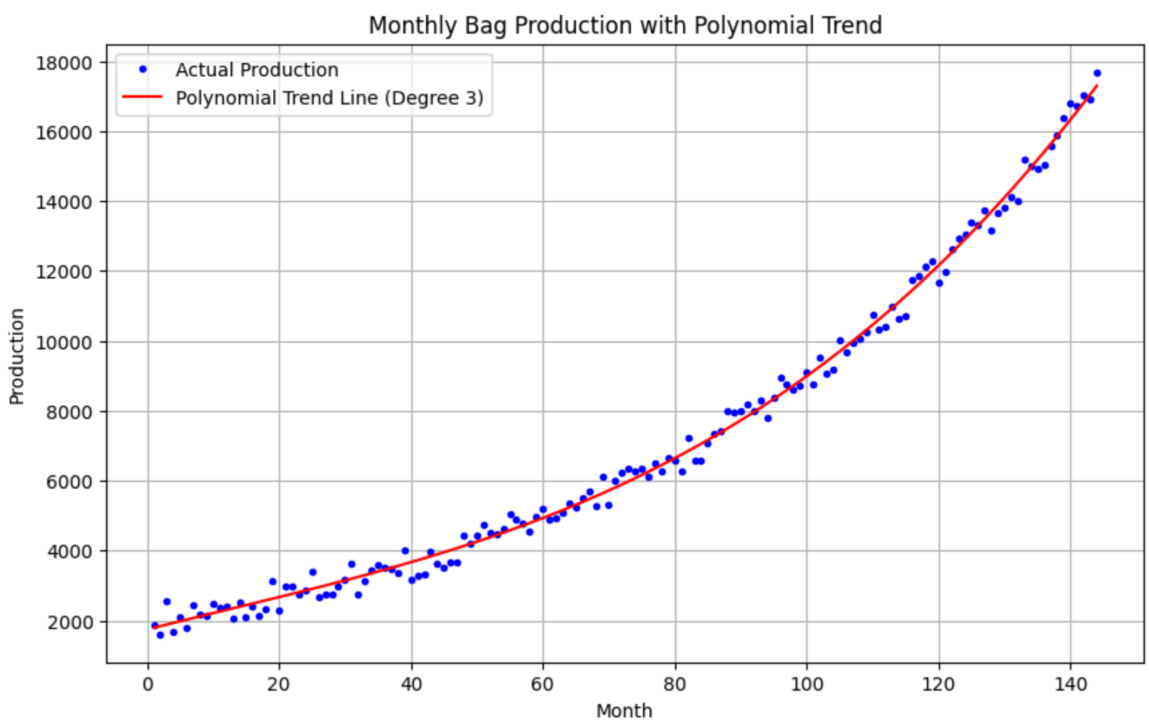
Nama : Natasha Kayla Cahyadi
NIM : 2702235891

AoL Scientific Computing

1. The monthly production of a certain type of bag from January 2018 to December 2023 (given as M1 to M144) has been analyzed to identify its trend. The observed data follows a **non-linear growth pattern**, making linear models unsuitable due to their inability to capture the curvature in the production trend. Instead, a **cubic polynomial model** was used, as it effectively balances complexity and accuracy, avoiding both underfitting and overfitting.

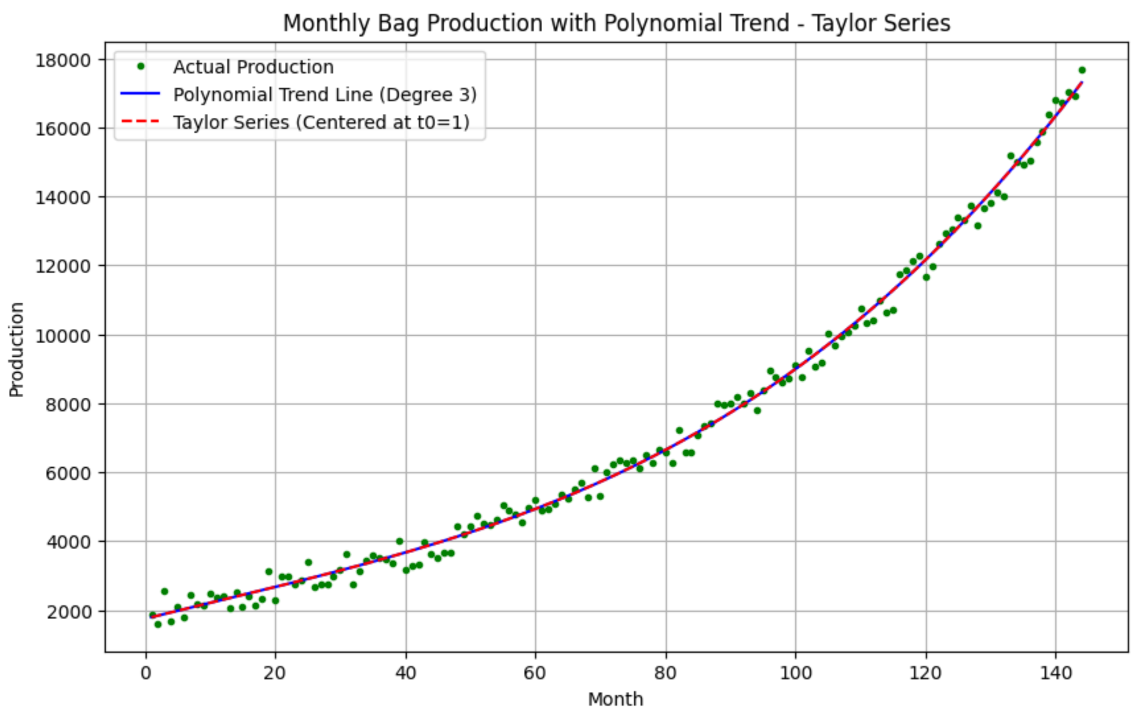
   The cubic polynomial model is mathematically represented as $P(x) = ax^3 + bx^2 + cx + d$, where $P(x)$ is the production at month x, and a, b, c, d are coefficients determined through regression. This model accurately captures the trend by aligning closely with the data points, as shown by the red line in the plot.

   The trend shows that production **increased gradually in the early months**, likely due to the initial scaling of operations. This was followed by a period of faster growth, possibly driven by higher demand or improved production efficiency. In the **later months**, the **growth started to slow down**, which might indicate that production is nearing capacity or the market is becoming saturated. This model helps us understand production trends better and plan for future needs more effectively.



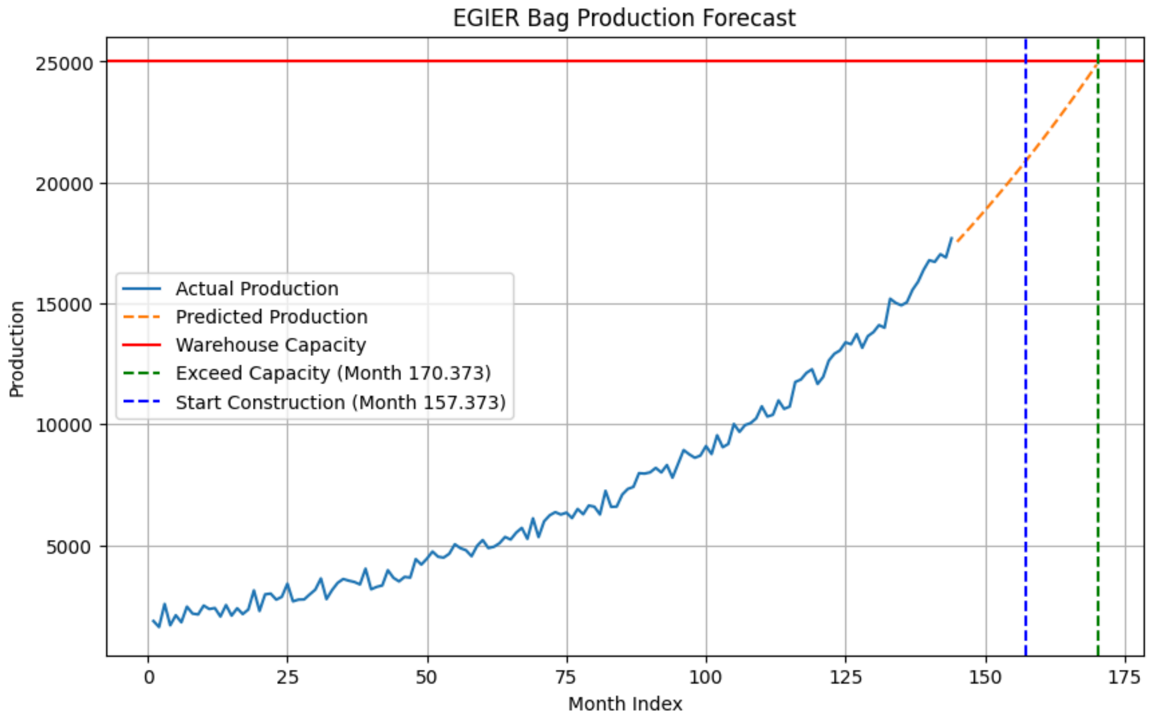
2. To approximate the mathematical model numerically, we use the Taylor series because it simplifies complex functions into polynomials, which are easier to compute. A Taylor series expansion works well with cubic models because truncating the series at the third degree exactly represents a cubic function. This ensures the model is both accurate and computationally efficient.

   For cubic functions, the Taylor series matches perfectly without any error because higher-order derivatives (beyond the third) are zero. This makes it ideal for our task, as it provides an exact fit for the production data while being easy to implement in a program.



   Polynomial Coefficients (Cubic):
   c_3: 0.004
   c_2: -0.134
   c_1: 47.224
   c_0: 1748.507
   Products Approximation in Month 100: 8990.562

3. Based on the graph and the warehouse capacity limit of 25,000 bags, we can analyze when EGIER will exceed the warehouse capacity and determine when they need to start constructing a new warehouse. The production is **projected to surpass** the warehouse capacity of 25,000 bags at **June 2032**. Since it takes 13 months to build a new warehouse, it is recommended for EGIER to **start construction** in **May 2031**. By starting at this time, the new warehouse will be ready by the time production exceeds the current storage capacity.



Predicted month to exceed warehouse capacity: Month 170

Recommended month to start construction: Month 157

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