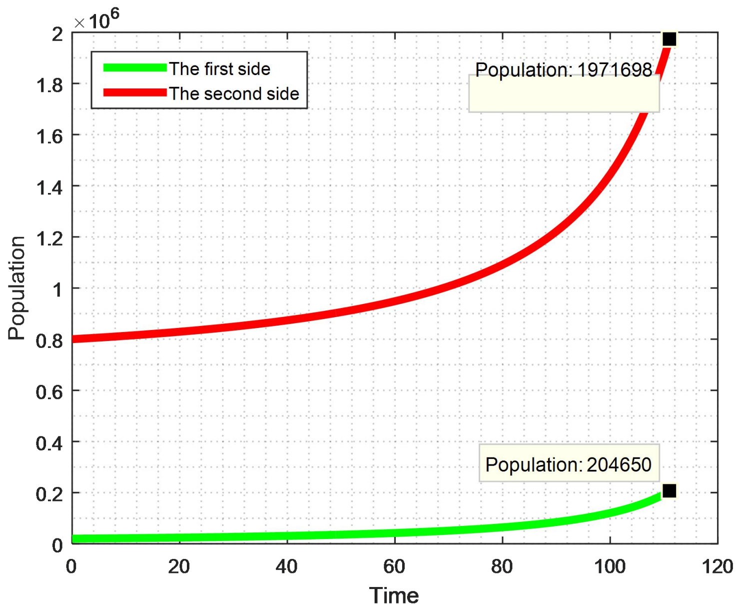
$$n_1 = 0, \quad n_2 = 0, \quad n_3 = 1, \quad n_4 = 1, \quad n_5 = 1, \quad n_6 = 1.$$



Case 1.2:

We have increased β_{10} the coefficient. The conflict is not resolved when

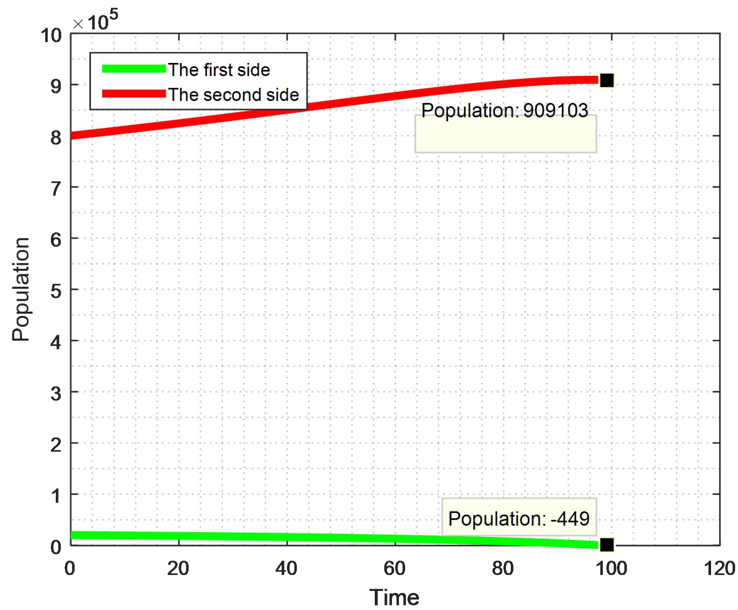
$$\alpha_{10} = 4 \cdot 10^{-11}, \alpha_{20} = 1 \cdot 10^{-11}, \beta_{10} = 1.2 \cdot 10^{-8}, \beta_{20} = 7.5 \cdot 10^{-8}$$
$$n_1 = 0, \quad n_2 = 0, \quad n_3 = 1, \quad n_4 = 1, \quad n_5 = 1, \quad n_6 = 1.$$



Case 1.3:

We have changed the power for α_{10} and α_{20} coefficients. The conflict is not resolved when

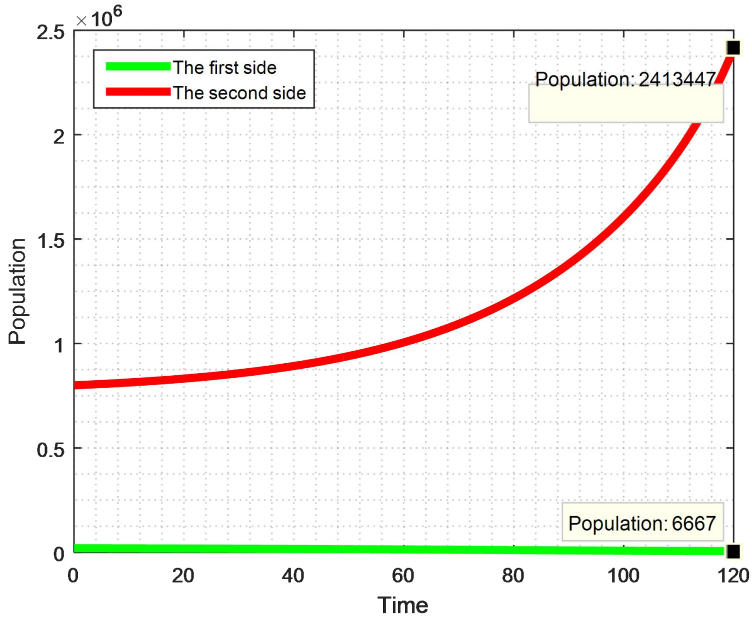
$$\alpha_{10} = 4 \cdot 10^{-10}, \alpha_{20} = 1 \cdot 10^{-10}, \beta_{10} = 1 \cdot 10^{-8}, \beta_{20} = 7 \cdot 10^{-8}$$
$$n_1 = 0, \quad n_2 = 0, \quad n_3 = 1, \quad n_4 = 1, \quad n_5 = 1, \quad n_6 = 1.$$



Case 1.4:

We have increased n_6 the coefficient. The conflict is not resolved when

$$\alpha_{10} = 4\cdot 10^{-10}, \alpha_{20} = 1\cdot 10^{-10}, \beta_{10} = 1\cdot 10^{-8}, \beta_{20} = 7\cdot 10^{-8}$$
$$n_1 = 0,\quad n_2 = 0,\quad n_3 = 1,\quad n_4 = 1,\quad n_5 = 1,\quad n_6 = 4\,.$$



Model 2

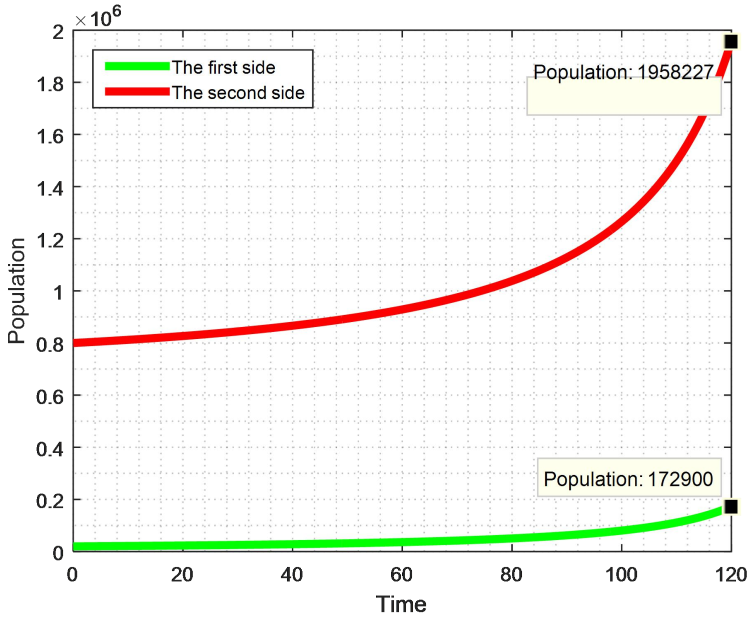
$F_1(t, N_1(t)) = -\gamma_1(t) N_1(t)$

$F_2(t, N_2(t)) = -\gamma_2(t) N_2(t)$

Case 2.1:

The conflict is not resolved $(t = T_1 = 120)$ when

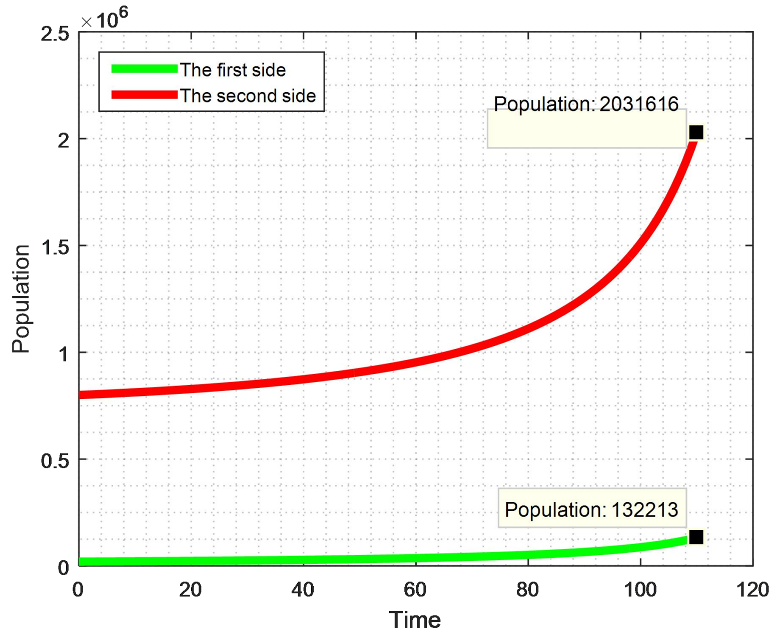
$$\alpha_{10} = 4\cdot 10^{-11}, \alpha_{20} = 1\cdot 10^{-11}, \beta_{10} = 1\cdot 10^{-8}, \beta_{20} = 7.5\cdot 10^{-8}, \gamma_{10} = 1\cdot 10^{-4}, \gamma_{20} = 1\cdot 10^{-4}$$
$$n_1 = 0,\quad n_2 = 0,\quad n_3 = 1,\quad n_4 = 1,\quad n_5 = 1,\quad n_6 = 1,\quad n_7 = 1,\quad n_8 = 1\,.$$



Case 2.2:

We have increased n_6 the coefficient. The conflict is resolved $(t = T_1 = 110)$ when

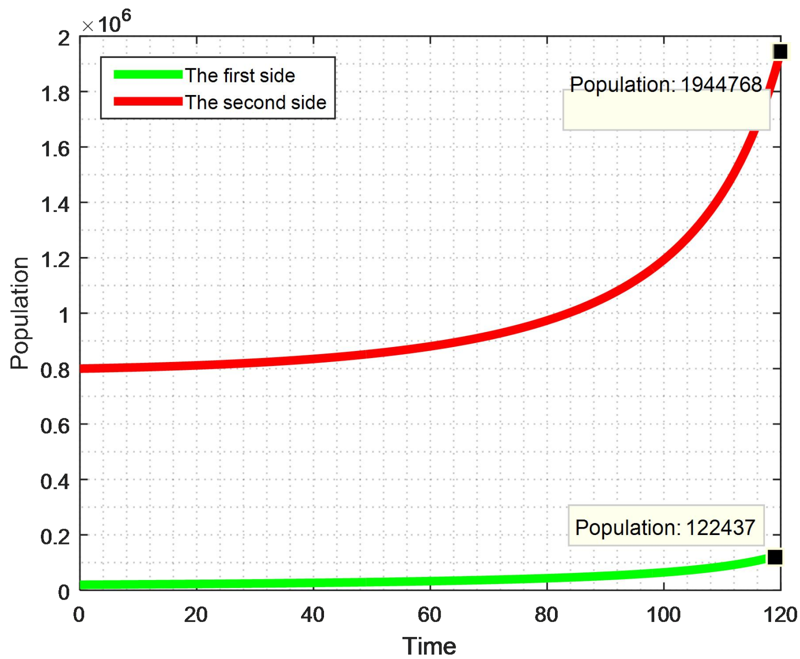
$$\alpha_{10} = 4\cdot 10^{-11}, \alpha_{20} = 1\cdot 10^{-11}, \beta_{10} = 1\cdot 10^{-8}, \beta_{20} = 7.5\cdot 10^{-8}, \gamma_{10} = 1\cdot 10^{-4}, \gamma_{20} = 1\cdot 10^{-4}$$
$$n_1 = 0, \quad n_2 = 0, \quad n_3 = 1, \quad n_4 = 1, \quad n_5 = 1, \quad n_6 = 1.5, \quad n_7 = 1, \quad n_8 = 1.$$



Case 2.3:

We have changed the power for γ_{10} and γ_{20} coefficients. The conflict is not resolved when

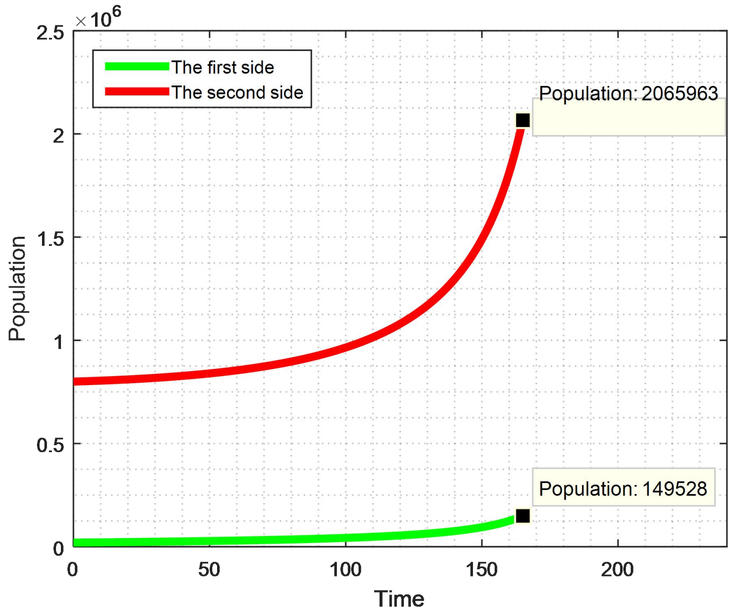
$$\alpha_{10} = 4\cdot 10^{-11}, \alpha_{20} = 1\cdot 10^{-11}, \beta_{10} = 1\cdot 10^{-8}, \beta_{20} = 7.5\cdot 10^{-8}, \gamma_{10} = 1\cdot 10^{-3}, \gamma_{20} = 1\cdot 10^{-3}$$
$$n_1 = 0, \quad n_2 = 0, \quad n_3 = 1, \quad n_4 = 1, \quad n_5 = 1, \quad n_6 = 1.5, \quad n_7 = 1, \quad n_8 = 1.$$



Case 2.4:

We have increased n_3 the coefficient. The conflict is resolved $(t = T_1 = 165)$ when

$$\alpha_{10} = 4 \cdot 10^{-11}, \alpha_{20} = 1 \cdot 10^{-11}, \beta_{10} = 1 \cdot 10^{-8}, \beta_{20} = 7.5 \cdot 10^{-8}, \gamma_{10} = 1 \cdot 10^{-3}, \gamma_{20} = 1 \cdot 10^{-3}$$
$$n_1 = 0, \quad n_2 = 0, \quad n_3 = 4, \quad n_4 = 1, \quad n_5 = 1, \quad n_6 = 1.5, \quad n_7 = 1, \quad n_8 = 1.$$



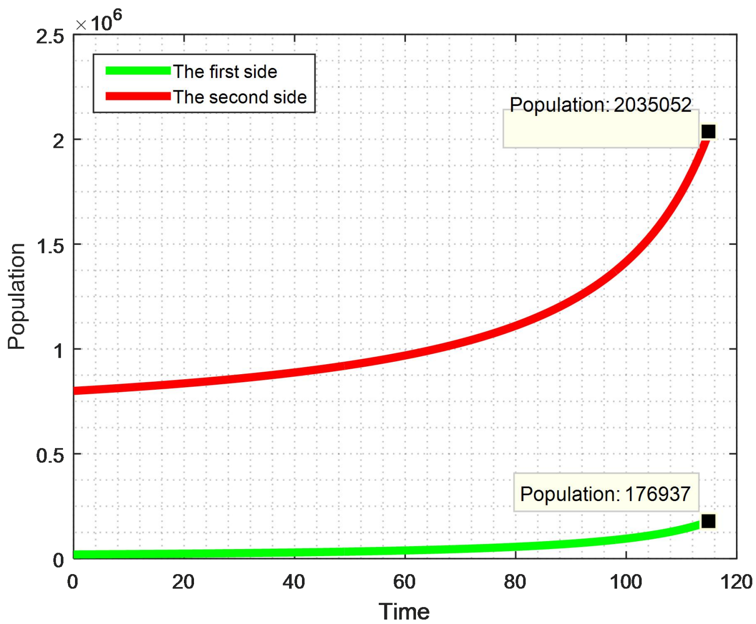
Model 3

$$F_1(t, N_1(t)) = \gamma_1(t)[a(t) - N_1(t)]$$
$$F_2(t, N_2(t)) = \gamma_2(t)[b(t) - N_2(t)]$$

Case 3.1:

The conflict is resolved $(t = T_1 = 115)$ when

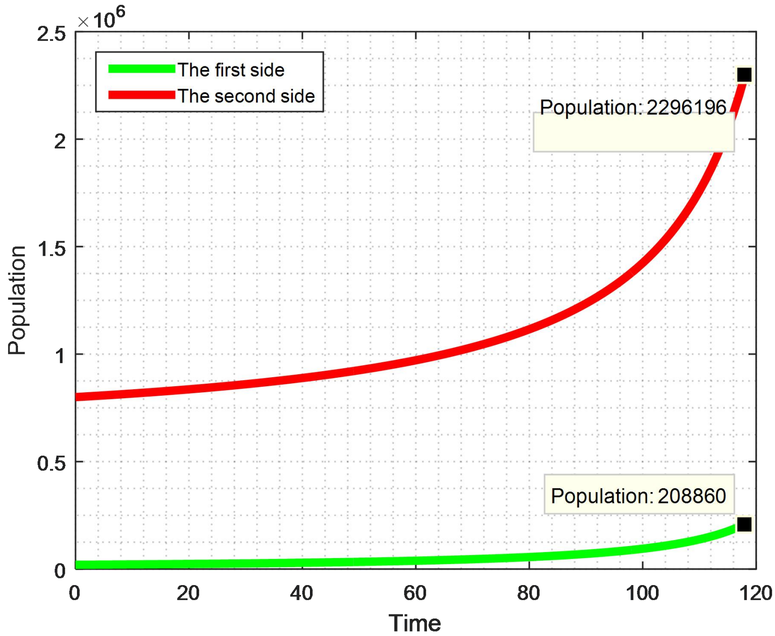
$$\alpha_{10} = 4 \cdot 10^{-11}, \alpha_{20} = 1 \cdot 10^{-11}, \beta_{10} = 1 \cdot 10^{-8}, \beta_{20} = 7.5 \cdot 10^{-8}, \gamma_{10} = 1 \cdot 10^{-4}, \gamma_{20} = 1 \cdot 10^{-4}$$
$$n_1 = 0, \quad n_2 = 0, \quad n_3 = 1, \quad n_4 = 1, \quad n_5 = 1, \quad n_6 = 1, \quad n_7 = 1, \quad n_8 = 1.$$



Case 3.2:

We have increased n_2 the coefficient. The conflict is not resolved $(t = T_1 = 118)$ when

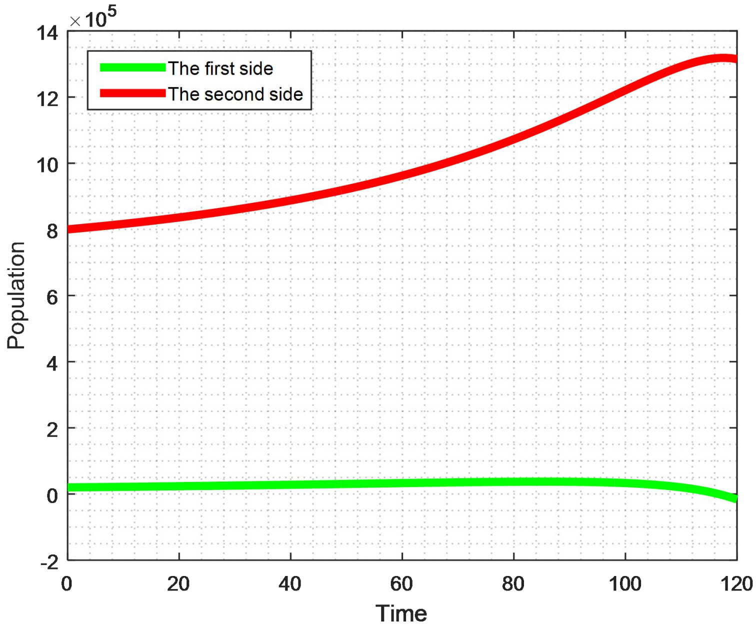
$$\alpha_{10} = 4 \cdot 10^{-11}, \alpha_{20} = 1 \cdot 10^{-11}, \beta_{10} = 1 \cdot 10^{-8}, \beta_{20} = 7.5 \cdot 10^{-8}, \gamma_{10} = 1 \cdot 10^{-4}, \gamma_{20} = 1 \cdot 10^{-4}$$
$$n_1 = 0, \quad n_2 = 0.3, \quad n_3 = 1, \quad n_4 = 1, \quad n_5 = 1, \quad n_6 = 1, \quad n_7 = 1, \quad n_8 = 1.$$



Case 3.3:

We have increased n_3 the coefficient. The conflict is not resolved.

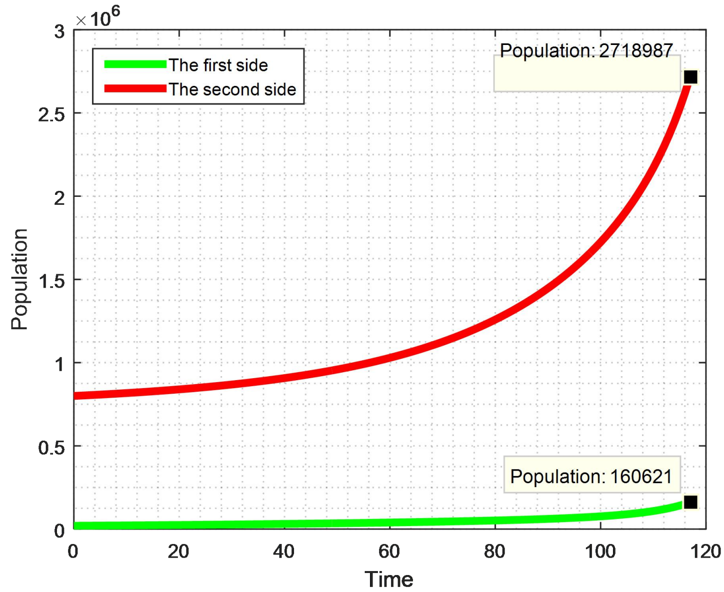
$$\alpha_{10} = 4 \cdot 10^{-11}, \alpha_{20} = 1 \cdot 10^{-11}, \beta_{10} = 1 \cdot 10^{-8}, \beta_{20} = 7.5 \cdot 10^{-8}, \gamma_{10} = 1 \cdot 10^{-4}, \gamma_{20} = 1 \cdot 10^{-4}$$
$$n_1 = 0, \quad n_2 = 0.3, \quad n_3 = 5, \quad n_4 = 1, \quad n_5 = 1, \quad n_6 = 1, \quad n_7 = 1, \quad n_8 = 1.$$



Case 3.4:

We have increased γ_{10}, n_4, n_8 the coefficients. The conflict is resolved when

$$\alpha_{10} = 4 \cdot 10^{-11}, \alpha_{20} = 1 \cdot 10^{-11}, \beta_{10} = 1 \cdot 10^{-8}, \beta_{20} = 7.5 \cdot 10^{-8}, \gamma_{10} = 4 \cdot 10^{-4}, \gamma_{20} = 1 \cdot 10^{-4}$$
$$n_1 = 0, \quad n_2 = 0.3, \quad n_3 = 5, \quad n_4 = 8, \quad n_5 = 1, \quad n_6 = 1, \quad n_7 = 1, \quad n_8 = 4.5.$$



Model 4

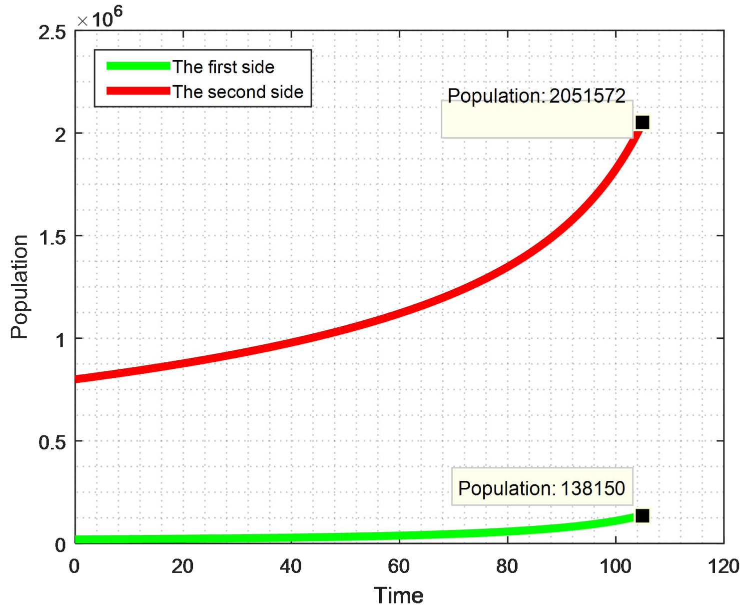
$F_1(t, N_1(t)) = -\gamma_1(t) N_1(t)$

$F_2(t, N_2(t)) = \gamma_2(t)[b(t) - N_2(t)]$

Case 4.1:

The conflict is resolved $(t = T_1 = 105)$ when

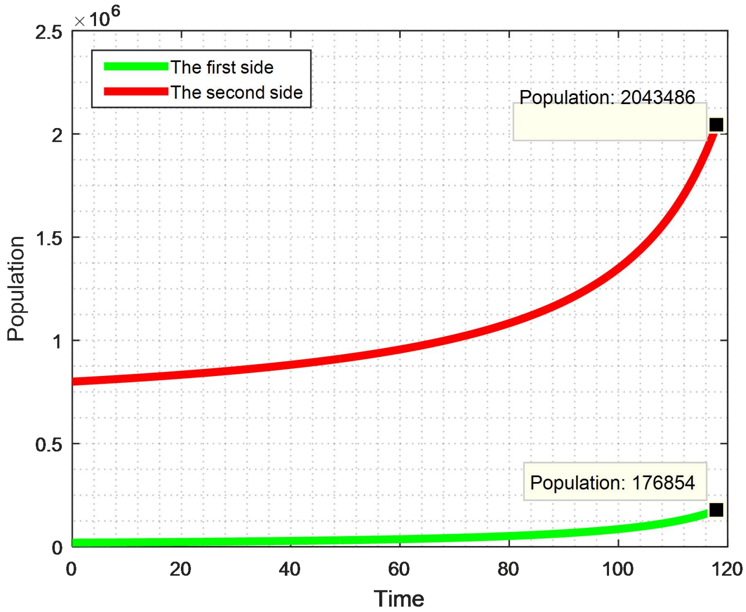
$$\alpha_{10} = 4 \cdot 10^{-11}, \alpha_{20} = 1 \cdot 10^{-11}, \beta_{10} = 1 \cdot 10^{-8}, \beta_{20} = 7.5 \cdot 10^{-8}, \gamma_{10} = 3 \cdot 10^{-3}, \gamma_{20} = 7 \cdot 10^{-3}$$
$$n_1 = 0, \quad n_2 = 0, \quad n_3 = 1, \quad n_4 = 1, \quad n_5 = 1, \quad n_6 = 1, \quad n_7 = 1, \quad n_8 = 1.$$



Case 4.2:

We have changed the power for γ_{10} and γ_{20} coefficients. The conflict is resolved $(t = T_1 = 118)$ when

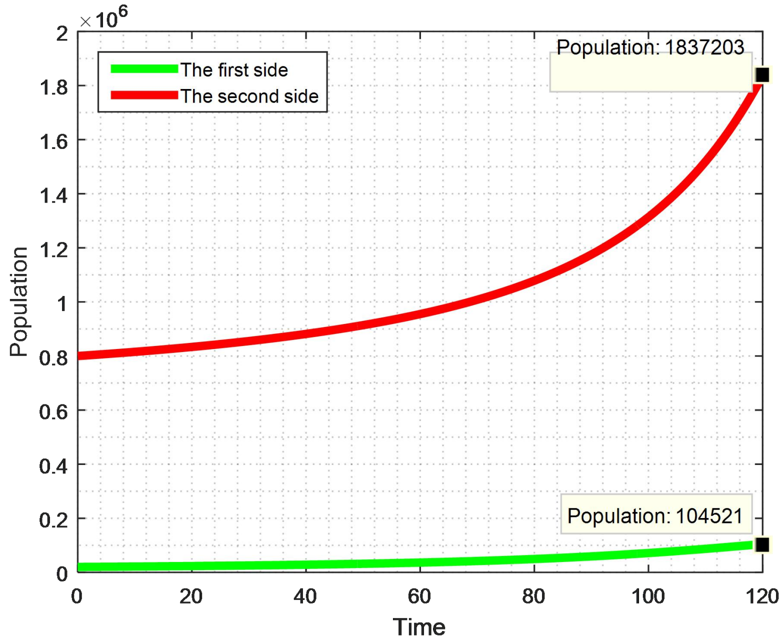
$$\alpha_{10} = 4 \cdot 10^{-11}, \alpha_{20} = 1 \cdot 10^{-11}, \beta_{10} = 1 \cdot 10^{-8}, \beta_{20} = 7.5 \cdot 10^{-8}, \gamma_{10} = 3 \cdot 10^{-3}, \gamma_{20} = 7 \cdot 10^{-3}$$
$$n_1 = 0, \ \ n_2 = 0, \ \ n_3 = 1, \ \ n_4 = 1, \ \ n_5 = 1, \ \ n_6 = 1, \ \ n_7 = 1, \ \ n_8 = 1.$$



Case 4.3:

We have increased n_7 the coefficient. The conflict is not resolved.

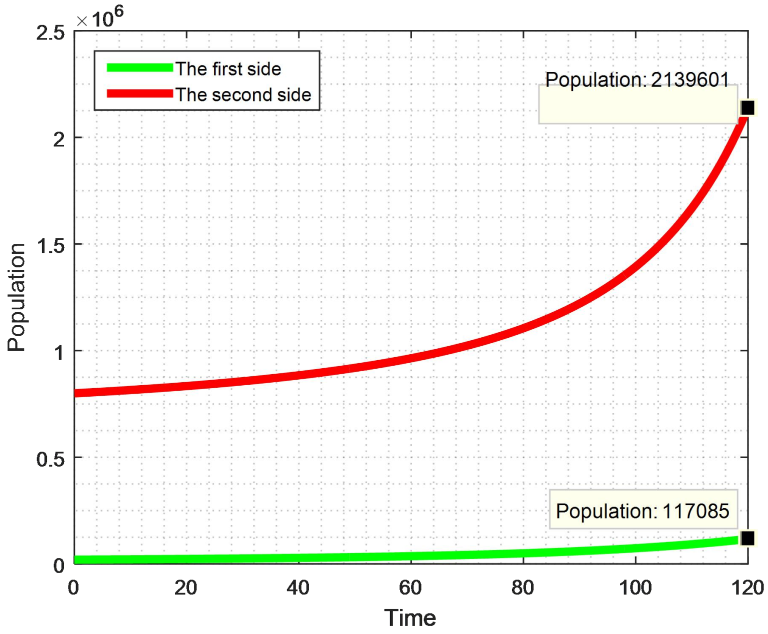
$$\alpha_{10} = 4 \cdot 10^{-11}, \alpha_{20} = 1 \cdot 10^{-11}, \beta_{10} = 1 \cdot 10^{-8}, \beta_{20} = 7.5 \cdot 10^{-8}, \gamma_{10} = 3 \cdot 10^{-3}, \gamma_{20} = 7 \cdot 10^{-3}$$
$$n_1 = 0, \ \ n_2 = 0, \ \ n_3 = 1, \ \ n_4 = 1, \ \ n_5 = 1, \ \ n_6 = 1, \ \ n_7 = 7, \ \ n_8 = 1.$$



Case 4.4:

We have increased n_6 the coefficient. The conflict is resolved when

$$\alpha_{10} = 4\cdot 10^{-11}, \alpha_{20} = 1\cdot 10^{-11}, \beta_{10} = 1\cdot 10^{-8}, \beta_{20} = 7.5\cdot 10^{-8}, \gamma_{10} = 3\cdot 10^{-3}, \gamma_{20} = 7\cdot 10^{-3}$$
$$n_1 = 0,\ \ n_2 = 0,\ \ n_3 = 1,\ \ n_4 = 1,\ \ n_5 = 1,\ \ n_6 = 1.2,\ \ n_7 = 7,\ \ n_8 = 1.$$



Conclusion

Thus, for all four mathematical models, in the case of variable coefficients of models that are taken as exponential functions, numerical results are obtained, showing in what case it is possible to resolve a political conflict and in which it is impossible.

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