Log Transformation in Regression

Linear Regression

In a linear regression, we assume that the relationship between the dependent variable and independent variable is linear, i.e., we specify the following relationship:

$$Y = a + bX$$

Log Transformations

But sometimes we also take the log-transformation of the linear regression. For example, consider the following relationship:

$$\log Y = a + b \log X$$

Here, we typically use the natural logarithms (base is $e \approx 2.718$) in log transformation.

The Log Function

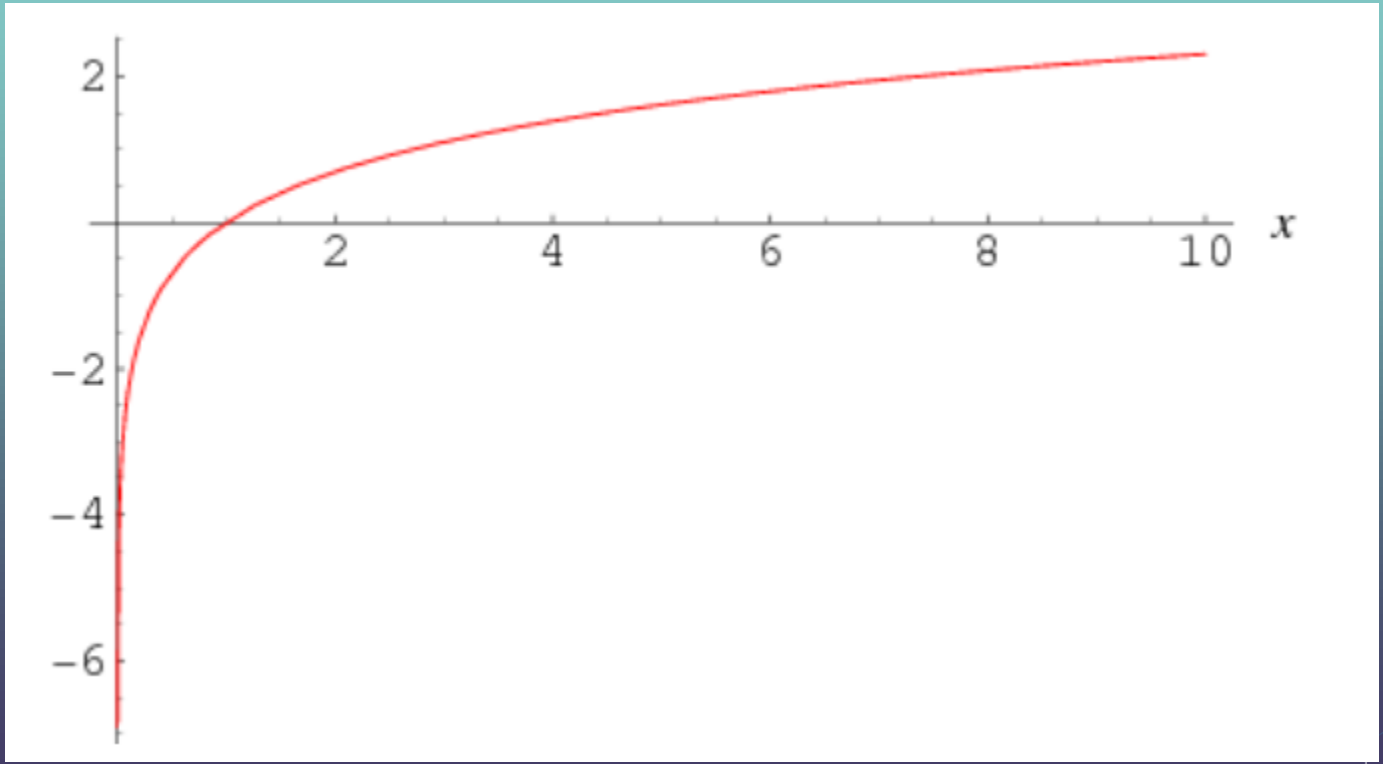
If $e^a = b$, then $\log(b) = a$, where $e \approx 2.718$

For example,

$$\log(10) \approx 2.3026$$

$$\log(100) \approx 4.6052$$

The Log Function



Question

When should we take log transformation instead of directly using the linear regression?

Types of log transformation

Linear-log models:

$$Y = a + b \log X$$

Log-linear models:

$$\log Y = a + b\, X$$

Log-log models:

$$\log Y = a + b \log X$$

Interpreting Linear-Log Models

$$Y = a + b \log X$$

This result suggests that if X increases by 1 percent, Y will increase by $0.01 \times b$.

Interpreting Log-Linear Models

$$\log Y = a + bX$$

For example, when $b = 0.04$, it means if X increases by 1, Y will increase by 4 percent.

Interpreting Log-Log Models

$$\log Y = a + b \log X$$

When X increases by 1 percent, Y will increase by b percent.

Very commonly used in economic modeling.

Fixed Effects

Fixed Effects

Suppose that we want to investigate the effect of month on consumers' spending. Here, the independent variable is the month, e.g., January, February, March, …

How to run this regression?

Fixed Effects

One solution: We can assign Jan = 1, Feb = 2, March = 3, … and then we can simply run a linear regression as usual.

Any issues with the above regression?

Fixed Effects

One solution: We can assign Jan = 1, Feb = 2, March = 3, … and then we can simply run a linear regression as usual.

Suppose that you find that $Y = 100 + 15 \times Month$, how would you interpret this result?

When the month grows, Y also increases. But wait, what do you mean by "month grows"?

Fixed Effects

One solution: We can assign Jan = 1, Feb = 2, March = 3, … and then we can simply run a linear regression as usual.

In addition, the above transformation implicitly assumes that Feb = 2 Jan, March = Jan + Feb, which does not make any sense!

Need a better way to regress.

Fixed Effects

Suppose that we want to run regress Y (hotel rating) on X (purpose of trip). Here, purpose takes the following values: business, couple, family, friend, solo, and unknown. We run a fixed effects regression as follows.

```
mydata <-
read.csv("https://ximarketing.github.io/class/teaching
files/r-exercise.csv", fileEncoding = "UTF-8-BOM")
result <- lm(Votes ~ factor(Purpose), data = mydata)
summary(result)
```

Fixed Effects

Here, we take business as a benchmark and compare other purpose against it.

```
Coefficients:
                          Estimate Std. Error t value Pr(>|t|)
(Intercept)               0.680605   0.008747  77.810  < 2e-16 ***
factor(Purpose)couple     0.120705   0.011177  10.800  < 2e-16 ***
factor(Purpose)family     0.048585   0.012091   4.018 5.86e-05 ***
factor(Purpose)friend     0.016965   0.016421   1.033  0.30153
factor(Purpose)solo       0.048603   0.018849   2.579  0.00992 **
factor(Purpose)Unknown    1.103785   0.016950  65.120  < 2e-16 ***
```

Fixed Effects

You can also change your benchmark (e.g., use family as your benchmark):

```
mydata$Purpose <-
relevel(factor(mydata$Purpose), ref =
"family")
result <- lm(Votes ~ factor(Purpose), data =
mydata)
summary(result)
```

Crowdfunding

Playing with Kickstarter Data

Question

Suppose that you have a great idea, and you believe that your idea can change the world.

But you need resources to implement the idea and turn it into reality. This may cost you hundreds of thousands of dollars.

But you do not have much money yourself. What should you do?

Crowdfunding

Are you familiar with these platforms?

Understanding Crowdfunding

4 Types of crowdfunding

Equity Based Crowdfunding

Debt-Based Crowdfunding

Rewards-Based Crowdfunding

Donation-Based Crowdfunding

Equity Based Crowdfunding

The backer receives shares of a company, usually in its early stages, in exchange for the money pledged.

Example: WEFUNDER

Debt Based Crowdfunding

Debt-based crowdfunding is a crowdfunding model used to raise capital by taking loans from several investors (lenders) who expect to be repaid their loan with an added interest over the period that the loan was “used”. The entire process takes place through a crowdfunding platform.

Example: PROSPER

Donation Based Crowdfunding

Donation-based crowdfunding is when money is raised to support a good cause. As the name suggests, funding is raised through a crowd of people who decide to donate a certain amount of money to the cause, normally via online platforms specifically designed for the purpose.

Example: 

Rewards Based Crowdfunding

Rewards-based, or seed, crowdfunding is a type of small-business financing in which entrepreneurs solicit financial donations from individuals in return for a product or service. There are about 19 times as many rewards campaigns as there are for its closely related counterpart, equity-based crowdfunding.

It is closely related to marketing and we focus on it in our class.

Simple Economics of Crowdfunding

In the following slides, we introduce some simple economics of crowdfunding, which is a summary of early observations of online crowdfunding. The materials are adapted from the work of Ajay K. Agrawal (University of Toronto), Christian Catalini (MIT) and Avi Goldfarb (University of Toronto).

Simple Economics of Crowdfunding

#1: Funding is not geographically constrained - When Sellaband offered royalty sharing to investors, more than 86% of the funds came from individuals who were more than 60 miles away from the entrepreneur, and the average distance between creators and investors was approximately 3,000 miles.

Simple Economics of Crowdfunding

#2: Funding is highly skewed - On the same platform, whereas 61% of all creators did not raise any money, 0.7% of them accounted for more than 73% of the funds raised between 2006 and 2009. Similarly, outcomes are highly skewed on Kickstarter, even conditioning the sample on successfully funded projects: 1% (10%) of projects account for 36% (63%) of funds.

Simple Economics of Crowdfunding

#3: Funding propensity increases with accumulated capital and may lead to herding - The propensity of individual funders to invest in a project increases rapidly with accumulated capital. On Sellaband, in a given week, funders were more than twice as likely to invest in creators who reached 80% of their funding goal, relative to those who had raised only 20% of it. The acceleration is particularly strong towards the end of the fundraising campaign, similar to online lending platforms, and raises concerns of herding behavior. At the same time, projects that are eventually successful might slow down in the middle of the process because of a bystander effect - a reduction in the propensity to fund by new individuals because of the perception that the target will be reached regardless.

Simple Economics of Crowdfunding

#4: Friends and family funding plays a key role in the early stages of fundraising - Friends and family disproportionately invest early in the funding cycle, generating a signal for later funders through accumulated capital. The asymmetry between friends and family and others in terms of funding behavior is strongest for the first investment decision but subsequently fades as funders are able to monitor the creator's progress directly on the crowdfunding platform.

Simple Economics of Crowdfunding

#5: Funding follows existing agglomeration - Despite the decoupling of funding and location, funds from crowdfunding disproportionately flow to the same regions as traditional sources of finance, perhaps due to the location of human capital, complementary assets, and access to capital for follow-on financing.

Simple Economics of Crowdfunding

#6: Funders and creators are initially overoptimistic about outcomes - On Sellaband, after a first wave of funded artists failed to deliver a tangible return on investment, funders revised their expectations downwards. Similarly, Kickstarter recently faced pressures to adjust its guidelines after a number of high-profile projects encountered delays or failed to deliver on their initial promises. In the technology and design categories on Kickstarter, estimates suggest that more than 50% of products are delivered late.

Simple Economics of Crowdfunding

#7: Crowdfunding capital may substitute for traditional sources of financing - Capital from crowdfunding may substitute for alternative sources such as home equity loans. As house prices rise in a specific geographic region, making it easier for entrepreneurs to use home-equity loans as a source of financing, the number of entrepreneurs who turn to crowdfunding decreases.

Simple Economics of Crowdfunding

"Crowdfunding has the potential to revolutionize the financing of small business, transforming millions of users of social media such as Facebook into overnight venture capitalists, and giving life to valuable business ideas that might otherwise go unfunded." - *The Wall Street Journal*

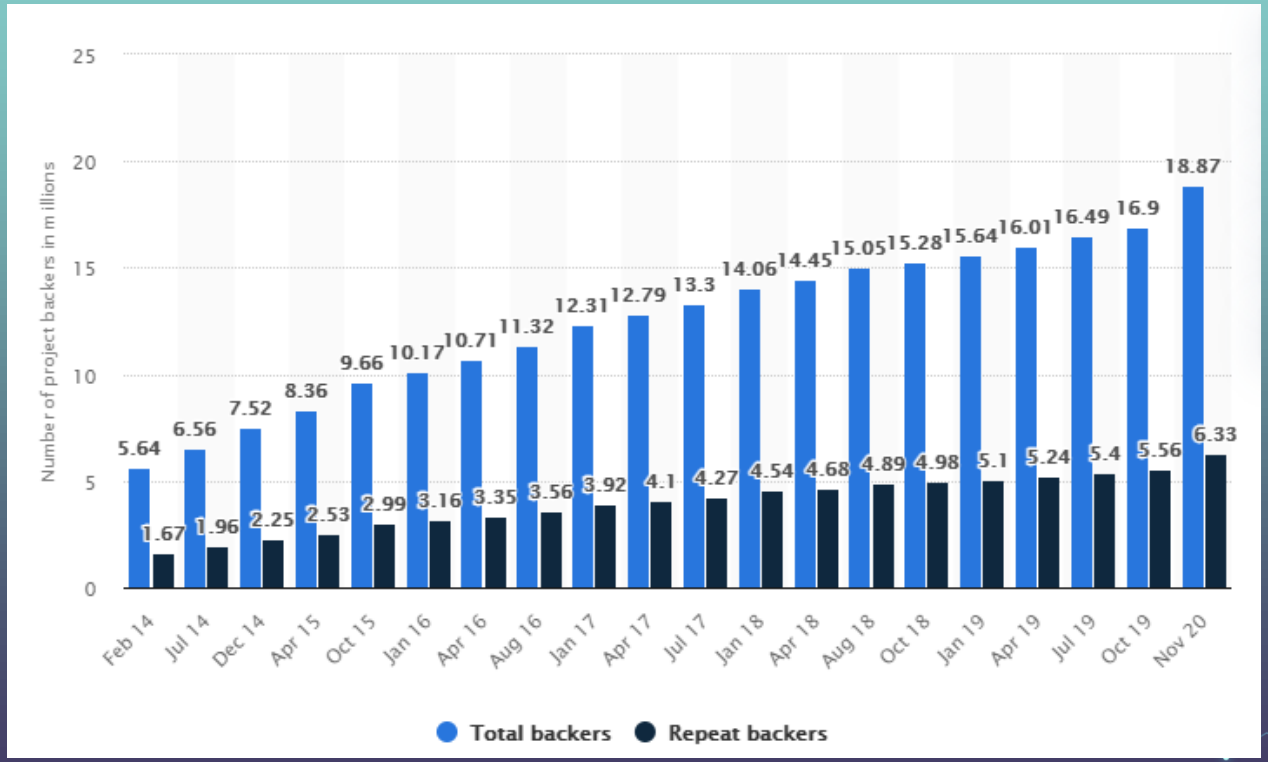
Simple Economics of Crowdfunding

"Besides, isn't this the type of innovation we should be encouraging? Unlike exotic derivatives and super-fast trading algorithms, crowdfunding generates capital for job-creating small businesses." - *The New York Times*

Simple Economics of Crowdfunding

"While founders raising cash from a big pool of small amounts of money are benefiting from quick access and the boost of popular interest, they are also forgoing some of the advice and experience of more traditional angel or venture-capital investors." - *The Financial Times*

Kickstarter



Product Categories in Kickstarter

Kickstarter supports almost all kinds of product categories including Art, Comics, Crafts, Dance, Design, Fashion, Film & Video, Food, Games, Journalism, Music, Photography, Publishing, Technology, and Theater.

Within each category, there are also several subcategories. For example, within the technology category, we have subcategories including gadgets, hardware, DIY electronics, flight, 3D printing, apps, camera equipment, etc.

Pebble Watch

Pebble Watch was a smartwatch developed by the Pebble Technology Corporation. Funding was conducted through a Kickstarter campaign running from April 11, 2012 to May 18, 2012, which raised $10.3 million; it was the most funded project in Kickstarter history, at the time.

Let's visit Pebble Watch's initial crowdfunding webpage to know more about here. Click here to go.

Recall that it is in 2012.

Pebble Watch


PERSONAL TECH

The New York Times

GADGETWISE

A Smartwatch Gains Some Style, but Few New Tricks


THE WALL STREET JOURNAL.

English Edition ▾ | Print Edition | Video | Podcasts | Latest Headlines

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TECH | PERSONAL TECHNOLOGY: REVIEW

Pebble Time Review: The Smartwatch That Beats Android Wear


Harvard Business Review

Pebble: Wearables Pioneer

Pebble Watch

In 2015, Pebble launched its second generation of smartwatches: the Pebble Time and Time Steel. The devices were similarly funded through Kickstarter, raising $20.3 million from over 75,000 backers and breaking records for the site. See the Kickstarter webpage here.

In 2016, Pebble shut down their subsequent Time 2 series watches and refunded Kickstarter backers, citing financial issues. It was purchased by Fitbit later.

Everyday Backpack

This versatile pack was designed by photographers who felt other camera bags on the market lacked the ability for them to fit all of their other equipment. The bag comes with a number of zippered pockets and waterproof pouches to fit anything you need, as well as versatile handles and anti-theft straps. The campaign's original goal was $500,000, but they ended up with 26,000 backers and $6,565,782 before they packed up and went home.

See the webpage here.

Kingdom Death: Monster 1.5

A board game based on the video game “Dark Souls” originally held the title for most funded board game of all time. That was until it’s sequel, Kingdom Death: Monster 1.5, came to play. The game essentially involves players creating characters, crafting weapons/gear, building civilizations and fighting monsters. Kingdom Death: Monster 1.5, which raised $1 million in the first 19 minutes it went live on Kickstarter, is expected to be available in 2020.

See the page here.

Life on the Line

Cristian Barnett is a professional photographer living in Cambridge, England. Mr. Barnett was so fascinated with the Arctic Circle that in 2006 he started visiting the countries intersected by the circle. After seven years and a dozen trips to that area, he decided to create a book called *Life on the Line*, which would contain a selection of portraits he had taken over the years. See here for more details about the project.

“All-Or-Nothing”

Most crowdfunding platforms like Kickstarter strictly implement an “all-or-nothing” policy. That is, the creator (entrepreneur) must set up a target for the project. If the collected fund exceeds the target, the project is successful, and the creator uses the fund to run the project. Otherwise, the project fails, and all the money will be fully refunded to the investors (backers, consumers).

LEARNING ABOUT KICKSTARTER

Our Mission

We want to know more about the emerging crowdfunding industry. By doing so, we can

(1) help entrepreneurs launch better projects and raise more funds from backers;

(2) help crowdfunding platforms design better features and recommend better projects to backers;

(3) help the government and public policymakers understand crowdfunding and regulate this industry.

Our Mission

But how to learn about online crowdfunding? You may rely on online materials, conduct surveys, interview experts…

But these methods are really outdated…

Today, you are going to use *real data* to investigate the crowdfunding industry! This is also what data scientists are doing nowadays!

THE DATA

I started to collect data from Kickstarter many years ago. At that time, crowdfunding was growing very fast, and many people wanted to figure out how crowdfunding really works.

I was one of the first a few people analyzing online crowdfunding using scientific methods.

BEFORE SEEING THE DATA...

Please go to the Kickstarter website (https://www.kickstarter.com/), browse a few Kickstarter projects.

If you an entrepreneur trying to launch a successful crowdfunding campaign, what do you want to learn from Kickstarter?

To answer these questions, which data do you need to collect?

The Data is Available at the Course Website

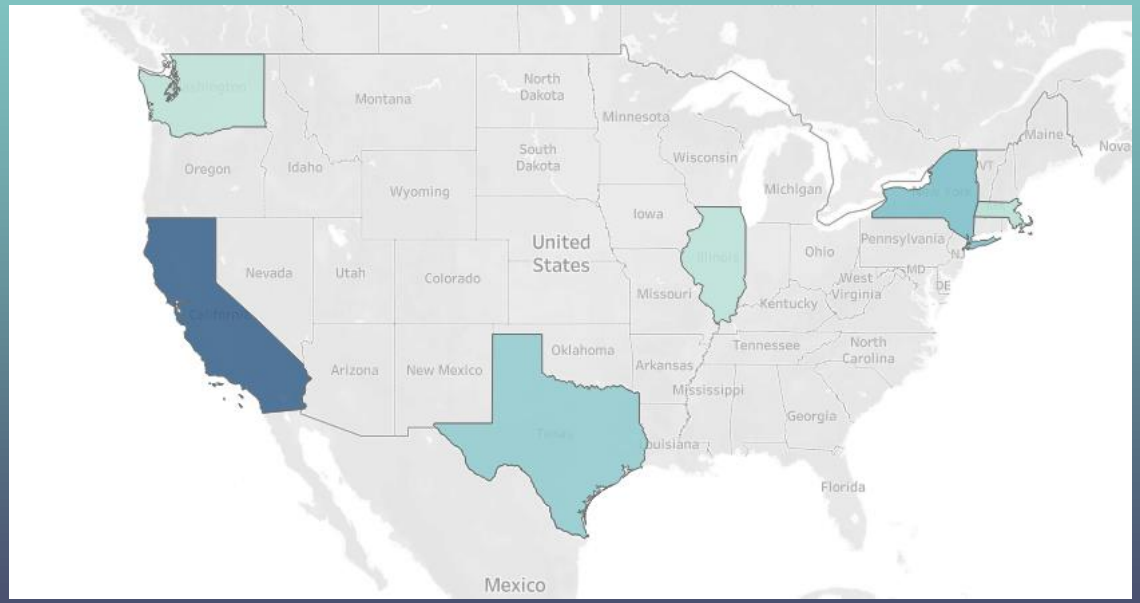
DATA

The dataset was scraped from Kickstarter, the largest online crowdfunding website.

It covers Kickstarter's technology category.

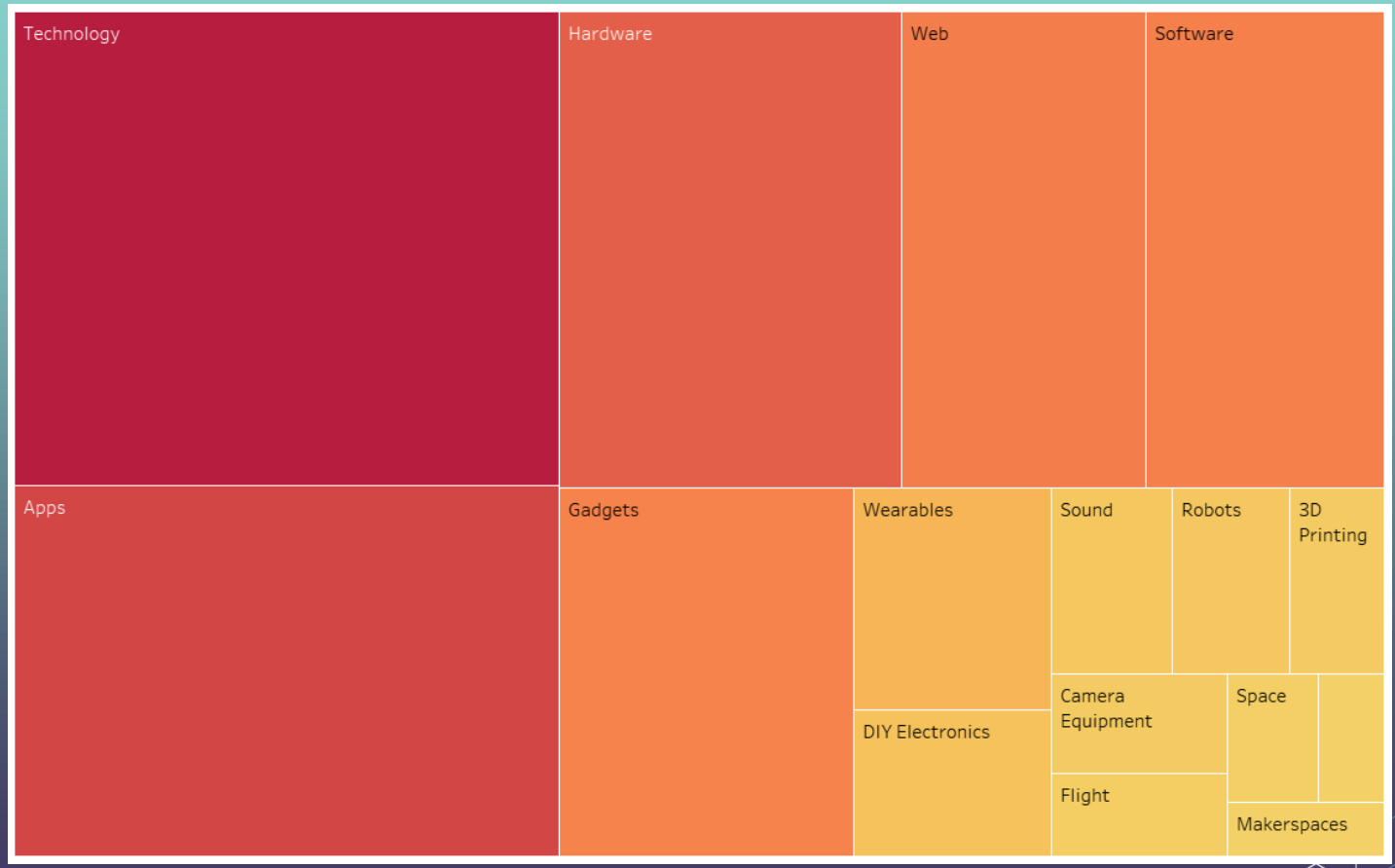
The data is collected from the following US markets: California, Illinois, Massachusetts, New York, Texas, and Washington State.

Location



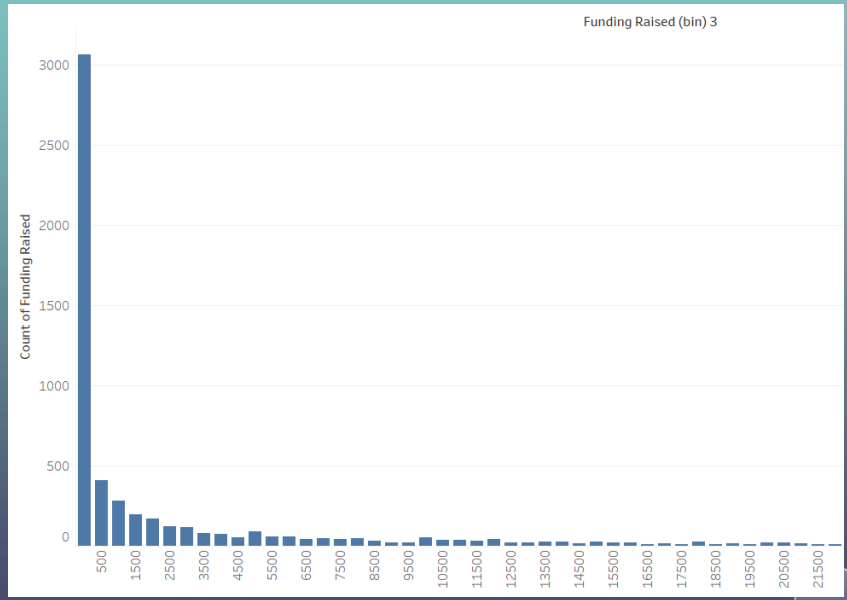
The dataset covers projects from six US states: California (CA), New York (NY), Texas (TX), Massachusetts (MA), Washington (WA), and Illinois (IL).

Subtype


Technology
Hardware
Web
Software
Apps
Gadgets
Wearables
Sound
Robots
3D Printing
Camera Equipment
Space
DIY Electronics
Flight
Makerspaces

Total Funding Raised

The total funding raised by an individual project, measured by US$. You can see from the histogram that the total funding raised is really an L-shaped distribution: Most projects received almost $0 while some projects are very successful.



Log Transformation

When we take the logarithm of the total funding raised, the distribution looks more like a normal distribution.

```
mydata$LogFundingRaised = log(mydata$FundingRaised
+ 1)
hist(mydata$LogFundingRaised)
```

Why we use Funding Raised + 1?

Log Transformation

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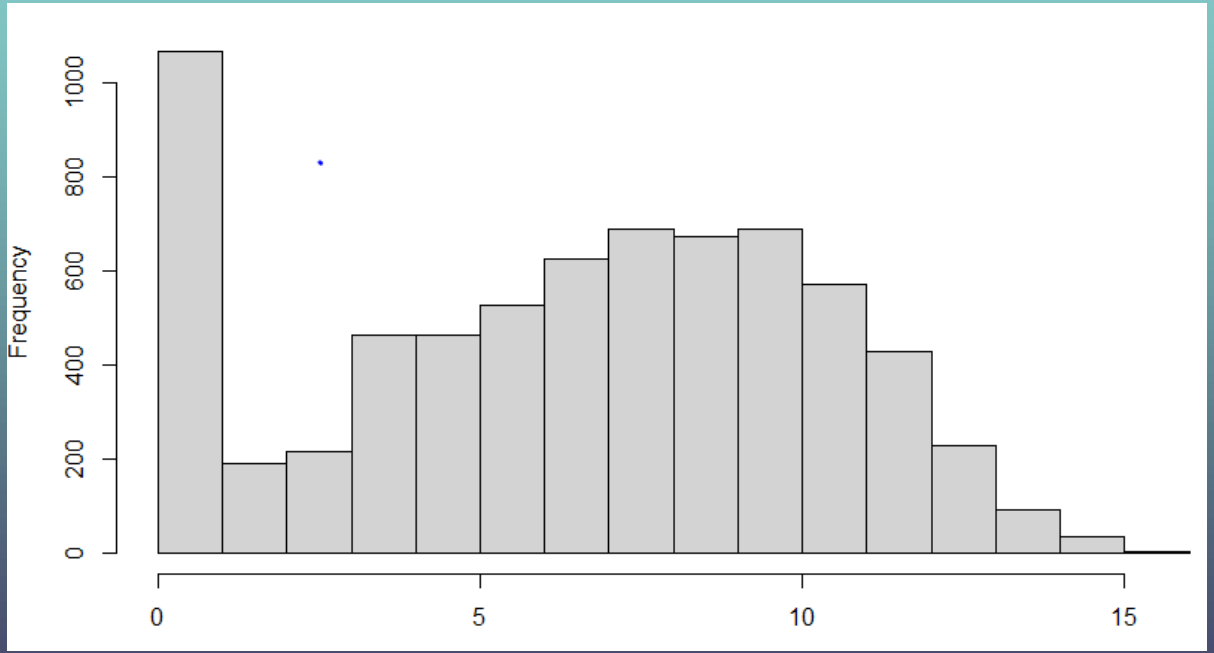
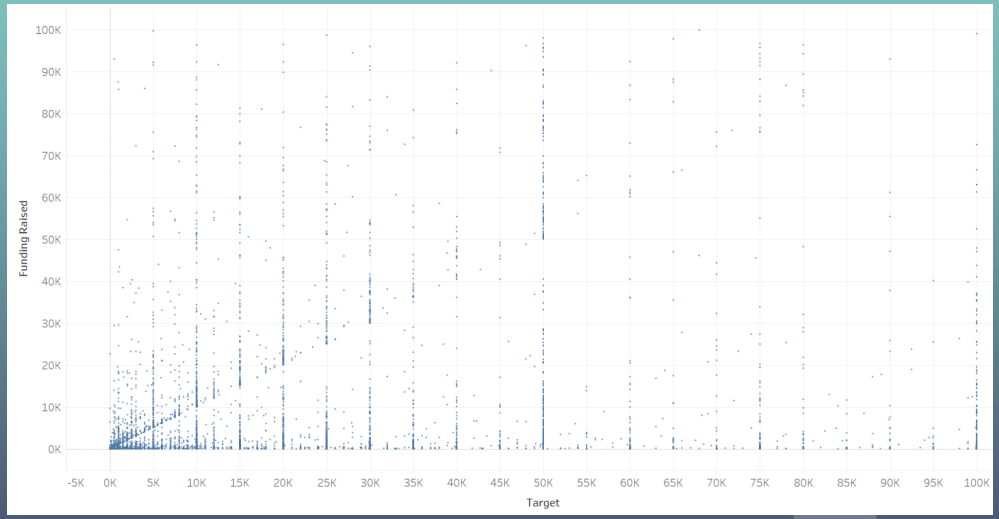


Target

At Kickstarter, each entrepreneur needs to specify a target for the project. The project is successful when the funds raised exceeds the target. Otherwise, the project fails and all the funds will be returned to the consumers.



Other Measures of Project Result

Outcome: Whether or not the project succeeded. It is a binary variable (1 = success, 0 = failure).

Backers: Number of people supporting the project. If you divide funding raised by the number of backers, you will get the average fund contributed by a backer.

Entrepreneurs' Personal History

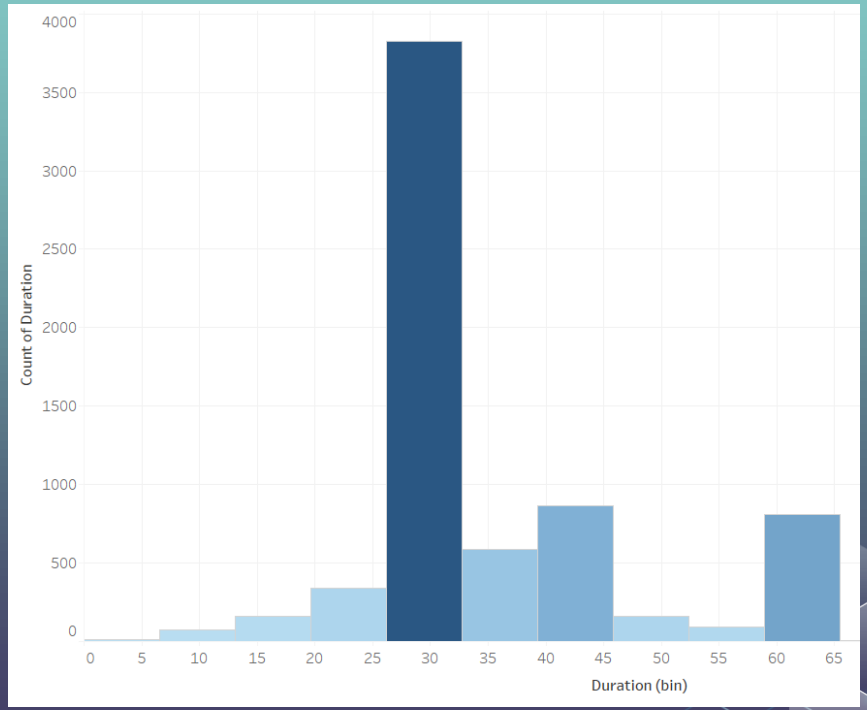
Created: Number of projects created by the same entrepreneur in the past. For example, 4 means the same entrepreneur had already created another 4 projects on Kickstarter.

Backed: Number of projects backed by the same entrepreneur in the past (i.e., the entrepreneur supporting others' projects on Kickstarter).

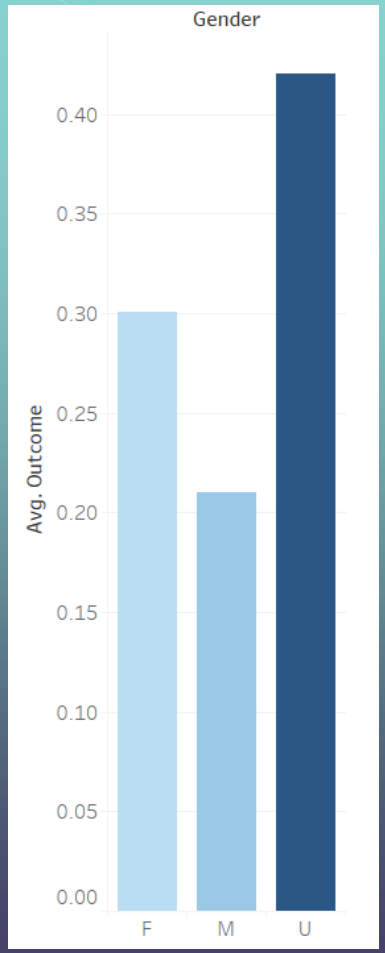
FbNumber: Number of Facebook friends the entrepreneur has.

Duration

The duration of a project's fund raising period (in days). Most projects have a duration of around one month.



Gender



In the dataset, we have three genders: males, female, and unknown. The gender is obtained by analyzing the creators' first name. Unknow refers to the case in which the name cannot be identified (e.g., a team name such as "marketing").

Some Other Variables

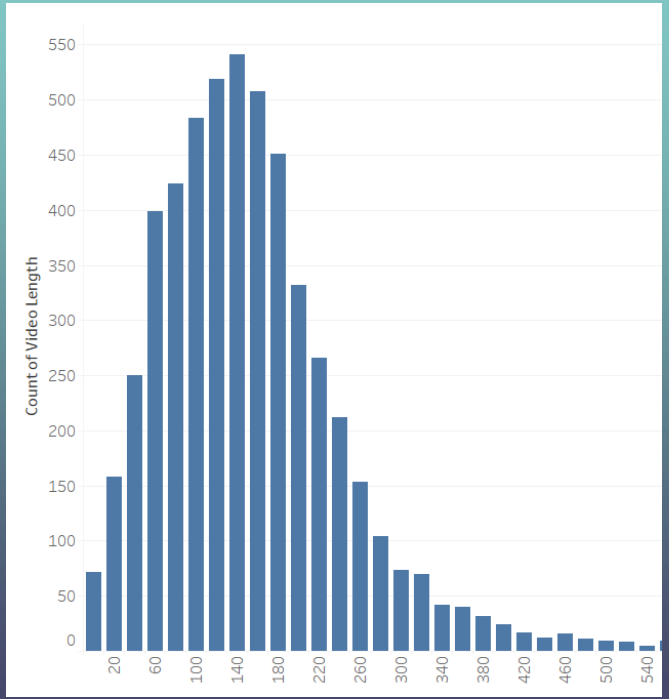
Video: Whether or not the project has a video. In the dataset, 76% of the projects have a video. Here, 1 means has video and 0 means no video.

Human: Whether or not the project's video features human-beings (usually the entrepreneurs themselves). 1 means has human-beings and 0 means no human-beings. This variable is set to 0 is the project does not have a video.

Computer: Whether or not the project's video features a computer. 1 means has computers and 0 means no computers. This variable is set to 0 is the project does not have a video.

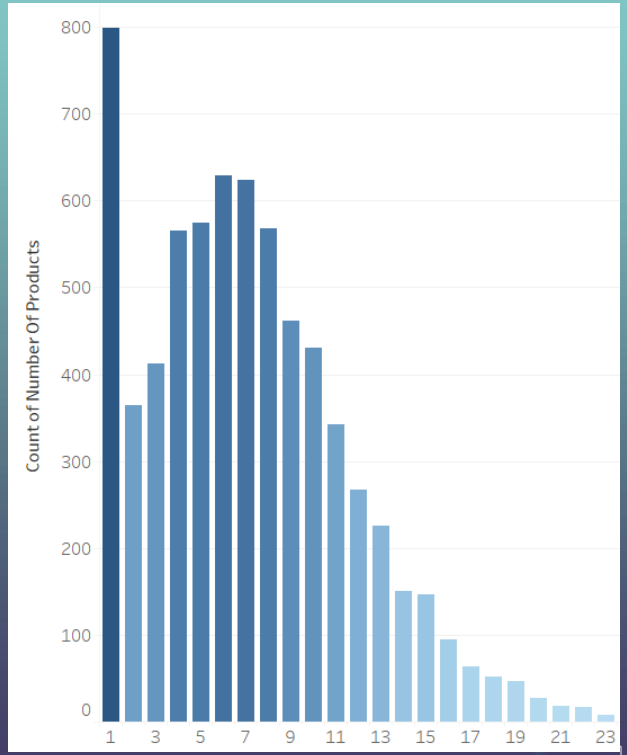
Some Other Variables

Video length: the duration of the video measured in seconds. For project without a video this variable is set to 0. The following is a histogram of video length (for projects with a video).



Some Other Variables

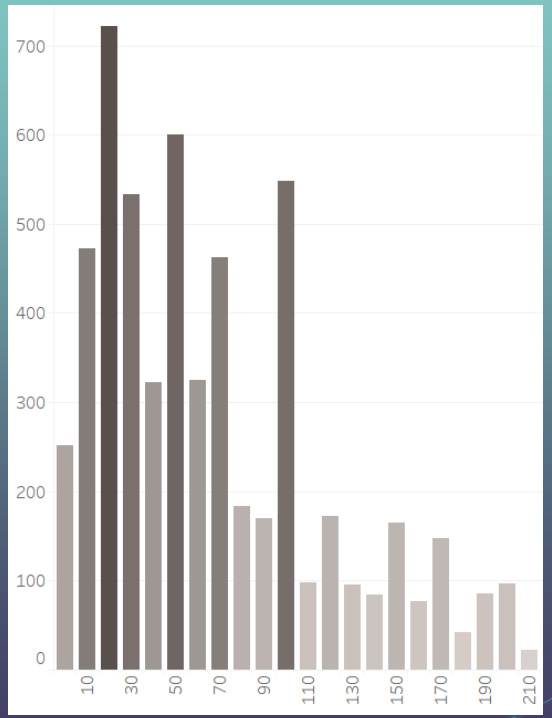
Number of Products: In a project the entrepreneurs often offer consumers a number of products to choose from. This variable measures how many products are offered in the project.



Some Other Variables

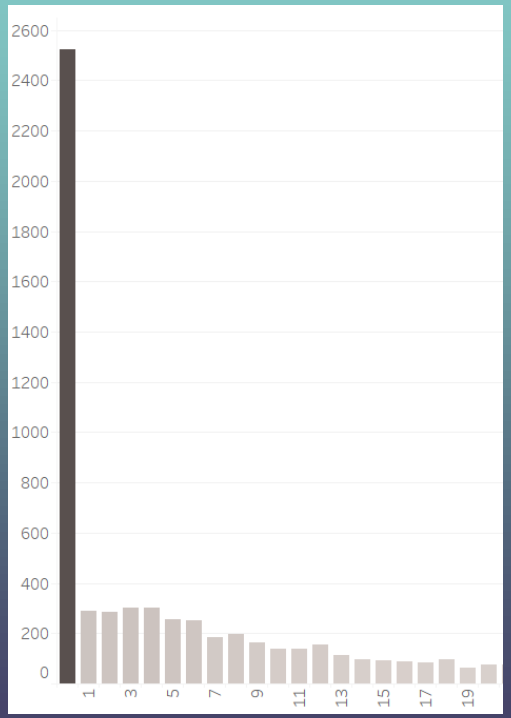
Price: A project may offer multiple products with different prices. Here, price means the median price among all product offerings.

Comments: Number of comments posted by consumers.



Some Other Variables

Photo Number:
Entrepreneurs often upload photos to their project description. This variable measures the number of photos uploaded to the project webpage.



Audio Measures

For projects with a video, we analyze their audio information:

Energy: Whether or not the audio pitch sounds energetic. A large number of an energetic audio pitch.

Content: Whether or not the audio pitch shows signs of content.

Upset: Whether or not the audio pitch shows signs of upset.

Angry: Whether or not the audio pitch shows signs of anger.

MaxAmpVol: The max sound volume. A greater number means louder sound.

What should we do?

Use the data to provide recommendations for the platform or the entrepreneurs. You can focus on anything that can be helpful for the platform or the entrepreneurs:

- How do male and female entrepreneurs behave differently on Kickstarter? (e.g., compared to females, males may be too aggressive in setting high targets.)
- Which type of video is most productive in terms of generating funds? (e.g., is having a lengthy video always beneficial?)
- What makes a successful crowdfunding project?

What should we do?

Each group should only ask one big or two small research questions in your project. Quality beats quantity. Choose the right data analysis methods and come up with a good answer to your questions, with implications for platforms or entrepreneurs.

You need to submit:

To save your time, you only need to submit a few pages of slides (no more than 15 slides) to Moodle covering your research question(s), data analysis (e.g., regression equations), findings, and implications. No reports/presentations are needed!

Deadline:	Class A:	Dec 25, 12:30 pm
	Class B:	Dec 25, 5:00 pm
	Class C:	Dec 27, 12:30 pm