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)

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1 Introduction to the Nonlinear Regression (Time Data) R Shiny tool
非線性迴歸（時間數據）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 analyze and predict certain data according to past history. Here we are going to introduce how to use our nonlinear regression based on time.
具體而言，根據歷史數據分析和預測未來趨勢是數學建模中的一項常見任務。以下是有關如何使用我們基於時間的非線性迴歸R Shiny 工具的指引。

2 Using the Nonlinear Regression (Time Data) R Shiny tool
使用非線性迴歸（時間數據）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：

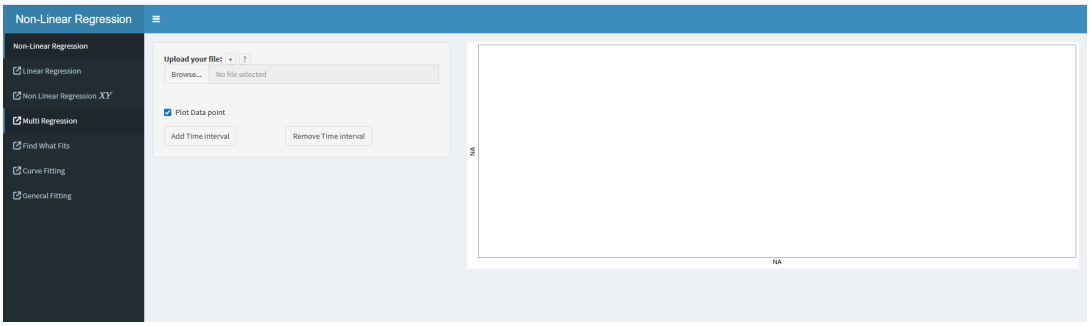
https://www.math.cuhk.edu.hk/app/mathmodel/tool.html

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/

for the Nonlinear Regression (time) R Shiny tool.
使用非線性迴歸（時間數據）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：



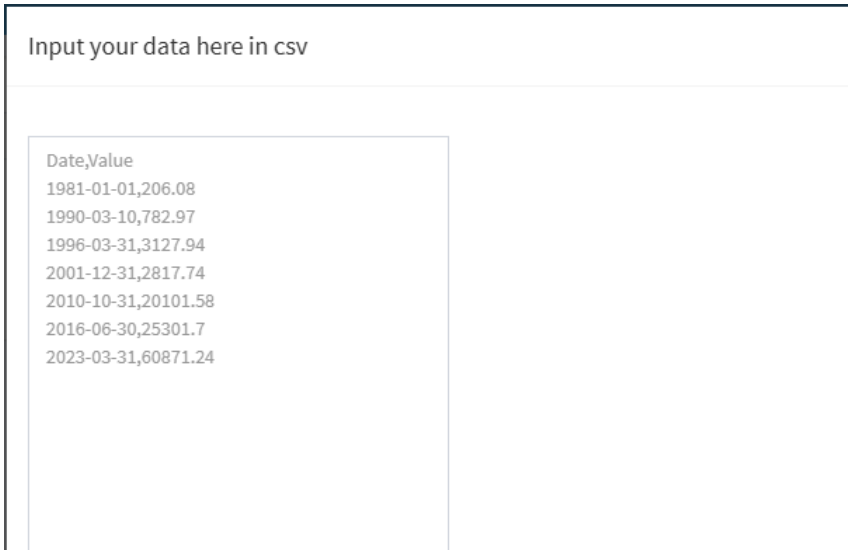
Don't worry if you think this is complicated! We will guide you step by step, and you can do nonlinear regression using our R Shiny tool.
如果你覺得這個界面有點複雜，不用擔心！我們會逐步引導你，讓你可以使用我們的R Shiny 工具進行非線性迴歸。

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。

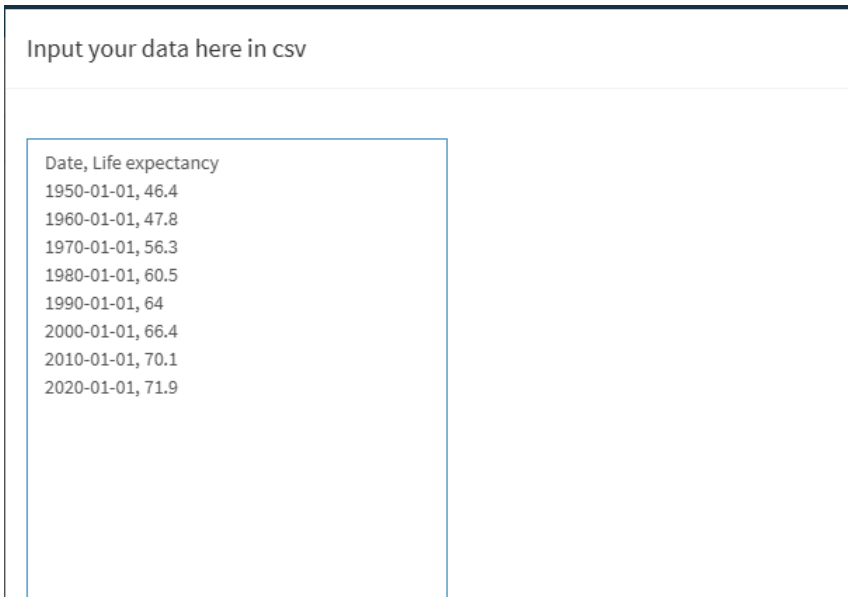
Firstly, the "?" gives you the general guide on data input.
首先，「?」按鈕會提供關於數據輸入的一般指南。

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：

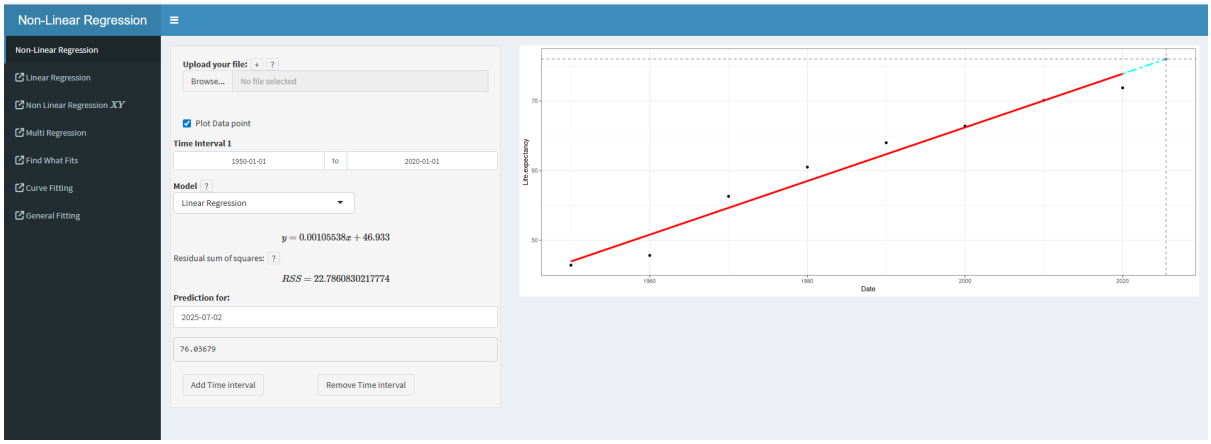


On the first line, you can input the names of the variables. For example, we can define the variable to be life expectancy. Therefore, on the first line we type "Date, Life expectancy". And then we input the dates and corresponding life expectancy. (Remark: if the data is based on years or even ten years, we can simply type the dates as yyyy-01-01)
在第一行，你可以輸入變數的名稱。舉例來說，我們可以將變數定義為「預期壽命」。因此，我們在第一行輸入「Date, Life expectancy」。然後輸入日期和相應的預期壽命。（備註：如果數據以年或十年為單位，我們可以簡單地將日期輸入為yyyy-01-01 的格式）

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：

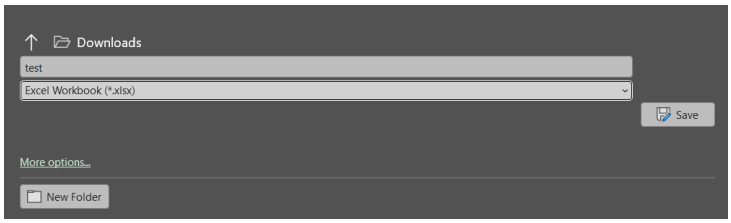


You can also upload an Excel file to the website directly. Firstly, you will need to prepare your Excel file like this:
你也可以直接將Excel 檔案上傳到網站。首先，你需要準備好Excel 檔案，格式如下：

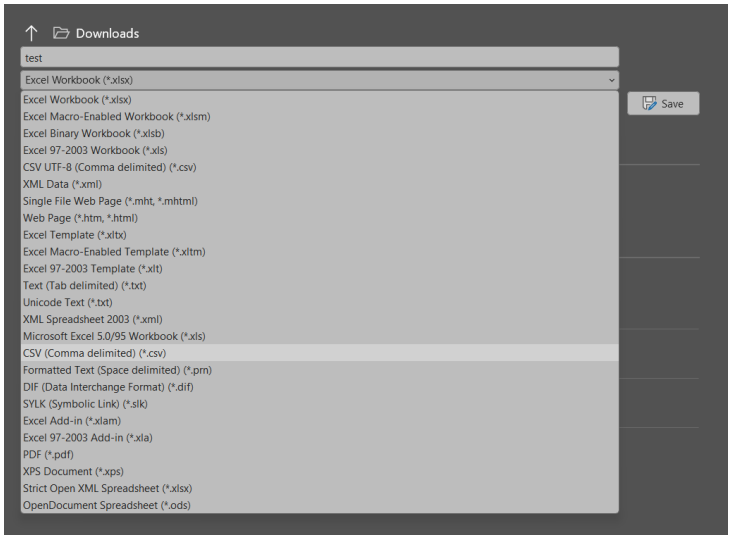
	A	B
1	Date	Life expectancy
2	1/1/1950	46.4
3	1/1/1960	47.8
4	1/1/1970	56.3
5	1/1/1980	60.5
6	1/1/1990	64
7	1/1/2000	66.4
8	1/1/2010	70.1
9	1/1/2020	71.9

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.
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：



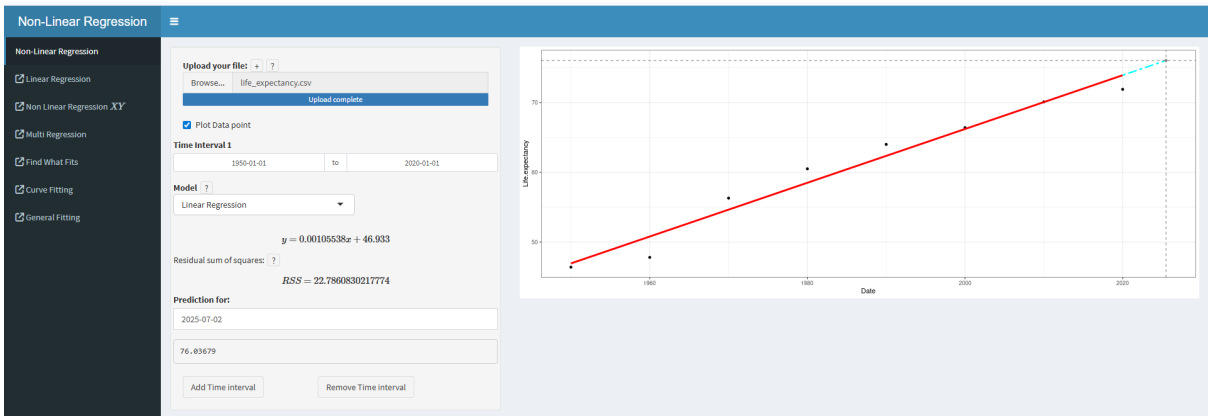
Expand the dropdown list, and look for the .csv format.
展開下拉列表，尋找.csv 格式。



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。

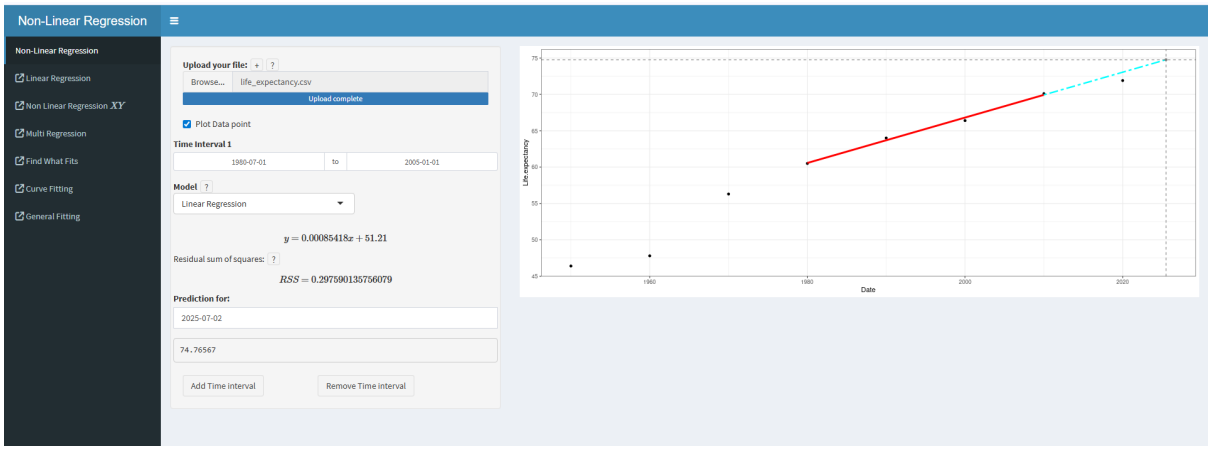
2.2 Step 2: Data analysis
步驟二：數據分析

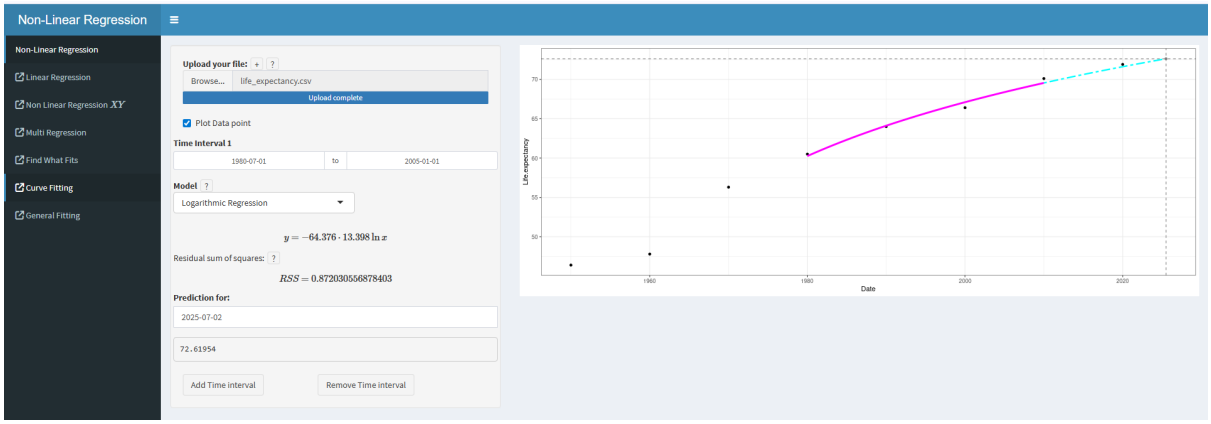
After you have inputted the dataset, now we can perform linear or nonlinear regression easily. Try to click different buttons on the page and now we will briefly explain their usage.
輸入數據集後，我們現在可以輕鬆地進行線性或非線性迴歸。嘗試點擊頁面上的不同按鈕，現在我們將簡要說明它們的用途。



2.2.1 Time Interval
時間區間

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:
此功能讓我們能夠根據特定的時間區間建立函數迴歸。請注意，時間區間必須在數據輸入的範圍之內。此外，你可以使用不同的模型來分析數據。例如，你可以得到以下結果：





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 be 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。）

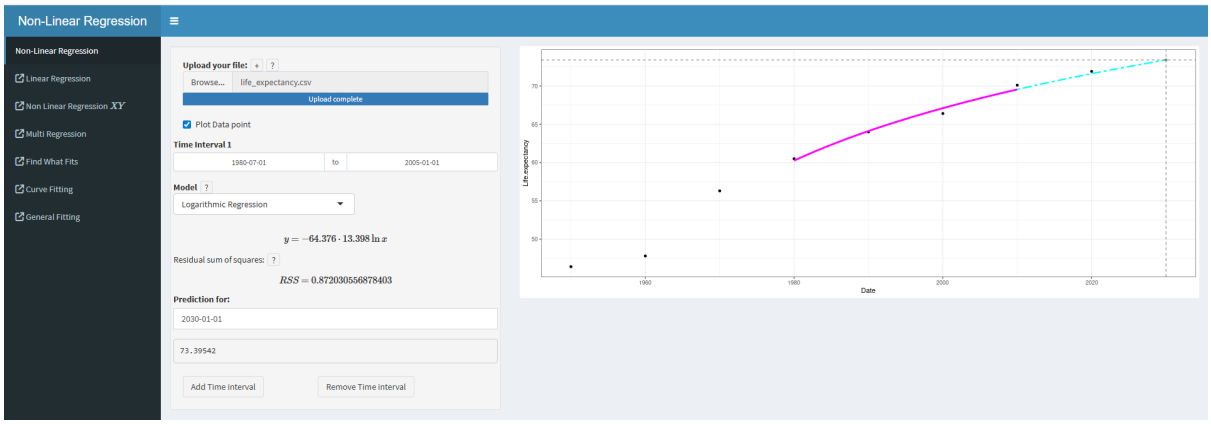
- Logarithmic Regression:
  對數迴歸：
  $$y = a + b \ln(x)$$
  (Remark: All data points with a non-positive x value are neglected.)
  （備註：所有x 值為非正數的數據點將被忽略。）

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。

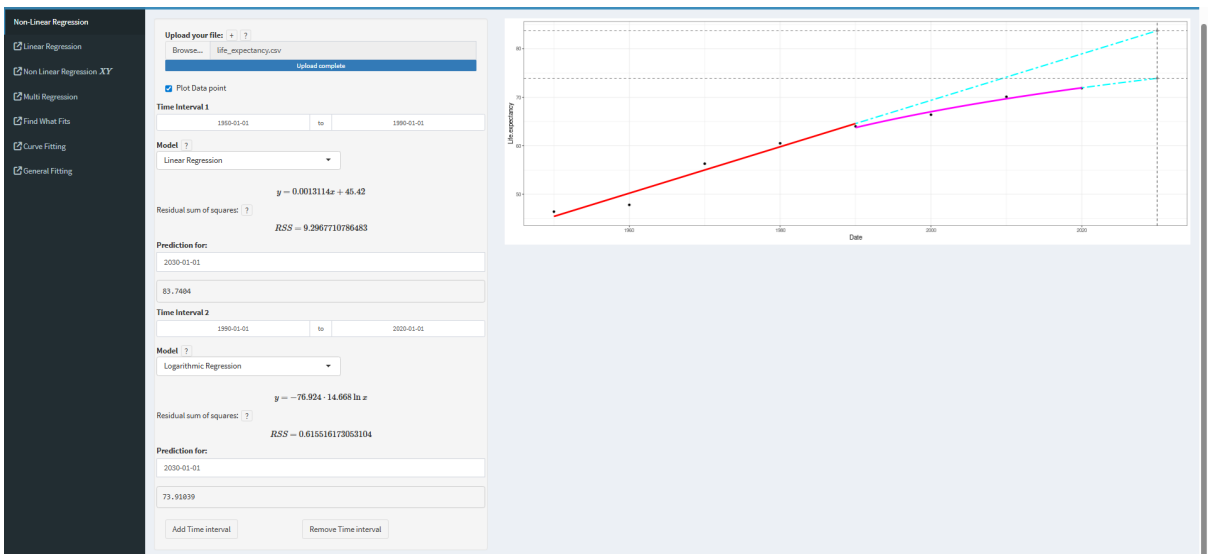
2.2.2 Prediction
預測

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.
在方框中輸入任何日期，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，而與垂直虛線的交點即為新值的預測結果。



2.2.3 Add Time Interval
添加時間區間

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:
在我們的R Shiny 工具中，我們可以在不同的時間區間使用不同的模型來分析數據。舉例來說，如果我們有充分理由相信1950 年至1990 年與1990 年至2020 年的趨勢有所不同，那麼我們可以將數據劃分為兩個不同的區間，結果將會如下所示：



As you can see, if we apply different model on different time intervals, we can have different predictions in the future too.
正如你所見，如果我們在不同的時間區間應用不同的模型，我們對未來的預測也會有所不同。

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 (Time Data) 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（時間數據）工具能能夠在你的數學建模探索旅程中提供協助。祝你一切順利！