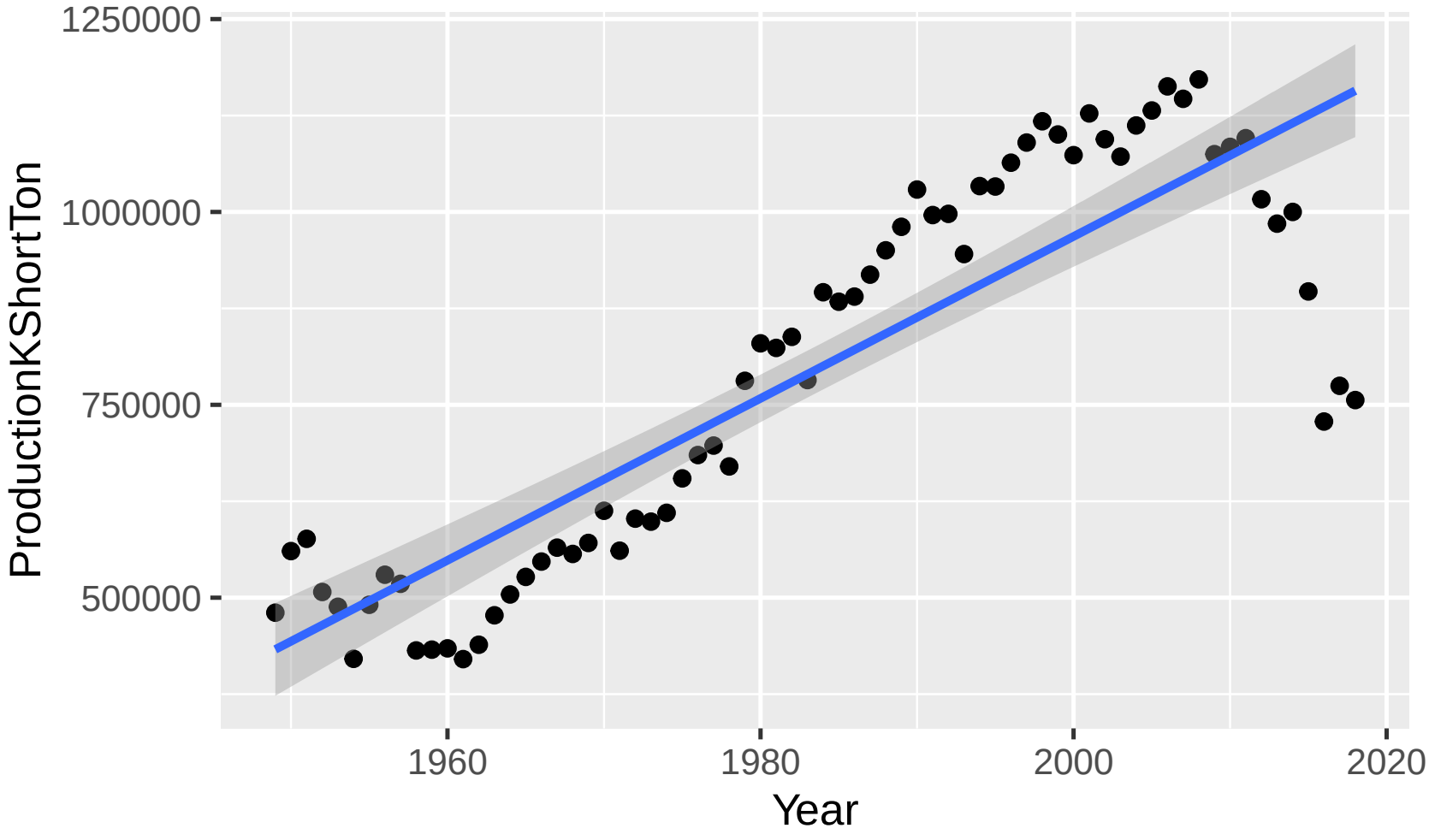
Energy Models

Overview of Energy Models

- Trend
- Time Series
- Guess based on experience
- Survey Based
- Scenario Planning
- I/O Models
- Energy Balance Models
- Game Theory
- Experimental/Behavioral

Trend

- Uses only patterns of the past to make forecasts about the future.
- Cram a line though the data.



Trend Comments

- General
  - Regression with time as RHS variable. $Y = time + \epsilon$
  - Other variables are often added, for example, weather variables. You can see this in some integrated resource planning models.
  - EC469 shows you how to do this.
  - Not everything is a line. You sometimes have to transform the data, logs and such are common.
- Problems
  - Only uses the past and does not show turns in trend.
    - I was 90 lbs at 15, 110 at 17, 130 at 18 and 220 at 26.
    - Today?
  - People don't react to prices and there is no change in technology.
    - See the coal data at the end. That is the natural gas fracking boom.
  - Growth of a subset can only exceed that of a superset for a while.
    - Facebook can only grow faster than the US, or world, economy for so long.

Trend Comments (Con't)

- Advantages
  - That said, it works for a lot of things and work when you have little time.
  - Plenty of energy modeling looks like this.
    - "If you don't have the time, throw in a trend line."
  - For looking a few periods into the future – it works. For longer term forecasts – don't do it.

Time Series

- Similar to trend only
  - May have $Y = ARMA(p, q)$
  - or include a trend $Y = time + ARMA(p, q)$
  - the AR part is past values of LHS
  - the MA part is past values of error term.
- EC 472 shows you how to do this.
- Most energy data has a trend to it, which must be included in the model.
- Best thought of, for now, as a refinement to the trend regressions with better treatment of residuals.
  - More accurate confidence intervals on existing data.
  - Slightly better with near-term forecasts.
- Similar problems as pure regression on trend.

There is way more to time series

- Macro is heavy into this.
- You may see macro heavy energy papers with Vector Autoregressions (VARs) which looks at many time series at once.
- Nice example of quick use by Borenstein about the California Cap and Trade (https://ei.haas.berkeley.edu/research/papers/WP281.pdf)
  - They produced the key result that the price will not be at a bound, upper or lower, only 19% of the time.
  - Quick analysis.

Guess based on experience

- Don't laugh, this works.
- Old hands make very good guesses based on experience.
- GDP even has components that are based on analyst's best judgement.
- This can be combined with incentivised polls or parimutuel betting to make it work better.
  - The Iowa Electronic Markets are a common example, though there are others. https://tippie.biz.uiowa.edu/iem/markets/

Incentivized Polls

- Guess Jamie's BMI. Closest to the actual gets $1.
- Skin in the game gives incentive for more thought.
- Only works when you will eventually find out actual.
- Oddly works better if you don't know how people are betting.
  - Can produce group-think bubbles, if you see how others are betting.
  - Easy to find the mode, but harder to tell if it is real.
- Can get expensive with many winners:
  - everyone guesses the same correct answer.
  - More expensive when there is less certainty.

Parimutuel Betting

- Guess Jamie's BMI. Correct answers split the pot with the others that got it right.
- Racetrack method.
- Less likely to get bubbles, but
  - Harder to see if there is a mode in the guess.
- Cheaper than incentivized poll if high probability of multiple winners.
- Cost does not increase with a priori certainty.

Survey Based

- Book gives some examples.
- Ask a bunch of experts about their best judgement and summarize
- Often expanded as a Delphi Survey
- For comically bad forecast see "Results of the Delphi IX Survey of Oil Forecasts" California Energy Commission, 1997. http://www.energy.ca.gov/reports/DELPHI-9.PDF

Delphi Surveys

- Ask each person *in private* for best guess.
- Compile results.
- Ask outliers why they said what they did.
- Give everyone:
  - The distribution of guesses for each parameter
  - The reasons the outliers gave for the answer the gave.
- Ask for another guess.
- Report the new distribution or repeat if desired.

Bayesian Truth Serum

This works best with multiple choice questions

The idea is that if you hold a particular belief, you are more likely to think that others agree.

- Ask each person what they think is most likely.
- Ask them about what others think – the probability distribution.
- Do some Bayes law majik.

Scenario Planning

- Too much variation to give one description.
- General Steps:
  - Choose some parameters of interest, e.g., environmental activism, sea level rise, fracking shown to cause earthquakes, etc.
  - Package them into narratives that are possible. Some improbable and some likely.
  - Decide how you would act now given that you know that that future will exist.
  - ?
  - Profit
- Example by National Renewable Energy Research Laboratory (NREL) did one for Hawaii.
  http://www.nrel.gov/docs/fy12osti/52442.pdf
  - Contractor reports tend to go long.
  - See page 6 for summary of the scenarios.
  - Contractor reports tend to use lots of acronyms.
  - Plug in Hybrid Electric Vehicle (PHEV)

Frequent use and abuse of scenarios analysis

- Rigging scenarios so that only one is taken seriously. (abuse)
- Choosing actions that will "work" in all scenarios. (abuse)
- Actual plans if a scenario becomes more likely, "Plans are worthless, but planning is everything." - Ike
- Creation of real options
  - Defer action until more information is available. Don't bring an umbrella everywhere, but have on near by if it starts to rain.
  - Create systems you can use when the situation is clearer. Think peaking power plants that only run a few days a year.

I/O Models

- Old school – 1920s Leontief
- Has an equilibrium concept
- Assumes fixed ratios are used in production
  - No reaction to price changes
  - No reaction to input price changes
  - Constant returns to scale.
- Often seen as part of a computable general equilibrium model to shorten run-times. REMI (http://www.remi.com/) and IMPLAN (http://implan.com/) use it in regional economic models.
- Will not ask you to do one unless you want to.
- Book has an overly long explanation.

Walk Through I/O model

$x_1 = \alpha_{1,1}x_1 + \alpha_{1,2}x_2 + d_1$

- x_1 is how much of good one that gets made.
- d_1 is how much final consumers want of good 1.
- $\alpha_{1,1}$ the amount of good 1 needed to produce good 1.
- $\alpha_{1,2}$ the amount of good 2 needed to produce good 1.
- Each good has an equation
- αs can be zero but there are restrictions on how many and where. The matrix needs to be invertable.

Matrix Form $x = Ax + d$ is solved as $x = (I - A)^{-1}d$

d is what you need to fight the war. X is what you need to produce to get d.

Warnings about the next models in book

- They are an unholy mix of estimates, in engineering sense, and estimates, in the statistical sense.
- They can be huge. The national energy modeling system has many modules and sub-modules.
  - http://www.eia.gov/forecasts/aeo/nems/overview/electricity.html
- The approaches are frequently combined.

"Estimate" to an Engineer and Statistician

- To an engineer, an estimate means taking some known or assumed values for parameters then performing some calculations to find a parameter of interest.
  - Example, building energy simulations like EnergyPlus. Put in windows, screens, walls, assume some values human behavior, and weather and out pops annual energy use.
  - Can work with *very* complex models, but is usually shaky with uncertainty.
- To a statistician, an estimate means taking data, repeated observations of a physical data generating process and calculating a summary statistic.
  - Example, estimate implied thermostat settings from gas use and R values of walls from a survey.
  - Treats uncertainty well but often lack the complexity of the engineering style models.

Combining Engineering and Statistician Style Estimates

- A typical Example is estimates of Unit Energy Consumption (UECs)
  - The EIA Residential Energy Consumption Survey (RECS) http://www.eia.gov/consumption/residential/reports/2009/methodology-end-use.cfm
  - California Residential Appliance Saturation Study (RASS) http://www.energy.ca.gov/appliances/rass/
- Check the details for RASS and see how they combine engineering estimates with regression analysis.
  - http://www.energy.ca.gov/2010publications/CEC-200-2010-004/CEC-200-2010-004-V1.PDF.
  - Often called a statistically adjusted engineering model.

Game Theory

- Not a full, all economy, model but a tool used to deal with decisions where:
  - There is not a monopoly or monopsony.
  - Not perfect competition.
- Also used for:
  - Dynamic interactions of firms, think how gasoline prices go up fast but down slow.
  - Auction and bidding, technically mechanism design which is game theory backwards, to get people to tell the truth or do the right thing.
  - Basis for a lot of modern "regulation" which focuses on encouraging competition to reach goals.
- Probably did some in EC 201 or EC 311, but we have a full class EC 321 and math has several.

Experimental/Behavioral

- The behavioral part is admitting that people and firms do not act rationally.
- Old school experiments, A/B testing and more, run on people
- Field experiments are common in economics now
  - Esther Duflo received the Bates Clark Award 2010
  - Bluffstone in Econ is running two now in Ethiopia and Nepal.
- Typical Issues
  - Internal validity
    - Can you really connect cause to effect?
    - Did you avoid bias and control for everything?
  - External validity
    - Does it work in real life?
    - Does it work on other people?
  - Ecological validity
    - Did the experiment look like the real world?

Overarching

- Every model is wrong
  - By definition they are simplifications of reality and they leave out details.
  - The real question is, "Did they leave out the right details?"
- Don't be deluded into, "Just look at the data".
  - You come to data with a model, you just don't know it.
  - The data never speak for themselves. You use data to test/support/refute hypotheses/theories.
- Using more than one model or technique and getting the same general result helps. It shows that your conclusion about reality is resilient to the implicit modeling assumptions.

Overarching (Con't)

- Keep in mind that modeling is an iterative process often driven by the researcher.
  - You try a model and then refine it based on the results.
  - It is an iterative process.
  - Your choices are molded by your objectives. "Get published" is common.
  - Great working paper on this by Gelman that expands on this idea "The garden of forking paths: Why multiple comparisons can be a problem, even when there is no "fishing expedition" or "p-hacking" and the research hypothesis was posited ahead of time" (http://www.stat.columbia.edu/~gelman/research/unpublished/p_hacking.pdf)