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# Python libraries for estimation of Weibull parameters

▼ You can see this file by checking out the link below

👉 Python libraries for estimation of Weibull parameters

## Libraries that I used

- pandas → for data preprocessing
- surpyval → for reliability analysis
- reliability → for reliability analysis

## Pandas

- Pandas is a software library in Python for data manipulation and analysis. It supports dataframe to manipulate a database table.
- You can use Series and DataFrame with Pandas.

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## SurPyval

https://surpyval.readthedocs.io/en/latest/index.html

https://surpyval.readthedocs.io/en/latest/

- Reliability and survival analysis library in Python
- This library can estimate parameters and print a plot.

**SurPyval Modeling Methods**

| Method | Para/Non-Para | Observed | Censored | Truncated |
|---|---|---|---|---|
| Maximum Likelihood (MLE) | Parametric | ☑ | Yes | Yes |
| Probability Plotting (MPP) | Parametric | ☑ | Yes | Limited |
| Mean Square Error (MSE) | Parametric | ☑ | Yes | Limited |
| Method of Moments (MOM) | Parametric | ☑ | No | No |

| Method | Para/Non-Para | Observed | Censored | Truncated |
|---|---|---|---|---|
| Maximum Product Spacing (MPS) | Parametric | ☑ | Yes | No (planned) |
| Kaplan-Meier | Non-Parametric | ☑ | Right only | Left only |
| Nelson-Aalen | Non-Parametric | ☑ | Right only | Left only |
| Fleming-Harrington | Non-Parametric | ☑ | Right only | Left only |
| Turnbull | Non-Parametric | ☑ | Yes | Yes |

- In specific distribution, 'MLE' is default method, but you can use other methods.
- SurPyval attempts to make parameter estimation possible for any distribution with arbitrary combnations of observations, censoring, and truncation.
- You can use various parametric and non-parametric estimation methods.

## Caution when you use the SurPyval

- The censored code is 1, and the failure code is 0 in Surpyval library → Therefore, you should be careful when you preprocess data.
- In minitab, you can set the censored code, and the failure code as you want.
- In Reliability, you can set censored values, failure values (not the censored code)
  - However, You should convert a DataFrame to a list.

💡 How to use

- **Jupyter notebook, colab, vscode, etc.**

```
# Install the library

pip install surpyval
```

```
# estimation of paramters by using the weibull distribution of surpyval

import surpyval as surv

result = surv.Weibull.fit([uptimes(722, 0 ...)], [censored code(0/1)], how = 'what modeling methods? ex)MLE')

# print a plot
result.plot()
```

```
# MTTF
result.mean()

# For more details, refer to my python code.
```

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## Reliability

https://reliability.readthedocs.io/en/latest/

- *reliability* is a Python library for reliability engineering and survival analysis.
- It significantly extends the functionality of scipy.stats.
- Plot is more intuitive than SurPyval.

#### Supported Distributions

| Aa Parametric Models | Fitting a specific distribution to data |
|---|---|
| Weibull Distribution | Fit_Weibull_2P |
| Exponential Distribution | Fit_Exponential_1P |
| Normal Distribution | Fit_Normal_2P |
| Lognormal Distribution | Fit_Lognormal_2P |
| Gamma Distribution | Fit_Gamma_2P |
| Beta Distribution | Fit_Beta_2P |
| Loglogistic Distribution | Fit_Loglogistic_2P |
| Gumbel Distribution | Fit_Gumbel_2P |
| Location shifting the distributions | |

## Caution when you use Reliability

- You can set failure values and censored values, but each information must be separated.
- In the case of Excel data, it is possible to import and convert your data by using the reliability.

  → https://reliability.readthedocs.io/en/latest/Converting data between different formats.html

How to use

```
# Install the library

pip install reliability
```

```
# estimation of parameters and print a plot

from reliability.Fitters import Fit_Weibull_2P
from reliability.Probability_plotting import Weibull_probability_plot
from reliability.Distributions import Weibull_Distribution
import matplotlib.pyplot as plt

# you should convert a DataFrame to list !

result = Fit_Weibull_2P(failure = [failure uptimes(722,0...)], right_censored = [censored uptimes(3, 500...)])

# print a plot

Weibull_probability_plot(failures = list_fail, right_censored = list_censored)
plt.show()

# MTTF

MTTF = Weibull_Distribution(alpha = result.alpha, beta = result.beta).mean
```

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## Minitab vs Python Library's Results with sample data

| | Python-SurPyval | Python-Reliability | Minitab |
|---|---|---|---|
| shape parameter | 0.47797 | 0.47797 | 0.477968 |
| scale parameter | 1294973.76215 | 1294977.38490 | 1294974 |
| MTTF | 2824605.90102 | 2824615.69632 | 2824606 |

- **The results between the minitab and SurPyval are the most similar.**

## Comparison of each program's result

**Python - SurPyval**

| Aa Data | # Shape Parameter | # Scale Parameter | # MTTF | # Probability of Failure | # Reliability | # Number of Suspension | Number of Fail |
|---|---|---|---|---|---|---|---|
| Sample Data(1) | 0.48137 | 1197531.18433 | 2575438.40219 | 0.02794 | 0.97206 | 1129 | 44 |
| Sample Data(2) | 0.47368 | 1396342.62614 | 3101719.32397 | 0.02751 | 0.97249 | 1130 | 43 |
| Sample Data(3) | 0.47877 | 1302376.87262 | 2831225.08271 | 0.02737 | 0.97263 | 1147 | 43 |

**Python - Reliability**

| Period | Shape Parameter | Scale Parameter | MTTF | Probability of Failure | Reliability | Number of Suspension | Number of Fail |
|---|---|---|---|---|---|---|---|
| Sample Data(1) | 0.48139 | 1197182.60554 | 2574489.25144 | 0.02794 | 0.97206 | 1129 | 44 |
| Sample Data(2) | 0.47369 | 1396107.83235 | 3101057.05628 | 0.02751 | 0.97249 | 1130 | 43 |
| Sample Data(3) | 0.47877 | 1302438.1842 | 2831393.55533 | 0.02737 | 0.97263 | 1147 | 43 |

**Minitab**

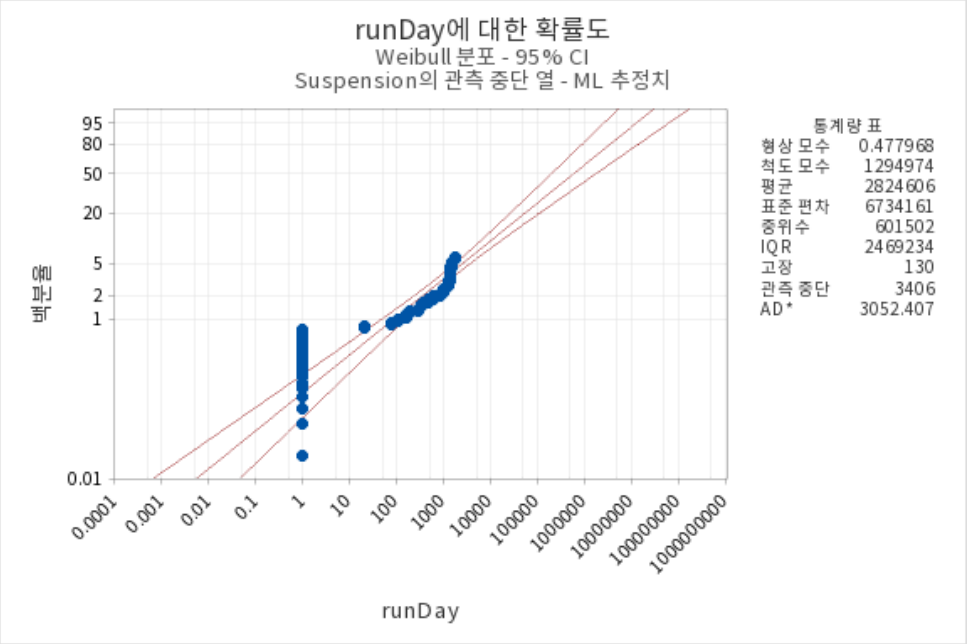
| Period | Shape Parameter | Scale Parameter | MTTF | Probability of Failure | Reliability | Number of Suspension | Number of Fail |
|---|---|---|---|---|---|---|---|
| Sample Data(1) | 0.48137 | 1197531 | 2575438 | 0.02794 | 0.97206 | 1129 | 44 |
| Sample Data(2) | 0.47368 | 1396343 | 3101719 | 0.02751 | 0.97249 | 1130 | 43 |
| Sample Data(3) | 0.47877 | 1302377 | 2831225 | 0.02737 | 0.97263 | 1147 | 43 |

**Weibull++**

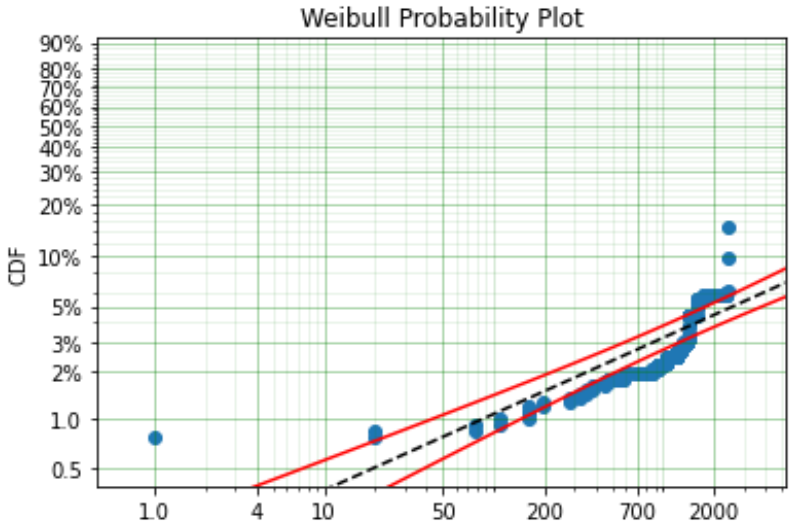
| Period | Shape Parameter | Scale Parameter | MTTF | Probability of Failure | Reliability | Number of Suspension | Number of Fail |
|---|---|---|---|---|---|---|---|
| Sample Data(1) | 0.48 | 1196754 | 2573277 | 0.0279 | 0.9721 | 1129 | 44 |
| Sample Data(2) | 0.47 | 1398258 | 3107226 | 0.0275 | 0.9725 | 1130 | 43 |
| Sample Data(3) | 0.48 | 1301719 | 2829379 | 0.0274 | 0.9726 | 1147 | 43 |

# Comparing each plot

## Minitab's Plot

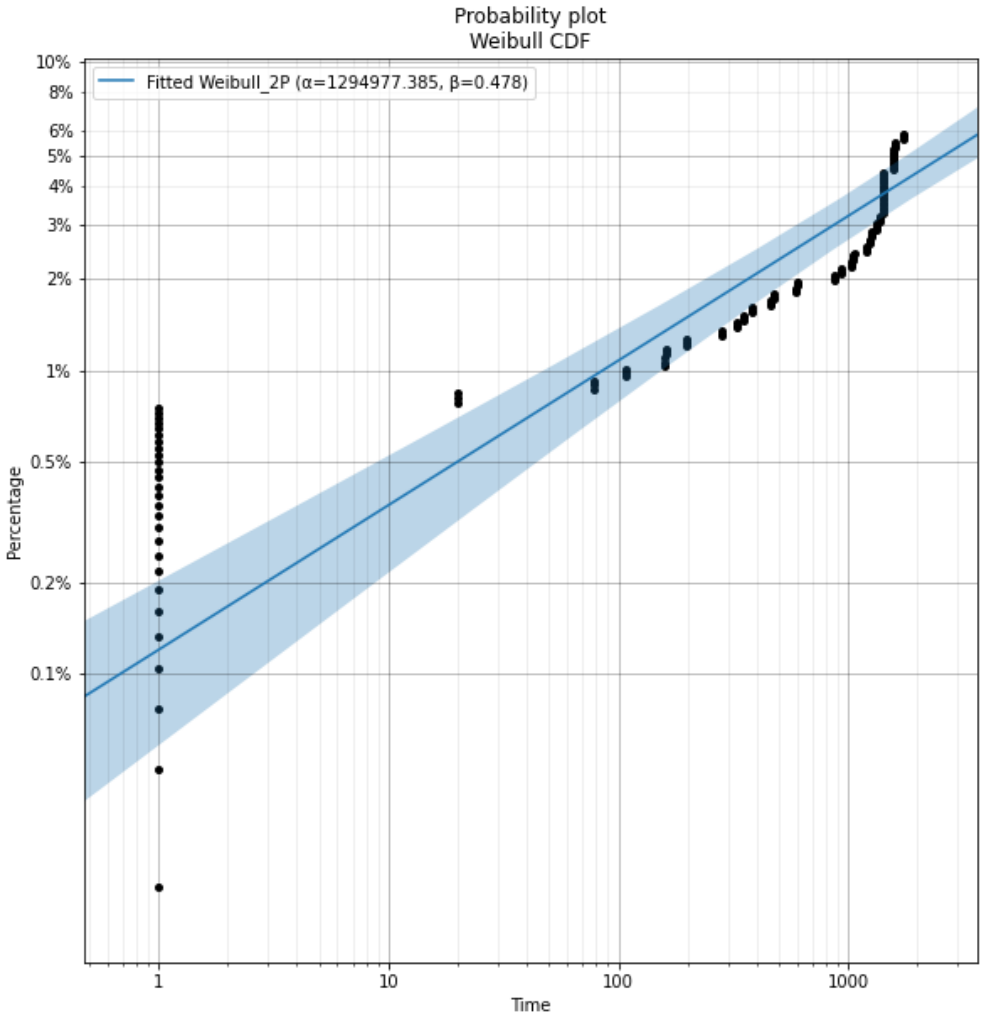



## Python - Surpyval's PLOT




- You can save the plot, but you can't modify it.

## Python - Reliability's PLOT




- Plot can be modified and saved.
- An intuitive graph

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## Using Weibayse, not the weibull distribution

- Weibayes small sample, zero and sudden death failure test and data analysis techniques in order to mathematically and graphically quantify the risk associated with assuming an incorrect value of the Weibull shape parameter, beta (beta).
- It should be used considering that it may be somewhat inaccurate.

### The library I used

- Weibull library

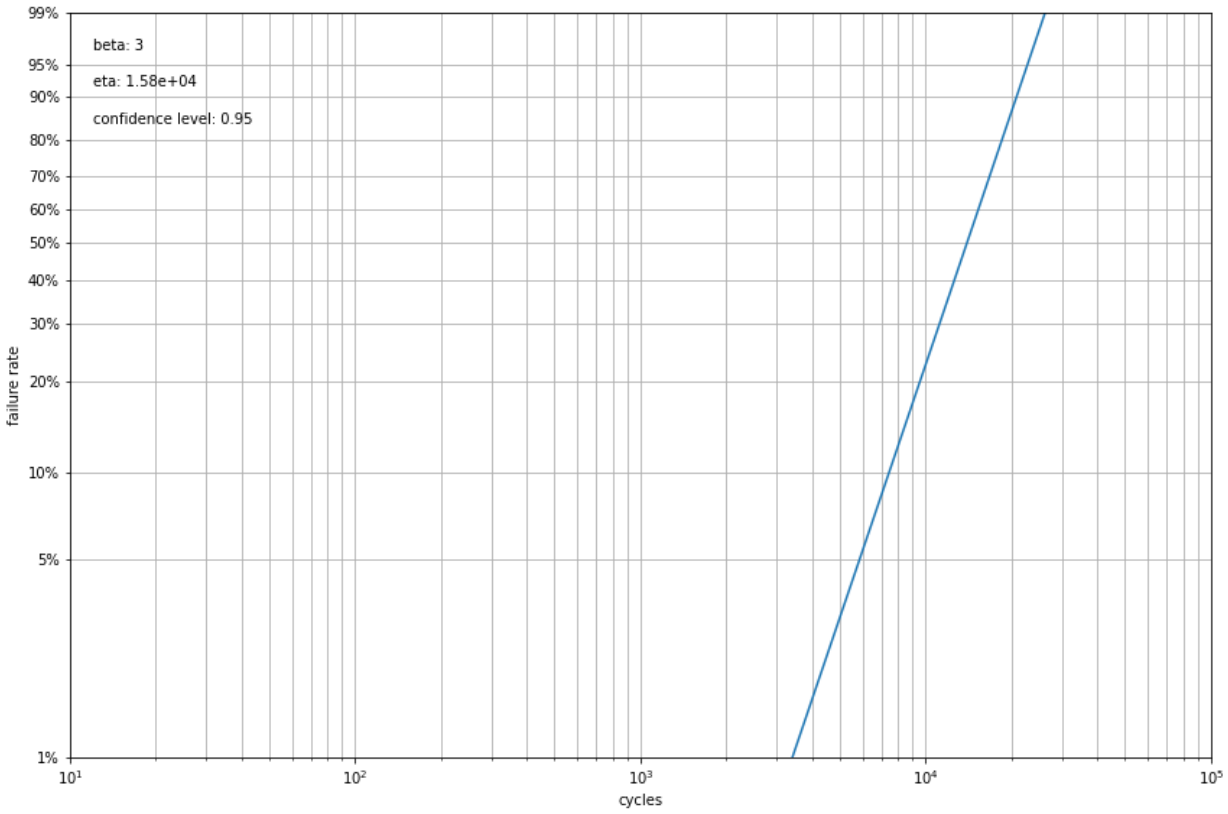
- It is necessary to convert a DataFrame to a list.
- https://weibull.readthedocs.io/en/v0.0.11/

💡 How to use

```
# Install the library

pip install weibull
```

```
# estimation of parameters and print a plot

import weibull

# you can designate a confidence level and beta

result = weibull.Weibayes(data = [uptimes], confidence_level= 0.95, beta = 1)

# print a plot

result.plot()
```

## Python - Weibull’s Plot (Weibayes)


beta: 3
eta: 1.58e+04
confidence level: 0.95
failure rate
99%
95%
90%
80%
70%
60%
50%
40%
30%
20%
10%
5%
1%
$10^1$
$10^2$
$10^3$
$10^4$
$10^5$
cycles