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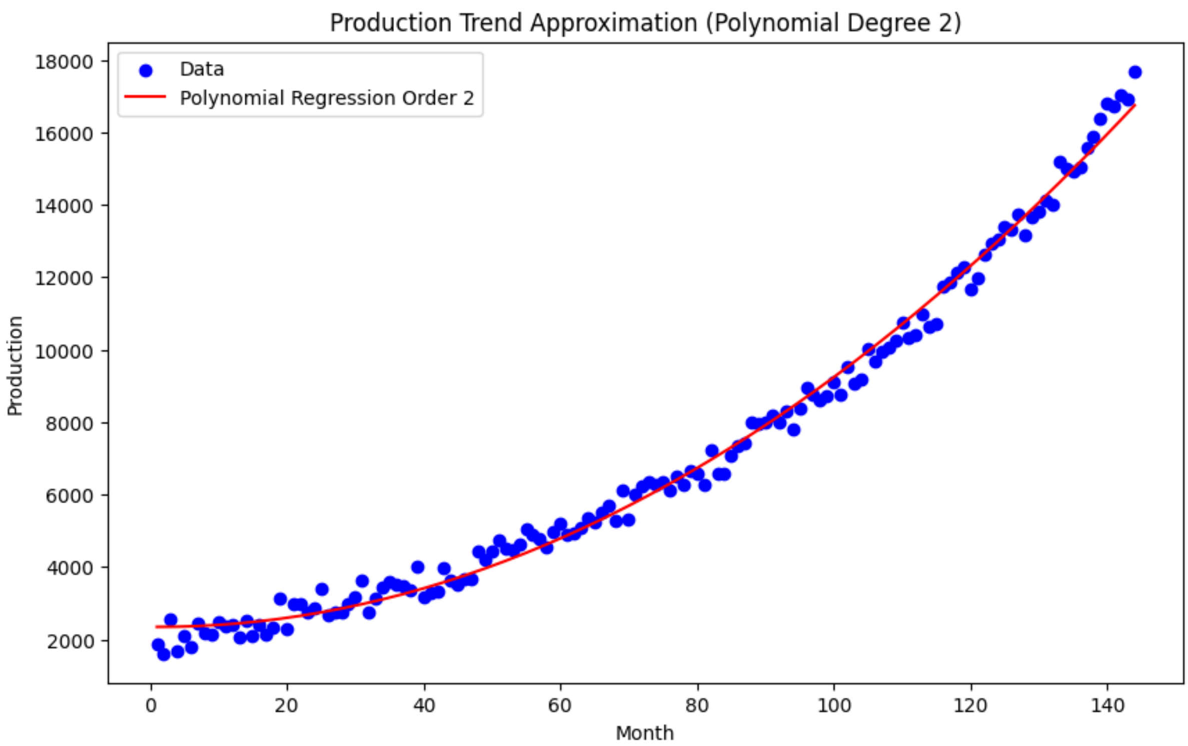
1. To find the trend of bag production from the data and provide a mathematical model that can accurately explain the production trend, I tried 3 methods, namely polynomial degree 2 and degree 3, and exponential:

A. Polynomial Degree 2

For polynomials degree 2, the mathematical model is $a.x^2 + b.x + c$

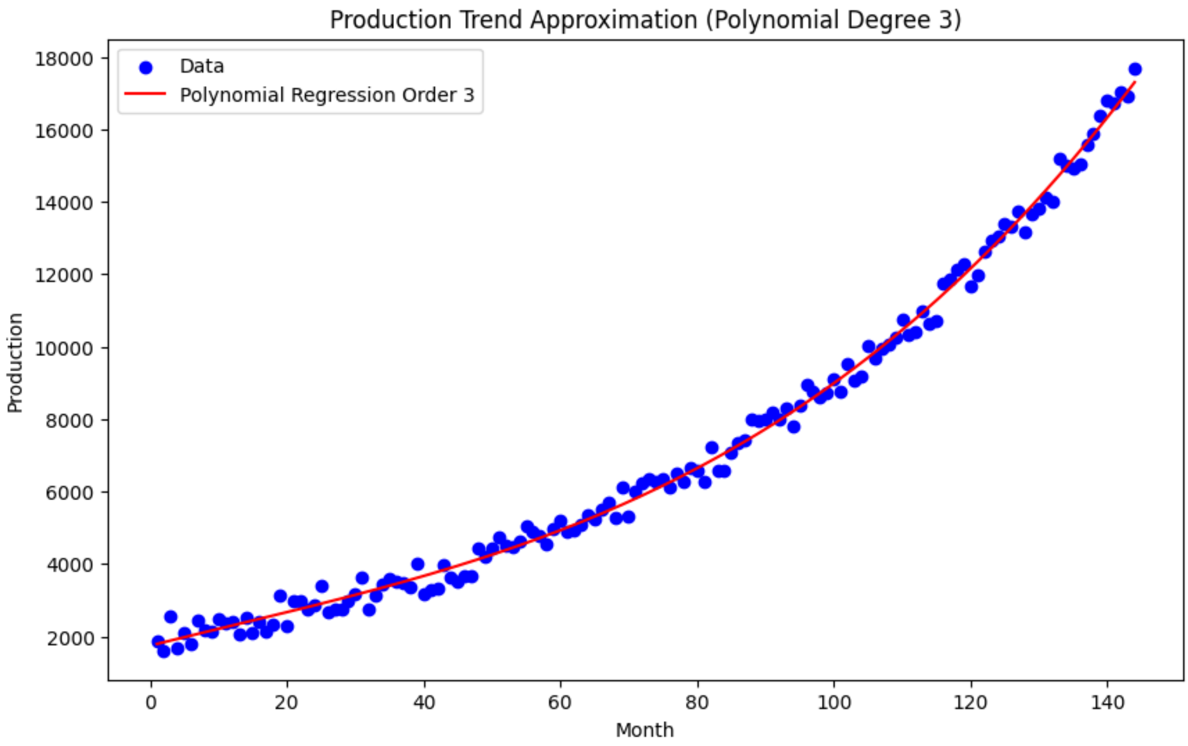


Mean Absolute Error (MAE): 292.626
Root Mean Squared Error (RMSE): 361.509
Mean Absolute Percentage Error (MAPE): 5.964%

B. Polynomial Degree 3

For polynomials degree 3, the mathematical model is

$$a.x^3 + b.x^2 + c.x + d$$

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Mean Absolute Error (MAE):  245.304
Root Mean Squared Error (RMSE):  288.436
Mean Absolute Percentage Error (MAPE): 4.988%
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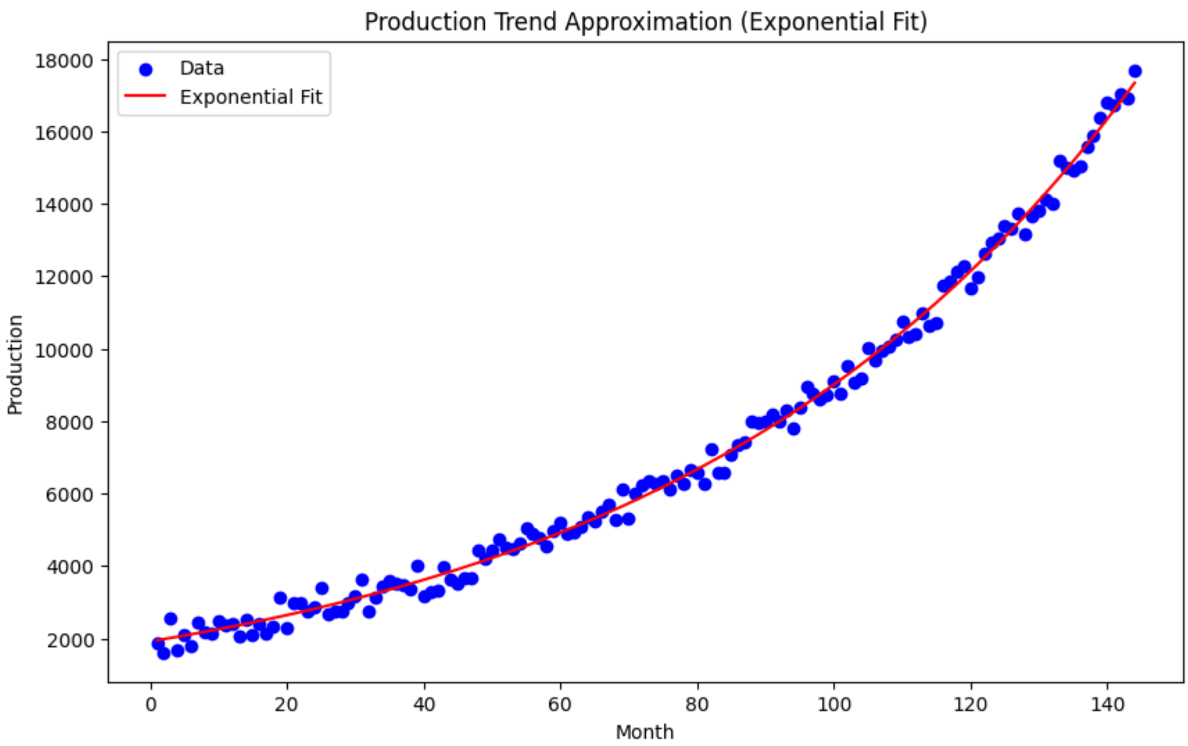
C. Exponential Regression

For exponential, the mathematical model is $a.e^{bx} + c$

Addition of a constant *c*

Because this production data has an initial value, which is M1(1863). The constant c allows the model to be more flexible in adjusting the initial value or offset of the dependent variable y which can better fit data that has a non-zero initial value. The constant c represents the initial value while a and b control the rate of growth or decline and its speed.

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Mean Absolute Error (MAE):  244.001
Root Mean Squared Error (RMSE):  285.571
Exponential Fit MAPE: 4.987%
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Based on the results of the three methods and the results of calculating errors using the MAE, RMSE, and MAPE metrics, I choose to use the exponential regression method. Here are the reasons why I chose the exponential regression method.

1. Mean Absolute Error (MAE)

   The Mean Absolute Error (MAE) is a very good KPI (Key Performance Indicator) to measure forecast accuracy. As the name implies, it is the mean of the absolute error.

$$\mathrm{MAE} = \frac{1}{n}\sum_{i=1}^{n} |x_i - x|$$

Where:

• n = the number of errors,

• Σ = summation symbol (which means add them all up),

• |xi – x| = the absolute errors.

Based on the results above, it is found that the MAE of polynomial degree 2 is **292.626** while MAE polynomial degree 3 is **245.304**, and MAE exponential is **244.001**, which is the lowest among the other 2 methods.

2. Root Mean Squared Error (RMSE)

   The Root Mean Squared Error (RMSE) is defined as the square root of the average squared error.

$$RMSE = \sqrt{\frac{\sum_{i=1}^{N} (Predicted_i - Actual_i)^2}{N}}$$

where, N is Total Number of Observations.

Based on the results above, it is found that the RMSE of polynomial degree 2 is **361.509** while RMSE polynomial degree 3 is **288.436**, and RMSE exponential is **285.571**, which is the lowest among the other 2 methods.

3. Mean Absolute Percentage Error (MAPE)

   Mean Absolute Percentage Error calculates the mean absolute percentage error (Deviation) function for the forecast and the eventual outcomes. MAPE is the average absolute percent error for each time period or actuals minus forecast divided by actuals.

$$MAPE = \frac{1}{n} \sum_{i=1}^{n} \frac{|y_i - \hat{y}_i|}{y_i} .100\%$$

Where:

yi is the actual observations time series,

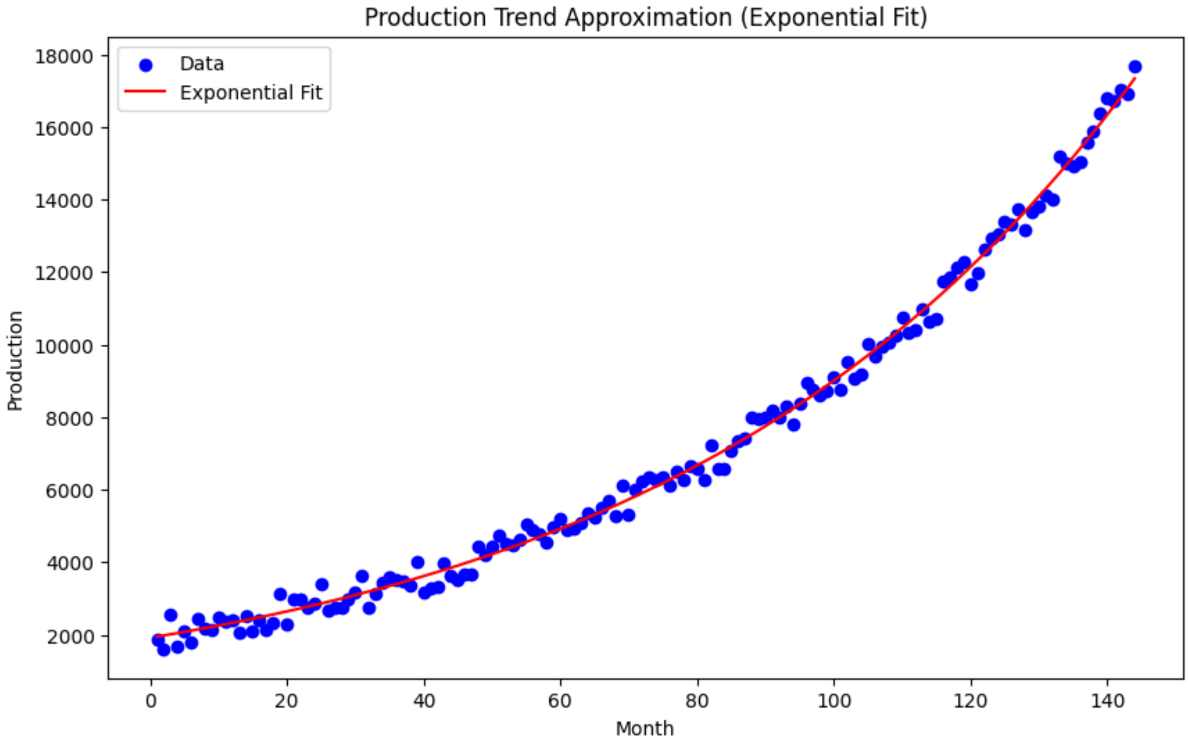
$\hat{y}_i$ is the estimated or forecasted time series,

n is the number of non-missing data points.

Based on the results above, it is found that the MAPE of polynomial degree 2 is **5.964%** while MAPE polynomial degree 3 is **4.988%**, and MAPE exponential is **4.987%**, which is the lowest among the other 2 methods.

So, based on the above 3 reasons, I choose to use the exponential method with the data trend graph and mathematical model:

Mathematical Model: $a.e^{bx} + c$



Reference:

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Jain, A. (2018). Important Model Evaluation Error Metrics. https://www.linkedin.com/pulse/important-model-evaluation-error-metrics-amit-jain