

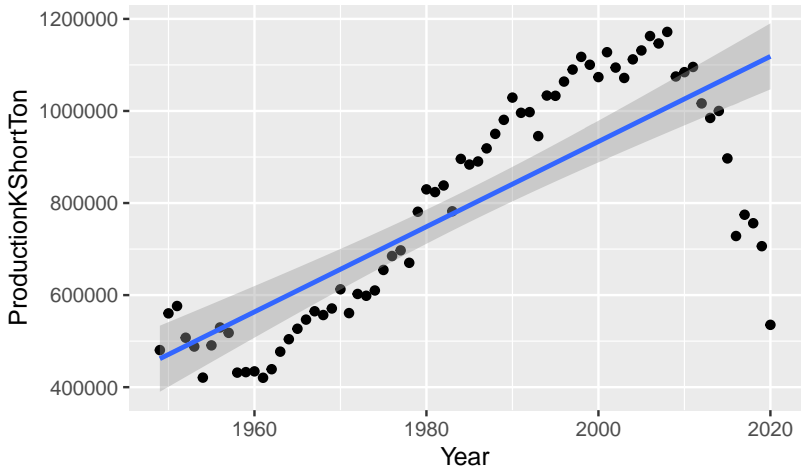
# Energy Models

# 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 through 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 judgment.
- ▶ 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.

# 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 they 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 one 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
- ▶  $\alpha$ s 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](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)  
<https://ww2.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 and others 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](http://www.stat.columbia.edu/~gelman/research/unpublished/p_hacking.pdf))