PA 4010
Public Affairs Decision Making

SESSION 8: BAYES THEOREM & UPDATING

THURSDAY, SEPTEMBER 12

Agenda for Today

- Workshop 2 on Tuesday (structuring to be group work)
- Homework 2 due Tuesday?

- Review potential alternative solution from last class
- Where have we been? How did we get here?

- Decision Making Under Uncertainty
  - Bayes Theorem

Alternative solution to example problem

Example 2:

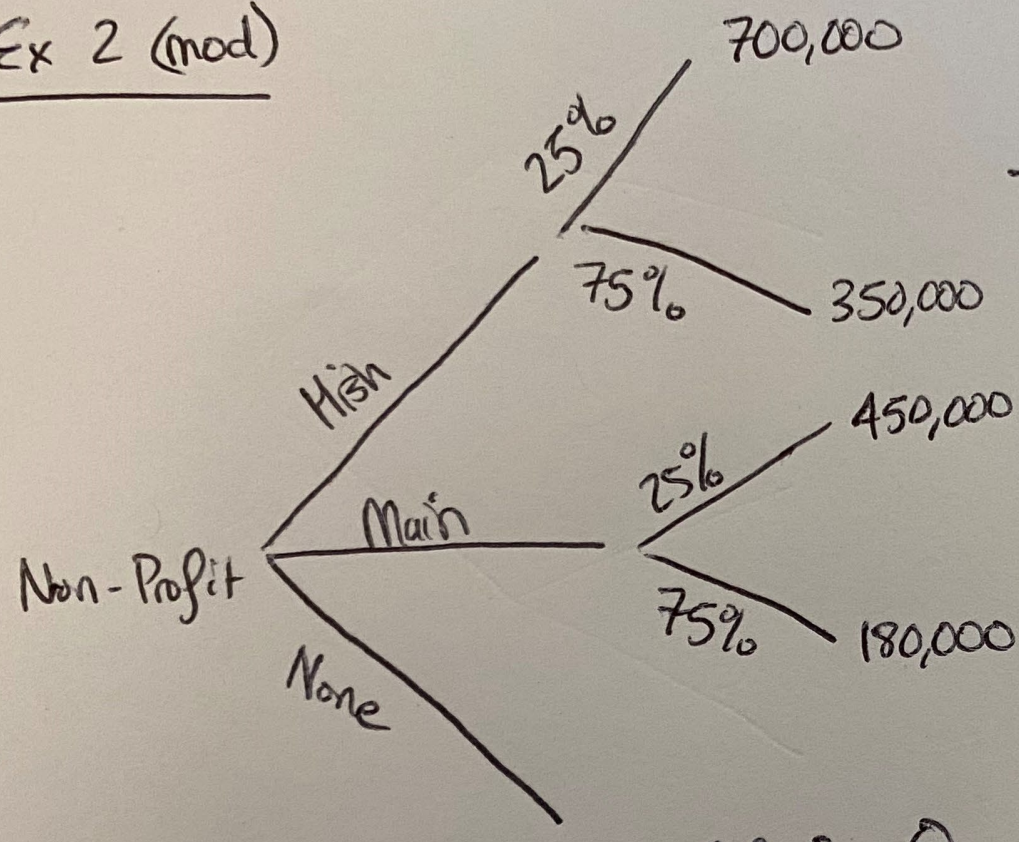
A non-profit is deciding whether to open a new location or not. It can afford to do so only if the maximum population that it serves is greater than 450,000 people (if it serves less, it will be ineligible for a grant, so this is critical). The city is currently re-designing the bus routes, and the traffic from the bus routes would be a huge boost to the client population that the non-profit could serve.

If there was a bus stop that opened on High St., 1M clients would walk past the non-profit's doors each day and they estimate that 70% of the people would be interested in their services. If there was no bus stop, the potential cliental would be 500,000 (and still 70% would be interested). There is a 25% chance that the city puts the bus line on High St.

If there was a bus stop that opened on Main St., 750,000 clients would walk past the non-profit's doors, and they estimate that 60% would be interested in the services. If there was no bus stop, the potential cliental would be 300,000 (and still 60% would be interested). There is a 45% chance that the bus route would run on Main St.

Which location (if any) should the non-profit choose?

Ex 2 (mod)



Expected Clients

437,500

301,500

0

"Cost" to Non Profit

↳ if Expected clients is > 450,000, cost is $0 due to grant.

→ If Expected clients is < 450,000, cost is > $0 b/c no grant

cost > $0

cost > $0

cost = $0 (didn't open)

Pick this b/c it minimizes cost

How did we get here?

Why think about
decision making at all?

How did we get here?

Why think about decision making at all?

1. Personally (as citizens), how can we make the best decisions given the information that we have?

2. Publicly (as policymakers), if we know how people are *supposed* to act and we see they don't, is there something we can do?

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1. Type I (intuitive) thinking

2. Type II (critical) thinking*

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Without requiring any critical thinking, how might we approach a problem?

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PrOACT

- Be clear about what is the problem that is being encountered.
- What constraints to solutions are necessary?
- For every potential solution, what are the consequences (intended or not) and *what are the tradeoffs*?

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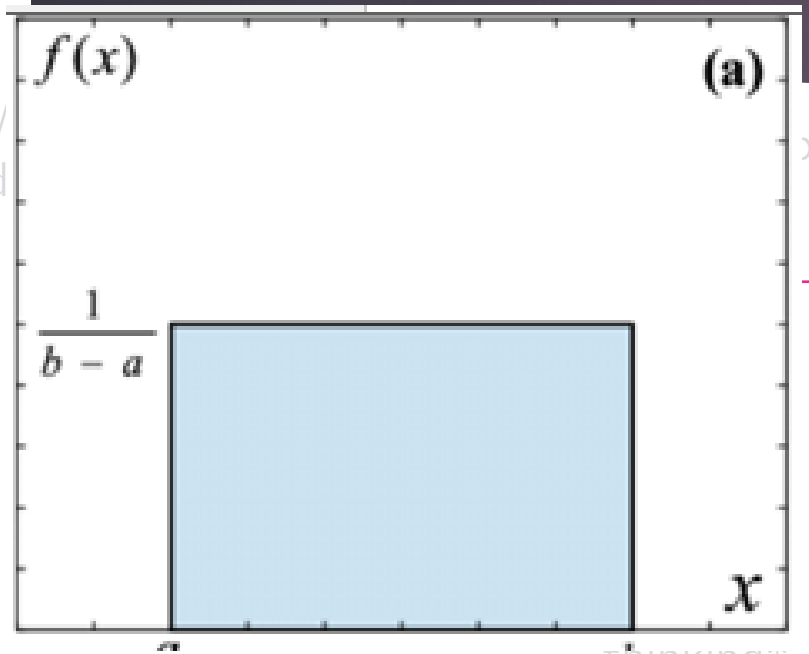
Rational decision making with certainty

How did we get here?



		Alternatives		
	Dorm	Single Apartment	Fratnerity House	House with Roommates
Objectives: Cost of rent (per semester)	0	28	85	100
Cleanliness	90	90	0	50
Ability to make friends	85	15	85	70
Distance to campus	100	50	50	50
Cost of food (per semester)	100	0	50	75
Total	115	125	120	175

Rational decision making with certainty

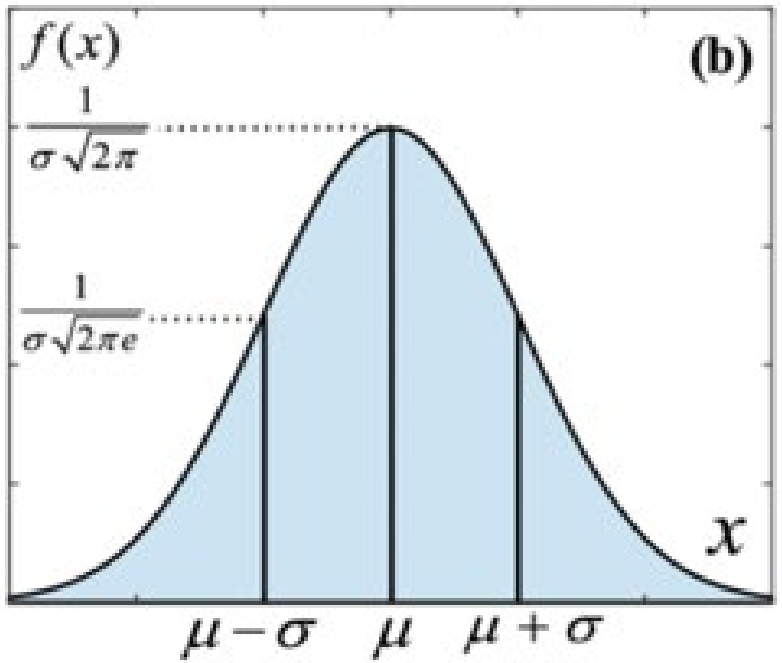
- Decision matrices with the implicit assumption that you know everything about the alternatives.
- Or rather that the distribution of potential outcomes is perfectly uniform.

- Roughly a cost / benefit analysis with some focus on opportunity costs.
- Weights
- Different utility functions
- Social utility functions and public decision making
- Relationship between decision matrices and indifference curves

How did we get here?

Rational decision making with certainty

Rational decision making with uncertainty

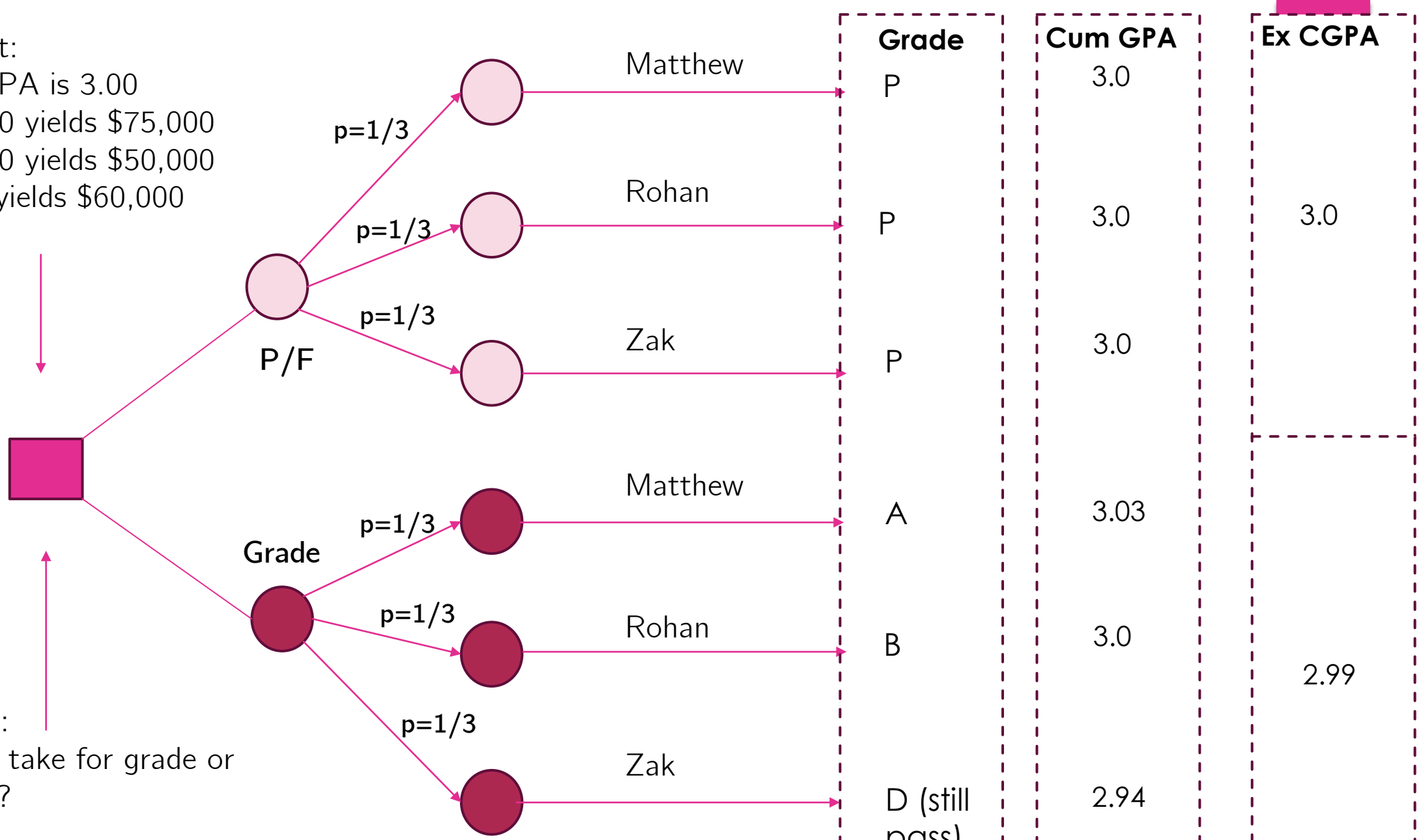


What if your ability to make friends (or earnings after college) is not known, but is a random variable with some non-uniform distribution?

Can we still make decisions even if we don't necessarily know what the outcome will be?

We use expected value. Given some known probability of an event occurring, we can make optimal decisions based on our expectation of the outcome.

Context:
Cum GPA is 3.00
- > 3.0 yields $75,000
- < 3.0 yields $50,000
- 3.0 yields $60,000



Problem:
Should I take for grade or pass fail?

How did we get here?

Rational decision making with certainty

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- Weights
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- Relationship between decision

2. Publicly (as policymakers), if we know how people are *supposed* to act and we see they don't, is there something we can do?

Rational decision making with uncertainty

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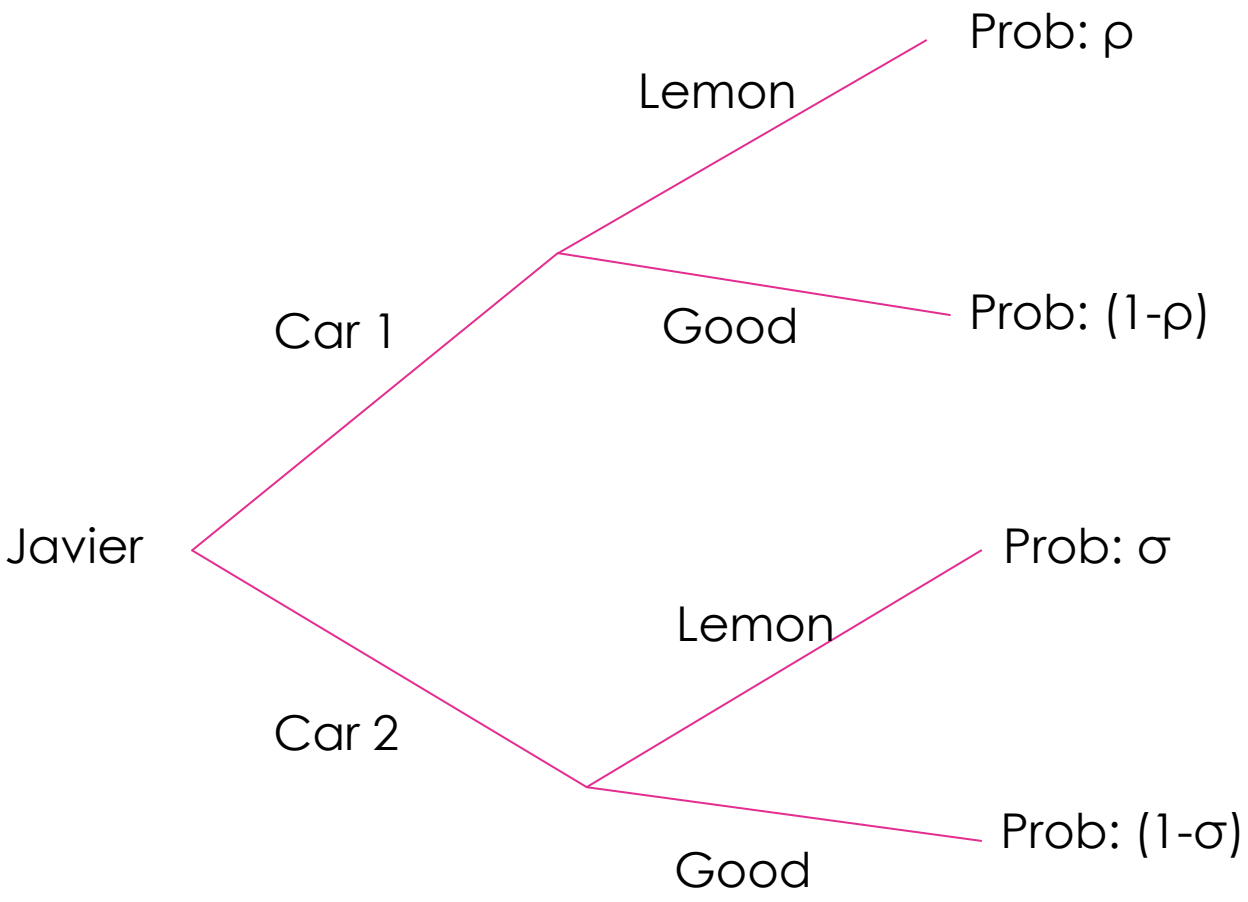
New: Thinking through probabilities. Usefulness and cautions

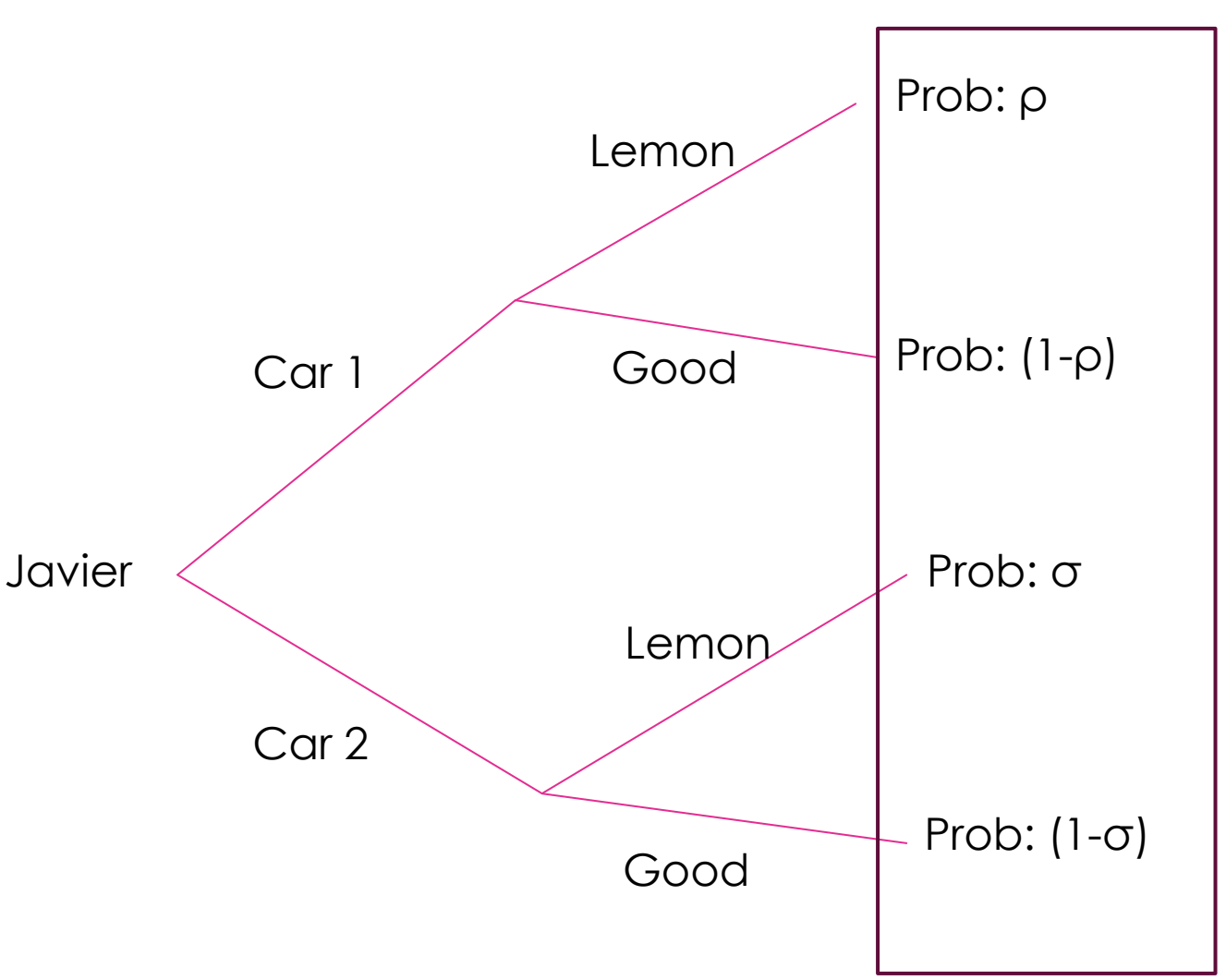
Bayes Theorem – update beliefs based on experience when information is not perfect.

Probabilities in decision trees are not perfectly known or exogenously determined.



Outcomes if branch is realized

Expected Outcomes for each car



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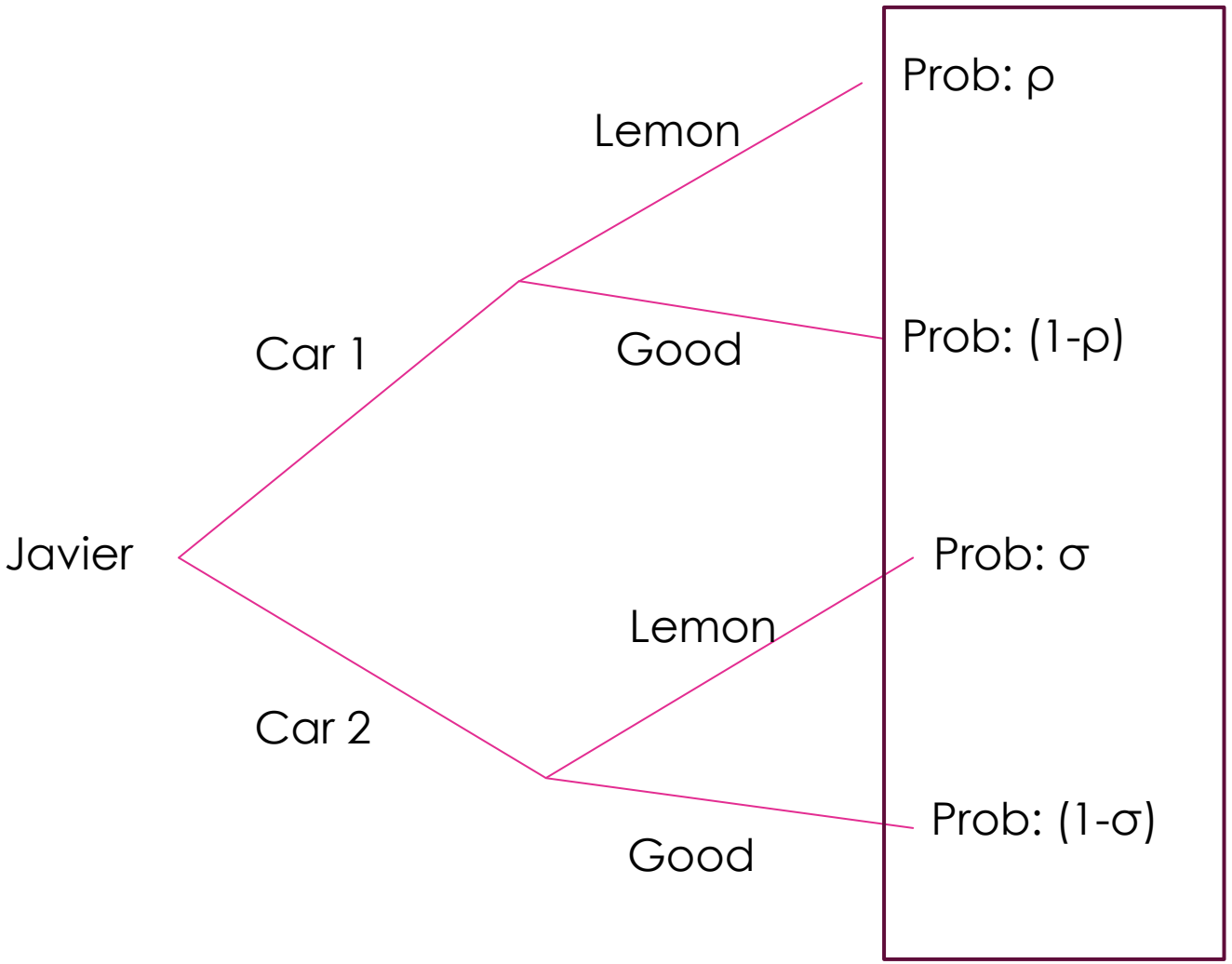
What's new is that we are introducing the idea that individuals might not have perfect information on these probabilities and they're deducing them from past experiences and beliefs.



Outcomes if branch is realized

Expected Outcomes for each car

What's new is that we are introducing the idea that individuals might not have perfect information on these probabilities and they're deducing them from past experiences and beliefs. **This will lead us into part 2 of this course.**

New information: extensions of probabilities

Conditional probabilities

- A conditional probability is the probability of something occurring, given some piece of relevant information.
- Example: The risk of lung cancer is about 1/17 (~5.8%).
- Should you really expect that 6 of the next 100 people that you meet will get lung cancer? Or rather that you will get cancer with 6% likelihood?

Conditional probabilities

- A conditional probability is the probability of something occurring, given some piece of information.
- Example: The risk of lung cancer is about 1/17 (~5.8%).
- Should you really expect that 6 of the next 100 people that you meet will get lung cancer?
  Probably not. In fact, the risk of lung cancer is highly dependent on your smoking behavior.

	Risk of Lung Cancer
Never smoker	1.5%
Current Smoker	13%

P(Lung Cancer) = 6%

P(Lung Cancer | Smoker) = 13%

P(Lung Cancer | Non-Smoker) = 2%

Conditional probabilities

- In research it's more common than you would think that people don't think about this (or think about it incompletely).

Conditional probabilities

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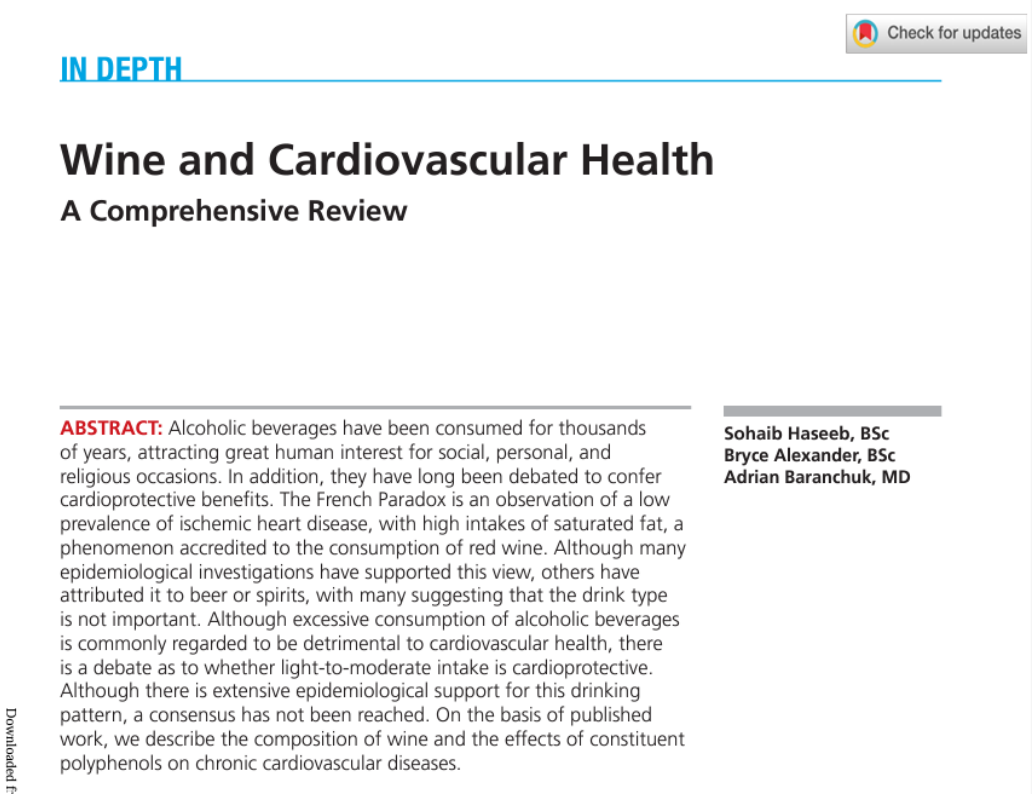

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IN DEPTH

Wine and Cardiovascular Health

A Comprehensive Review

ABSTRACT: Alcoholic beverages have been consumed for thousands of years, attracting great human interest for social, personal, and religious occasions. In addition, they have long been debated to confer cardioprotective benefits. The French Paradox is an observation of a low prevalence of ischemic heart disease, with high intakes of saturated fat, a phenomenon accredited to the consumption of red wine. Although many epidemiological investigations have supported this view, others have attributed it to beer or spirits, with many suggesting that the drink type is not important. Although excessive consumption of alcoholic beverages is commonly regarded to be detrimental to cardiovascular health, there is a debate as to whether light-to-moderate intake is cardioprotective. Although there is extensive epidemiological support for this drinking pattern, a consensus has not been reached. On the basis of published work, we describe the composition of wine and the effects of constituent polyphenols on chronic cardiovascular diseases.

Sohaib Haseeb, BSc
Bryce Alexander, BSc
Adrian Baranchuk, MD

Example: Red wine is linked to better cardio health and longer lives.

What's potentially wrong with this research?

Conditional probabilities

- In research it's more common than you would think that people don't think about this.

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Rate of Drinking Among Americans, by Income and Education

Based on combined 2021-2022 data

	Yes, drink %	No, total abstainer %
Household Income		
$100,000 or more	80	20
$40,000 to $99,999	63	37
Less than $40,000	49	51
Education		
Postgraduate	75	25
College graduate only	76	24
Some college	65	35
No college	51	49

Based on U.S. adults aged 18+

Get the data • Download image

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Conditional probabilities

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Household income affects wine consumption. About 53 percent of consumers earning more than $100,000 a year drink wine, according to the survey. By comparison, only 15 percent of consumers earning less than $50,000 annually drink wine.

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Education is also a factor. About 52 percent of wine drinkers are college graduates, according to Wine Market Council. The general population includes 44 percent of college graduates.

Although there is extensive epidemiological support for this drinking pattern, a consensus has not been reached. On the basis of published work, we describe the composition of wine and the effects of constituent polyphenols on chronic cardiovascular diseases.

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Conditional probabilities

- In research it's more common than you would think that people don't think about this.

- What's wrong here?
  - Red wine is positively correlated with wealth and education.
  - Wealthy and educated people have more time and money to spend on [other] healthy activities and food.
  - So maybe you're just picking up on a wealth phenomenon --- not really much to do with wine itself.

Conditional probabilities

- Another example from Emily Oster in *Expecting Better*...
- Women who drink coffee are more likely to miscarriage during pregnancy. Should you avoid coffee?
  - Pr(Miscarriage | Coffee) is high. So if you reduce prevalence of coffee drinking, you're reduce miscarriage.

- What's the potential issue here?

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  - Coffee drinking increases with age. Women who are older tend to have more pronounced issues during pregnancy.
  - So is coffee related to miscarriage?

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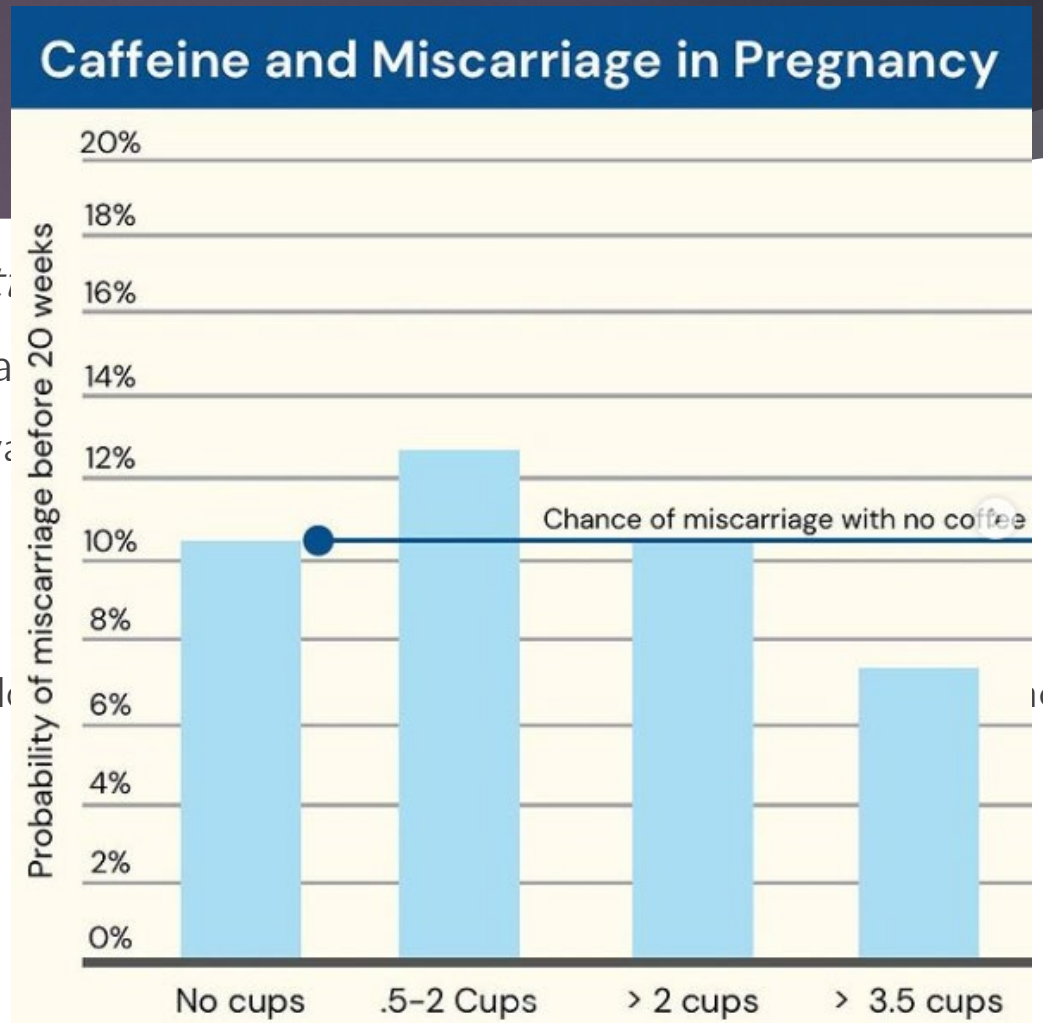
- What's the potential issue here?
  - Coffee drinking increases with age. Women who are ol ıcy.
  - So is coffee related to miscarriage? **Probably not.**



Bayes Theorem

Bayes Theorem is an incredibly powerful formula that relates [absolute] event probabilities and conditional probabilities. And perhaps more powerfully, it allows us to inverse conditional probabilities. (for more, see Hastie & Dawes Chapter 8)

→ This is especially useful for updates beliefs on something.

Bayes Rule:

$$P(A|B) = \frac{P(B|A) * P(A)}{P(B)}$$

Prior belief that the food is good.

Belief of the probability that the food at restaurant is good given a good Yelp review you've read.

Belief of the probability of a good Yelp review given the food is actually good.

Probability of a good Yelp review.

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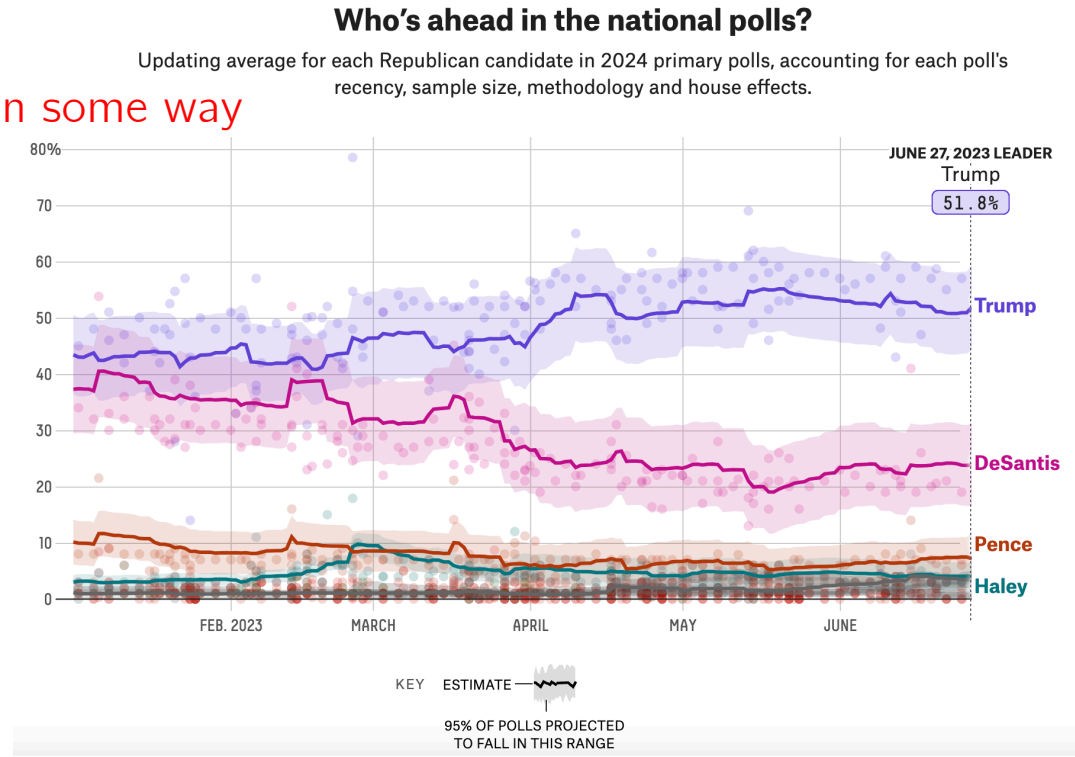

FiveThirtyEight

Bayes Theorem (Policy example: "Ban the Box")

Ban the Box, Criminal Records, and Statistical Discrimination: A Field Experiment

U of Michigan Law & Econ Research Paper No. 16-012

69 Pages • Posted: 15 Jun 2016

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Sonja B. Starr
University of Chicago

Abstract

"Ban-the-Box" (BTB) policies restrict employers from asking about applicants' criminal histories on job applications and are often presented as a means of reducing unemployment among black men, who disproportionately have criminal records. However, withholding information about criminal records could risk encouraging statistical discrimination: employers may make assumptions about criminality based on the applicant's race. To investigate this possibility as well as the effects of race and criminal records on employer callback rates, we sent approximately 15,000 fictitious online job applications to employers in New Jersey and New York City, in waves before and after each jurisdiction's adoption of BTB policies. Our causal effect estimates are based on a triple-differences design, which exploits the fact that many businesses' applications did not ask about records even before BTB and were thus unaffected by the law.

Our results confirm that criminal records are a major barrier to employment, but they also support the concern that BTB policies encourage statistical discrimination on the basis of race. Overall, white applicants received 23% more callbacks than similar black applicants (38% more in New Jersey; 6% more in New York City; we also find that the white advantage is much larger in whiter neighborhoods). Employers that ask about criminal records are 62% more likely to call back an applicant if he has no record (45% in New Jersey; 78% in New York City) — an effect that BTB compliance necessarily eliminates. However, we find that the race gap in callbacks grows dramatically at the BTB-affected companies after the policy goes into effect. Before BTB, white applicants to BTB-affected employers received about 7% more callbacks than similar black applicants, but BTB increases this gap to 45%.

Bayes Theorem (Policy example: "Ban the Box")

Previously: People being hired were asked whether they were a felon (convicted of felony) or not.

- Article finds that before BTB, applicant is 62% more likely to be called back if had no felony record.

Now: Employers can no longer use criminal status as criterion for employment. So employers use 'heuristics' based on their prior beliefs.

- Central idea is that employers *believe* (no matter how correct or not) that someone's race makes him more likely to be felon. By removing the ability to ask about felony, employers are making decisions on the basis on race as a heuristic for criminality.

$$\Pr(\text{Felony}|\text{Black}) = \frac{\Pr(\text{Black}|\text{Felon}) * \Pr(\text{Felon})}{\Pr(\text{Black})}$$

Result: Conditional on felony-status, prior to BTB, white applicants received 7% more callbacks than black applicants. After BTB, this gap grew to 45%.