Warranty Cost Prediction

PURDUE UNIVERSITY | The Data Mine

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DELTA

Introduction

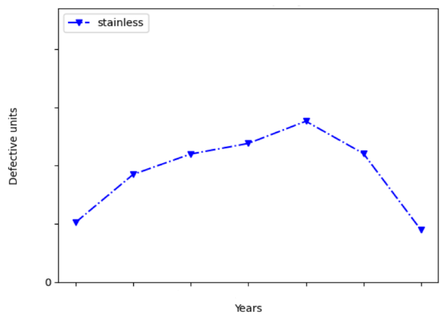
Delta Faucet offers a lifetime warranty on its products, covering repairs and replacements. These repairs can be costly, leading to full product replacements at an even higher expense. To better anticipate warranty expenses, we aim to predict when products will fail, allowing for more accurate budgeting of warranty claims.

Project Goals:
· Analyzed warranty, sales, and service data to uncover failure patterns and reduce costs.
· Develop a predictive model to estimate future warranty costs, enabling proactive budget planning

Exploratory Data Analysis

- Identified key variables and analyzed trends in units sold and failure rates over time, highlighting peak sales years
- Explored potential correlations between sales volume and time periods to support the modeling process

Annual Defective Units by Year



The graph above illustrates the amount of units that fail every year and the data provided for the year of 2024 was half the actual value

Modeling Time-Dependent Failures

A non-homogeneous Poisson process was used to represent the increasing likelihood of faucet failures over time.

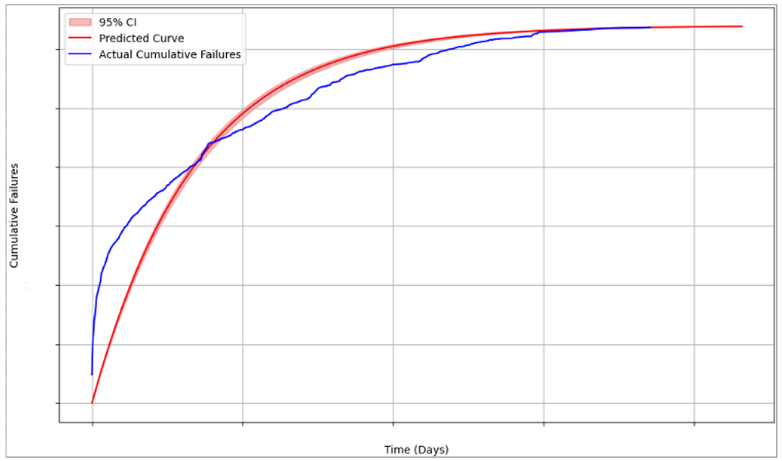
- Verified the model using three statistical tests: Laplace, Anderson-Darling, and Lewis-Robinson
- Determined the log-linear intensity function provided the best fit for the failure data
- Computed maximum likelihood estimates through numerical optimization
- Calibrated predictions after observing initial underestimation in early periods

Data Analysis Steps

1. Filter data to products that failed at a higher rate
2. Conduct hypothesis tests to confirm NHPP suitability
3. Identify the best intensity function and estimate parameters
4. Compare actual vs. predicted failures and calculate errors
5. Adjust predictions to correct first-year underprediction
6. Estimate warranty costs using adjusted failure predictions

Cumulative Predictive Model

Predicted vs.Actual Cumulative Failures



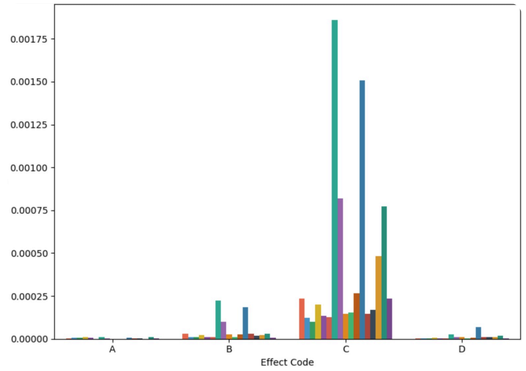
The NHPP model accurately forecasts failures after the 500-day mark. Under-prediction before day 500 was corrected through data driven adjustments. The validated NHPP model now reliably forecasts failure rates throughout a faucet's lifespan.

Business Value

Identify:
- Faucet failures at any point in their life cycle
- Common causes of early failures
- Potential correlations between failure causes

Provide:
- Insights to improve faucet manufacturing processes
- Data-driven conclusions to identify failing components

Faucet Failure Proportions by Effect Code



The graph above shows the failure rate per SKU and finish, with each bar representing a single SKU

SKU Testing Results

Defect Prediction Accuracy by SKU

Parent SKU	Defect Percentage
A	8.8
B	39
C	61.9
D	6.4
E	34.8
F	20
G	5
H	18.7
I	12.9
J	2.3
K	9.1
L	2.4
M	3.2
N	8.3
O	5.5
P	48.5
Q	40.5

The model above predicts the defects of faucets with less than 10% of margin of error for most SKUs.

- Almost half of the SKUs show that the model underpredicted the number of defects
- The Parent SKU highlighted in red has a 61.9% error and was the least accurate whereas SKU in green has a 18.7% error which shows a relatively successful forecast

Conclusion

- A non-homogeneous Poisson process effectively predicted faucet failures
- Under-prediction during the first year was corrected through data-driven model adjustments
- The model's predictions improved budget planning and financial forecasting for warranty claim costs
- Data analysis identified common failure causes, allowing Delta Faucet to refine manufacturing processes and reduce defects

Future Goals

- Develop a web application that calculates projected warranty costs for additional SKUs
- Analyze and explore additional factors that may impact the faucet production process

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