THE CHINESE UNIVERSITY OF HONG KONG
Department of Mathematics

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

Modeling with R Shiny (Nonlinear Regression XY)

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1 Introduction to the Nonlinear Regression (XY) 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 perform nonlinear regression based on some data points $(x_1, y_1), (x_2, y_2), \ldots, (x_n, y_n)$. Here is the guideline on how to use our Nonlinear Regression (XY) R Shiny tool.

2 Using Nonlinear Regression (XY) R Shiny tool

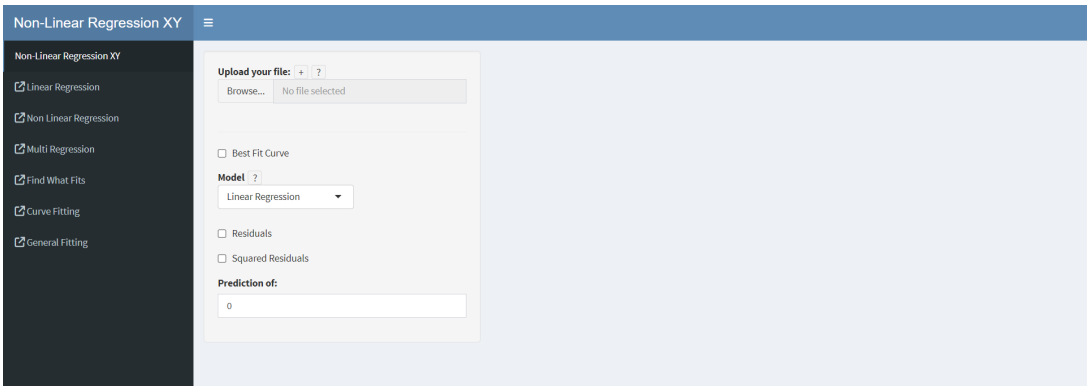
To use the tool, you can go to our main website:

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-xy/

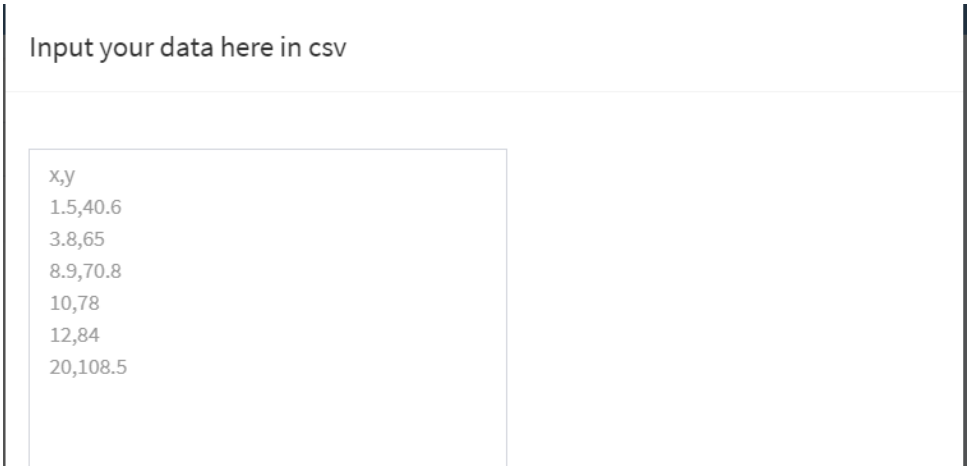
for the Nonlinear Regression (XY) R Shiny tool.
After getting into the website, you can see the following:



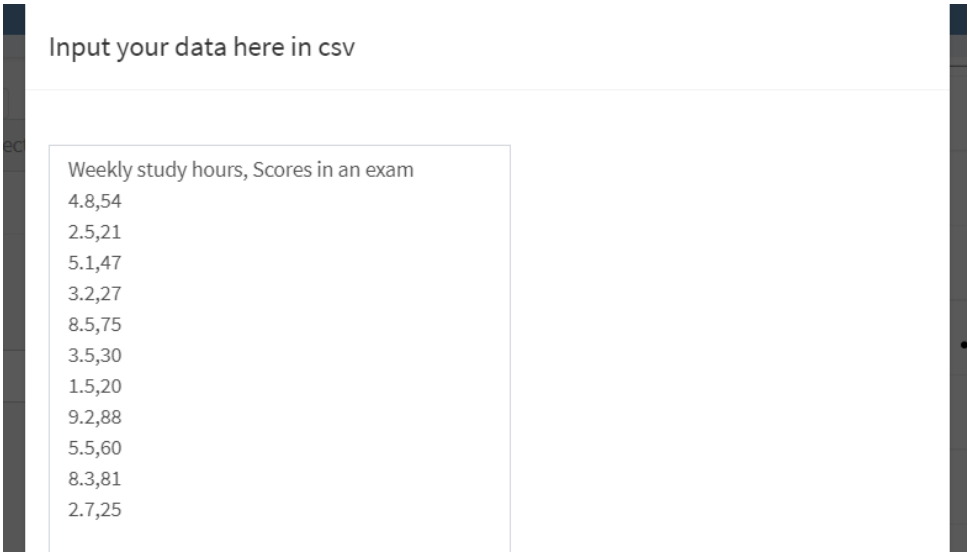
Don't worry if you think this is complicated! We will guide you step by step, and you can do nonlinear regression using our R Shiny tool.

2.1 Step 1: Data input

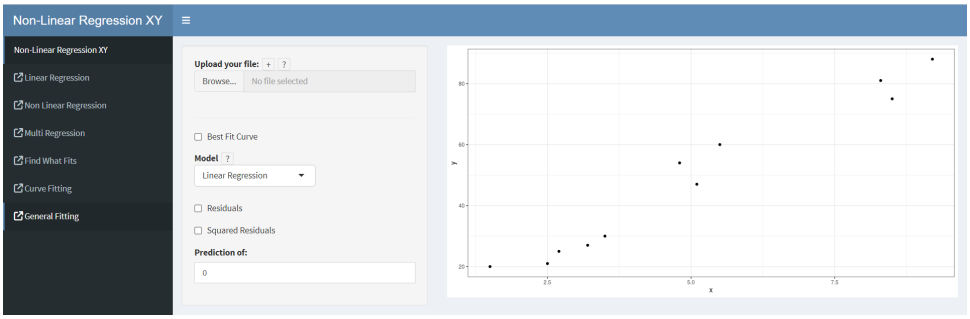
At the top left-hand corner, you can see "Upload your file", this is where we input the data. There are three different buttons.
Firstly, the "?" gives you the general guide on data input.
Secondly, the "+" allows you to input data directly. After clicking it, you can see the following:



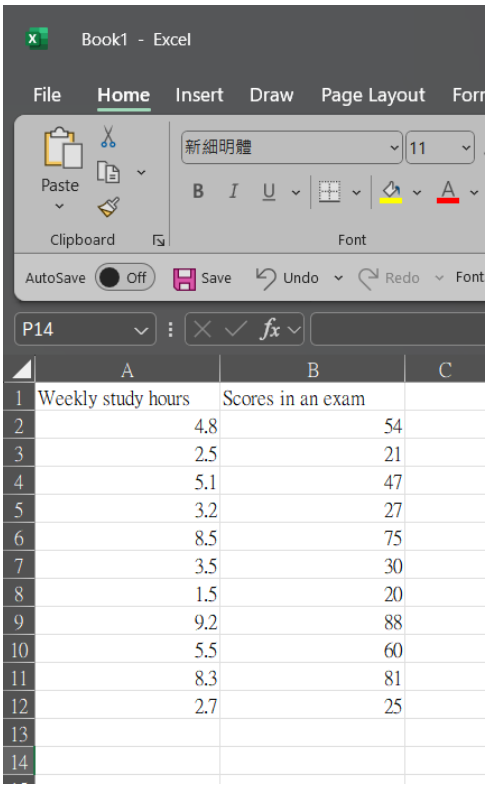
On the first line, you can input the names of the variables for the x-axis and y-axis respectively. For example, we can define the x-axis as "weekly study hours by different students" and the y-axis as "scores the students got in an exam" to see the correlation between them. Therefore, on the first line we type "Weekly study hours, Scores in an exam"
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:



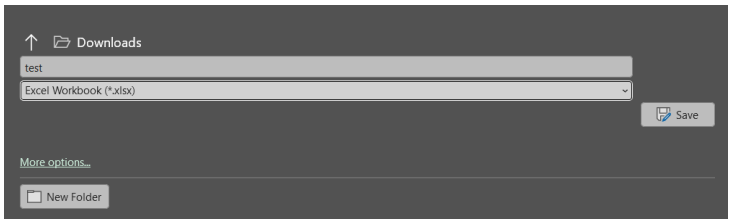
You can also upload an Excel file to the website directly. Firstly, you will need to prepare your Excel file like this:



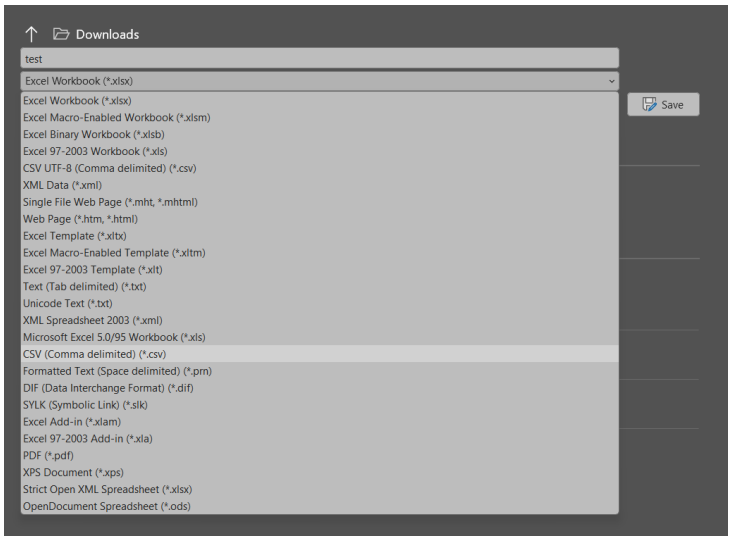
	A	B	C
1	Weekly study hours	Scores in an exam	
2	4.8	54	
3	2.5	21	
4	5.1	47	
5	3.2	27	
6	8.5	75	
7	3.5	30	
8	1.5	20	
9	9.2	88	
10	5.5	60	
11	8.3	81	
12	2.7	25	
13			
14			

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:



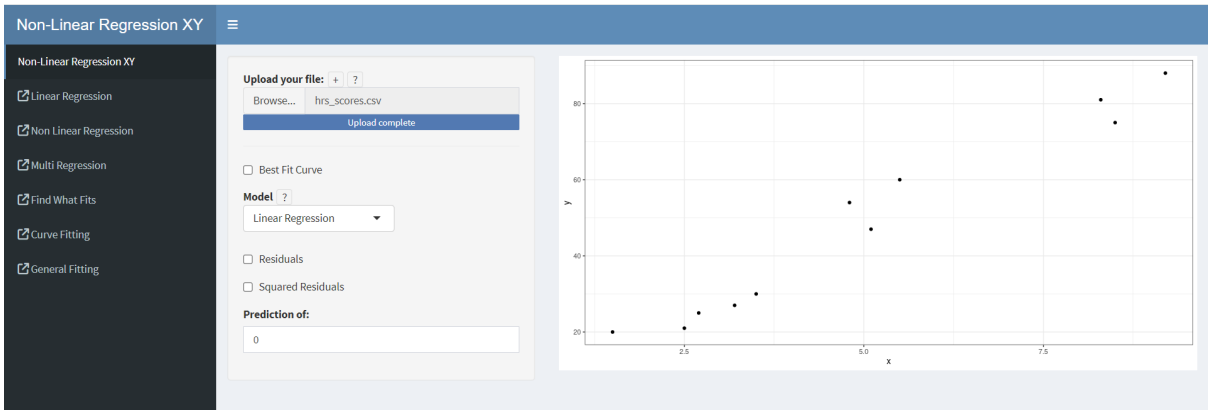
Expand the dropdown list, and look for the .csv format.



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

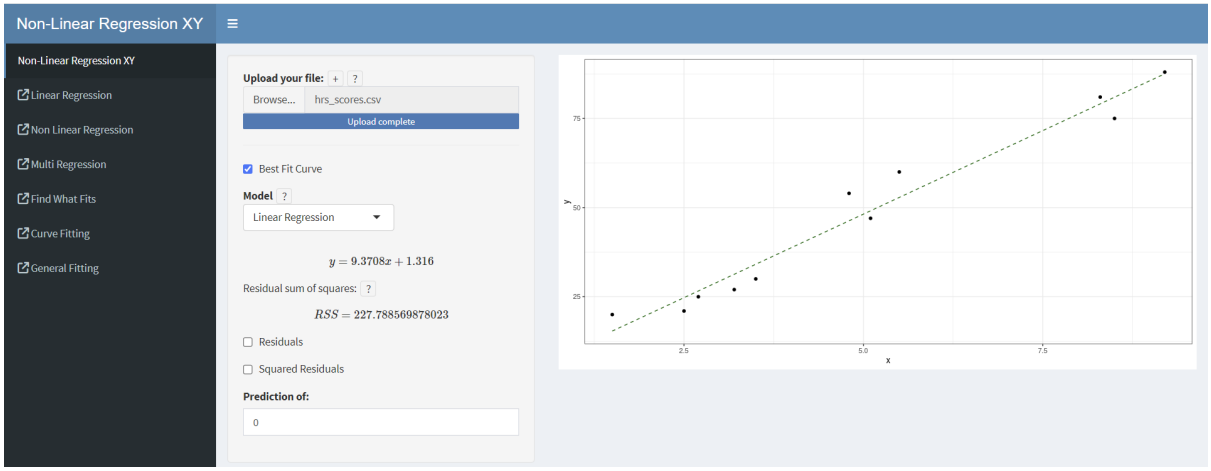
2.2 Step 2: Data analysis

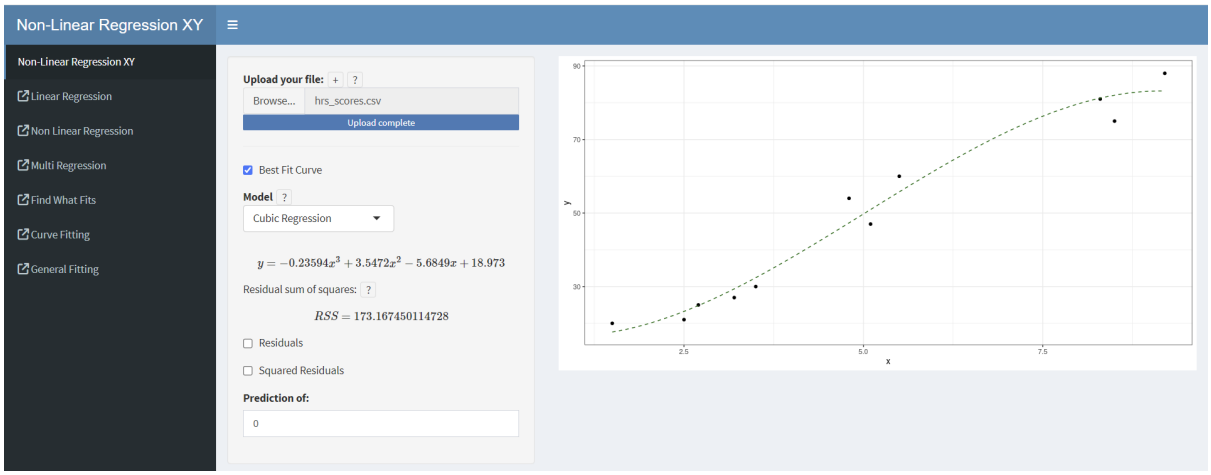
After you have inputted the dataset, now we can perform linear or nonlinear regression easily. Try to click different buttons on the page and now we will briefly explain their usage.



2.2.1 Best Fit Curve

This directly gives you the "best fit curve" under the model you are selecting. The following screenshot demonstrates the best fit curve under the linear model, which actually gives you the linear regression of the data points. Of course, you can also use other models for the regression, just like the second screenshot.





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 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:

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

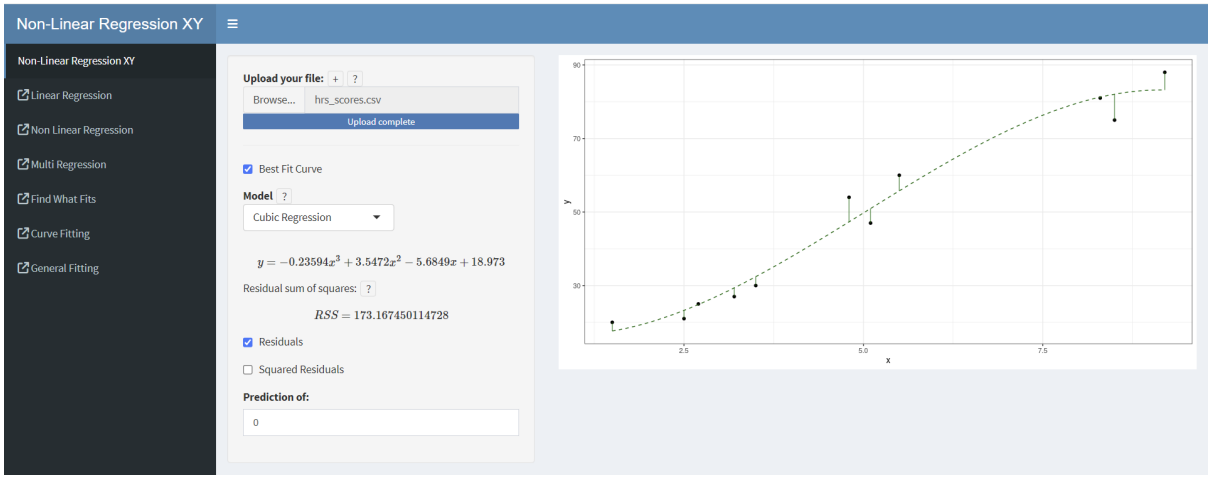
(Remark: All data points with a non-positive x value are neglected.)

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.

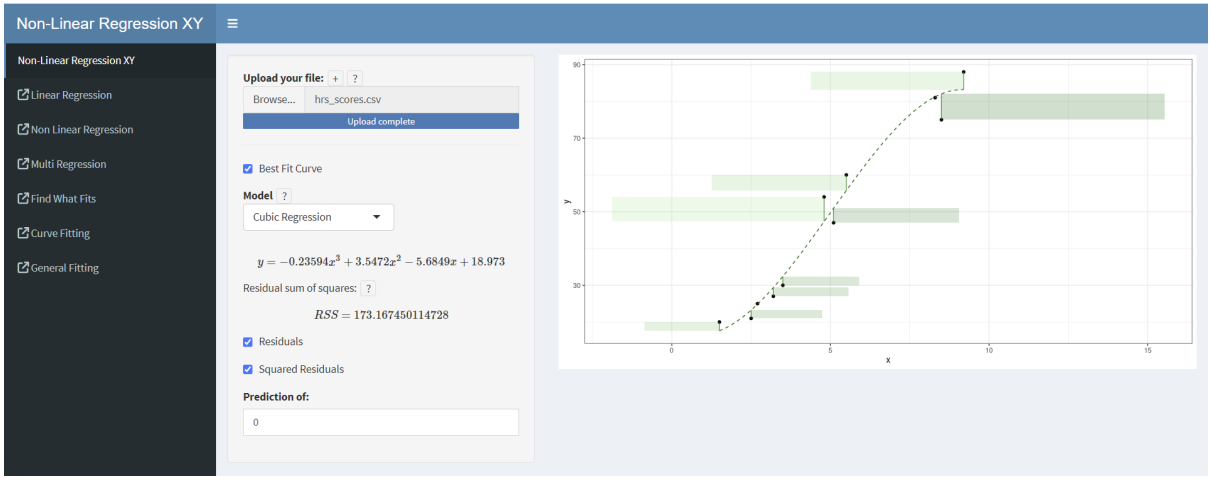
2.2.2 Residuals

This gives us a set of vertical lines, showing the difference between each of our original data points and the regression curve.



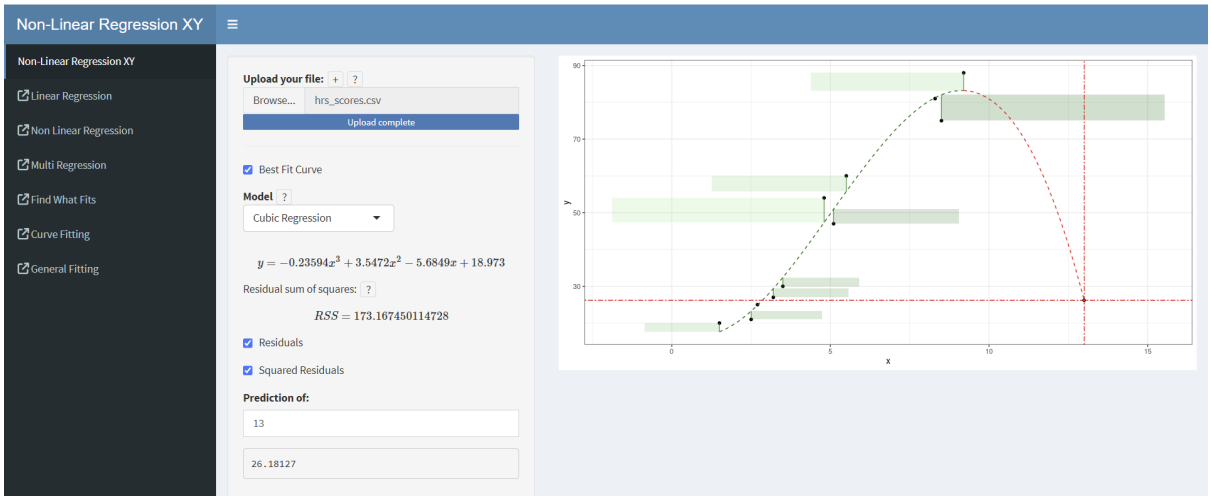
2.2.3 Squared Residuals

This function visualizes the square of residuals as the area of the rectangles. In fact, it is originally a square with side length equal to the residual, just that in the graph, the vertical and horizontal scales are different, and that makes the shape look like a rectangle.



2.2.4 Prediction

By typing any number 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 red vertical line gives you the prediction of the new value.



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 (XY) tool may help you with your mathematical modelling journey. Good luck!