THE CHINESE UNIVERSITY OF HONG KONG
Department of Mathematics

Mathematical Modeling Project Team
mathmodel@math.cuhk.edu.hk

Modeling with R Shiny (Nonlinear Regression - Time Data)

Last updated: 03/07/2025

1 Introduction to the Nonlinear Regression (Time Data) R Shiny tool

R is a powerful statistical programming language that allows us to perform data analysis, which is useful for mathematical modeling. Even better, we have set up a set of online tools using R Shiny so that you can perform various mathematical modelling tasks without any coding background.

In particular, a common task in mathematical modelling is to analyze and predict certain data according to past history. Here we are going to introduce how to use our nonlinear regression based on time.

2 Using the Nonlinear Regression (Time Data) R Shiny tool

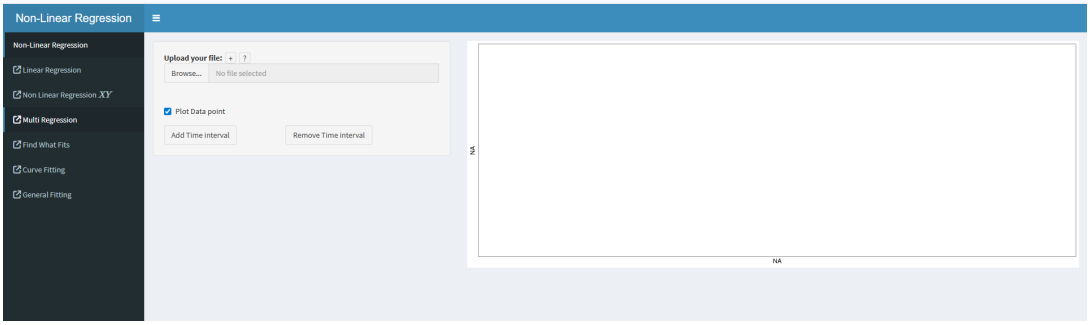
To use the tool, you can go to our main website:

https://www.math.cuhk.edu.hk/app/mathmodel/tool.html

for the list of tools, or simply go to

https://mathmodelcuhk.shinyapps.io/non-linear-regression/

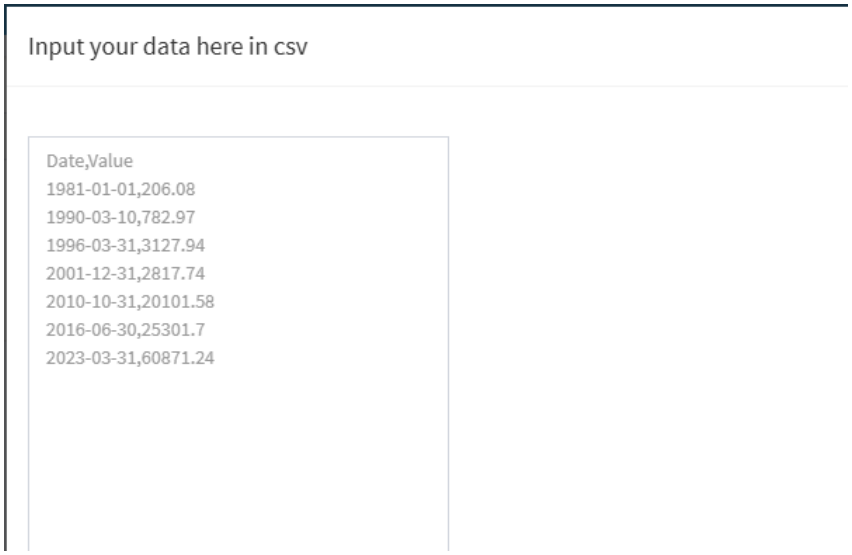
for the Nonlinear Regression (time) R Shiny tool.
After getting into the website, you can see the following:



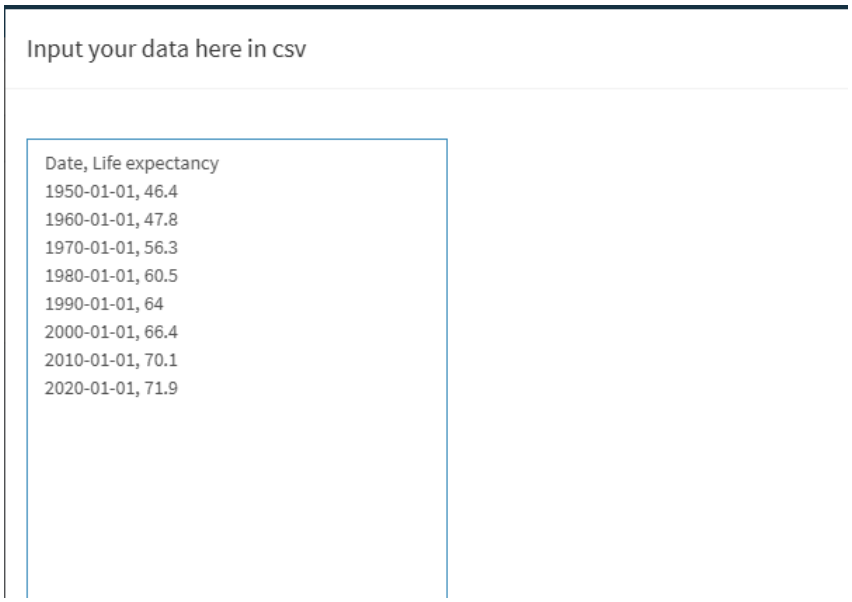
Don't worry if you think this is complicated! We will guide you step by step, and you can do nonlinear regression using our R Shiny tool.

2.1 Step 1: Data input

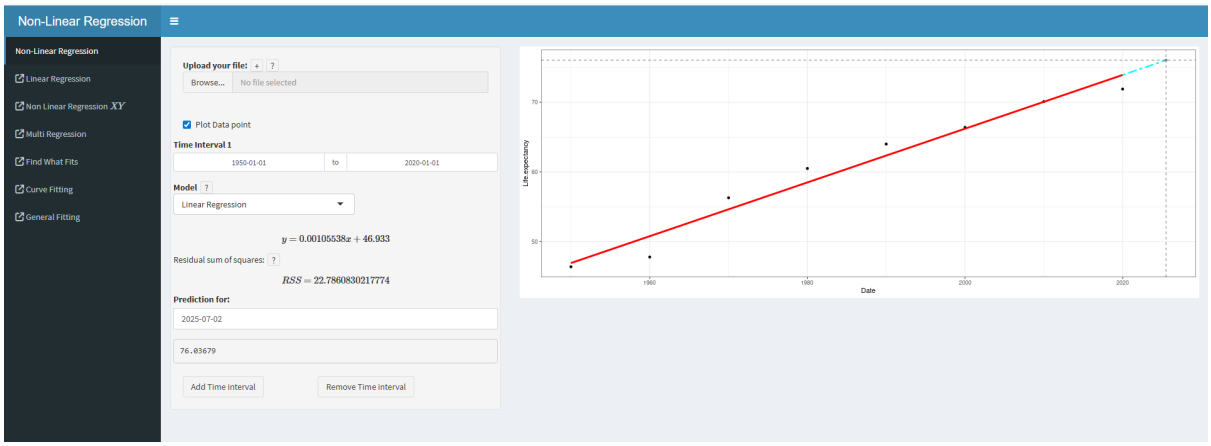
At the top left-hand corner, you can see "Upload your file", this is where we input the data. There are three different buttons.
Firstly, the "?" gives you the general guide on data input.
Secondly, the "+" allows you to input data directly. After clicking it, you can see the following:



On the first line, you can input the names of the variables. For example, we can define the variable to be life expectancy. Therefore, on the first line we type "Date, Life expectancy". And then we input the dates and corresponding life expectancy. (Remark: if the data is based on years or even ten years, we can simply type the dates as yyyy-01-01)
For the following lines, you can simply type in the data points respectively. You should be able to have a result that looks like this:



Scroll down and press “submit”. Your data points should be shown on the screen like this:

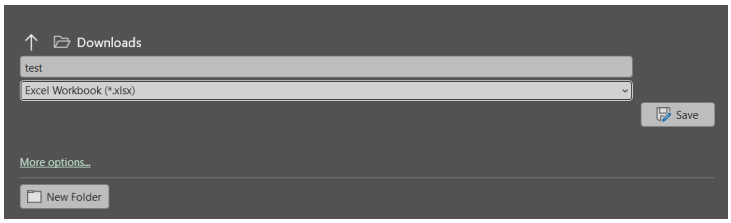


You can also upload an Excel file to the website directly. Firstly, you will need to prepare your Excel file like this:

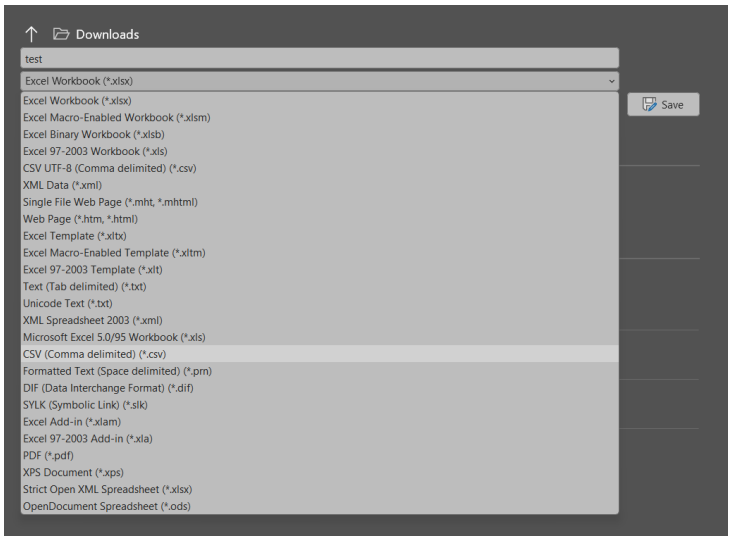
	A	B
1	Date	Life expectancy
2	1/1/1950	46.4
3	1/1/1960	47.8
4	1/1/1970	56.3
5	1/1/1980	60.5
6	1/1/1990	64
7	1/1/2000	66.4
8	1/1/2010	70.1
9	1/1/2020	71.9

Then go back to our website, press the “Browse...” button and look for the file stored on the computer. After uploading, you will see your data points shown on the graph.

If you face any problem regarding the upload, you may need to save your Excel file in .csv format. To do so, you can go to file → save as, and you can look for the following:



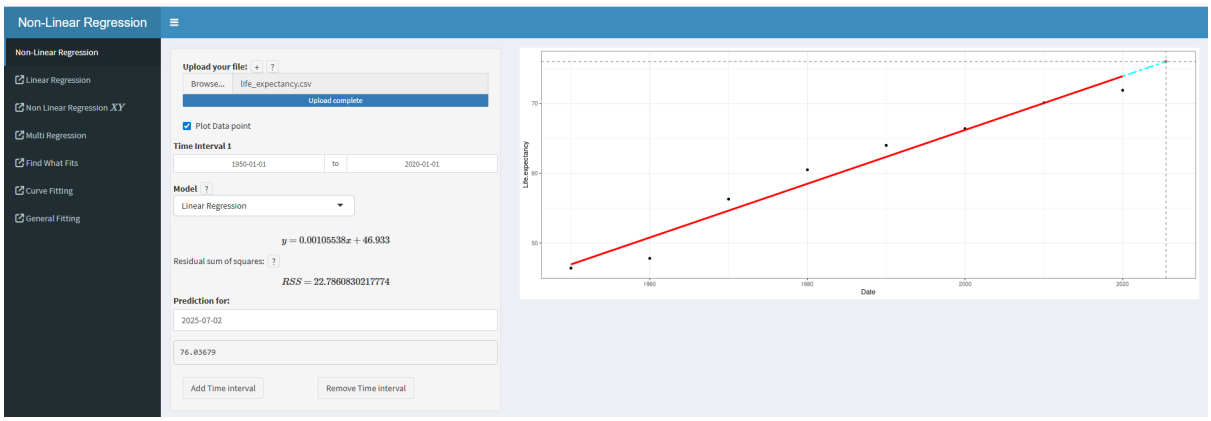
Expand the dropdown list, and look for the .csv format.



After that, you can upload the file onto our website, and it will work normally.

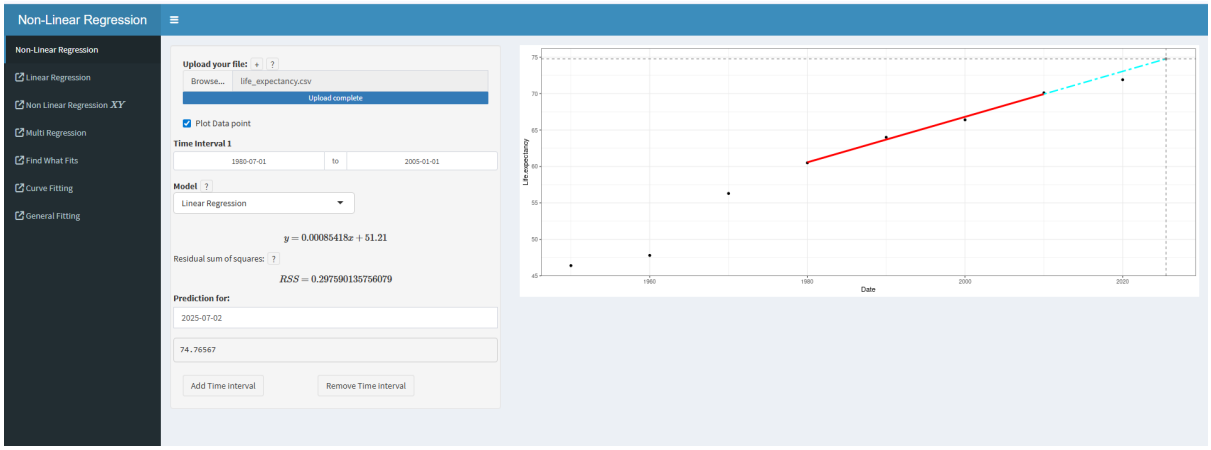
2.2 Step 2: Data analysis

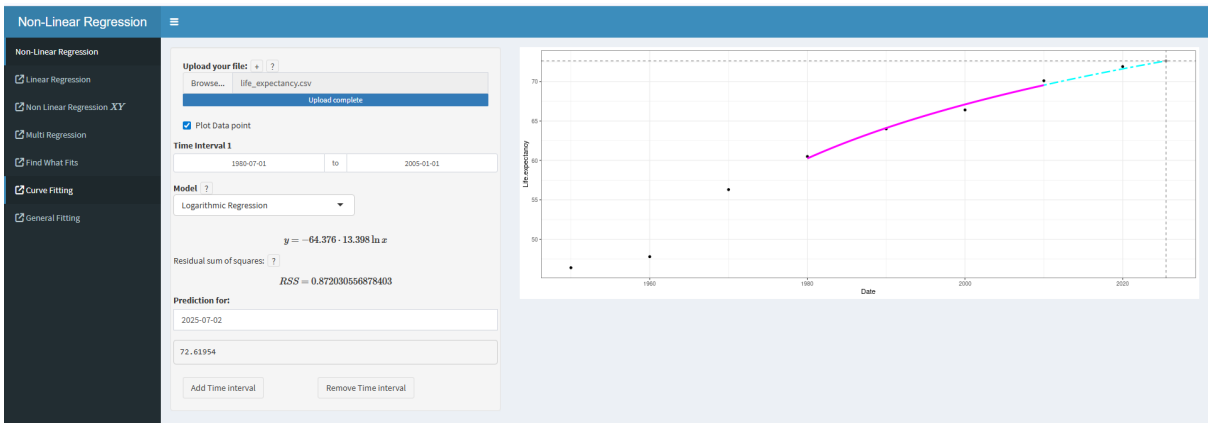
After you have inputted the dataset, now we can perform linear or nonlinear regression easily. Try to click different buttons on the page and now we will briefly explain their usage.



2.2.1 Time Interval

This allows us to create function regressions based on a certain time interval. Please note that the time interval must lie between the data inputs. Also, you can use different models to analyze the data. For example, you can have the following:





The available models include:

- Linear Regression:
$$y = ax + b$$
- Quadratic Regression:
$$y = ax^2 + bx + c$$
- Cubic Regression:
$$y = ax^3 + bx^2 + cx + d$$
- Polynomial Regression:
$$y = a_n x^n + a_{n-1} x^{n-1} + \cdots + a_1 x + a_0$$
where n is the prescribed power (Remark: When n is set to be too large, some parameters may exceed the minimum computation limit and be neglected.)

- Power Regression

$$y = ax^b$$

(Remark: We solve for the best-fit power model by considering the following linearized model: $\ln(y) = \ln(a) + b \cdot \ln(x)$. Therefore, all data points with a non-positive x or y value are neglected.)

- Exponential Regression:

$$y = ab^x$$

(Remark: We solve for the best-fit exponential model by considering the following linearized model: $\ln(y) = \ln(a) + \ln(b) \cdot x$. Therefore, all data points with a non-positive y value are neglected.

- Logarithmic Regression:

$$y = a + b\ln(x)$$

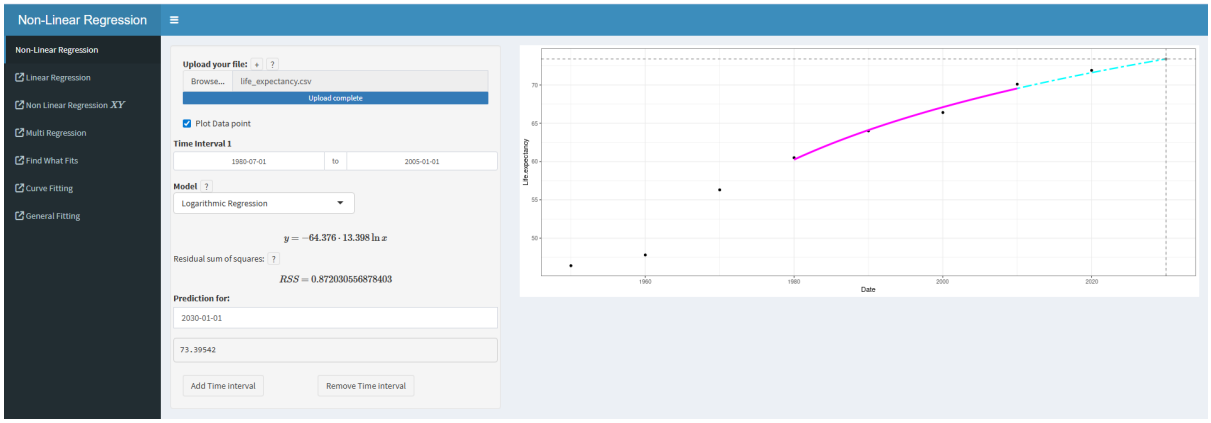
(Remark: All data points with a non-positive x value are neglected.)

Together with the graph, the tools also tell you different related information, such as the equation of the best fit curve and the residual sum of squares. The residual sum of squares measures how well this curve can approximate the dataset we have. You can use this to compare which model is better for the regression, too. (Please note that a low residual sum of squares does not always imply the model we are using is a good one.)

If you have any questions about the values we are showing you, of course you can always search online. But there's also a "?" next to each variable; click it, and there will be a short introduction about it.

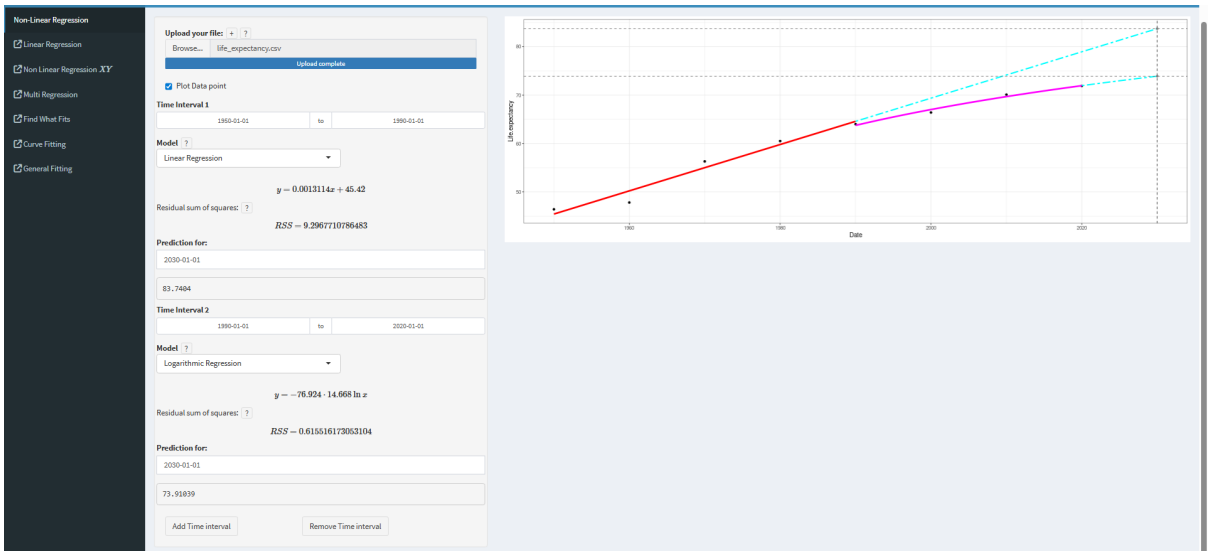
2.2.2 Prediction

By typing any date into the box, we can know the corresponding prediction of the y-coordinate according to our regression curve. You can also see how the regression line is extended, and the intersection with the vertical dotted line gives you the prediction of the new value.



2.2.3 Add Time Interval

In our R Shiny tool, it is possible to analyze the data using different models in different time intervals. For example, if we have strong enough reason to believe that the trend from 1950 to 1990 and 1990 to 2020 are different, then we can divide them into two different intervals, and the result will be like this:



As you can see, if we apply different model on different time intervals, we can have different predictions in the future too.

3 Conclusion

Nonlinear regression is a very powerful tool in mathematical modelling. By considering different nonlinear regression models, we can understand the trends in datasets and make predictions. We hope that this R Shiny Nonlinear Regression (Time Data) tool may help you with your mathematical modelling journey. Good luck!