

## Introduction to Nonlinear Dynamics

### **Modelling the GDP and trade dynamics of USA and India**

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This is a set of guidelines for you to follow when analysing the data pertaining to the GDP and trade dynamics of USA and India. The purpose of this exercise is to give you practical experience in working with national economic data. For this task you need a basic understanding of what we have done so far in the class. The following items give a description of the contents of the other files in the folder, along with some suggestions for the mathematical modelling.

- **The data files:** There are three of them. One is named `India_GDP_Trade.dat`, and it contains data in three columns. The first column gives the time (in years) starting from 1960 and ending in 2020. The second column gives the annual GDP value of India and the third column gives the annual trade value of India. For USA, there are two data files. One, named `US_GDP.dat`, gives time in the first column from 1960 to 2020. The second column of this file gives the annual GDP value of USA. Similarly, the other data file on USA, named `US_Trade.dat`, gives time in the first column (from 1960 to 2019) and the trade value of USA in the second column. In all cases the GDP and trade values are given in US dollars.
  - **Reading material:** There is an article in a .pdf-formatted file named `kr0822arX.pdf`. Read Sections II, III, IV & VI carefully. Also study Figs.1, 6, 7 & 12, and note alongside the parameter values in Table I. All of these will help you with the mathematical modelling.
  - **The mathematical modelling:**
    1. In the article, Eqs. 1, 2, 3, 4 & 5 pertain to the application of the logistic equation in modelling the GDP and trade growths of both USA and India. Use these equations to model the growth of the GDP and trade of the two countries. Apply the model equations on the data provided in the three data files, as mentioned above. The outcome of this modelling exercise will be to reproduce Fig.1 (for USA) and Fig.6 (for India). The parameters used for the modelling are to be read from Table I.
    2. A second-order coupled autonomous system involving the GDP and trade leads to Eq. 6, which, on approximating Eqs. 4 & 5 in the linear order, gives the solution in Eq. 7. Plotting Eq. 7 in a log-log graph, gives a linear fit, as in Fig.7 for USA and Fig.12 for India. Applying Eq. 7 on the GDP and the trade data for both countries, reproduce Fig.7 and Fig.12. Use the relevant parameter values in Table I.
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