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Modeling with R Shiny (Nonlinear Regression XY)

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1 Introduction to the Nonlinear Regression (XY) R Shiny tool
非線性迴歸(XY) R Shiny 工具簡介

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.
R 是一種功能强大的統計程式語言，讓我們能夠進行數據分析，對數學建模十分有用。更理想的是，我們利用R Shiny 建立了一系列線上工具，讓使用者即使不具備程式設計背景，也能夠執行各種數學建模任務。

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.
具體而言，根據若干數據點$(x_1, y_1), (x_2, y_2), \ldots, (x_n, y_n)$ 進行非線性迴歸是數學建模中的一項常見任務。以下是有關如何使用我們的非線性迴歸(XY) R Shiny 工具的指引。

2 Using Nonlinear Regression (XY) R Shiny tool
使用非線性迴歸(XY) R Shiny 工具

To use the tool, you can go to our main website:
如要使用此工具，可前往我們的主網站：

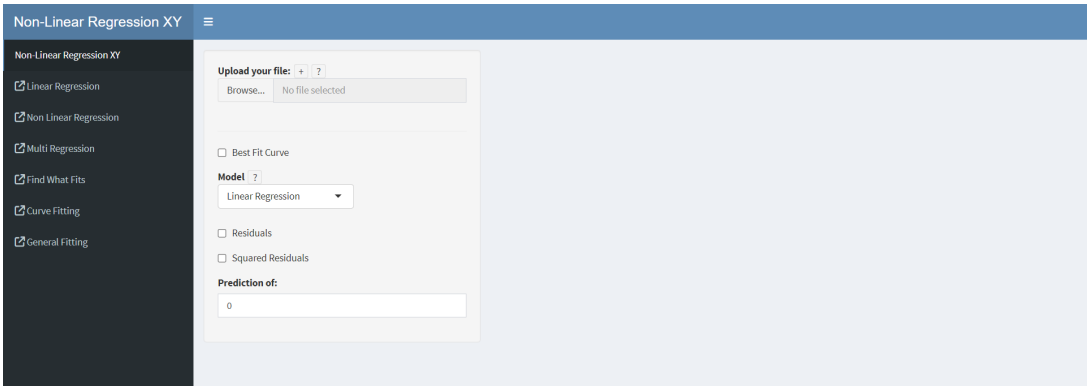
https://www.math.cuhk.edu.hk/app/mathmodel/tool.html

for the list of tools, or simply go to
瀏覽工具列表，或直接前往

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

for the Nonlinear Regression (XY) R Shiny tool.
使用非線性迴歸(XY) R Shiny 工具。

After getting into the website, you can see the following:
進入網站後，你會看到以下畫面：



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.
如果你覺得這個界面有點複雜，不用擔心！我們會逐步引導你，讓你能夠順利使用我們的R Shiny 工具進行非線性迴歸。

2.1 Step 1: Data input
步驟一：數據輸入

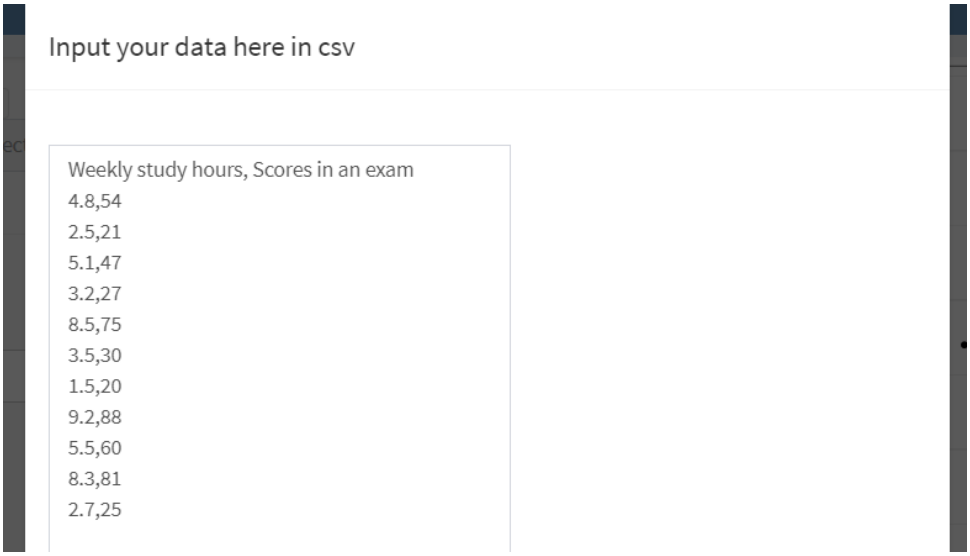
At the top left-hand corner, you can see "Upload your file", this is where we input the data. There are three different buttons.
在左上角，你會看到「Upload your file」，這就是我們輸入數據的地方。這裡有三個不同的按鈕。

Firstly, the "?" gives you the general guide on data input.
首先，「?」按鈕會提供關於數據輸入的一般指南。

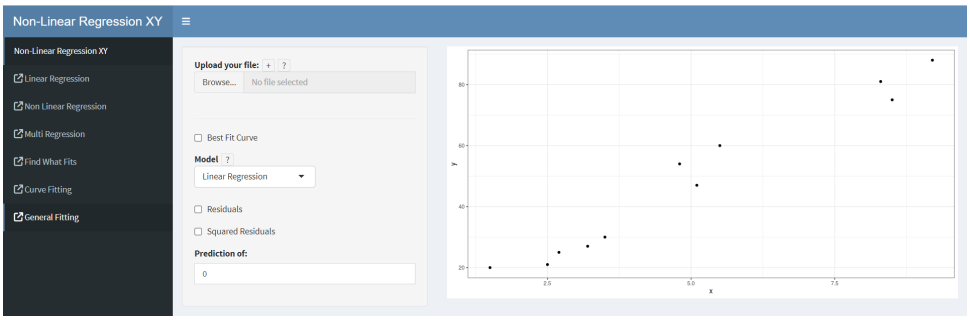
Secondly, the "+" allows you to input data directly. After clicking it, you can see the following:
其次，「+」按鈕讓你可以直接輸入數據。點擊後，你會看到以下畫面：

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"
在第一行，你可以分別輸入x 軸和y 軸的變數名稱。舉例來說，我們可以將x 軸定義為「學生每週温習時數」，y 軸定義為「學生考試分數」，以觀察兩者之間的相關性。因此，我們在第一行輸入「Weekly study hours, Scores in an exam」。

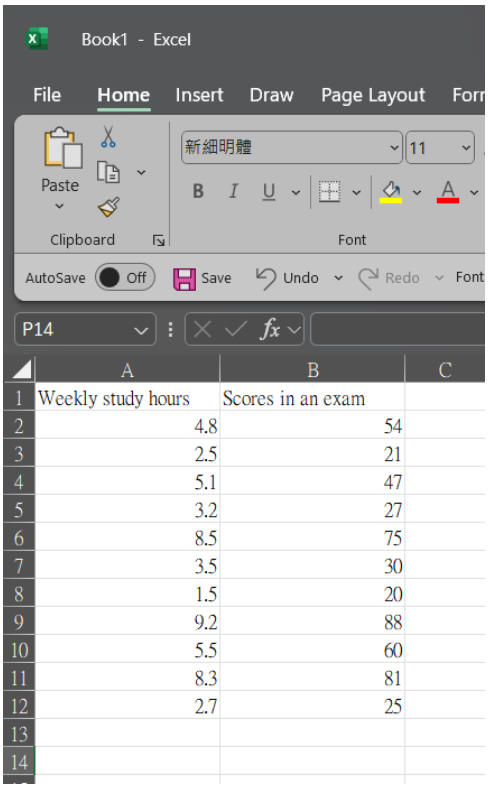
For the following lines, you can simply type in the data points respectively. You should be able to have a result that looks like this:
在接下來的行數，你可以分別輸入各個數據點。你應該會得到類似這樣的結果：



Scroll down and press "submit". Your data points should be shown on the screen like this:
向下滾動並按下「submit」，你的數據點應該會在屏幕上顯示，如下所示：



You can also upload an Excel file to the website directly. Firstly, you will need to prepare your Excel file like this:
你也可以直接將Excel 檔案上傳到網站。首先，你需要準備好Excel 檔案，格式如下：

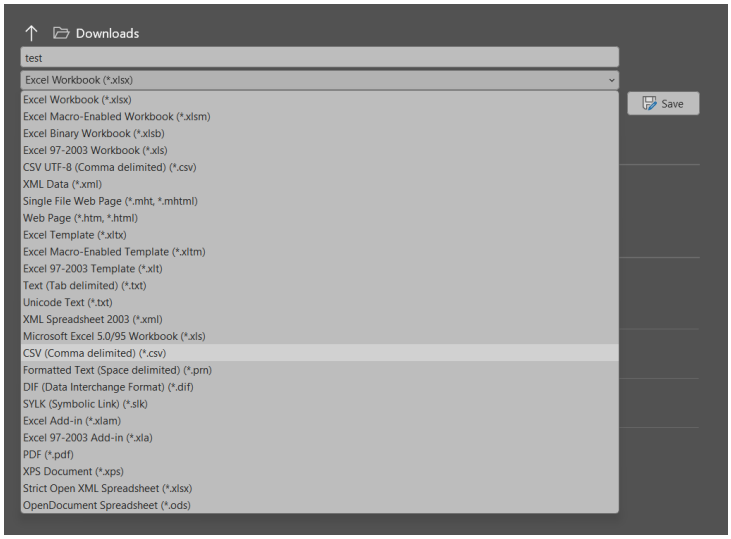


	A	B	C
1	Weekly study hours	Scores in an exam	
2	4.8	54	
3	2.5	21	
4	5.1	47	
5	3.2	27	
6	8.5	75	
7	3.5	30	
8	1.5	20	
9	9.2	88	
10	5.5	60	
11	8.3	81	
12	2.7	25	
13			
14			

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.
然後返回我們的網站，按下「Browse...」按鈕，尋找儲存在電腦上的檔案。上傳完成後，你會看到數據點顯示在圖表上。

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:
如果在上傳時遇到任何問題，你可能需要將Excel 檔案儲存為.csv 格式。方法是前往「檔案」→「另存新檔」，然後尋找以下選項：

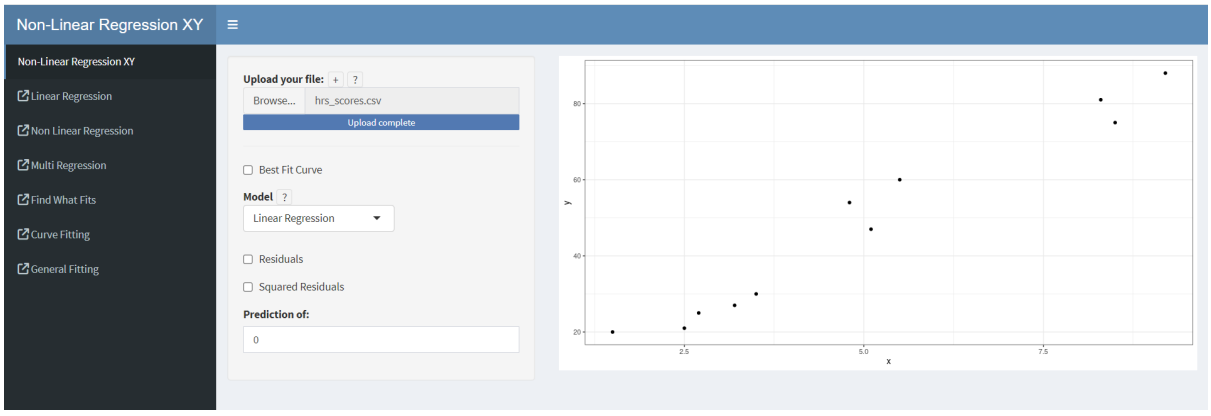
Expand the dropdown list, and look for the .csv format.
展開下拉列表，尋找.csv 格式。



After that, you can upload the file onto our website, and it will work normally.
完成後，你可以將檔案上傳到我們的網站，它就能正常運作了。

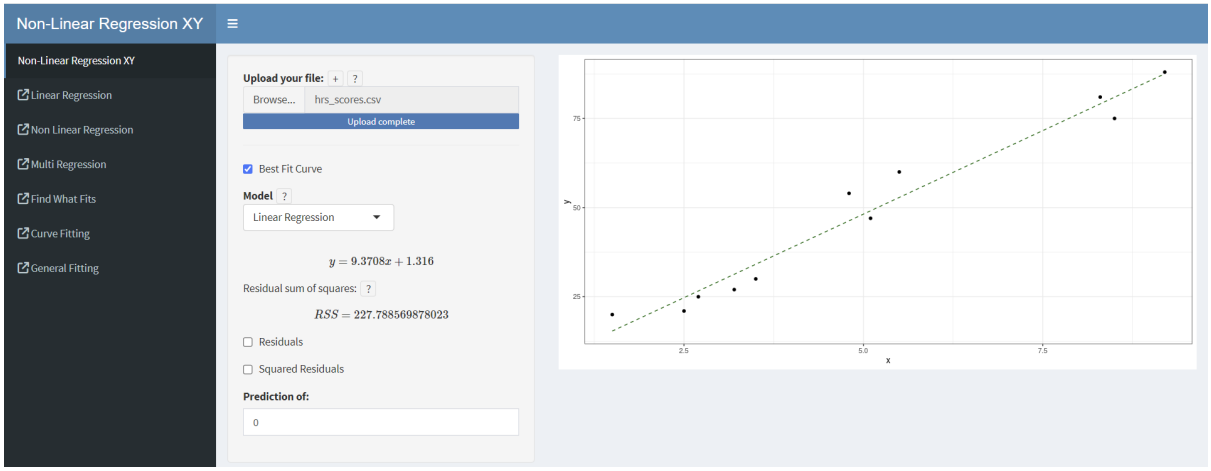
2.2 Step 2: Data analysis
步驟二：數據分析

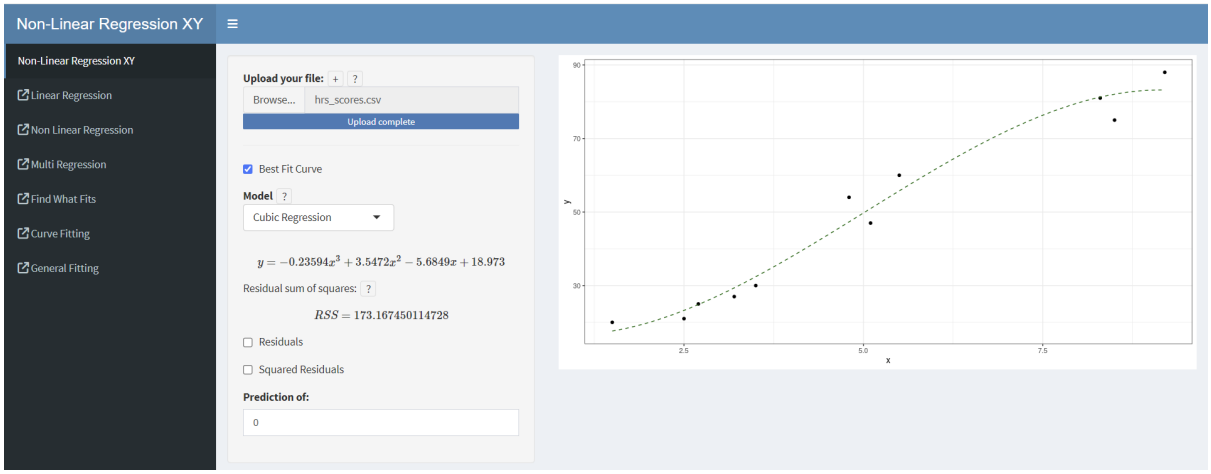
After you have inputted the dataset, now we can perform linear or nonlinear regression easily. Try to click different buttons on the page and now we will briefly explain their usage.
輸入數據集後，我們現在可以輕鬆地進行線性或非線性迴歸。嘗試點擊頁面上的不同按鈕，現在我們將簡要說明它們的用途。



2.2.1 Best Fit Curve
最佳擬合曲線

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.
此功能會直接顯示在所選模型下的「最佳擬合曲線」。以下截圖展示線性模型下的最佳擬合曲線，實際上就是數據點的線性迴歸結果。當然，你也可以使用其他模型進行迴歸，正如第二張截圖所示。





The available models include:
可供選擇的模型包括：

- Linear Regression:
  線性迴歸：

$$y = ax + b$$

- Quadratic Regression:
  二次迴歸：

$$y = ax^2 + bx + c$$

- Cubic Regression:
  三次迴歸：
  $$y = ax^3 + bx^2 + cx + d$$

- Polynomial Regression:
  多項式迴歸：
  $$y = a_n x^n + a_{n-1} x^{n-1} + \cdots + a_1 x + a_0$$
  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.)
  其中n 是指定的次數（備註：當n 設定過大時，部分參數可能超出最小計算限制而被忽略。）

- Power Regression:
  冪迴歸：
  $$y = ax^b$$
  (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.)
  （備註：我們通過考慮以下線性化模型來求解最佳擬合冪模型：$\ln(y) = \ln(a) + b \cdot \ln(x)$。因此，所有$x$ 或y 值為非正數的數據點將被忽略。）

- Exponential Regression:
  指數迴歸：
  $$y = ab^x$$
  (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.
  （備註：我們通過考慮以下線性化模型來求解最佳擬合指數模型：$\ln(y) = \ln(a) + \ln(b) \cdot x$。因此，所有$y$ 值為非正數的數據點將被忽略。）

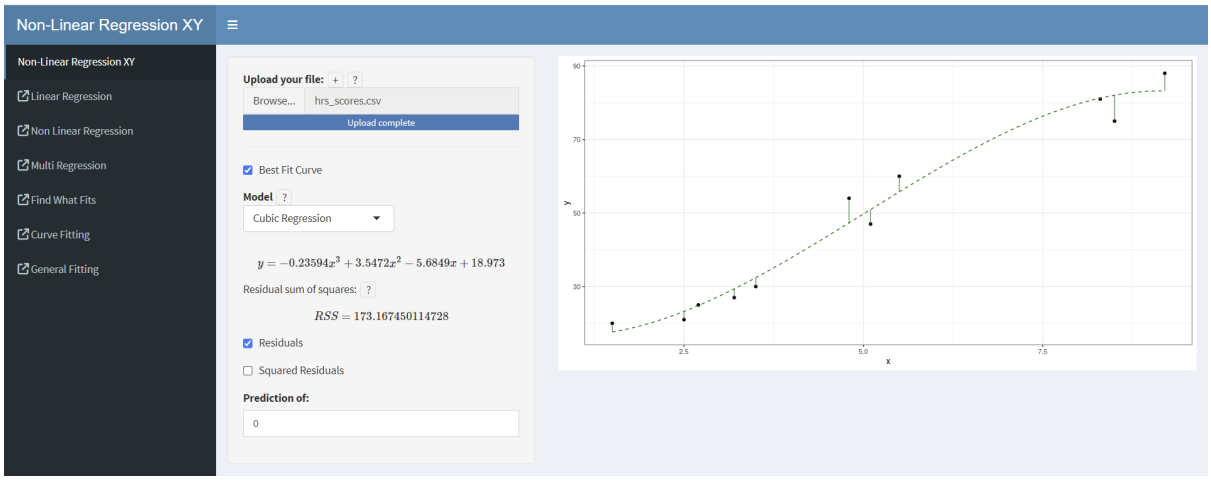
- Logarithmic Regression:
  對數迴歸：
  $$y = a + b \ln(x)$$
  (Remark: All data points with a non-positive x value are neglected.)
  （備註：所有x 值為非正數的數據點將被忽略。）

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.)
除了顯示圖表外，工具還會提供各種相關資訊，例如最佳擬合曲線的方程式和殘差平方和。殘差平方和用於衡量這條曲線對我們現有數據集的近似程度。你也可以利用這個數值來比較哪個模型更適合進行迴歸分析。（請注意，殘差平方和較低並不一定表示我們使用的模型是好的。）

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.
如果你對我們顯示的數值有任何疑問，當然可以隨時在網上搜尋。不過，每個變數旁邊也有一個「?」按鈕；點擊它，便會出現相關的簡要說明。

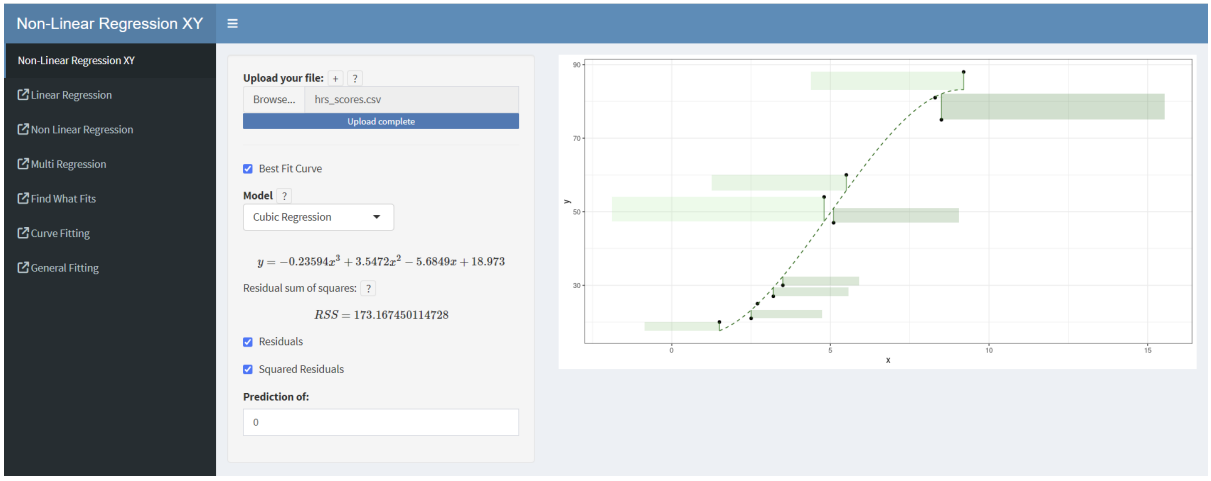
2.2.2 Residuals
殘差

This gives us a set of vertical lines, showing the difference between each of our original data points and the regression curve.
此功能會顯示一組垂直線，表示每個原始數據點與迴歸曲線之間的差異。



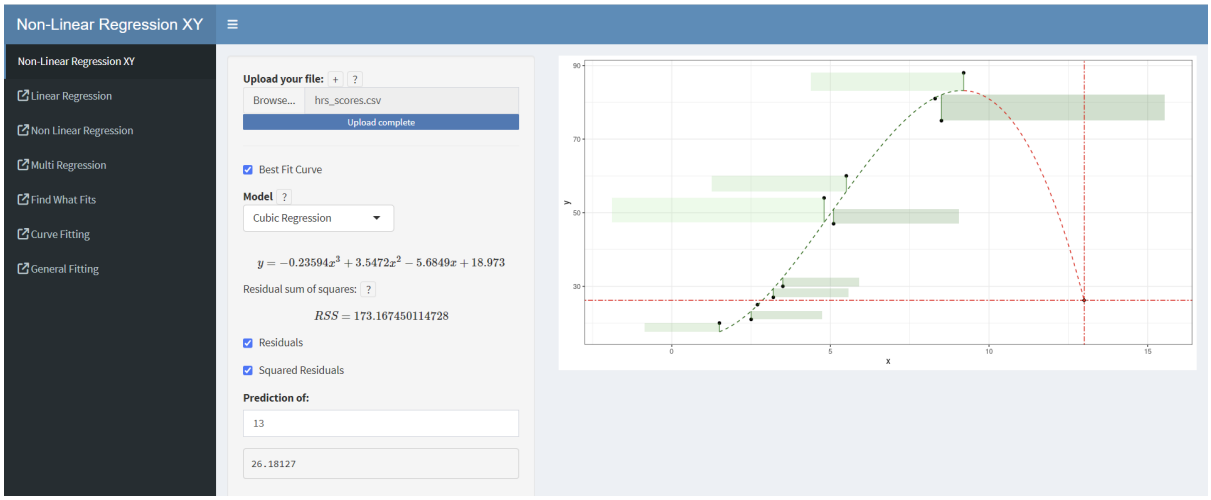
2.2.3 Squared Residuals
平方殘差

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.
此功能將殘差的平方以矩形面積的形式可視化。實際上，它原本是一個邊長等於殘差的正方形，只是由於圖表中垂直和水平的比例尺不同，使得形狀看起來像一個矩形。



2.2.4 Prediction
預測

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.
在方框中輸入任何數值，我們便能根據迴歸曲線得知對應的y 坐標預測值。你還可以觀察迴歸線如何延伸，而與紅色垂直線的交點即為新值的預測結果。



3 Conclusion
總結

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!
非線性迴歸是數學建模中極具價值的工具。透過考慮不同的非線性迴歸模型，我們能夠深入理解數據集的趨勢並進行預測。我們衷心希望這個R Shiny 非線性迴歸(XY) 工具能夠在你的數學建模探索旅程中提供協助。祝你一切順利！