Teaching Economics with Computation
Undergraduate Data Science X Economics

Building Economics Curriculum based on Jupyter

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Outline for Talk

- Econ and DS/CS - growing student interest
- Notebook Based Instruction
- Data Science X Economics at Berkeley?
- Building a new lower division class - Data 88E
- Building a new class - Econ 148

Part 1

- Data Science is ascendant in Economics!
- *What quantitative **skills** should students be learning ?*

Prominent Economists on Data Science

"I think Econometrics could use a lot of the techniques that are common in Data Science, such as bootstrapping…techniques for data-driven procedures and there's a lot of really creative ideas in terms of presenting data …" - David Card

"I write Jupyter Notebooks, I write Python, try my models out in Python, and it's very empowering…I think the students at Berkeley are lucky.. The things you have now! " - Thomas Sargent

"The Data Science tools may well turn out to be in the first half of the 2000s the equivalent of a *fine chancery hand* was in Oxford or Cambridge in the 1400s, just as a facility with the document formats and commands of the Microsoft office at the end of the 1900s: practical, general skills that make you of immense value to most if not nearly all organizations." - Brad DeLong

"If Economics continues to be the major it is now, and Data Science emerges as an alternative, a good chunk of people who are currently going into economics will realize that it makes much more sense to become a Data Science major, with a minor in economics - and I would say they're making the right choice!" - Steven Levitt

"During the pandemic, you could track comfort with social interactions using Open Table reservations. I don't have to tell you all how closely you can track rents in pricey Bay Area neighborhoods using tools like Zillow, Apartments.com, and Apartment List. These types of housing data inform the Federal Reserve's understanding of inflation. I am confident your generation will transform our capability to use high-frequency, real-time data, applying your unique perspectives to deepen our understanding of how our economy is evolving." Lisa Cook

Who is doing this well?
Shout out to some leaders ~ a couple favorites

Raj Chetty - Harvard Big Data

Sargent and Stachursky - QuantEcon

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Where can you study this major?
Early movers ~ a couple favorites

Home   About Us ˅   People ˅   Degree Programmes ˅   Continuing Education And Training ˅   Consulting ˅   News & Events ˅

Prospective Students

HOME / PROSPECTIVE STUDENTS / UNDERGRADUATE PROGRAMME / DATA SCIENCE AND ECONOMICS

| STATISTICS | DATA SCIENCE AND ANALYTICS | DATA SCIENCE AND ECONOMICS |

Major in Data Science & Economics

Bachelor of Science (Honours) with Major in Data Science and Economics

The Data Science and Economics (DSE) cross-disciplinary programme (XDP) aims to produce students who have strong fo... science and economics as well as hands-on experience with empirical analysis of economic data, to analyse and interpret the loc... on individuals, organisation, society and the global economic ecosystem.

The student learning outcomes are:

NUS Singapore - Major in DS and Econ

CONTACT | NEWS | MAKE A GIFT

THE KENNETH C. GRIFFIN DEPARTMENT OF **ECONOMICS** THE UNIVERSITY OF CHICAGO

BA IN ECONOMICS WITH SPECIALIZATION IN DATA SCIENCE

Home /
/ BA

Career Planning

Honors BA Thesis

Oeconomica

The specialization in data science provides advanced training in computation and data analysis beyond the basic methods discussed in the empirical methods sequence. **Students pursuing the specialization will acquire relevant technical skills that are highly sought after in both academia and the private sector.**

UChicago - BA in Economics with Specialization in Data Science

Two chosen from:		200
ECON 21300	Data Construction and Interpretation in Economic Applications	
ECMA 31320	Applications of Econometric and Data Science Methods	
ECMA 31330	Econometrics and Machine Learning	
ECMA 31340	Big Data Tools in Economics	
ECMA 31350	Machine Learning for Economists	
ECMA 38010	Empirical Industrial Organization	

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A few of many programs in this realm

- MIT -"Computer Science, Economics, and Data Science" major
- Harvard - Joint Major in Computer Science and Economics
- U Chicago - Data Science specialization within its Economics major

- Drexel's - STEM-designated BS in Economics and Data Science
- Northeastern - BS in Data Science and Economics
- Washington University - BS in Computer Science + Economics

But few dedicated new classes in this area ~ mostly combinations of existing classs

Top Undergraduate Majors at UC Berkeley 2024
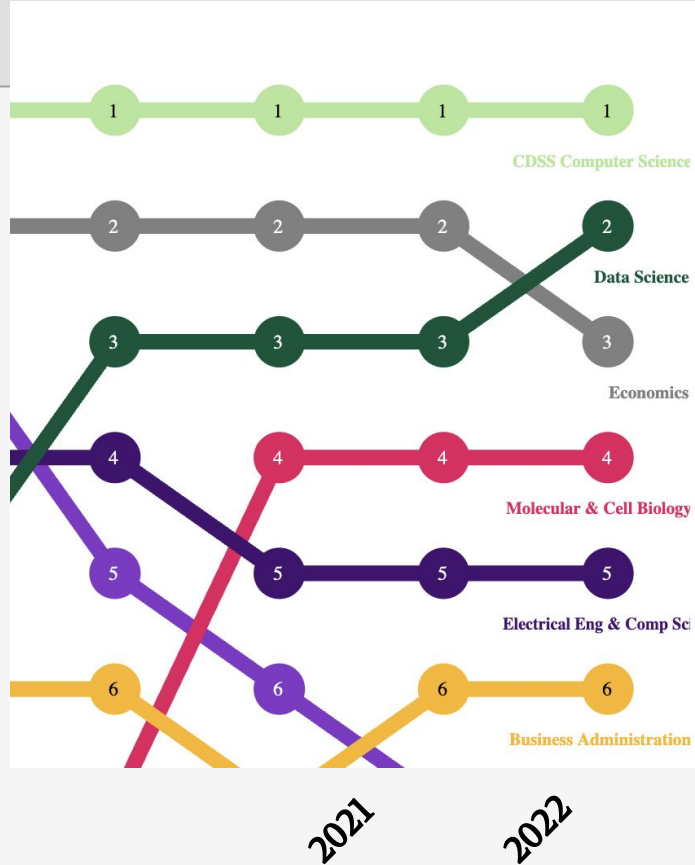
891   Computer Science

846   Data Science

678   Economics

510   Elec Eng and Computer Science

425   Business Administration

20%

10%

Top 5 Domain Emphases within Data Science Major UC Berkeley 2025 (n=~2000)

Most Common Domain Emphases

Business & Industrial Analytics	597
Economics	538
Cognition	236
Computational Methods in Biology	129
Applied Mathematics & Modeling	264

Over 50% in Econ or Business

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Most Common Second Majors –
Within 2024 Data Science Double Majors

Most Common Multiple Majors

Computer Science	266
Economics	248
Cognitive Science	108
Statistics	67
Applied Mathematics	65
Business Administration	65
Molecular & Cell Biology	64

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Total Majors for comparison: English - 243   History - 134 (with ~40 FTE?)

Double Majors Graphic

	CDSS Computer Science	Data Science	Economics	Business Administration	Applied Mathematics	Molecular & Cell Biology	Electrical Eng & Comp Sci	Cognitive Science	Statistics	Mathematics
CDSS Computer Science		●	●	●	●			●	●	●
Data Science	●		●	●	●	●		●	●	
Economics	●	●								
Business Administration	●	●	●							
Applied Mathematics	●	●	●							
Molecular & Cell Biology		●		●						
Electrical Eng & Comp Sci			●							

2025 Spring

Data Science : Economics (Different Divisions)
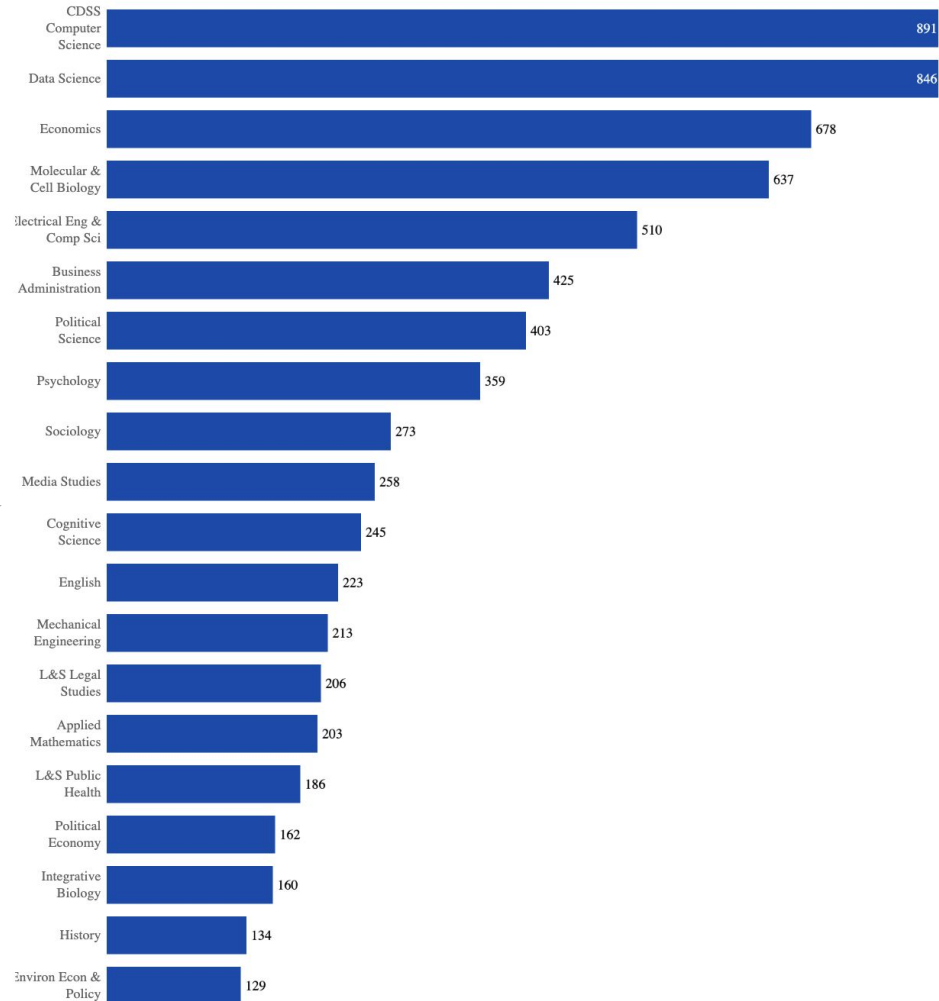
191 co-occurences

Biggest Majors at UC Berkeley

Econ and DS
Double Major = 248
corresponds to 12th
biggest major

Twenty Largest 2023-24 Majors: Bachelor Degree Recipients
Includes majors with 11 degree recipients or more

Major	Recipients
CDSS Computer Science	891
Data Science	846
Economics	678
Molecular & Cell Biology	637
Electrical Eng & Comp Sci	510
Business Administration	425
Political Science	403
Psychology	359
Sociology	273
Media Studies	258
Cognitive Science	245
English	223
Mechanical Engineering	213
L&S Legal Studies	206
Applied Mathematics	203
L&S Public Health	186
Political Economy	162
Integrative Biology	160
History	134
Environ Econ & Policy	129

Part 2 – Interactive Computing is changing teaching

- 7 years supporting Jupyter instruction on campus
- Learning Open Source software approach to teaching

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Metacognition ~ Hypothesis ~ Praxis

- Tools built for reproducibility are powerful for pedagogy
- Data Science curriculum built on Open Source tools
  - Explicit and Implicit Learning
  - First year students learn Jupyter/ Numpy ~ scaffold to more
  - Teaching staff learn Github / open publishing
- Simultaneously teach Computational Thinking & Inferential Thinking
  - Social Science students need Data Science skills / methods
  - CS/ML students need inference & domain applications
- *"Notebook based instruction" - an evolution in how we teach?*

Lessons learned from first 5 years supporting DS instruction in other classes

- Some things stick - some do not - up to instructor
- Econometrics class
  - Econ - depends on each instructor - Python, R
  - Env Econ - 7-8 semesters passing from instructor to instructor
- Does the instructor incorporate interactivity into lecture
  - *Lecture notebooks / Demos / Live coding*
  - *Data / Lessons from assignments into class narrative*
- Is there a support system for students starting computation?
  - Can existing GSIs support computation
  - Can other supports be put into place
- Student Teams can make awesome curriculum

What are the open science tools that students learn in a notebook based approach ?

- Students learn elements of coding at the same time as statistics
- Students learn within literate code documents
- Consistent environments across learners has equity angle
- Courses built on Github / transparency in curriculum
- Lead with data - reproducible studies - project based approach
- Instructors can build/stitch notebooks into OER textbooks
  - (*I have never seen a Stata/Sas/Matlab stitched textbook*)
- Autograding - where there are closed form solutions
- AI world is built on Python tooling / Github

Part 3 – Notebooks in Economics Courses

- Quantitative courses across Social Science
- Across Economics curriculum

Data Science: Social Science Core Methods Courses

Course	Instructor	Terms	Github Repo
Political Science 3	Broockman, Little, Wittenberg	4 semesters 330 seats / 500 in major	Fall 2021 Lectures and Assignments
Sociology 5	Harding	3 semesters 235 seats/350 in major	Global Civil Conflicts
Economics 140	Bianchi / Edwards	4 semesters 450 seats/760 in major	Fall 2021
Environmental Economics and Policy 118	Villas-Boas, Magruder	6 semesters 120 seats/ 200 in major	Fall 2021
UGBA 88	Miller / Huntsinger	~7? Semesters 60 in class	Fall 2019
City Planning 101/201	Chapple	3 semesters 100 in class	Spring 2021
Public Health 142	Riddell/ Kang Dufour	4 semesters 345 in class	Fall 2021

Economics 140 – Econometrics
Environmental Economics and Policy 118– Econometrics

Econ 140

Core required methods class ~ 450

- 4th semester post Stata!
- 6 semesters R, 4 semesters Jupyter Python
- Building more in R in coming semesters
- Python Notebooks built by undergrad GSI double major

EEP 118

Core required methods class ~ 150

- 8th semester post Stata!
- Jupyter R
- Smooth handoff across instructors
- Notebooks built by Grad Student teaching over the summer

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Problem 1. Golden State Warriors

The 2015-16 season was historic for Stephen Curry and the Golden State Warriors. They finished the regular season with a 73-9 record, which beat out the Chicago Bulls 1995-96 record of 72-10 for the best regular season record in NBA history. This question takes a statistical look at the business of pro basketball. The accompanying dataset `nba.csv` contains information on 269 NBA players for one specific season. Here is a description of some of the variables in the dataset:

Variable	Description
wage	player's salary for the season in thousands of nominal dollars
exper	number of years in the league
age	age of the player
coll	years of college completed
games	number of games played that season
minutes	total number of minutes player in the season
guard	dummy indicator whether player plays guard position
forward	dummy indicator whether player plays forward position
center	dummy indicator whether player plays center position
points	season average number of points per game played
rebounds	season average number of rebounds per game played
assists	season average number of assists per game played

```
# Don't forget to run this cell that reads in the data
nba = pd.read_csv("nba.csv")
nba.head()
```

Question 1.a. To begin with, test whether players who play the guard position are paid the same as other players. Be sure to report the results of your test including the t-statistic and p-value.

Governments in many African countries have recently adopted fertilizer subsidies as an attempt to increase agricultural productivity for small farmers. However there is widespread debate over whether these are effective policies. To generate evidence Carter, Lajaaj and Yang (2021) partnered with the Mozambican government to run a randomized controlled trial, in which farmers were randomly offered a voucher for subsidized fertilizer. (The paper is Subsidies and the African Green Revolution: Direct Effects and Social Network Spillovers of Randomized Input Subsidies in Mozambique *American Economic Journal: Applied Economics* 13(2).)

We are going to work with a subset of their data for this problem set to estimate the effects of fertilizer use on maize yields.

Part A:

Suppose the government did not conduct a randomized controlled trial. Instead they surveyed farmers and compared maize yields for those who did and did not use fertilizer. Would this comparison allow you to estimate the effect of fertilizer on maize yields? Explain why or why not using both words and potential outcomes notation. How would the expression for the estimated impact of fertilizer on maize yields differ if fertilizer use were randomized?

Answer here

Part B:

Now let's analyze the RCT data. The dataset contains observations of nine maize farmers from 390 farm households. The variables are as follows

- *respid*: This is just the unique ID for each farmer
- *lyieldr*: This is the log of maize yields
- *vouch*: This is the treatment variable of interest - equal to 1 if the household was given a voucher to purchase fertilizer (i.e. in the treatment group) and 0 otherwise (i.e in the control group)
- *irrigprev*: This is a dummy equal to 1 if households used irrigation and 0 otherwise
- *pestdprev*: This is a dummy equal to 1 if households used pesticides and 0 otherwise
- *hhhmale*: This is a dummy equal to 1 if the household head is male and 0 if the household head is female
- *hhhage*: This is the age of the household head
- *hhheduc*: This is the number of years of education of the household head
- *hhsize*: This is the number of members in the household

Note that all variables other than maize yield were measured *before* the distribution of vouchers. For irrigation and pesticide use, they were measured the year before the voucher intervention.

a) Before running any regressions, show how you can obtain the average treatment effect (ATE) of fertilizer vouchers on (log) maize yields. Then write down the regression you could use to estimate the ATE.

Open Science – Open Curriculum

- Most Economists post working papers, are required to post datasets for journal submissions
- Few post their syllabi,
  - Fewer their lecture notes,
  - Fewer their homeworks
- Many courses behind LMS wall (eg Canvas)

Can we put syllabi in the public domain!?

How to incentivize this?

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Economics

Wide range of implementations

Not coordinated

Class	Instructor	Description
Economics 172 - Development (Fall 19)	Miguel	Three problem sets in R markdown, adapted by GSIs, run on RStudio in Datahub
Economics 141 - Econometrics (SP 19)	Graham	GSI adapted Professors Latex to Jupyter, option to compute on Datahub
Economics 135 - Economic Growth (SP 20)	De Long	Adaptation of new materials from 101B in Jupyter Python on Datahub
Economics 175 - Economic Demography	Goldstein	Problem sets for class from R studio run on own server
Environmental Economics 118 - Econometrics (Fall 19)	Magruder	Conversion of Econometrics course to Jupyter R notebooks on Datahub
Environmental Economics 153 (SP 19)	Ligon	Innovative materials in Jupyter Python on Datahub
Environmental Economics 147 (SP 19)	Fowlie	Electricity market in California in notebook for Energy Strategy Game
Environmental Economics 102 (Fall 19)	Karp	Illustrations of intertemporal concepts, built by GSI Jupyter Python on Datahub
Energy and Resources 131 (Fall 18, Fall 19)	Callaway	Machine learning in Energy and Environmental Applications Jupyter Python on Datahub
UGBA 88 - Data and Decisions (Fall 18, Fall 19)	MIller	Data 8 Connector, Intro Class and LD requirement for Haas students
Data 88 - Economic Models (Fall 19, SP 20)	Van Dusen	Data 8 Connectors - at Econ 1/Econ 100 level, plus survey of upper division classes

ECON 172 – Economic Development

Align with principles of reproducibility

Redo homeworks from

- ▪ PDF
- ▪ Stata
- ▪ Word

Run on server in browser and save GSI time!

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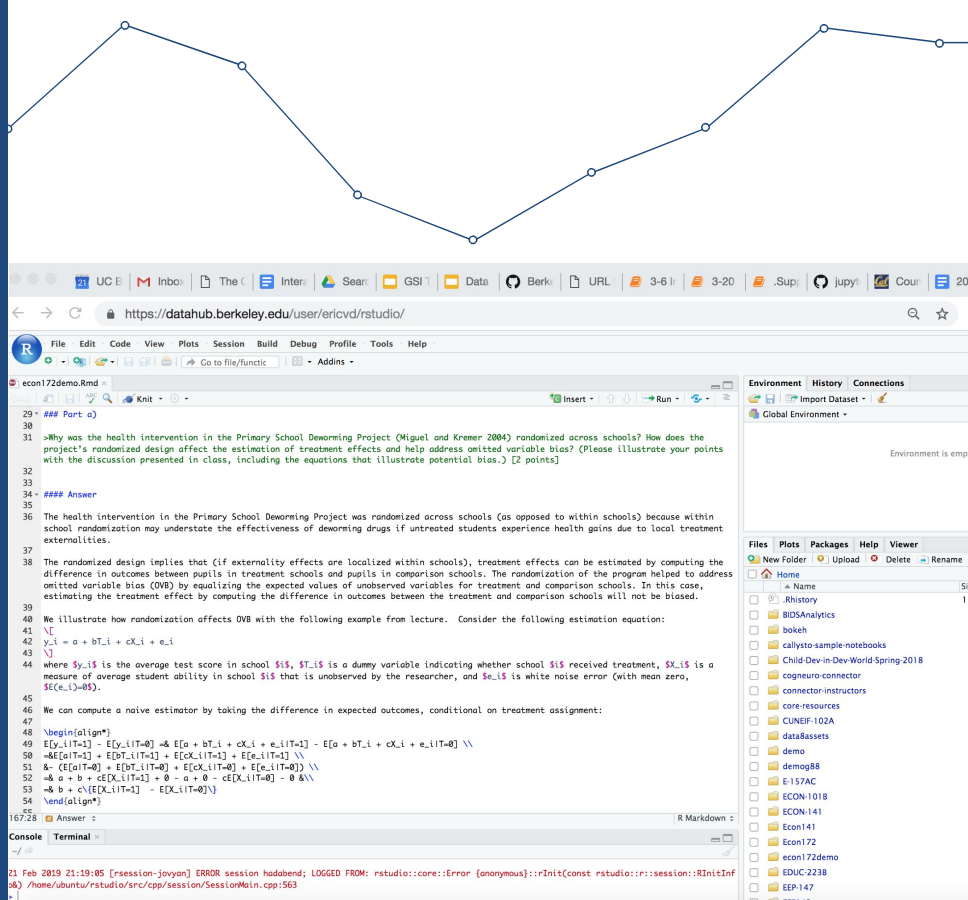
Part 4 – We built some new classes – Econ X DS

- Lower Division - Data 88E

- Upper Division - Econ 148

Took the Data Science open source toolkit and applied it to Econ
Built for skills, topics, interests missing from existing classes

Data Science Modules – Economics

Interactive Textbook

Teaching Economics Principles though Data and Programming

https://data88e.org/fa24/

Jupyterbook – Github Repo / Github pages

> ### DATA88
> EconModels
>
> **Data 88: Economic Models Textbook**
>
> Search this book...
>
> Demand & Market Equilibrium
> Supply & Elasticity
> **Public Economics**
>   Taxes and Subsidies
>   **Surplus**
>   Other Forms of Government Intervention
> Production
> Utility
> Development
> Game Theory
> Behavioral Economics
> Finance
> Inequality
> Econometrics
> Macroeconomic Policy
> Bibliography

Note on the Demand and Supply Curves

As pointed out above, the matrix we saw with rows of surpluses and columns of prices resembles the demand curve in the sense that we can see a diagonal line separating participants from non-participants. This is no coincidence. This idea is essentially what the demand and supply curves depict, except that due to there usually being many participants in a market, we simplify the concept to a continuous curve as opposed to a set of discrete values. This is helpful not only for visualization, but as we will soon see we can use these curves to find rates of change, which will prove to be useful as well.

Earlier we had a matrix of each individual's surplus at each price point, and the overall surplus at each price point. Notice how as the price decreased, surplus increased. Let's see this exact same concept illustrated on a familiar demand curve. Take a few moments to adjust the slider controlling the market price to see how consumer surplus behaves.

Demand Curve with Consumer Surplus Shaded

Consumer Surplus: 15

Market Price: $5

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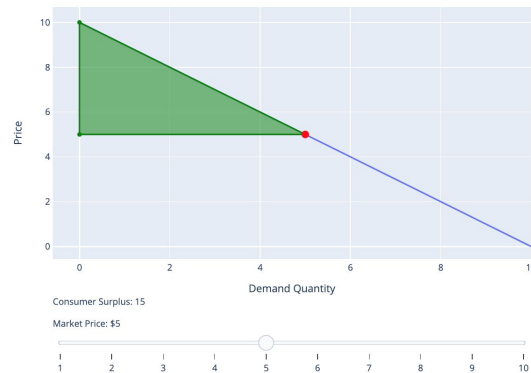
Data 88E is divided into 2 parts, both with an emphasis in real-world data

Re-examine basic economic principles

Supply & Demand

Elasticities

Taxes & Welfare

Production

Utility

Survey economics subdomains

Development

Financial

Econometrics

Behavioral

Inequality

Game theory

Macroeconomic policy

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Content made for Data 88E

Lecture

2 hrs weekly

Delivered mainly through slides, but often with reference to notebooks

Lecture Notebooks:

Demos, topical, motivation for Labs

Labs

1 week, shorter assignments

Associated with each lecture

Started during class

Projects

2 week, longer assignments

Autograded using Otter

Often based on an Economics paper

Textbook

Written in Jupyter Notebooks and compiled using Jupyter Books

Free, online, and open source

Rebuilt and updated frequently

Original team Eric + 6 students in DS/Economics
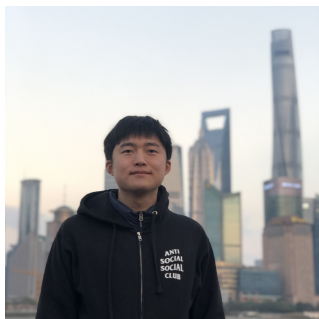
Alan Liang
(EE)CS, Economics

Amal Bhatnagar
Economics, DS

Andrei Caprau
CS, Economics, DS

Chris Pyles
CS, DS

Shashank Dalmia
Economics, DS, Statistics

Umar Maniku
Economics, DS

Eric Van Dusen
Tech and outreach Lead , DSUS
Lecturer

Many more students in current team!

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Some examples of Data 88E

Market Supply Curve
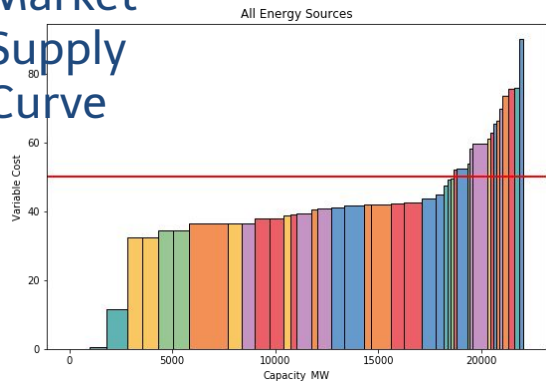
Lorenz Gini Inequality
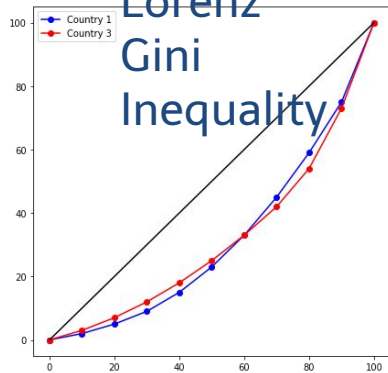
Least Squares Regression
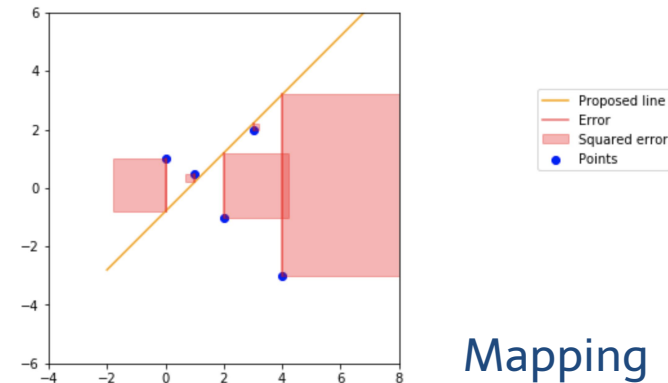
Options Portfolio
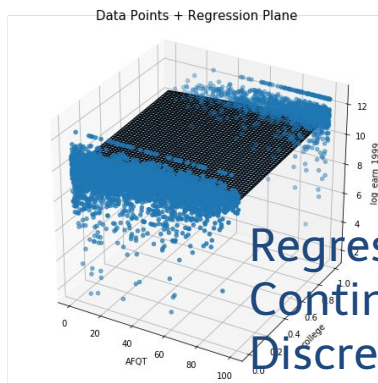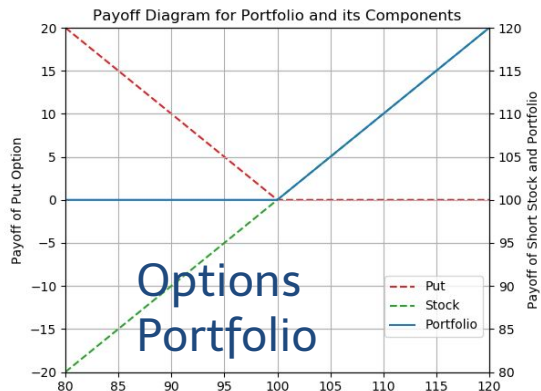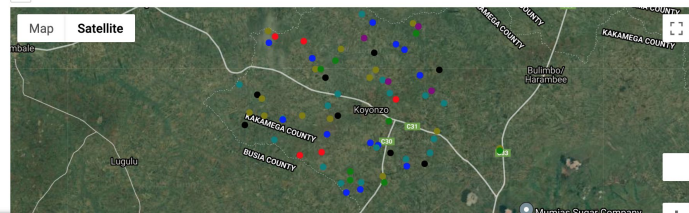
Regression Continuous Discrete

Mapping Demo

Data 88E – Demand Survey

Find the Sheet ID in the URL of the Google Sheet!

Take a look at the data https://docs.google.com/spreadsheets/d/1jp-XrFPk0eUNDUVWGa7Rmw9b0P8_jobTG0oLpvcHB9s/edit?resourcekey=&gid=418675525#gid=418675525

```
[17]:  sheet_id = "1jp-XrFPk0eUNDUVWGa7Rmw9b0P8_jobTG0oLpvcHB9s"
       sheet_name = "Form1"
       url = f"https://docs.google.com/spreadsheets/d/{sheet_id}/gviz/tq?tqx=out:csv&sheet={sheet_name}"
```

Read it into a datascience table

```
[18]:  demand_table = Table.read_table(url)
       demand_table
```

[18]:

Timestamp	Coffee	Burrito	GreekTix	iPhone
9/4/2024 12:05:19	0.5	2.5	25	250
9/4/2024 12:05:29	1	5	50	500
9/4/2024 12:05:41	1.5	7.5	75	750
9/4/2024 12:05:54	2	10	100	1000
9/4/2024 12:06:05	2.5	12.5	125	1250
9/4/2024 12:06:17	3	15	125	1250
9/4/2024 12:06:30	3.5	17.5	175	1750
9/4/2024 12:06:39	4	20	200	2000
9/4/2024 12:41:43	0.5	2.5	25	250
9/4/2024 14:55:09	3.5	12.5	25	500

Data 88E – Demand Survey

```
[5]: demand_table.ihist("Burrito",bins=7)
```
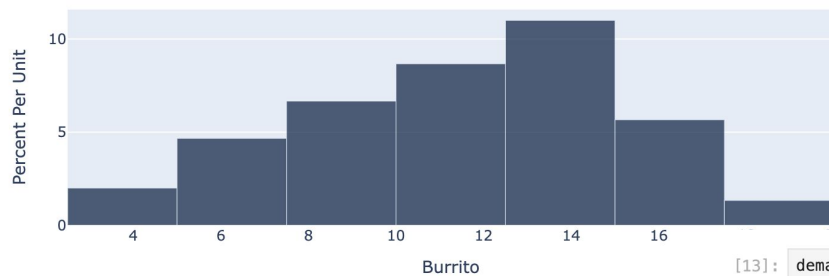


```
[13]: demand_curve.iscatter("Cumulative Count","Price", fit_line=True)
```
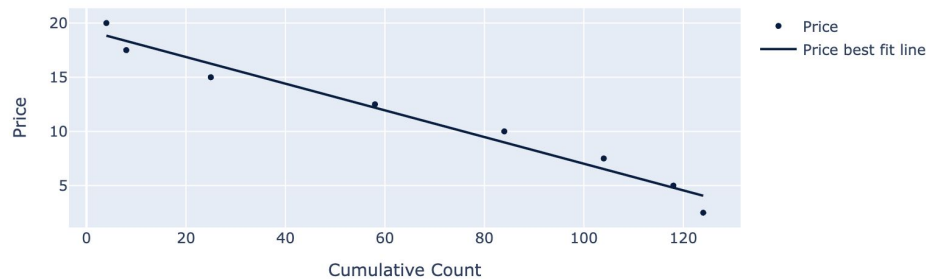
# Data 88E – Demand Curve as scatter / fit line

Avocados

Let's examine some historical data on non-organic a[...]
2018. The original dataset is taken from Kaggle and [...]

```
[2]: avocados = Table.read_table("avocados.csv")
     avocados
```

[2]:

Date	Average Price	Total Volume
2015-12-27	1.05	692206
2015-12-20	1.15	637091
2015-12-13	1.22	616016
2015-12-06	1.06	694982
2015-11-29	1.05	651639
2015-11-22	1.04	709444
2015-11-15	0.99	775849
2015-11-08	1.4	599884
2015-11-01	0.97	869927
2015-10-25	1.55	561342

```
[3]: avocados.scatter("Total Volume", "Average Price", width = 7, height = 7)
     plt.title("Demand Curve for Avocados", fontsize = 16);
```
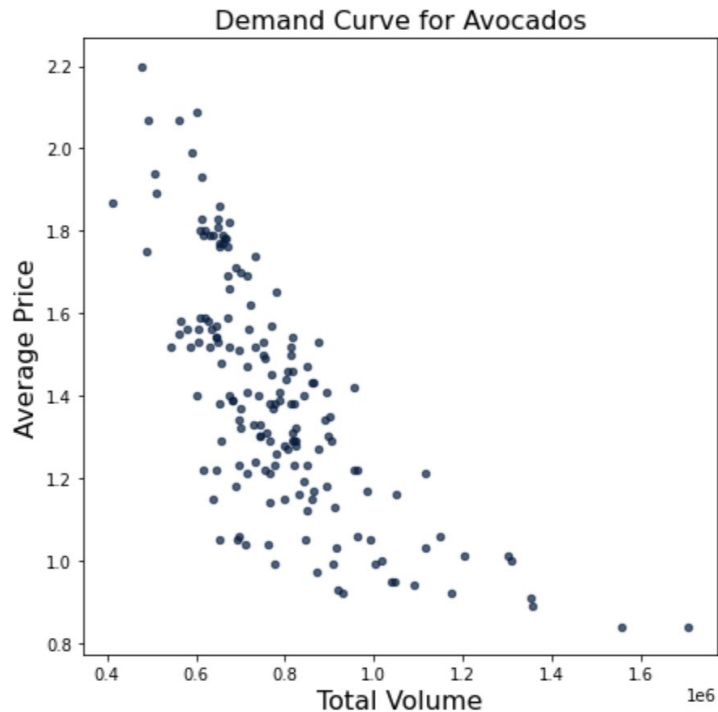
Econ 148 – www.econ148.org

3 semesters
- 150 & waitlist on initial offer
- 225 & waitlist

Econ 148

- **Home**
- Syllabus
- Resources
- Staff

LINKS

- Ed
- DataHub
- Gradescope

Data Science for Economists

UC Berkeley, Spring 2023

Instructor: Eric Van Dusen (ericvd@berkeley.edu)

Lecture: MWF 1PM–2PM, **Office Hours:** See Ed

[Zoom links] [Lecture recordings]

The following breakdown is tentative. All assignments are available for public consumption on our GitHub.

The class website is being built at the moment.

1. Introduction and Basic Tools

Jan 18:	1	Introduction and Course Overview slides · code
Jan 20:	2	Overview of Technology slides · code
		LAB 0 Intro to Notebook
		SURVEY 1 Pre-Semester Survey (due Jan. 27)

(Listed in Econ not in Data)

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Econ 148 – topic list

SQL – supermarket scanner data

API – National statistics FRED /IPUMS

- CO2 Emissions by sector

Visualization – GeoPandas – Dubai housing ownership

Kenya Drinking Water – Randomized Controlled Trials

IPUMS – Card Miami – Mariel Boatlift Study

Intro to Machine Learning

- Time series – Zillow vs CPI
- Survival Analysis – Telco Churn, Credit Risk
- Classification / Logit

Source and structure data
Inference
Hypothesis Testing
Modeling

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Econ 148 – outcomes

Econ students looking to add quantitative skills

DS students looking to add contexts and applications

Journal Article reproduction as final project

Guest speakers who do Data Science / Big Data

    UC Endowment risk manager

    David Card – working on DS teams at Amazon

    Big Data projects – remote sensing in Africa

Vibecession – the Notebook

Vibecession

- Twitter / Social Media
- FT article

Source series on FRED / Yahoo

- Build dataset in Pandas
- Machine Learning model
- Visualization

What was Consumer Sentiment Index on October 2024, and what does an econometric model predict that it would have been

- Get Data from Fred
- Make all data monthly
- Get a couple more series from Yahoo Finance
- Merge them
- Build an econometric model
- Compare before and after COVID

Vibecession

FRED data
Consumer Sentiment
As predicted by indicators

UC Berkeley
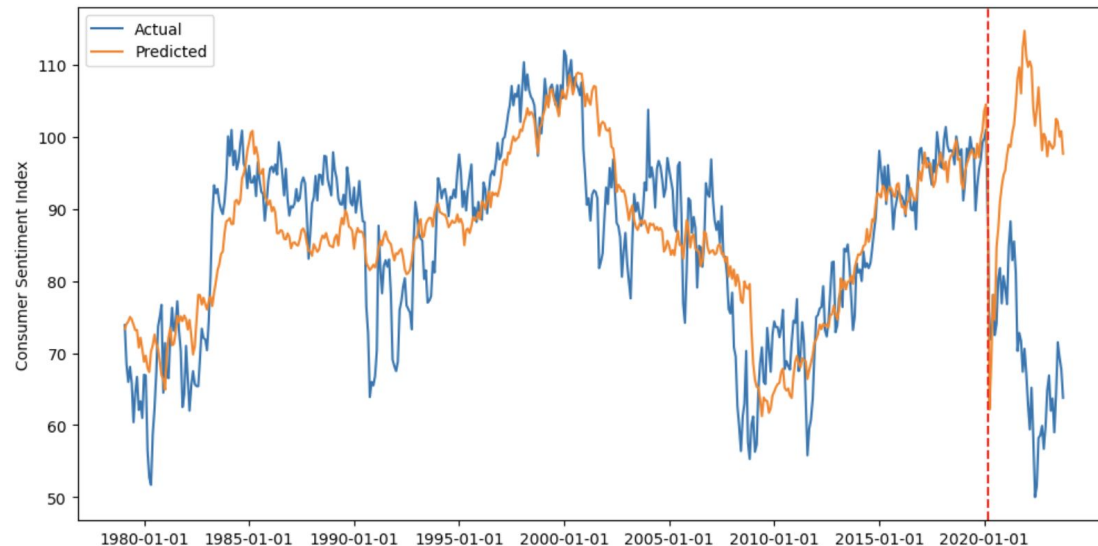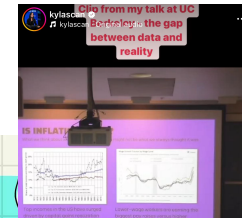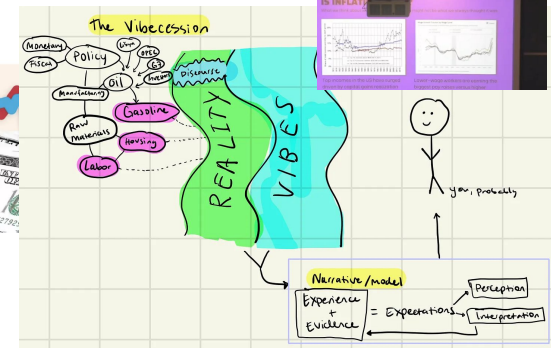
Kyla Vibecession

Videos ⋮

Are We Still In A 'Vibecession'? with Kyla Scanlon

YouTube · Morning Brew Daily
Sep 2, 2024

'Vibecession' creator Kyla Scanlon on the Fed, a TikTok ban ...

YouTube · MarketWatch
1 month ago

Kyla Scanlon on the "Vibecession", the Vibe Economy, and ...

YouTube · Mercatus Center
Aug 11, 2024

2024
JET SYMPOSIUM ON TEACHING ECONOMICS

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Bloomberg Opinion

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AUGUST | **1-3** | **2024**

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Part 4 – Demo – Vibecession – Lecture Notebook

Open the Notebook and follow along!

github.com/ericvd-ucb

https://github.com/UCB-Econ-148/econ148-sp24/blob/main/lec/Lec13.2/vibes.ipynb

Try this link and then hit Runtime> RunAll

https://colab.research.google.com/github/UCB-Econ-148/econ148-sp24/blob/main/lec/Lec13.2/vibes.ipynb

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Everything is on Github – take it

https://github.com/data-88e

https://github.com/ucb-econ-148

AI – where are we at

LLMs are really good at Python

- Assessment is tough
- Students can do more
- I can make awesome curriculum
- AI is run on Python
- I taught Small LM in April – ask me about this!

Econ 148 Midterm – on PrairieLearn in a Lab with locked down browser – with Jupyter Python integration

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Appendix
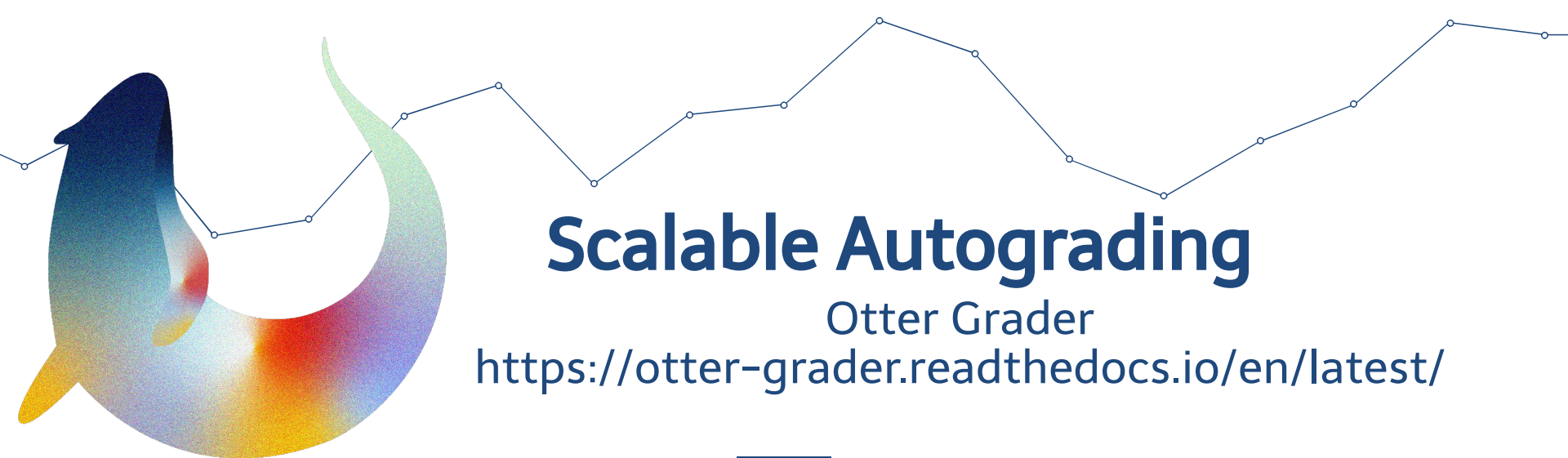
Scalable Autograding

Otter Grader
https://otter-grader.readthedocs.io/en/latest/

Modular, component based

Can run local independent of server

Many Classes – Grading runs in Docker container on Gradescope Server

Extension for R

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Jupyter Books
Tool for creating interactive textbooks
https://jupyterbook.org/

jupyter {book}

Online textbooks for data-driven courses

Build online textbooks using a collection of Jupyter Notebooks and Markdown files

Contents and source files are open-source

Adaptability promotes collaboration across disciplines

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Econn 148 – JupyterLite

https://www.econ148.org/sp23-student-lite/lab/index.html
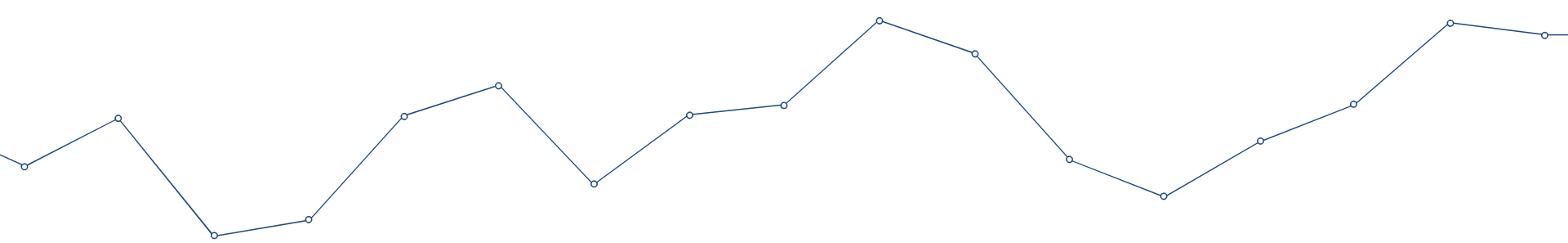
What is the Berkeley Data Science Teaching Stack?

- Teach with computational notebooks
  - Free services like Colab
- All software is Free OSS
  - Any machine can run - no software licence
  - Low setup burden
- Teaching in notebooks, scaffold with platform to make textbooks, Autograding
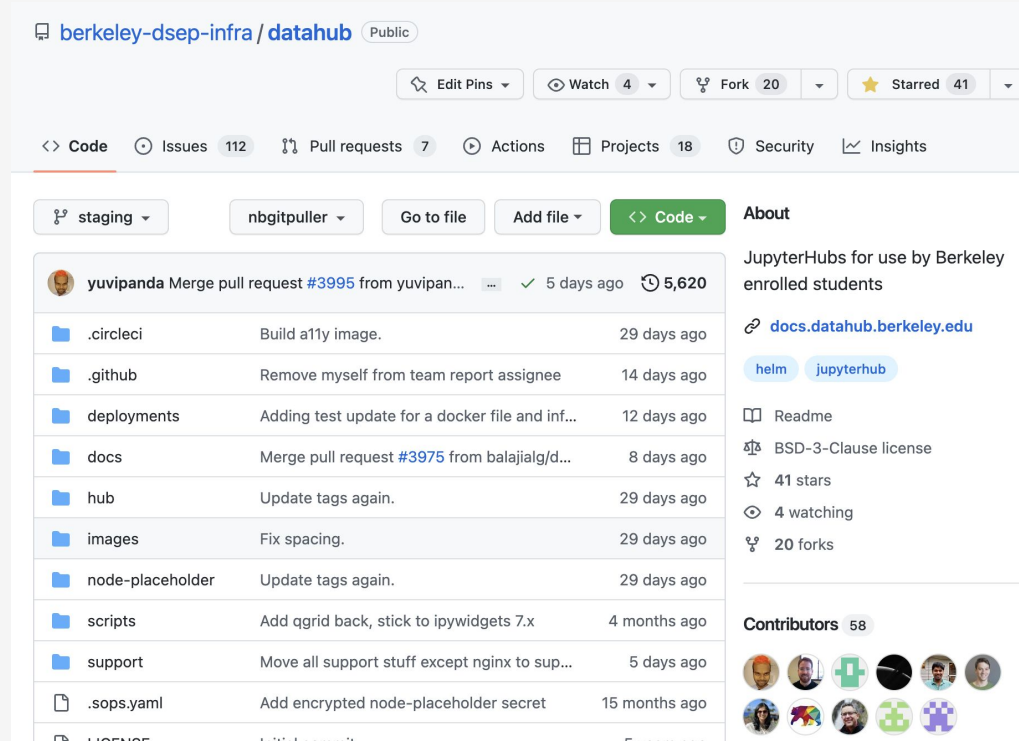
What is the Berkeley Data Science Teaching Stack?

- Free textbook, open-source software stack and open-source curriculum approach
  - *the server, the textbook, the packages, the grader, the homeworks... in public Github repos*
- *Building a whole class based on this workflow*
  - *Student GSI*