Session 5: Thinking Electrons

5.1 – Thinking Electrons – Modeling People

- Thinking Electrons vs. Purposeful Actors
- Purposeful, Thinking Actors who are Diverse
- Frameworks: 1) Rational, 2) Behavioral, and 3) Rule Based
- Context emphasizes which framework is best.

- **Rational Model:** Objective function (mathematical) to maximize. People OPTIMIZE the Objective function.
- **Example:** $Utility = C^{0.5}L^{0.5}$,
  C = consumption, L= leisure
  Note: diminishing impact on utility with as C & L increase

- **Behavioral Model:** *Observe* people are not rational.

- **Rule Based Model:** e.g., Schelling, simple rule that is close to what people actually do.

Can look at how people react in each of these model frameworks. Sometimes they have different results, sometimes not. Will look at examples of when each model matters or not.

5.2 – Rational Actor Models

- Logical but people are not always logical. Will describe application to decision making and games.
- Objective and Optimizing to that objective.
- Firms – maximize profits,
  Individuals – maximize utility,
  Political Candidate – maximize votes
- **Firm quantitative example.** Revenue = P x Q , quantity = q and price = p = 50 - q. Revenue is maximized at $\frac{dR}{dq} = 0 = \frac{d(q(q-50))}{dq} = 2q - 50$
  or
  $q = 25$ and $R = 25(25) = 625$
- **Apply to:** Investments, Purchases, Educational level, Vote for

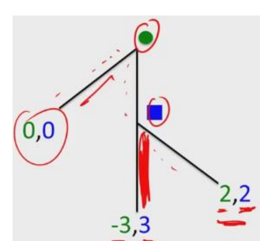
- Rational does not imply selfish. Example: $100 What is my objective function? Could be following

Me	Friend
$100	**0**
$50	**$50**

- **Selfish:** Objective = me
  Altruistic: Happiness of others.
- **Example:** I: income ($40K), C: consumption, D: donations with an Objective:
  $C^{.5}D^{.5} = \sqrt{C}\sqrt{D}$
  Maximize: $C^{.5}(40 - C)^{0.5}$ by finding derivative
  at $0 = 0.5(40 - 2C)/\sqrt{40C - C^2}$ or
  $0 = 40 - 2C$ & $C = 20$ and $D = 20$ which is equally rational and altruistic.

- **Decision vs Game:**
  Decision: Objective depends only on own action
  Game: Objective depends on actions of others
- **Normal Form Game:** my (2) best choice depends upon what (1) does. Recall dominant choices from game theory. Point here is assume (1) is rational so will choose 'City', and therefore (2) should choose 'City'. Note for (1) 'City' dominates whereas (2) is 'mixed'.

- **Extensive Form Game:** Action is sequential. Green is person (1), Blue is person (2). Green moves first. Green will choose (0,0) because if choose to let (2) move, rational for (2) to choose (-3,3) to maximize his return. Thus (1) best move is (0,0).



Quiz: Which of the following questions is an example of a game? (1) You will lose profit if you take a week away from work, but your productivity will increase if you get rest. How many days should you take off? (2) You want to go to a baseball game but you hate sitting in traffic and will only go if there is lots of parking available. Do you go to the game? (3) You have $100 dollars and need to buy a friend a gift. You also want to donate some. How much do you spend, and how much do you donate? (4) None, They are all decisions.
Ans: (3) **Explanation:** traffic is dependent upon the decisions of others, hence your decision is part of the 'try to avoid traffic' game.

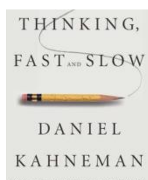
- **When do you expect rational thinking:** (1) Large stakes involved, (2) Repeated decisions offer learning,
  (3) Group Decisions, and (4) Easy decisions.
- **Roger Myer:** Rational Behavior is an important **benchmark** because: (1) unique in most cases, (2) easy to solve for in many cases, (3) People learn, and (4) mistakes tend to cancel so average tends to rationality.
- **Irrational behavior:** (1) not unique, (2) can be very hard to model, not easy.

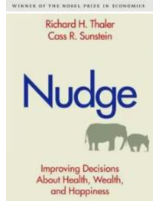
Summary: Rationality is a good benchmark that identifies an objective that actors optimize decisions to achieve.
But, as we shall see, there are cases where people consistently bias away from optimal decision-making behavior.

5.3 – Behavioral Models

Behavioral models: Supported by observational studies and neurology

- **Daniel Kahneman –** *Thinking Fast & Slow*
  Slow – logical thinking
  Fast – more emotional, gut driven.
- **Cass Sunstein -** *Nudge*
  Human biases have real implications. Systematic mistakes offer levers for policy makers.





Examples:
(1) Prospect Theory – gains and losses viewed differently
(2) Hyperbolic Discounting – how much we discount the future
(3) Status Quo Bias – tendency to stick with what we have and avoid changes.
(4) Base Rate Bias – influenced by what we are currently thinking

Prospect Theory:
Example: Choose A ($400 for sure) or choose B ($1000 with 50% probability, $0 otherwise). Most people choose A, particularly as if each is very large, say $4 million vs. $10 million.
Point: As amounts get larger, people are risk averse. BUT, if made to pay instead of win, i.e., Choose A (-$400 for sure) or choose B (-$1000 with 50% probability, $0 otherwise). Most people choose B. ***People are risk averse over gains and risk loving over losses.*** This is an example of systematic bias over rational decision-making. MLO note – expected value is associated with a large number of trials

Hyperbolic Discounting:
Example: Option A: $1000 today, Option B: $1005 tomorrow. Most people choose A over B.
BUT if: Option A $1000 in a year, Option B: $1005 in a year and a day, most choose B over A. A rational actor would choose the same in both cases (B actually). Why? ***Discount the same short period of time difference in the near future more than the same short period of time difference in the far future (one day in this example).***
Can ignore chocolate cake a week in the future but put one in front of me today and 'chomp'!

Status Quo Bias:
- ○ Check box to contribute to pension fund, OR
- ○ Check box to NOT contribute to pension fund

Example: Donate organs: UK uses 'check box to donate' with 10% marking the box. Europe countries using 'Not contribute organs' have only 10% marking the box. Implies strong status quo bias.

Base Rate Bias:

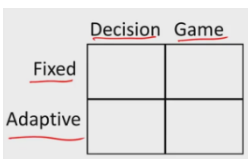
Ask year box made then ask what price. The first number influences the estimate of the second number.

Quiz: Irrationally borrowing money at high interest rates may be an example of which type of bias? (1) Base Rate bias, (2) Status Quo bias, (3) Prospect Theory, (4) Hyperbolic Discounting.
Ans: (4) Hyperbolic Discounting.
Explanation: Loan has immediate payoff. Cost of borrowing is too high, but since it can be deferred until much later, the cost appears acceptable.

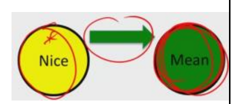
Conclusions: (1) Lots of Biases, (2) WEIRD – Western, Educated, Industrial, Rich, Developed countries, (do they apply universally?) (3) People will learn, (4) Computationally difficult (to include all biases) so we tend to simplify.
Frame: Start with a rational model, then consider what biases may need to be included and what experiments to verify your bias selection. In short, Rational Model plus some biases is a good start.

5.4 – Rule Based Models

Examples: Schelling, Granovetter, Ovation, Rational
Types:
Fixed, Decision;
Fixed, Game;
Adaptive,
Decision;
Adaptive, Game



Fixed Decision:
Optimal, and Random Choice
Most Direct 'Route' (may look good, but not be optimal)



Fixed Strategy:
Divide evenly or Tit for Tat Moore Machine –
Tit for Tat - change state if opponent switches
Grim Trigger – if defect go to mean and stay there.

Quiz: Alice is nice one day, mean the next, then nice again, and so forth. Her friend Bob follows the 'tit-for-tat' rule. His reactive behavior manifest one day after encountering Alice, and vice-versa: in other words, his 'tit' comes one day after Alice's 'tat'. Assuming Alice starts off nice, how will Bob act on the seventh day of the week? (1) Mean, (2) Nice.
Ans: (1) Mean
Explanation: Alice will be mean on day 6. Since Bob goes tit-for-tat, he will be mean on the next day which is day 7.

Adaptive Decision Rules: Chocolate Chip cookie making, Gradient based methods (find a hill keep climbing), Random search (changing to see what happens)
Adaptive Strategies: Best response to what others are doing, or mimic (copy) what others does.

Observations: Sometimes optimal rules are simple, example
Objective: Happiness (H) depends on chocolate (C) and movies (M) with $H = C^{0.5}M^{0.5}$ with
$p_c = price/chocolate$ and $p_m = price/movie$
$H_{max} => p_c N_c = p_m N_m$ where N_m is number of movies and N_c is number of chocolates.
Macro Economy simple rule: 20% food, 30% transportation, 40% housing, 10% entertainment.

Observations:
Simple rules can often be exploited, example.
Bargaining Rule: Accept only if I get 60% initially.
Demand 1 % less each round. Note this can be driven to down to zero by the counter party.

Why Rule Based Models?
- Easy to model
- Capture Main effects
- Ad Hoc (but not everyone is the same as you)
- Exploitable (simple, non-adaptive)

5.5 – When Does Behavior Matter

Models Considered: Rational, Behavioral, Rule Based

Quiz: When we construct a model, we want to think about how the agents will be acting: rationally, behaviorally, or according to simple rules. We gather data about how agents will act, and use this information to construct the model. This thought process is best characterized by which of the following? Hint: think back to the first lecture on "Why We Model". (1) Understanding patterns, (2) Calibration, (3) Estimating hidden parameters, (4) Retrodiction

Ans: (2) Calibration

Explanation: When we construct a model, we want to mimic the real world as accurately as possible. This process is known as calibration.

What does it matter what model we use? It depends, one reason we model is to see how important it is to model.

Examples: Market and Race to the Bottom

Two Sided Market.

Buyers (B) with [0,100] distribution of purchase value

Sellers (S*) with [50,150] distribution of sales price

Only need to be concerned about relevant ones:

Buyers (B*) with purchase value [50,100] and

Sellers (S*) with sales price [50,100]

Result probably average price around $75.

Now assume people are biased but not super strategic, so may rely on focused bids, $50, $60. Only small deviation from $75.

Zero Intelligence (ZI) agent: These agents bid some random number from their threshold:

B_{ZI} bids B_o - N_r where N_r is random (> 0) and

S_{ZI} offers at S_o + N_s where N_s is random (> 0).

Result is again a value near $75. In markets, there is so much influence such as in supply – demand curves that we don't care so much about modeling behavior.

Race to the Bottom: Pick a number in [0,100]. The closest to 2/3 of the mean wins. What happens?

Rational bidder: Bids zero, as follows logic of always being 2/3 of what others predict (perfectly symmetric game) the mean of the picks to be. Graphic shows chasing mean to zero from a mean of 6.

6 mean = 6
2/3(6) = 4
2/3(4) = 8/3

Biased bidder: Many guess 50, because confused, too complicated, lazy thinker.

Rule Based bidder: Tends to become a combination of rational and biased because don't follow rational logic all the way to zero. Some stop at various steps along the way. Note many are using 'best response' to expected guess of mean. 50➔33➔22➔14

50
2/3(50) = 33
2/3(33) = 22
2/3(22) = 14

Two rational and one irrational Player. Let R: Rational people, X: Irrational person. Mathematically $R = {}^{2}/_{3}\left(\frac{R+R+X}{3}\right)$ or $R = {}^{2X}/_{5}$. Assume X chooses 50, then $R = 20$. ***Bottom line, if everyone is rational, choose zero, otherwise some other number is best choice.***

Quiz: Imagine that you're playing a "race to the bottom" game with four irrational players instead of just one. Assume that all four of these irrational players will answer 50. Also suppose there are two rational players: you and one other. What is the rational number for you to choose? Please round your answer to the nearest whole number.

Analysis: $R = {}^{2}/_{3}\left(\frac{2R+4X}{6}\right)$ or $18R = 4R + 8X$ or $14R = 8X$ or $R = \frac{4X}{7}$ at $X = 50$, $R = 28.57$ ➔ 29

Ans: 29

Summary:

Rational behavior is a good starting point. Then we should consider bias. Finally, we should try a simple rule. How much difference in the outcome? If difference is small, then behavior has small influence (invariant). If large then have to investigate why and which model is most appropriate. Most applications of models merit review of whether any of the three are applicable alone or in combination.