

Optimizing the Aquisition of Heavy Equiptment for Small Businesses

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Introduction

- With this project will introduce a decision analysis tool to help real estate development companies evaluate decisions for the acquisition of real-estate development equipment.
- The target decision maker for this tool is the owner or executive of a small-medium sized real-estate development company.
- For companies of this nature, financial resources are often limited so it is imperative for them to make a wise decision regarding the acquisition of heavy equipment.
- The goal of this project is to augment a classic rent vs buy analysis with a catastrophic failure analysis of equipment based on use.

Motivation

- A poor acquisition decision can lead to project failure, injury to personnel and significant loss of capital which can be crippling to a small business.
- Making the right acquisition decisions can greatly improve the financial posture of the business by reducing cost and risk.
- Inform decision makers as to which method of acquisition makes sense for their business and what condition of equipment they should acquire to meet their goals.

Decision Problem

- The main decision the business owner must make is whether they should buy or lease the equipment, should they buy with a loan or in cash, and what condition of equipment should they buy (new, used, or very used).

Decision Problem Cont'd

We define the decision maker's action set A as the set of actions the user can make within our decision tool.

Decision Problem: Action Set

Let $\alpha_1, \alpha_2, \dots, \alpha_n \in A$

where:

α_1 = Buy a new bulldozer with cash

α_3 = Buy a new bulldozer with loan

α_5 = Rent a bulldozer

α_6 = Buy a used bulldozer with cash

α_6 = Buy a used bulldozer with loan

Decision Problem: State Space

We define the state space X as the set of possible outcomes.

Let $\chi_1, \chi_2 \in X$

where:

$\chi_1 = 1$, The bulldozer suffers a catastrophic failure

$\chi_2 = 0$, The bulldozer does not suffer a catastrophic failure.

We assume our random variable will take the form of a Poisson distribution over a period of time.

Decision Problem: Parameter Space

We define the parameter space Θ as the set of unobserved parameters that will represent the period of time until a catastrophic failure is expected.

Let $\theta_1, \theta_2, \dots, \theta_n \in \Theta$

where:

θ_1 = The probability of a catastrophic mechanical failure in the next 5 years

θ_2 = The probability of a catastrophic mechanical failure in the next 10 years

θ_3 = The probability of a catastrophic mechanical failure in the next 15 years

Poisson Distribution

Expresses the probability of a given number of events occurring in a fixed interval of time or space if these events occur with a known constant mean rate and independently of the time since the last event.

A discrete random variable χ is said to have a Poisson distribution with parameter $\lambda > 0$, if, for $\chi = 0, 1, 2, \dots$, the probability mass function of χ is given by:

$$P(\chi = X) = \frac{\lambda^X \times e^{-\lambda}}{X!}$$

where:

$$\mu = \lambda$$

$$\sigma^2 = \lambda$$

$$e = 2.71828\dots$$

- Difficult to find bulldozer failure data
- Generate data sets using python based on used bulldozer sellers
- Bulldozer price is mainly based on work hours, age plays a small factor
- Data set represents bulldozers that filed in a year
- With this data set we can calculate the failure rate and lambda values for our poisson function

Data: Cont'd

| A | B | C | D |
|-----------|-----|------------|--------|
| Name | Age | Work-Hours | Value |
| Crawler_0 | 6 | 9174 | 177150 |
| Crawler_1 | 9 | 23625 | 77602 |
| Crawler_2 | 15 | 35454 | 10040 |
| Crawler_3 | 3 | 1389 | 166834 |
| Crawler_4 | 1 | 4665 | 310745 |
| Crawler_5 | 19 | 25476 | 64842 |
| Crawler_6 | 19 | 33522 | 3960 |
| Crawler_7 | 4 | 4135 | 331090 |

Decision Problem: Example

According to collected bulldozer failure data, the average failure rate for a bulldozer with 50,000 work hours is 0.7 catastrophic failures per year. Failures follow a Poisson distribution. What is the probability that this bulldozer will experience a catastrophic failure in the next 5 years?

χ = number of failures expected = 1

$\lambda = .7 * 5 = 3.5$

$$P(\chi = 1) = \frac{\lambda^{\chi} \times e^{-\lambda}}{\chi!} = \frac{3.5^1 \times e^{-3.5}}{1!} = 0.10569$$

Thus, within a 5 year period, a bulldozer with 50,000 work hours has a 10.6% chance of experiencing a catastrophic failure.

Predictive Model

- The novel predictive value this tool will provide is it's ability to predict catastrophic equipment failure given it's wear. This will reduce uncertainty for a decision maker who is assessing used equipment options.
- This uncertainty is directly related to the payoff of our decision model as there is a monetary benefit to purchasing a used piece of equipment over new equipment. However, used equipment poses a higher risk of catastrophic mechanical failure.

- The value of this tool is in minimizing the cost of ownership for the decision maker. The tool helps decision makers weigh the pros and cons of renting, buying new, and buying used and helps balance risk v.s monetary benefit to accomplish the organization's goals.
- $Payoff_{risk} = P(\chi = 1) * TotalCost$
- The lower the number the better as we want to minimize risk.

The End