SSA456, PP46000. Applied Medical Cost-effectiveness Analysis; SSA45600. Policy Analysis Methods and Applications

Instructor: Harold Pollack (director, haroldp@uchicago.edu)
Winter Quarter 2015. Thursdays, 9-11:50 in Room E1, SSA

This joint public policy and social service administration course examines the intellectual bases and analytic tools for the professional practice of policy analysis, with an emphasis on economic policy analysis in the form of cost-benefit analysis, decision analysis, and cost-effectiveness analysis. Many examples will be drawn from medicine and public health, whi_2014ch offer particularly clear application of the basic methods. However we will also draw upon examples and challenges from environmental policy, criminal justice, transportation, and welfare policy.

Topics to be covered will include cost-benefit analysis, decision analysis, quality of life and cost measurement, model development and parameter estimation, and cost-effectiveness methods. Students will have weekly problem sets and instruction in a computer lab that will provide them with hands on experience performing decision analysis and cost-effectiveness analyses. Students taking this course will be prepared to take Advanced Applications of Cost-Effectiveness Analysis, which provides doctoral-level training in this area.

Key Highlights:

- There will be weekly assignments, the first is due week 2 before class.
- Final grade will be based on the weekly assignments (50 points), class participation (10 points) and the final exam (40 points). All groups are expected to complete each assignment in accordance with university regulations regarding academic integrity. **All individuals are expected to contribute to group work**.
- The course will make extensive use of the University's Web-based course management system, *Chalk*. Students are responsible for information posted on the website. Assigned readings will be available via *Chalk*.
- Instruction to Login to *Chalk*:
    - Go to https://chalk.uchicago.edu
    - You will be prompted to enter your CNET ID
    - You wil be prompted to enter your CNET password
    - Select SSA45600. Policy Analysis Methods and Applications.
- Each week, students should consult the website before class for questions, announcements about readings and assignments, and discussions of class material. Teaching notes, links and other materials will also be posted on the site. **If you have any difficulties entering the site, please email us.**
- Students will learn to use and develop decision models using the TreeagePro® software.

Textbook: Michael Drummond, *Methods for the Economic Evaluation of Health Care Programmes*, Third Edition, Oxford University Press. Please buy a copy. It is a useful reference.

Week 1 January 8

The Landscape of Policy Analysis and Economic Evaluation (Part I)

Decision Analysis, Cost-Benefit Analysis, Cost-Effectiveness Analysis

Book Sections (Drummond): pp. 1-71.

Sarah L. Taubman, et al., Medicaid Increases Emergency-Department Use: Evidence from Oregon's Health Insurance Experiment, *Science*, January 2, 2014.

Week 2 January 15

The Landscape of Policy Analysis and Economic Evaluation (Part II, Methodology and Cost Analysis)

Book Sections (Drummond): pp. 72-150, 173-189.

Optional advanced reading: **Theoretical Foundations and Advances of Medical Cost-Effectiveness Analysis**

Meltzer, David. "Accounting for Future Costs in Medical Cost-Effectiveness Analysis," *Journal of Health Economics* vol. 16, no. 1, February 1997, pp. 33-64.

Week 3 January 22

Conducting Decision Analysis

Readings:

Book Sections (Drummond): pp. 277-322. (Review pp. 103-133.)

Screening Tests and Conditional probabilities.

Harris RA, Washington AE, et al. Cost utility of prenatal diagnosis and the risk-based threshold. *Lancet* 2004; 363(9405): 276-82.

Paltiel AD, Weinstein MC, Kimmel AD, et al. Expanded screening for HIV in the United States – an analysis of cost-effectiveness. *New England Journal of Medicine* 2005; 352: 586-595.

Week 4 January 29

Psychology of Decision Making - Heuristics and Biases

Readings: Tversky A, Kahneman D. Judgement under uncertainty: heuristics and biases. *Science*, 1974; 185: 1124-1131.

Daniel Kahneman, *Thinking fast, thinking slow*, selections.

Sendhil Mullainathan and Eldar Shafir, *Scarcity: Why having too little means so much*, selections.

Shlomo Benartzi, Ehud Peleg, and Richard Thaler, "Choice architecture and retirement savings plans," *Behavioral Foundations of Public Policy*, pp. 246-263.

Week 5 February 5

Decision Modeling using Software

Treeage decision analysis software materials

Marshall DA, Kleinman SH, Wong JB, et al. "Cost-effectiveness of nucleic acid test screening of volunteer blood donations for hepatitis B, hepatitis C and human immunodeficiency virus in the United States," *Vox Sanguinis* 2004; 86: 28-40.

Week 6 February 12

Valuing Life and Health—Cost-Benefit Analyses of Crime

Cost-benefit analysis

Michael Kinsley on Arsenic.

Book Sections (Drummond): pp. 211-241.

Readings:

Environmental matters

Cohen, M., Rust R., et. al. "Willingness to pay for crime control programs." *Criminology* 2004 (1) : 89-110.

Skim Basu, A, Paltiel, AD, and Pollack HA "Social costs of robbery and the cost-effectiveness of substance abuse treatment," *Health Economics*, 2008, 17(8):927-46.

Week 7 February 19

Conducting and interpreting cost-utility analysis

The following are optional reading for this lecture that may be fun to look over.

Hirth RA, Chernew ME, Miller E, et al. Willingness to pay for a quality-adjusted life year: in search of a standard. *Medical Decision Making* 2000; 20: 332-342.

Ubel PA, Hirth RA, Chernew ME, Fendrick AM. What is the price of life and why doesn't it increase at the rate of inflation. *Archives of Internal Medicine* 2000; 163: 1637-1641.

Drummond, review 137-207.

Week 8 February 26

Quality of Life Measurement and introduction to Markov chains

Stiggelbout AM. "Assessing patients' preferences." In: *Decision Making in Health Care: theory, psychology, and applications*; Chapman GB, Sonnenberg FA (Eds), Cambridge Un. Press, 2000; p. 289 -312.

Introduction to Markov Modeling

Book Sections (Drummond): 277-322

Readings:

Sonnenberg FA; Beck JR. Markov models in medical decision making: a practical guide. *Medical Decision Making* 1993 Oct-Dec; 13(4): 322-38.

Gibbons RD, Meltzer D, Duan N. Waiting for organ transplantation. *Science* 2000; 287 (5451): 237-238.

Mandelblatt JS, Cronin KA, Bailey S, et al. Effects of mammography screening under different screening schedules: model estimates of potential benefits and harms. *Annals of Internal Medicine* 2009; 151: 738-747.

Week 9: March 5

Markov Models and experiments

Readings:

Gary Burtless, "The Case for Randomized Field Trials in Economic and Policy Research," *Journal of Economic Perspectives*, 1995 9(2), pp. 63-84.

Odds-and-ends reading packet.

Week 10: Reading period March 12

Review and applications

Week 11: March 19. In-class final exam

SSA/Harris 456

Harold Pollack, and occasional supporting cast

January 8 2015

Roadmap for today

- Boring course mechanics
- Decision analysis
  - Should you marry your girlfriend?
  - Diagnostic tests
- If time: mopup and whirlwind intro to economic tools
  - Economic analysis as an aid to centralized decision-making
  - Cost-benefit, cost-effectiveness, cost-utility analysis (CBA, CEA, CUA)

"Are you just pissing and moaning, or can you verify what you're saying with data?"

Polonius-like preliminaries

- Joint Harris/SSA course..
  - Examines the intellectual bases and analytic tools for the professional practice of policy analysis, with an emphasis on cost-benefit analysis, decision analysis, and cost-effectiveness analysis.
  - Many examples will be drawn from medicine and public health, which (a) are important, and (b) offer particularly clear application of the basic methods even if you are not a health person.
  - We will also draw upon examples and challenges from environmental policy, criminal justice, transportation, child welfare, and public assistance policies.
- Students taking this course will be prepared to take more advanced applications of cost-effectiveness analysis, which provides doctoral-level training in this area.
- Or not… this works as a stand-alone class too

Textbook

- **Methods for the Economic Evaluation of Health Care Programmes**
- Third Edition
- Drummond, Sculpher, Torrance, O'Brien, Stoddart

Grading and activities

- Students will have weekly problem sets and instruction in a computer lab that will provide them with hands on experience performing decision analysis and cost-effectiveness analyses.
- This has its moments of frustration, but is also cool and fun.
- You can make cool graphs and pictures to bring to job interviews.
- There will be weekly group assignments starting from week 2.
- Final grade will be based on the weekly assignments (50%), class participation (10%) and the in-class final exam (40%).
- Old final exams will be provided so that you know what to expect.
- The course will make extensive use of the University's Web-based course management system, Chalk. Students are responsible for information posted on the website. Assigned readings will be available via Chalk.
- Given multiple course listings, we will use ONE chalk site for everything. Leave us your name and email, and we will make it happen.

Activities – Problem Sets and Software

- Initial problem sets will be solved without software
- In subsequent weeks, we will distribute download instructions for Treeage Pro

Obligatory tough-guy slide

- We often discuss assignments during the class in which they are due. So assignments must be handed in before class.
- No need for super-fancy publishing. But h/w must be neat and clear, and performed in accordance with university regulations for academic integrity.
- You do not have to be in a group if you prefer to go solo.

Some historical and conceptual notes

Why do we need policy analysis? (or Why bother?)

- Resources (people, time, facilities, equipment, knowledge) are scarce
- Choices must and will be made about resources
- Life without analysis
  - Difficult to identify relevant alternatives
  - Unknown perspective
  - Uncertainty surrounding decisions

A useful checklist for economic evaluation (pp. 28-29)

- Was a well-defined question posed in answerable form?
  - Did the analysis examine both costs and effects?
  - Did it involve explicit comparisons of alternatives?
  - Was the analysis viewpoint stated.
    - Agency perspective, client/patient perspective, payer perspective, "social perspective"
  - Was the analysis placed into a particular decision-making context?

A useful checklist for economic evaluation (pp. 28-29)

- Were competing alternatives well-described?
  - Who would do what to whom, where, how often?
  - Is there a "do nothing" option?
- Was the effectiveness of different alternatives credibly described?
  - Randomized trial in some ways best, if generalizable to actual practice.
  - Effectiveness data collected through systematic study of the literature.
  - Observational data collected—if so some discussion of accompanying limitations and biases.
- Were the important and pertinent costs and consequences identified for each alternative?
  - From multiple viewpoints?
  - What kinds of costs are involved?
- Were these costs and consequences accurately measured, and in the appropriate units?
  - Market values for marginal costs
  - What about non-market items such as caregivers' time or clinic space?
  - Were data sources transparent and the values credible for these things?

A useful checklist for economic evaluation (pp. 28-29)

- Were costs and consequences adjusted for their different timing?
  - $1000 today is worth more than $1000 five years from now.
  - The same is true of 1000 lives (less intuitive)
- Were incremental costs and consequences considered relative to explicit alternatives?

A useful checklist for economic evaluation (pp. 28-29)

- Was due allowance made for uncertainty and variation of key parameters (sensitivity analysis)?
  - Sometimes uncertainty in key parameters influences policy choices.
    - How fast is the earth warming or medical costs growing?
  - Sometimes different populations merit different choices.
    - Optimum HIV prevention services/person among injection drug users more intensive than HIV prevention/person among UC undergraduates.
- Did presentation/discussion of results engage key issues of interest to pertinent stakeholders?
  - Implementation issues
  - Political/distributional concerns
  - Generalizability across populations
- Did presentation candidly present study limitations
  - Known unknowns
  - Unknown unknowns

Memory Lane

- Origins in WWII logistics
  - Modern industrial management to "rationalize" resource allocation.
  - Emergence of social science in early 20th century (UC!)
  - Progressive ideals of scientific management and the experimenting society
    - Dewey *The Public and its Problems* (UC!). Included idea that social science could critique actions and arguments of the powerful.
  - Winston Churchill abandoning French Air Force after explicit decision analysis
  - The massive effort to mobilize U.S. manpower and economy in WWII.
  - Pentagon
    - "Whiz kids" of early 1960s trying to rationalize budget (*Best and the Brightest* provides devastating account) (sometimes UC)
    - OMB, CBO, GAO, other efforts to get a handle on sprawling federal budget.
    - Late 1960s establishment of public policy schools, APPAM, etc.
    - Health care, especially in European social democracies (why?) (not UC)
  - Social experiments
    - RAND Health Insurance Experiment (HIE), Denver Income Maintenance Experiment (DIME), System to Turn Unemployed People into Doctors.

History of policy analysis

- Harold's lifetime
  - Pentagon of 1960s
    - "Whiz kids" of early 1960s trying to rationalize budget (*Best and the Brightest* provides devastating account) (sometimes UC)
    - OMB, CBO, GAO, other efforts to get a handle on sprawling federal budget.
  - Social policy
    - Social science played an *apparent* role in great society programs, became identified with liberal policy solutions among conservatives. Became identified with technocratic sell-out among left.
    - Late 1960s establishment of public policy schools, APPAM, etc.
    - Health care, especially in European social democracies (why?)
  - My liberal students liked these methods better after George W Bush administration

Not only historical.

- Current examples?

Faces of policy analysis

- Torgerson speaks of "3 faces" of policy analysis.
  - Knowledge replacing politics
  - Knowledge as a mask for politics
  - Knowledge as a self-conscious part of the political/deliberative process
- What do you think he is getting at?

Interesting quote

- Nate Silver on financial crisis 2/11/2009:

So if I'm telling you to lay off the ideological smelling salts (not that you will) and that your ideas on policy are probably not contributing very much to the discussion (don't worry -- neither are mine) then what, exactly, do I want you to do?

What I'm asking you to do is to clear the playing field. ***This is neither the time nor the place for mass movements -- this is the time for expert opinion.*** *Once the experts (and I'm not one of them) have reached some kind of a consensus about what the best course of action is (and they haven't yet), then figure out who is impeding that action for political or other disingenuous reasons and tackle them -- do whatever you can to remove them from the playing field. But we're not at that stage yet.*

"Argumentative function" of policy analysis vs "decisionism"

- The "argumentative function" of policy analysis.
  - That policy analysis makes its greatest contribution by generating evidence and argument
- "Decisionism" and its premises
  - Who frames the alternatives?
  - Presumes unitary decision maker
  - Excessive focus on outcomes rather than fair/ democratic/transparent process

Defining Policy Problems

Not Everything Bad is a Policy Problem

Conditions vs. problems....
Otherwise we would have a "Cure for Death" program

Policy problems require

Clear operational definition
Interest and attention from key decision-makers
Technical opportunities
(Potentially) receptive external environment
Good fit with mandate and capabilities of your organization
Measurable success and failure

Good Policy Problems

- Are often missed opportunities
  - Some examples I like of "inreach"
    - "Teenagers who come to our clinics for negative pregnancy tests are not counseled to prevent future pregnancies."
    - "Our substance abuse treatment program does not screen for HIV infection."
- Usually can be defined and quantified
  - It's hard to solve a problem you can't specify
- Are stated to avoid smuggling implicit solution
  - "Not enough shelter for the homeless" seems to presume a set of solutions.

Assembling Information: Causal Models

- Do we have/need a good mechanistic model?
  - We want to improve the health of poor people. So we enact a policy that broadens access to Medicaid (at $3000/per or whatever).
  - Why are people uninsured? Because they have chronic illness? Because they are not willing to purchase insurance at the offered price? Because they think they can free-ride.
  - How would getting people insured help them
  - Try to make explicit the *implicit* model in your head.
- Increased Medicaid → Higher rates of health insurance coverage → Greater use of health care services → Improved health.
- If you think about this, the logic can be challenged at every step.
  - Expanded Medicaid may serve people who would have been insured anyway (crowd-out)
  - Expanded coverage may not address nonfinancial barriers to accessing care.
  - Increased health care utilization may not improve health
- The point here is not to attack any specific policy, but to remind us that the goal here is improved health, and Medicaid expansion is merely a means to that end. Maybe mobile blood pressure vans in south Chicago would do more, per dollar spent, than getting people insurance coverage? At least at the outset, you want to think broadly about potential policy solutions.

Gaps & limitations of causal models as policy frame

- Causal models can also lead us astray when they lead us away from the policy problem at hand.
  - Social science models are often good for understanding patient/client behaviors but do not address other aspects of the problem.
  - Powerful models may confine our thinking to one interpretive lens.
  - Examples: economics gives powerful, but sometimes grossly oversimplified account of behavior.
  - We often have to make policy without the benefit of good causal models.
  - Sometimes we can show that good programs work, but we don't know why.

What this course gives you

- We'll practice the nuts and bolts of decision analysis, cost-effectiveness, cost-benefit, cost-utility analysis
- Lots of health examples, since these are often the clearest applications
- Hitting other areas too
- Problem-solving, not too many theorems

Decision Analysis

Illustrative problems

- Should I buy a $700 or $7000 engagement ring for my girlfriend?
- Should I conduct a prenatal diagnostic test for a congenital disorder?
- How can decision analysis help me understand the critical parameters that would change my clinical or policy recommendation?

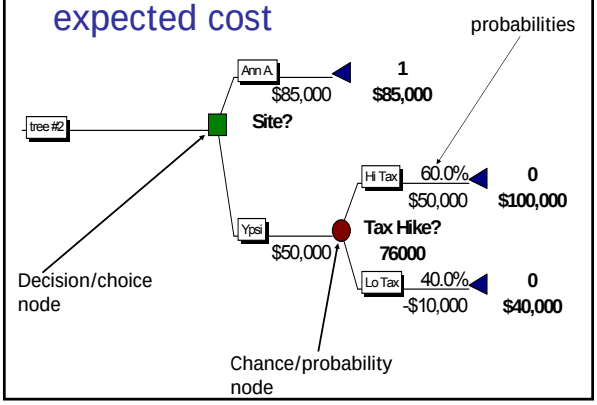
Example

Where should we build our new human subjects painful Test lab (near a rival university, for deniability)? Which has lower costs?

Ann Arbor costs $85,000 for sure.

Ypsilanti will cost $50,000 for sure, but the city is also changing tax codes. With 60% probability the city will raise the bill $50,000 more, and with 40% probability it will lower taxes $10,000.

A resulting decision tree for expected cost



Some things to notice

- We compute the expected payoff, a weighted average of all the possible payoffs, weighted by the probability of an event occurring.
  - $76,000=50,000+0.6*50,000+0.4*(-10,000)
- In this case, the expected payoff is in dollars, but dollars are not the only or best outcome.

Is expected financial return always best measure of payoff?

- Suppose in my first job I am an investment manager at YMCA. For my first assignment....
  - I can make investment #1, which has a sure return of $50,000.
  - I can make investment #2, which has a 50% chance of making $120,000, and a 50% chance of making $0.
- Investment #2 has higher expected return. Other issues here?

You will examine some problems that are even more important

- Why do this?
  - If we frame decisions more carefully, we would make better decisions
  - Decision trees are always oversimplified, but they force us to be explicit in a useful way.
  - They allow us to use some powerful tools in a useful way.
  - They are cool for job interviews.

Today's irrelevant public health "product placement"

"Once upon a time, there was a frozen pizza, and inside the pizza some very bad monsters lived. Their names were refined white flour, reconstituted tomato, and processed cheese. But the worst monster of all was called pepperoni!"

Non-stupid thing: HIV Screening

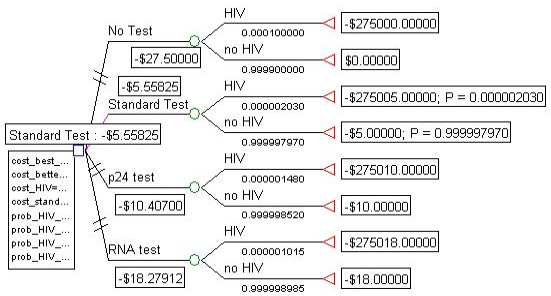
Standard HIV antibody testing of blood donors ($5/donor) does not catch all HIV-infected blood. Recently-infected individuals do not yet generate the biological materials that make for a positive result. Thus, there is a 22-day "window period" of undetected infection.

We can spend more money (another $5/donor) on a specialized p24 antigen test to reduce the window period to 16 days. Alternatively, we can spend an additional $8/donor to reduce this period to 11 days using some RNA technology.

The rate of new HIV infections among blood donors is 3.4 per 100,000 person-years. What should we do?

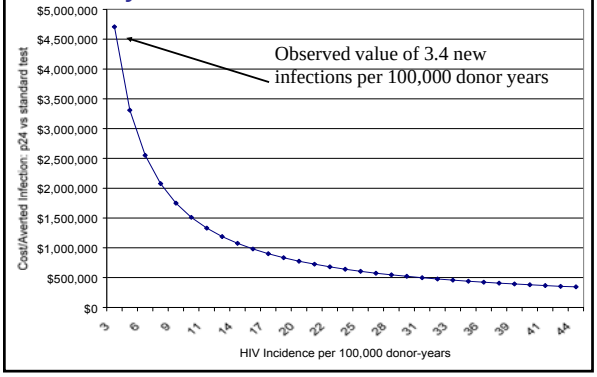
Some facts: If we don't test anyone, the estimated probability of donor infection is 1 per 10,000. With the standard test, the probability of donor infection drops to 2.049/million. With the p24 test, the probability of infection drops to 1.49/million. With the RNA test, the probability drops to 1.025/million.

You will learn how to do this! Impress your friends!



If we value an averted HIV infection at $275,000, the standard test is best. You could actually do this by hand. But what if this $275,000 figure is too low?..... What if the population has higher risk?

Cost-Effectiveness of p24 vs Standard Test: Sensitivity to the rate of HIV infections



So….

- For p24 to be cost-effective compared with standard testing,
  - HIV incidence must be **very high** to justify better but quite costly screening. (Which might be true in some high-risk donor populations).
  - Or we value an averted HIV infection very highly.
  - Institute of Medicine recommended AGAINST p24 testing of blood for this reason.
  - Blood industry has implemented p24 testing anyway. Maybe the industry did the right thing.

Some other things we will learn about re "Decision Analysis"

- Screening tests, and how they go wrong
  - Sensitivity and specificity
  - Positive predictive value
  - Bayes Rule and conditional probabilities

Street facts about screening tests

- Suppose I lead a team of child welfare professionals who are screening for child abuse/neglect
- We know from experience that 3% of parents abuse or neglect their kids. (This is called *prevalence*)
- Suppose that
  - If a parent **truly does** abuse or neglect her child, we identify and flag this 75% of the time. (This is called *sensitivity*)
  - If a parent **does not** abuse or neglect her child, we identify and flag this 99% of the time. (This is called *specificity*)
- How "accurate" is this screening test?
- What do we even mean by "accurate?"
- Suppose I screen 10,000 parents. I get…..

These numbers imply the below critical table

	Actually is good parent	Actually is bad parent	Total
Labeled "bad parent"	97 (1% of 9700) False positives	225 **(75% sensitivity)** True positives	322 (number labeled "bad parent")
Labeled "good parent"	9,603 **(99% specificity)** True negatives	75 (25% of 300) False negatives	9,678 (number labeled "good parent")
Total	9,700 (97% of 9700)	300 **(3% prevalence)**	10,000

That table allows me to answer some interesting questions

- If a parent is labeled "bad parent," what is the probability that she actually is? This is called ***positive predictive value*** (PPV).
  - In this example, PPV=225/322=69.88%
- If a parent is labeled "good parent," what is the probability that she actually is? This is called ***negative predictive value*** (NPV).
  - In this example, NPV=9603/9678=99.2%
- Note something
  - Sensitivity and specificity are technical properties of the screening test itself.
  - PPV and NPV are properties of both the screening test and of the population being tested, in particular the prevalence of bad parenting.
- When prevalence is low, NPV is usually really high. For PPV to be high, the screening test must be **really** specific. Otherwise false positives become a huge problem.

Putting this in different language

- PPV is "How likely is this person to be a bad parent, given that our test says she is."
  - PPV=P[bad parent|+ test]
- NPV is "How likely is this person to be a good parent, given that our test says she is."
  - NPV=P[good parent|- test]

Same test in higher prevalence population

	Actually is good parent	Actually is bad parent	Total
Labeled "bad parent"	70 (1% of 7000) False positives	2250 **(75% sensitivity)** True positives	2,320 (number labeled "bad parent")
Labeled "good parent"	6,930 **(99% specificity)** True negatives	750 (25% of 3000) False negatives	7,680 (number labeled "good parent")
Total	7,000 (97% of 9700)	3,000 **(30% prevalence)**	10,000

What if we increased the prevalence and used the same screening test?

- Sensitivity and specificity are technical properties of the screening test itself.
- PPV and NPV are properties of both the screening test and of the population being tested, in particular the prevalence of bad parenting.
  - PPV=2250/2320=96.98%
  - NPV=6,930/7,680=90.2%
- ***Is this test good or bad?*** That depends on what we do with the information and the costs of false positives and false negatives.

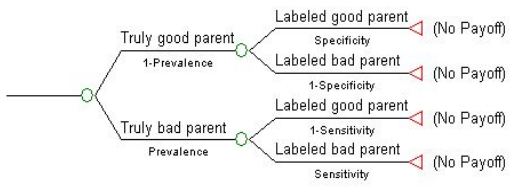
Let me beat this to death a bit

- How does this relate to Bayes' Rule?
- PPV=P[bad parent|+ test] =P[bad parent AND+ test]/P[+test]=2250/2320.
- Note the denominator P[+test] comes from two things: the true positives (2250 people) and the false positives (75 people). This leads to
- P[+test]=P(bad parent)P[+test|bad parent] + P(good parent)P[+test|good parent]
- In our example,
- P[+test]=prevalence*sensitivity+(1-prevalence)*(1-specificity)
- And so...
- PPV= prevalence*sensitivity/ [prevalence*sensitivity+(1-prevalence)*(1-specificity)]

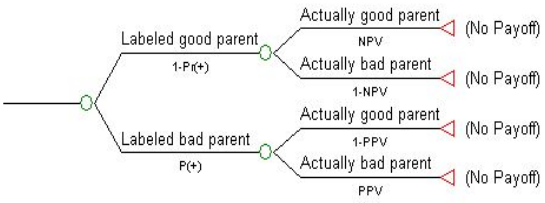
How does this look as a probability tree?

- There are really two trees one might look at?
- The first I call "the God tree," because it's what God sees.
- The second is what I call "the clinical tree" because that's got the information clinicians know when they must make a decision.

This suggests one probability tree... Kindof the way God sees things



Clinicians or policymakers must typically act on the basis of this (mathematically equivalent) clinical tree



We'll come back to this, and to the "value of information"

- Screening for cancer, birth defects
- Perfect vs. imperfect information
- Information is only valuable when it changes my behavior!
  - For example: The value of a prenatal diagnostic screen might depend upon patient attitudes about abortion or other matters.
- Psychological exceptions and traps in behavioral economics/cognitive psychology.

Now…. Let's jump to cost benefit analysis and all that stuff

Illustrative policy questions

- Resource allocation for HIV prevention
  - How can UNAIDS allocate $$ to prevent the most HIV infections? This is a cost-effectiveness question
- Is the world spending too much on HIV?
  - Compared with malaria or other diseases: this is a cost-utility question.
- Is the world spending too much on HIV compared with kindergartens?
  - This is a cost-benefit question.

Cost-Benefit/Cost-Utility/Cost-Effectiveness Analysis

- Basic use in centralized decision-making
- Providing yardstick for similar (or different) interventions.
- Cost-minimization (feh!) vs. CEA vs. CUA vs. CBA
- That warmly evocative term: "Quality-adjusted life-year."
  - In a later session, how does one measure quality of life?

CBA/CUA/CEA in regulatory policy

- Some economists and advocates would like to require CBA for all environmental/health /safety regulations
  - Office of Management and Budget is the key place in government where such methods are used. Executive order requires such analyses for major regulatory policies.
  - This is a major political step, in part because CBA takes so long and is often so difficult.
  - Non-economists frequently distrust these methods.
  - Stringent environmental regulations often "fail" CBA tests when human health is the major criterion for benefit

Advantages of requiring CBA

- Requires transparent analysis that increases public accountability
- "Ignorance revelation—explicit analyses can uncover critical unknowns in a controversial policy.
- Allows greater comparability of seemingly disparate policies (lead paint abatement vs. pollution abatement at coal plants).

Cost-Benefit Analysis: Why Do It?

- Should we do cost-benefit analyses of Big Mac vs. Whopper?
  - One has special sauce and an extra bun.
  - One has tomato, more meat, gobs of mayonnaise.
- OK this is dumb, but why?
- How is this different from doing cost-benefit analysis of CT scanners or flu vaccines or substance abuse treatment for burglars?
- What (if anything) is different or unique about health care and other sensitive social policy applications?

Whose Perspective?

- "Societal perspective" is the best reference case for public policy and public decision-making.
  - Includes all costs and all health benefits
  - patients
  - providers, others such as public programs that make disability payments.
  - Anyone else affected
- The key political weakness: "Social" is not the perspective of any particular group.
  - Transfers from one group to another "wash out" of societal perspective, but occasionally interest stakeholders.

Whose Preferences Count?

- Quality of life (measured somehow) is the key endpoint for most clinical/public health interventions.
- Evaluated by whom? Patients? "Community"?
  - In general, US-PHS says: Use the preferences and perceived gains from the viewpoint of a representative cross section of the entire community, not the specific affected patients.
  - Do you agree?

Different Kinds of Analysis

- Cost Effectiveness Analysis (CEA)
  - Measure specific outcomes
    - Heart attacks
    - Cancers
    - Days little Johnie was smoking marijuana
- Cost Utility Analysis (CUA)
  - Convert Outcomes to Quality of Life units
- Cost Benefit Analysis (CBA)
  - Convert Outcomes to Dollar values

Cost-Effectiveness Analysis

Numerators & Denominators

- CEA is about incremental costs per unit of outcome.
  - Cost per averted infection, cost/QALY, etc.
- All health effects from an intervention go in the denominator
- Which costs go in the numerator?
  - Medical prices.
  - Costs/benefits to caregivers associated with an intervention.
    - Alzheimer intervention reduces need for family caregiving. The value of caregiver's time goes in numerator. Intervention might (in principle) have negative costs from societal perspective.

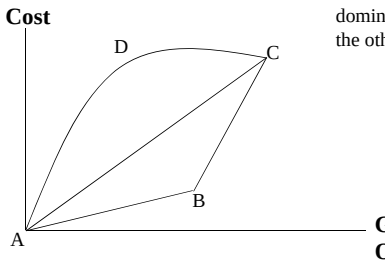
CEA is ALWAYS <u>Relative</u> to some baseline (perhaps "usual care"

$$\frac{\text{Cost of option 2} - \text{Cost of option 1}}{\text{Outcome from option 2} - \text{Outcome from option 1}}$$

Example: Needle exchange costs $500,000 and accompanies 47 new HIV infections in a population. Drug treatment costs $1,000,000 and is associated with 42 new infections over the same period. Doing nothing costs $0 and leads to 55 new infections.
<u>Question #1</u>: What is the incremental cost-effectiveness of treatment over needle exchange? Answer: (1,000,000-500,000)/(42-47)=$100,000 per averted infection.
<u>Question #2</u>: What should we do? Answer depends on 2 factors: What is the available budget? How much do we value averted infections?

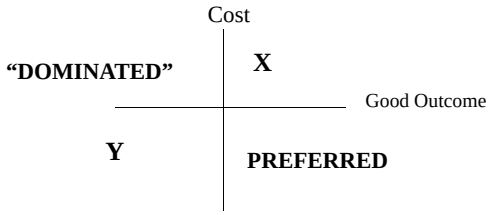
Caution: R-rated slide coming up next…

Multiple Alternatives



Which option is clearly dominated? Can we rank the other 3?

CEA is ALWAYS Relative (Incremental)



Question: Which is better: X or Y?
Answer: It depends on how much one values the outcome.

CEA—Which counseling should primary care doctors do during a 9-minute exam

- <u>Time</u> is the main scarce resource.
- Goal: allocate your time to maximize health benefit (say extra days of life) given that one has 9 minutes for counseling activities.
- The following Table would have been great if the data weren't made up, but this is the right idea

Counseling and Time

Intervention	Expected days of prevented disability	Required time (minutes)
Pap smear	50	5
Blood pressure	50	1
Cholesterol	47	2
BMI check	35	1
Clinical breast exam/mamm counseling	45	2
Nutrition counseling	25	2
Seat belt lecture	17	1
Smoking cessation counseling	22	4

So what do we do?

- We do not rank interventions by their health impact, since the most powerful ones may take too much time….
- We compute effectiveness ratios… the health impact per minute required to accomplish the task…

Intervention	Expected days of prevented disability	Required time (minutes)	Effectiveness Ratio (Days of Prevented Disability per minute spent)	Cost (in minutes) per day of prevented disability
Pap smear	50	5	10	0.1
Blood pressure	50	1	50	0.02
Cholesterol	47	2	23.5	0.043
BMI check	35	1	35	0.029
Clinical breast exam/mamm counseling	45	2	22.5	0.044
Nutrition counseling	25	2	12.5	0.08
Seat belt lecture	17	1	17	0.059
Smoking cessation	22	4	5.5	0.182

Now rank by effectiveness ratio….

- Now we rank the interventions by effectiveness ratio. We do the best one. If this leaves some time left over, we move on to the next intervention.
- We keep going until we have used up the nine minutes available for interventions.

Intervention	Expected days of prevented disability	Required time (minutes)	Effectiveness Ratio (Days of Prevented Disability per minute spent)	Cost (in minutes) per day of prevented disability
Blood pressure	***50***	***1***	***50***	***0.020***
BMI check	***35***	***1***	***35***	***0.029***
Cholesterol	***47***	***2***	***23.5***	***0.043***
Clinical breast exam/ mamm	***45***	***2***	***22.5***	***0.044***
Seat belt lecture	***17***	***1***	***17***	***0.059***
Nutrition counseling	***25***	***2***	***12.5***	***0.080***
Pap smear	50	5	10	0.1
Smoking cessation	22	4	5.5	0.182

This is deep, man.

- We stop at nutrition counseling. The opportunity costs of Pap smear or smoking cessation interventions (measured in terms of time that could be used for other interventions) are too high.
- It doesn't matter how much society values (say in dollars) preventing a day of disability. If disability-days are the yardstick, we know what to do.

More deepness, man.

- We can the expected health impact of performed counseling activities to find that each 9-minute visit is estimated to prevent 50+35+47+45+17+25=219 disability days.
  - This is about 24.3 prevented days of disability per minute of counseling. This is the *average* effectiveness of the intervention.
- What is the value (in terms of prevented disability) of having 5 more minutes for counseling?
  - We could then also provide Pap smears, and prevent an additional 50 days of disability.
  - This is about 10 prevented days of disability per minute of counseling, reflecting the diminished effectiveness ratio of the remaining interventions.

Is more time really worth it?

- Dunno. CEA cannot tell us whether a disability day is worth the cost of the intervention. This requires cost-benefit or cost-utility analysis.

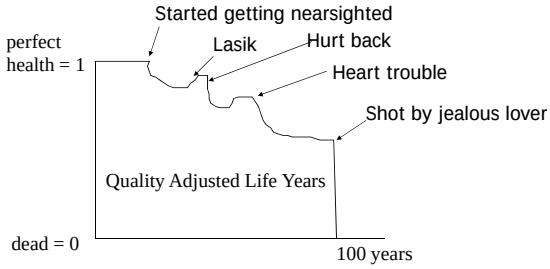
Cost-Utility Analysis (CUA)

Computing QALYs

- Identify relevant outcomes/ health states from each alternative

  For example:
  - No complication
  - Minor complication
  - Severe complication
  - Death
- Measure QALYs for each outcome
  - (perhaps changing over time)
- Aggregate values for all outcomes for each alternative

Quality Adjusted Life Years: This is your life (I just love this graph).



QALY Scale

- Perfect health is an abstraction
- States worse than death exist
  - (value < 0)
  - We hope you are not experiencing this now.
- More is better
- Intervals are appropriately measured
  - Moving from .1 to .2 is the same as moving from .8 to .9
- William Dale will talk about how this is measured

How much should we pay for one Quality-adjusted life year?

- Many analysts use $50,000—really bad at this point.
- Occasionally see $100,000
- Review of literature suggests that reasonable values should exceed $150,000/QALY

Cost-Benefit Analysis (CBA)

Example

- A 1992 analysis of prenatal care found that expanded Medicaid benefits cost $4.2 million per infant life saved. Is this worth it?
- Relevant comparisons
  - Child safety seats for cars estimated to cost $5.5 million per life saved.
  - $4.2 million could provide one year's early childhood education for 1,000 kids or one year's cash welfare assistance to 1000 families.

Cost-Benefit Analysis

- Express all outcomes in dollar terms, so that one can compare different kinds of outcomes on the same scale.
- Consumer and producer surpluses are benefits (in dollar-units). Deadweight losses are costs (in dollar terms).
- Decision rule: Add up all the benefits and costs associated with specific choices, and choose the option with the greatest net benefit.
- CBA is conceptually an excellent approach, but is the most difficult to accomplish in practice.

Ethical Issues in CBA/CUA/CEA

- Rich vs. Poor
  - Rich people value their time more than poor people do. Suppose we can spend $1 billion to either save 50m hours of rich people's time at the airport, or to save 50m hours of poor people's time at the bus terminal.
  - Should we therefore spend more money fixing the airport than we spend fixing the bus station, because flyers are more affluent?
  - Yes indeed—that's what the method says. But the rich people should pay for it!

Sick vs. well

- Sick people have lower quality of life. Does CUA imply that we should spend less to extend their lives?
  - "Not dead yet" advocacy group.
- Does "quality adjustment" discriminate against persons with disabilities?
  - What do you think?
  - (Then Jack and I will say what we think).

Sick vs. well

- This is a sensitive issue since people who actually live with a disability typically rate their QOL more highly than people who don't have the condition say they would rate their QOL if they were to get it.
- Process of "adaptive preference formation"

Old vs. young

- Should young people get explicit priority in life-expending or life-improving interventions? If so, is this because they have more expected QALYs or because older people have already gotten a chance for many fun experiences.
- Young people are also more economically productive. How should this be factored in?

Tangible vs. intangible issues

- Is Yellowstone valuable…
  - Because 2.9m people visited last year and generate consumer surplus?
  - Because 100m would like someday to visit?
  - Because we value the animals that survive there?
  - Because the animals value themselves?
- Objections to "commodification" of environmental and health concerns.
- How would we put dollar values on intangible valuations?

Present vs. future

- We'll come back to that….

Critiques of utility as foundation of social decision-making

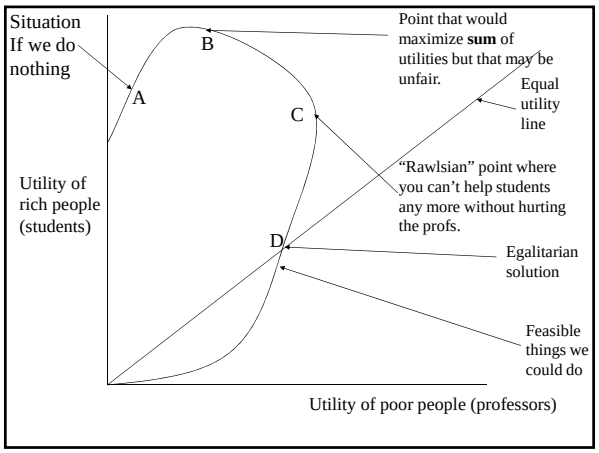
- Individual rights hard to handle in an economic framework.
  - Suppose 50,000 Romans (not to mention cable TV audience) enjoy watching Jack eaten by lions. CBA might conclude that if enough people get enough pleasure, we should feed him to the lions. This is hard to square with ideas about integrity and character in public policy. Less dramatically, we might run roughshod over individual rights to create aggregate economic benefit.
  - Harvard Law students opposed profiling. Five minutes later, most favored a procedure to rank airline passengers based on various factors including age, whether they had paid cash, race/ethnicity, etc. if this would save the average passenger 30 minutes/flight.
- Things that give individuals the most satisfaction are not always the most urgent/important needs. If you want $5000 from me for a kidney transplant, this deserves greater weight than asking for $5000 to build an idol in your backyard, even if you would value the idol more.

Kaldor-Hicks Criterion of Cost-Benefit Analysis

- If I have a choice of projects,
  - Add up all the gains to the winners
  - Subtract all the losses to the losers.
  - The difference is the net benefit
  - Choose the project that produces the biggest (positive) net benefit.
- The winners could compensate the losers and still come out ahead
  - Whether they **actually do** is kind of secondary on the standard account. This is a distributional concern

Equity/efficiency

- Basic idea of Cost-Benefit Analysis, Cost-Effectiveness, and Cost-Utility analysis is to maximize total utility given budget constraints. This makes sense for an individual, but doesn't obviously make sense for a society.
  - Do we add up everybody's utilities? Do we take an average?
  - Maybe poor people deserve more weight?
  - How do we compare utilities across people and does willingness-to-pay appropriately capture that?



Which Point is Best?

- Compared with the initial point "A," there is room for mutual gain by some policy intervention. This seems obvious.
- The sum of utilities is maximized at point "B." But this gives almost all the benefits of cooperation to one group.
- The egalitarian solution "D" gives students and profs the same utility. This is more fair than point "B" but is implausible--both groups could both do better at point C.

Utility Maximization

- Maximize the sum of utilities through CBA.
  - Pushes to point "B" in the diagram.
  - Good for making incremental decisions for people like ourselves. "Nicht zo gut" for large social decisions where distributional concerns are so important.
  - Distributional issues are especially problematic for the disabled--who may not get many utility-units out of a given dollar of social resources.
  - This approach would still justify subsidies to the poor, given declining marginal utilities of income.
    - Robbing Peter to pay Paul makes sense if Paul would derive a lot more benefit from the money.

Give poor people added weight in calculations

- "Social welfare function"
  - Weight the interests of the poor (the disabled, professors, etc.) more than those of more socially advantaged groups
- More sensitive to distributional concerns than the utilitarian approach.
  - This is what we often implicitly do anyway.
  - Not clear what the weights should actually be or how distributional concerns should be balanced with other competing goals.

"Rawlsian" Difference Principle

- Strongly emphasizes the well-being of the least-off. In designing basic social institutions, inequality is only justified when *the least well-off themselves* benefit from the process that produces inequality.
  - On this view, capitalism creates inequality, but is justified because even poor people benefit from the larger economy made possible by strong work incentives.
  - If poor people were better off in Sweden than in the U.S., Rawls would say that we should adopt their system even if we had a more efficient economy that works better for people such as ourselves.
- Pushes to point "C" in the diagram.

Applying CBA/CEA/CUA internationally

- Policy analysis matters more in poor countries than in USA.
  - We can afford to waste money. They can't.
  - We spend much more (per life saved) on AIDS and polio than we do on $5 mosquito nets to protect against malaria.

Applying CBA/CEA/CUA internationally

- Policy analysis is harder to do in low-income contexts.
  - Less data available and fewer experts to do it.
  - Markets and politics work very differently from U.S. So we don't always understand context well.
  - More profound implementation questions, especially when contracts/property rights can't be enforced.
    - Corruption issues
    - Natural resource depletion is sometimes ignored if no one owns the resources. (Commons problem).

Applying CBEA/CEA/CUA internationally

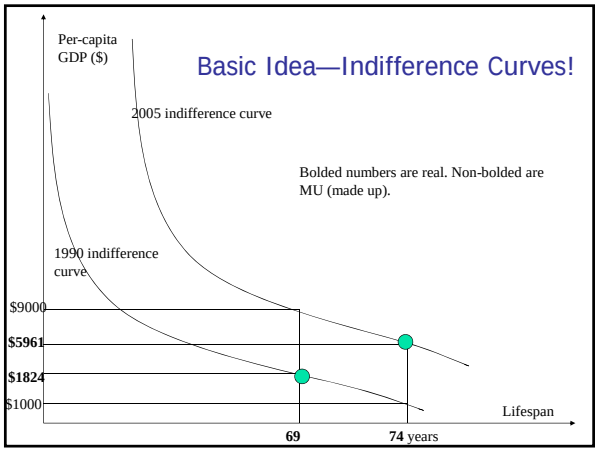
- Lack of market signals for marginal costs and benefits.
  - In U.S., we generally use market proxies because price=MC. You can't do that when prices are distorted, such as when the price of scarce raw materials is half true MC.
  - When unemployment is 40%, wages overstate the true cost of labor inputs.
  - If factories are not penalized for pollution, the market price of the output exceeds the true social benefits of production.
  - Market failures in capital markets produce very high interest rates, which discourages investment in the future.
  - "General equilibrium" effects can be important: Reducing large fuel subsidies can have unintended consequences when fuel is a key input for farmers.

Analyses still informative

- One example
  - In foreign health assistance, a standard threshold for cost-utility analysis is that cost/QALY shouldn't exceed per-capita GDP.
  - What do you think about this?

International example

- In 1990, China's average lifespan was 69 years, and inflation-adjusted (to 2014) per-capita GDP was $1,824/yr.
- In 2005, China's average lifespan was 74 years, and inflation-adjusted per-capita GDP was $5,961/yr.
- How valuable (in dollars!) was the five years of increased lifespan to Chinese people?



Value of increased life & health

- In 1990, how much would people have been willing to pay (per year) to raise lifespan 5 years?
  - We know how to do this! It's the amount they would be willing reduce their income to get to the longer lifespan without ending up on a lower indifference curve than the 1990 value.
  - As drawn, this is $1824-$1000=$824/yr.
- From 2005 perspective, how much is the same health gain worth? It is the amount people would have to be paid to give back their 5 years of extended life without ending up on a lower indifference curve than the 2000 value.
  - As drawn, this is $9,000-$5,961=$3,039.
  - The health gain is worth much more in the year 2005. Why?

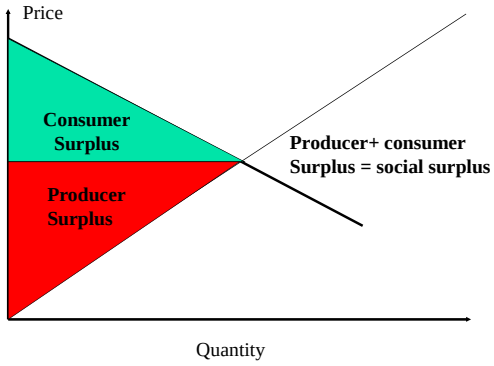
Some lessons

- Preferences change with wealth
  - Imposing our own preferences about safety, health, environment on much poorer countries might harm them.
  - As developing countries get richer, they will be more willing to address the same issues. (So what is our excuse!)

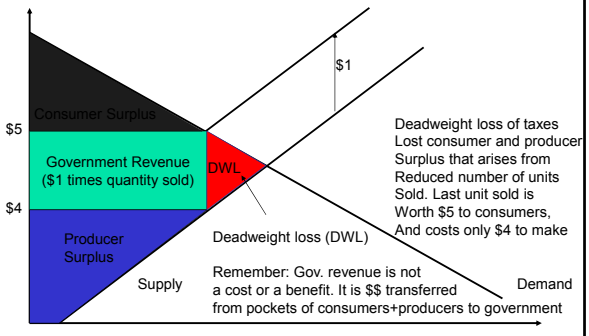
CBA and microeconomics

- Consumer and producer surplus, are in units of dollars. So they plug right into CBA calculations.
- So is Dead Weight Loss (DWL). Amount of consumer and producer surplus lost due to taxes, monopoly, or other departures from efficient market outcomes is social cost.

Microecon memory lane



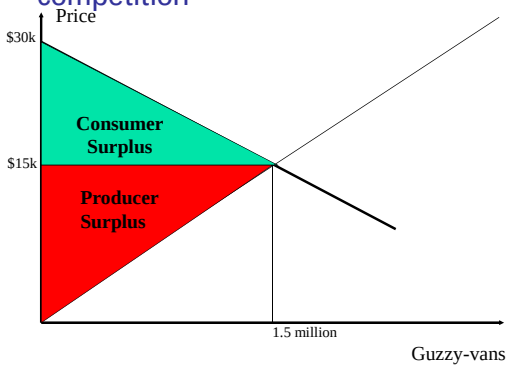
Deadweight loss of taxes—that's the social cost.



CBA of protectionism

- Suppose annual demand for guzzy-vans is given by
  - $Q_D(P)=100\ (\$30{,}000-P)$.
- Domestic annual guzzy-van supply is given by
  - $Q_S(P)=100\ P$.
- If there were no world market, the equilibrium price satisfies
  - $100\ (\$30{,}000-P)=100\ P$, or
  - $P=\$15{,}000$, with 1,500,000 vans sold.
- Consumers and producers split a total surplus of
  - ½ (30,000)1,500,000=$22.5 billion, $11.25 billion for producers and $11.25 billion for consumers.

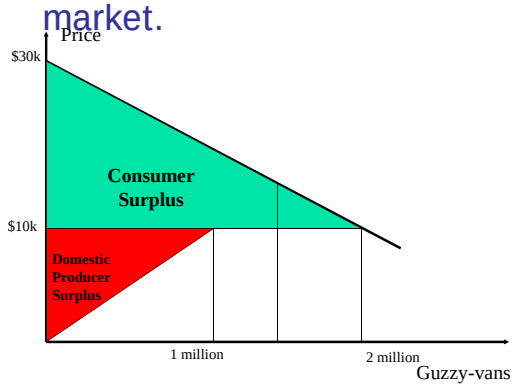
This is the picture with no world competition



CEA of protectionism

- Unfortunately for domestic suppliers, low-wage competitors emerge who can produce an unlimited supply of minivans at the world price of $10,000.
- If the government allows competition, how do things change?
- How can we make this a CBA-type question?

This is the picture with global market.



CEA of protectionism (assumed to save 50,000 jobs)

- Under no restriction,
  - CS= ½ ($30,000-$10,000)(2m)=$20 billion
  - Domestic PS=½ ($10,000)(1m)=$5 billion
  - So total surplus is $25 billion—a big win for consumers and a big loss for producers.
- Natural CEA question: What is the annual **cost per job saved**, from different perspectives?
  - From consumer perspective: (20-11.25) billion/50,000=$175,000/job.
  - From social perspective: (25-22.5) billion/50,000=$50,000/job.
- The costs of protection seem more reasonable from the social perspective than it does from the consumer perspective because large producer surpluses are lost to foreign competition.

SSA456 Problem Set Due 2/5/2015

Introduction to decision analysis

1. Screening Sausage. The Food and Drug Administration has the daunting task of screening food for bacterial contamination with limited resources. They screen meat processing plants to prevent widespread food poisoning which can lead to death. The FDA wants to argue for an increased number of food screeners which may increase the rate of weeding out infected meat but will cost more money. Let's focus on sausages.

Suppose that one in every 20,000 sausages has bacterial contamination. The current level of food screening to detect this problem has a sensitivity of 50% and a specificity of 95% in detecting contaminated sausages. Infected sausages that get through cause serious illness. The costs of current screening are $0.05 per sausage. If a person gets sick, this costs the industry $10,000 per case in bad publicity. If a sausage is wrongly labeled contaminated, it is discarded, costing the firm $0.25 per sausage.

An enhanced screening technology is available that increases the sensitivity to 75%, with no change in specificity. The cost of the enhanced screening is $0.10 per sausage. The size of the market doesn't matter for the answer. But you may suppose 20 million sausages are consumed per year.

A. Draw out a decision tree showing current screening and enhanced screening.
B. Which option is best for the industry?
C. By whatever method you choose, find the most you are willing to pay for the enhanced screening technology.

2. My knee.

… Hurts from an ACL injury. My doctor has proposed a $4,000 surgery. It has a 75% probability of fixing the problem and a 25% probability of failing. If the operation works, I will derive $6,000 worth of benefit, providing for me a $2,000 benefit. If the operation doesn't work, it has no value to me, and my $4,000 is simply lost. The operation itself is painless with no need for disruptive recovery. So this is just a money issue for me.

A. If I have no other opportunity to collect information, should I have the surgery? Please provide a decision tree with the answer to the question addressed by solving the tree.
B. Rather than fly blindly as in part (A), I can have a painless MRI diagnostic scan, which costs $800. It tells me with perfect accuracy whether or not the surgery will work, allowing me to avoid unnecessary surgery. Provide a revised decision tree that includes the diagnostic scan.
C. Should I pay for the scan?
D. **Optional**: What is the most I am willing to pay for the scan?

3. **Breast Feeding and HIV**: **The 1990 dilemma**

During the 1970s, many public health authorities sought to promote breast feeding over formula feeding in Sub-Saharan Africa and South Asia. Breast feeding provided many benefits to new mothers and to their children, and is cheaper than formula feeding. Formula feeding creates especially serious problems when sanitary drinking water is unavailable or when poor mothers excessively dilute the formula. Suppose—in a particular country--that non-HIV-related child mortality rates among breast feeders is 4 percent. Suppose that the comparable figure for non-HIV-related mortality risk among formula feeders is 8 percent, independent of mothers' HIV status. Then HIV came along. Suppose that 26 percent of infants born to HIV-infected women are infected prior to the first week of life. Assume [ridiculously] there is no way to prevent that. Moreover, assume that an uninfected infant who is then breastfed by an infected mother is estimated to have a 14 percent probability of contracting HIV (usually in the first few months). All HIV-infected infants will die.

A. Assume that health care providers must give uniform feeding recommendations to HIV-infected and uninfected women in a given community. This could occur for cultural reasons, for reasons of confidentiality, or because HIV testing is simply infeasible for one reason or another. If HIV prevalence is huge, formula feeding is clearly best. If HIV prevalence is zero, breast feeding is clearly best. In a particular country, HIV prevalence among pregnant women is 50 percent. Create a decision tree to determine whether formula feeding or breast feeding minimizes infant/child mortality.

B. **Optional**: What is the best recommendation at this level of HIV prevalence?

Ford Pinto

4. Please read the attached case regarding the Ford Pinto case.
    a. Taking Ford's numbers as given, assemble a decision tree that indicates the optimal policy from Ford's perspective.
    b. From a wider social perspective, use SSA456 course materials to defend one aspect of Ford's analysis, and to criticize one aspects of Ford's analysis.
    c. From a cost-utility perspective, did Ford make the right decision not to upgrade its fuel system? What is the most you would be willing to pay to fix this manufacturing defect?

Problem Set #3
Due January 25

1. **Pre-K interventions as crime prevention.** Individuals can grow up to be high-level offenders (H), low-level offenders (L), or non-offenders (N). Assume criminals begin committing their crimes on the 16th birthday. **From that day forward**, the lifetime social cost of crime committed by the H's is $600,000. In like fashion, the social cost of crime committed by low-level offenders is $150,000. Non-offenders don't commit any crimes. Suppose policymakers employ a social discount rate of 5%.

Offenders are drawn from a population of youngsters in the local community. That community is considering a universal preschool prevention intervention that would (among other benefits) prevent some youth from becoming offenders in the first place. The intervention would require an up-front investment of $5,000 per student, all spent around the time students reach age of 4. In the pertinent community, policymakers anticipate the following outcomes, with and without the preschool program.

	No intervention	Universal pre-K
Percentage of "at-risk" kids who become non-offenders (N)	80%	90%
Percentage who become low-level offenders (L)	10%	5%
Percentage who become high-level offenders (H)	10%	5%

A. Draw a tree with all relevant probabilities and payoffs.
B. Assume a 12-year lag between the up-front investment and the (potential) beginning of youths' criminal career. [That means that the social costs of crime starting twelve years from now needs to be divided by $(1+r)^{12}$]. Based solely on its value for crime reduction, is the pre-K intervention worth it?
C. *Optional*: What is the most a policymaker would be willing to pay for this pre-K intervention?

2. HAP runs a hospital's blood bank. He orders blood from a national consortium every Sunday for the week. He can keep a continuing stock of a perishable rare blood type, O^{--}. Since this blood perishes within a week, this gets expensive. It costs $1,000/week for every unit stored. This money is totally wasted if the blood goes unused. On the other hand, it costs $10,000/unit to get an emergency order when this type is needed. Over time, HAP identifies that the probability of needing specific amounts is given by the following:

Units of O^{--}	Proportion of weeks over the past decade in which this number of units were needed
0	50%
1	15%
2	15%
3	10%

4	10%

A. Draw a decision tree that you would use to solve this problem?
B. How many units of blood should a hospital order every week?

3. (Please use clinical decision trees to solve all aspects of this problem.) Walter's Dog and Pony show is scheduled to appear in Chicago July 14, 2014. (Historically, it rains 25 percent of the time on this date.) The profits obtained heavily depend on the weather. If it rains, the show loses $15,000. If it is sunny, the show makes $10,000. Given sufficient warning, Walter can cancel the show, but this will cost $1000. Walter's goal is to maximize his expected profits.

a. Absent any specific weather information, should Walter hold the show?
b. For $1,000, Accuweather.com sells a perfect weather report that would tell him with perfect accuracy ahead of time what the weather will be on that date. He can use this information to hold or to cancel the show. Would Walter be willing to buy it?
c. Walter also has the opportunity to buy a slightly less accurate report from mostlyaccuweather.com. This costs only $300. That weather forecast is 80% sensitive and 90% specific in detecting rain. Is this a better or worse deal than the perfectly accurate Accuweather test?

4. Shiny teeth—preparing for Markov chains. Crest and Colgate battle for market share. Each brand has a positive number of consumers, but Crest customers are slightly more brand-loyal. Market studies indicate the following patterns:

	Will buy Crest next time shopping	Will buy Colgate next time shopping
Bought Crest last time shopping	0.90	0.10
Bought Colgate last time shopping	0.15	0.85

For simplicity, assume that there are 1 million toothpaste consumers.

A. Using a spreadsheet or any other method, find the long-term market share of each brand. Initially, Crest has 75% market share.
B. Repeat A, but assume Crest starts out with 50 percent market share. Notice anything?

5. The Zeckhauser roulette game. Suppose I value my life at $6 million, and death at $0. I am forced to play two related games of Russian Roulette. In the traditional game, I have a 1/6 chance of dying, and a 5/6 chance of surviving. In the riskier game, I have a 2/6 chance of dying, and a 4/6 chance of surviving.

a. **Without doing any calculations**. Suppose I could "buy a bullet" (reducing my absolute probability of death by 0.16666… in each game, thus from 0.1666…. to zero in the traditional game, and 0.333333… to 0.16666…. in the riskier game) Intuitively speaking, would you pay more for the bullet in the first game, or the second?
b. Now draw a decision tree and find your maximum WTP in the setups described in (a). Did this match your intuitive guess from (a)?

Problem Set 5. Please do all problems in TreeAge. Practice with trees

SSA456: Due before next class

1. (Please use clinical decision trees to solve all aspects of this problem.) Walter's Dog and Pony show is scheduled to appear in Chicago July 14, 2015. (Historically, it rains 25 percent of the time on this date.) The profits obtained heavily depend on the weather. If it rains, the show loses $15,000. If it is sunny, the show makes $10,000. Given sufficient warning, Walter can cancel the show, but this will cost $1000. Walter's goal is to maximize his expected profits.

a. Absent any specific weather information, should Walter hold the show?
b. For $1,000, Accuweather.com sells a perfect weather report that would tell him with perfect accuracy ahead of time what the weather will be on that date. He can use this information to hold or to cancel the show. Would Walter be willing to buy it?
c. Walter also has the opportunity to buy a slightly less accurate report from mostlyaccuweather.com. This costs only $300. That weather forecast is 80% sensitive and 90% specific in detecting rain. Is this a better or worse deal than the perfectly accurate Accuweather test?

2. Screening Sausage. The Food and Drug Administration has the daunting task of screening food for bacterial contamination with limited resources. They screen meat-processing plants to prevent widespread food poisoning which can lead to death. The FDA wants to argue for an increased number of food screeners which may increase the rate of weeding out infected meat but will cost more money. Let's focus on sausages.

Suppose that one in every 20,000 sausages has bacterial contamination. The current level of food screening has a sensitivity of 50% and a specificity of 95% in detecting contaminated sausages. Infected sausages that get through cause serious illness. The costs of current screening are five cents per sausage. If a person gets sick, this costs the industry $10,000 per case in bad publicity. If a sausage is wrongly labeled contaminated, it is discarded, costing the firm $0.25 per sausage.

If screening can be enhanced with more screeners, the sensitivity rises to 75%, with no change in specificity. The costs of the enhanced screening rises to $0.10 per sausage.

A. Draw out a decision tree showing current screening and enhanced screening.
B. This doesn't matter for the answer. But suppose 20 million sausages are consumed per year. What policy option is optimal based on annual costs?
C. Conduct the following sensitivity analysis: At what prevalence of contaminated sausages would you be exactly indifferent between the usual and the enhanced screening?

3. My knee.

… Hurts from an ACL injury. My doctor has proposed a $4,000 surgery. It has a 75% probability of fixing the problem and a 25% probability of failing. If the operation works, I will derive $6,000 worth of benefit. If the operation doesn't work, it has no value to me. The operation itself is painless with no need for disruptive recovery. So this is just a money issue for me.

A. If I have no other opportunity to collect information, should I have the surgery? Please provide a decision tree with the answer to the question addressed by folding back the tree.

B. Rather than fly blindly as in part (A), I can have a painless diagnostic test, which costs some $800. It tells me with perfect accuracy whether or not I should proceed with the surgery. Should I pay for the test? Provide a revised decision tree that includes the diagnostic test. The best way to do this problem is with the clinical tree, which matches the information available to patients and clinicians. However I will accept the God tree with full credit.

C. A cut-rate test is available from Guido Sarducci, Ltd. The Sarducci test costs only $300. However, it sometimes gets things wrong. If surgery would actually work, the Sarducci test says that it won't work 10% of the time. If the surgery would actually fail, the Sarducci test gets this wrong 20% of the time. Draw a decision tree that describes my decision.

D. In comparison with all my other options, would I want to buy the Sarducci test?

E. Do a two-way sensitivity analysis of the cost of the two tests.

F. *Optional Dick Morris test question*: If the Sarducci test were sufficiently inaccurate (yes I know this is vague), it wouldn't be worth it here, even if it were free. Use a clinical tree in TreeAge to determine how bad it would have to be before the test is worthless. Do a two-way sensitivity analysis in which you vary the specificity and the sensitivity of the test from 0% to 100% [Yes the word "sensitivity" is used twice for completely different purposes.] Any surprises?

4. HIV screening of blood.

Standard HIV antibody testing of blood donors costs about $5/donor. As noted in class, it does not catch all HIV-infected blood. Recently-infected individuals do not yet generate the biological materials that make for a positive result. Assume there is a 22-day "window period" of undetected infection. It doesn't really matter for policy analysis, but assume there are 16,000,000 donations every year.

We can spend more money (for a total of $10/donor) on a specialized p24 antigen test to reduce the window period to 16 days. Alternatively, we can spend $13/donor to reduce this window period to 11 days using some RNA technology.

Assume that each contaminated unit of blood infects an average of one recipient. Epidemiological studies indicate that the rate of new HIV infections among uninfected blood donors is 3.4 per 100,000 person-years. With the standard test, the probability of donor infection is 2.049/million. With the p24 test, the probability of infection drops to 1.49/million. With the RNA test, the probability drops to 1.025/million. Assume that we value preventing an HIV infection at about $275,000.

A. Calculate how many blood recipients would be infected under each policy.

B. Use Treeage to draw a decision tree comparing the different options. What is the optimal policy?

C. How would your answer to (B) change if you questioned the $275,000 figure? This is a sensitivity analysis question.

D. The price of p24 tests falls from $10 to $7. Is it worth it? In what price ranges is it the optimal policy?

E. Suppose the 3.4 per 100,000 estimate is wrong. (This would scale the three numbers in (a) proportionately.) How would the optimal policy change as we varied this number from rate from 3.4 per 100,000 to something ten times as large? Where are the "cut points" where the recommended policy would actually change?

F. Perform a two-way sensitivity analysis in which you vary both parameters you explored in (D) and (E).

5. Breast Feeding and HIV: **The 1990 dilemma**

During the 1970s, many public health authorities sought to promote breast feeding over formula feeding in Sub-Saharan Africa and South Asia. Breast feeding provided many benefits to new mothers and to their children, and is cheaper than formula feeding. Formula feeding creates especially serious problems when sanitary drinking water is unavailable or when poor mothers excessively dilute the formula. Suppose—in a particular country--that non-HIV-related child mortality rates among breast feeders is 4 percent. Suppose that the comparable figure for non-HIV-related mortality risk among formula feeders is 8 percent, independent of mothers' HIV status. Then HIV came along. Suppose that 26 percent of infants born to HIV-infected women are infected prior to the first week of life. Assume [ridiculously] there is no way to prevent that. Moreover, assume that an uninfected infant who is then breastfed by an infected mother is estimated to have a 14 percent probability of contracting HIV (usually in the first few months). All HIV-infected infants will die.

A. Assume that health care providers must give uniform feeding recommendations to HIV-infected and uninfected women in a given community. This could occur for cultural reasons, for reasons of confidentiality, or because HIV testing is simply infeasible for one reason or another. If HIV prevalence is huge, formula feeding is clearly best. If HIV prevalence is zero, breast feeding is clearly best. Suppose HIV prevalence among mothers is 40 percent. Use TreeAge to create a decision tree to determine whether formula feeding or breast feeding minimizes infant/child mortality.

B. Add a branch to your tree to answer the following: How does child/infant mortality under the best uniform recommendation compare to what would happen if HIV-infected women could be told to formula feed and uninfected women are told to breastfeed?

C. Use sensitivity analysis to solve the following problem. Suppose the World Health Organization needed to give recommendations to communities of the following form: If HIV prevalence among pregnant women exceeds X, tell all women to formula feed. If HIV prevalence is below X, tell all women to breast feed? Find X.

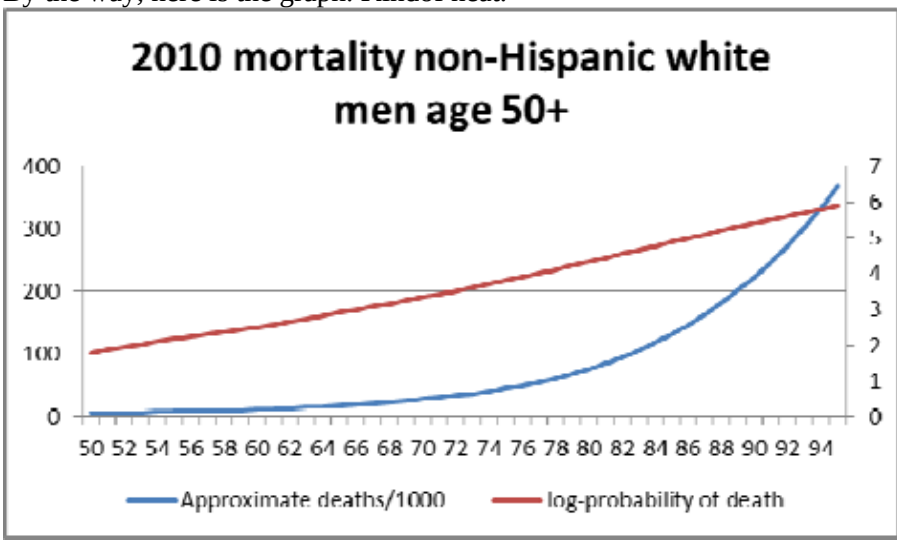
Problem set—SSA 456, Finishing Markov

1. Willingness to pay for improved survival

Between 1992 and 2010, survival markedly improved for white men. The below life tables are accurate between the ages of 50 and 85 or so. (For 1992, I could not get decent data above age 85. So the last three entries are made up and stupidly assumed to be identical to 2010. This obviously understates the survival gain.) Each entry indicates annual deaths per 1000 people. (For example a 50-year-old had a 0.005144 probability of dying before his 51st birthday in 2010, and an 0.00545 probability of death in 1992.) Assume things smoothly vary within each 5-year increment. Assume we are doing this problem from the perspective of someone who is now age 50.

	2010	1992
50	5.144	5.45
55	7.517	8.71
60	10.613	14.2
65	15.386	22.43
70	23.381	33.64
75	36.825	50.6
80	60.021	77.27
85	102.06	113
90	169.16	169.16
95	260.06	260.06
100	1000	1000

By the way, here is the graph. Kindof neat.



A. How does the probability of reaching age 85 increase between the two years? You will need to create a variable pDeath in the "Tables" section under Tree Properties to do this. Set things up so that the first_STAGE corresponds to age 50, and so on.
B. What is the improvement in expected lifespan for individuals who reach age 50? Age 65?
C. Suppose that individuals have a discount rate of 3%. From the point of view of that 50-year-old, what is a reasonable economic valuation of that health improvement over that 15-year period? You may use the $150,000 per QALY benchmark I mentioned earlier in the course.

D. Repeat C assuming that everyone dies on their 85st birthday, since I had to make up the data for the old-old folk.

2. Time-dependent probabilities: Welfare spells

May Jo Bane and David Ellwood performed many statistical analyses of long-term welfare dependence that influenced the 1996 welfare reform. In their book, *Welfare Realities: From Rhetoric to Reform*, Table 2.1 reports the following table: (*Since it is estimated with actual data, note that the values jump around a bit for some years. Why do you think this is?)*

Years on welfare (index)	Probability of exiting during the year (value)
1	0.31
2	0.26
3	0.21
4	0.23
5	0.18
6	0.16
7	0.13
8	0.18
9	0.07
10	0.16
11	0.20
12	0.15
13	0.19
14	0.11
15	0.11
16 and all later months	0.10

E. Create a Markov tree in Treeage in which an individual begins on welfare, and has the above probabilities of exiting the welfare rolls. You will need to create a variable pExit in the "Tables" section under Tree Properties to do this.
F. Suppose policymakers impose a five-year limit on the length of time people can be on welfare. What is the probability that a recipient will hit this limit in this one welfare spell?

3. Unemployment and job search

You are a worker worried about job security. In your economic sector, jobs are pretty transient. Every month there is a 0.03 probability that you will be laid off. If you are laid off, you go on unemployment insurance (UI), which pays $900 per month. Every month that you are laid off, you have the following probabilities of being offered another job:

	Probability of this being your best offer this month	Monthly pay for the duration of the job
"Good" job	10%	$2,000
"Bad" job	10%	$1,200
"No job" offer	80%	-------

You have a discount rate of 6% per year or 0.5% per month. Assume the following for no good reason: (1) You only get zero or one job prospect per month. (2) UI benefits never expire. (3) People only search for jobs when they are unemployed.

A. You are now unemployed. You are trying to figure out a general strategy to guide your job search. Your policy is one of two alternatives: "Take any job that is offered," or "take only the Good job." Draw the Markov tree you would use to determine which policy maximizes your expected present value of future income.
B. Find the optimal policy for an individual.
C. Suppose the government wants to set UI benefits so that unemployed workers are willing to take bad jobs when these are offered. What is the highest that the government can pay in monthly UI benefits before unemployed workers refuse the "Bad" jobs?

4. Three strikes

Steven Raphael of Berkeley has been examining how public policies towards incarceration have changed over the past generation. He is very interested in understanding why incarceration rates have increased so dramatically. He computed the below state transition matrices, which correspond to transition probabilities over a given year.

Table 2.6
Comparison of a Reduced Three-State Transition Probability Matrix for 1980 and 2005

Panel A: 1980

Origin State	Destination State		
	Not Incarcerated, not on parole	Incarcerated	Parole
Not Incarcerated, not on parole	0.99937	0.00063	0
Incarcerated	0.08211	0.52830	0.38958
Parole	0.40390	0.13073	0.46538

Panel B: 2005

Origin State	Destination State		
	Not Incarcerated, not on parole	Incarcerated	Parole
Not Incarcerated, not on parole	0.99826	0.00174	0
Incarcerated	0.12697	0.50629	0.36674
Parole	0.29738	0.29335	0.40927

A. Imagine that all individuals begin as 16-year-olds who have never been incarcerated and that people have 40-year criminal "careers." Use TreeAge to find the steady-state incarceration rates in 1980 and 2005. Describe the difference in incarceration rates (in standard units of per 100,000 people) in the two different years.
B. Re-incarceration of parolees is one of the largest differences between current policies and those which pertained thirty years ago. Suppose we could change parole policies so that they were the same in 2005 as in 1980 but left everything else the same. What would this do to steady-state incarceration rates?
C. *Three strikes* and similar laws are another new development since 1980. Modify your tree to include a new kind of variable, a "tracker" variable called "strikes," which increases by 1.0 every time someone goes from a non-incarcerated to an incarcerated state. Run the model for 40 years. Use Monte Carlo simulation to find the probability that an individual will experience at least three strikes in 1980, and then in 2005.

Hint: You can manipulate tracking variables as follows: Start at the root of your tree with your "values list" in the same way that you wish to create a variable. You will see a menu entry

“tracker names/Properties.” You can then add a tracker called “strikes” with an initial value of zero.

You then go to each terminal node corresponding to a transition into incarceration, right-click, and selecting “define tracker” in the menu. You will see the word “strikes,” and you can highlight that, which will open a formula box that says “strikes =” at the top. If you highlight “trackers” under group, “strikes” will appear. Double click on that. Strikes shows up in the top formula box, and you type “+1” after it and click OK.

Every time someone is newly incarcerated, “strikes” is then incremented by 1. Under the analysis menu, you can then choose Monte Carlo trials (microsimulation) to explore how many times individuals get at least three strikes.

Problem Set #3
Due January 29

1. **Pre-K interventions as crime prevention.** Individuals can grow up to be high-level offenders (H), low-level offenders (L), or non-offenders (N). Assume criminals begin committing their crimes on the 16th birthday. **From that day forward**, the lifetime social cost of crime committed by the H's is $600,000. In like fashion, the social cost of crime committed by low-level offenders is $150,000. Non-offenders don't commit any crimes. Suppose policymakers employ a social discount rate of 5%.

Offenders are drawn from a population of youngsters in the local community. That community is considering a universal preschool prevention intervention that would (among other benefits) prevent some youth from becoming offenders in the first place. The intervention would require an up-front investment of $5,000 per student, all spent around the time students reach age of 4. In the pertinent community, policymakers anticipate the following outcomes, with and without the preschool program.

	No intervention	Universal pre-K
Percentage of "at-risk" kids who become non-offenders (N)	80%	90%
Percentage who become low-level offenders (L)	10%	5%
Percentage who become high-level offenders (H)	10%	5%

A. Draw a tree with all relevant probabilities and payoffs.
B. Assume a 12-year lag between the up-front investment and the (potential) beginning of youths' criminal career. [That means that the social costs of crime starting twelve years from now needs to be divided by $(1+r)^{12}$]. Based solely on its value for crime reduction, is the pre-K intervention worth it?
C. *Optional*: What is the most a policymaker would be willing to pay for this pre-K intervention?

2. HAP runs a hospital's blood bank. He orders blood from a national consortium every Sunday for the week. He can keep a continuing stock of a perishable rare blood type, O^{--}. Since this blood perishes within a week, this gets expensive. It costs $1,000/week for every unit stored. This money is totally wasted if the blood goes unused. On the other hand, it costs $10,000/unit to get an emergency order when this type is needed. Over time, HAP identifies that the probability of needing specific amounts is given by the following:

Units of O^{--}	Proportion of weeks over the past decade in which this number of units were needed
0	50%
1	15%
2	15%
3	10%

4	10%

A. Draw a decision tree that you would use to solve this problem?
B. How many units of blood should a hospital order every week?

3. (Please use clinical decision trees to solve all aspects of this problem.) Walter's Dog and Pony show is scheduled to appear in Chicago July 14, 2014. (Historically, it rains 25 percent of the time on this date.) The profits obtained heavily depend on the weather. If it rains, the show loses $15,000. If it is sunny, the show makes $10,000. Given sufficient warning, Walter can cancel the show, but this will cost $1000. Walter's goal is to maximize his expected profits.

a. Absent any specific weather information, should Walter hold the show?
b. For $1,000, Accuweather.com sells a perfect weather report that would tell him with perfect accuracy ahead of time what the weather will be on that date. He can use this information to hold or to cancel the show. Would Walter be willing to buy it?
c. Walter also has the opportunity to buy a slightly less accurate report from mostlyaccuweather.com. This costs only $300. That weather forecast is 80% sensitive and 90% specific in detecting rain. Is this a better or worse deal than the perfectly accurate Accuweather test?

4. Please read the attached (slightly edited) essay. Discuss in your group and then write a 2-3 paragraph essay regarding how situations like this might be handled in a way that would encourage better decision-making. The narrator in this story has some suggestions. Don't feel bound by them in considering your response.

Lessons From the ER

I held my wife's hand as the technician applied cool gel to her chest. At first, the ultrasound images were the fuzzy black-and-whites I remembered from before our daughters were born. After a few touches to the LCD screen, a breathtaking three-dimensional movie began to run. It featured V's heart, its thick walls beating yellow against a black background.

The technician maneuvered a trackball to reveal the various parts undulating in unison. Colored regions displayed blood velocity and turbulence through the different chambers. Suspended in virtual space, V's heart looked every millimeter the impregnable pump I had always assumed it was.

V is 46, does four hard workouts every week on the stepping machine, eats sensibly, and has a resting pulse of 60. So when she woke me at 2 A.M. and calmly reported funny chest pains radiating to her shoulder blades and down her arms, the obvious came to mind, but it was hard to really believe. V and Rebecca had been coughing and feverish for a week. The three of us had embarrassing cold sores. Acid reflux, a sore diaphragm -- anything seemed more likely than a heart attack.

You need a hard head and a soft heart to manage a loved one's medical emergency. It's surprisingly easy for smart people to be nudged by circumstance and human frailty into doing careless or foolish things. We had two sleeping daughters across the hall. The thought of them

waking up to flashing ambulance lights was daunting. We worried about leaving them or dragging them to an emergency room. Still, V had never felt anything like this. We had to do something. So we threw on some clothes, and drove to the 24-hour urgent-care center a half-mile from our house.

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Several people made mistakes in V's care. The worst and most deadly mistake was ours: going to this urgent-care center. V's symptoms demanded a 911 call. I knew better -- or I certainly should have. I am a certified expert. I've served on expert panels of the Institute of Medicine, no less.

I was swayed to discount what was happening --V, a clinical nurse specialist, was, too -- by disbelief, by her recent illness, and by her general fitness. We were also swayed by the expected hassle and expense of an ER visit. We envisioned paying a large bill to be prescribed some Tums. Last year, V went out-of-network for urgent care. That cost $700.

In part, we hesitated because that was exactly what the modern health-insurance system is designed to make us do. A quarter-century ago, the RAND Health Insurance Experiment (HIE) established the basic argument for deductibles and co-payments in insurance. HIE remains the most important policy experiment in American history. Its most potent finding was that people who got free care used 40 percent more services than did others assigned to cost-sharing plans. Yet the free care produced little measurable additional benefit for the average patient. These results are often cited in support of co-payments and deductibles designed to discourage inappropriate care. Policy-makers and payers are particularly concerned about the real and alleged over-use of emergency care. Charging higher co-payments is one obvious response.

It seems counterintuitive that demand for ER services would be sensitive to price. If you slice off your finger with a steak knife, you won't be thinking about the money. Yet it turns out that many ailments -- V's included -- are ambiguous, and so price matters. RAND investigators found that individuals in cost-sharing plans reduced ER use by one-third when compared with the free-care group.

Co-payments did discourage wasteful use among HIE participants. ER visits in relatively non-urgent categories such as sprains and back pain were 47 percent less frequent in cost-sharing plans. Unfortunately, co-payments also discouraged appropriate use. Participants enrolled in the cost-sharing plans were 23 percent less likely to seek ER care for "more urgent" problems, including fractures and asthma.

Most patients cannot reliably distinguish appropriate from inappropriate ER use. In many cases, even experts find the distinction fuzzy. I once co-wrote a study of a managed behavioral health plan that imposed a 50 percent co-payment on psychiatric ER visits. Do we really want to impose these barriers? When someone feels that funny chest pain, how long do we want her to dither before seeking help?

V and I made a critical decision in choosing the urgent-care clinic. Your first medical provider in an emergency determines who will frame the initial hypotheses of your illness, who will coordinate your care, and, often, the person who hears the cleanest direct account of what is

wrong. I had never been inside this imposing structure, which advertises and charges as an emergency-department affiliate of a local hospital. We arrived to find it nearly empty. The staff promptly took an electrocardiogram (EKG) that looked normal and administered aspirin and nitroglycerin. V took a gastrointestinal cocktail of antacid and lidocaine in case this was acid reflux. It seemed to help, which I found reassuring. They administered a chest X-ray. After bumpy preliminaries, they administered the standard cardiac-enzyme tests.

Key enzyme levels were very high, indicating that heart cells had died and had released their hidden proteins. Yet the staff remained unsure that the test equipment was working. As the tests were rerun, the staff tried to administer a CT scan, but the intravenous dye infiltrated into V's forearm, causing excruciating pain.

I remained convinced this was all an annoying set of benign, if painful, screw-ups.

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I cannot say why I was not more forceful in getting V out of there. Throughout, she seemed fine, talking normally, except that her chest, and then her arm, really hurt. My alarm steadily increased as the realization sank in that something could be genuinely amiss. An amazing four hours after arriving, we received the repeated enzyme tests. That's when the ambulance was called to transport V to a real hospital. I gingerly asked the doctor about taking her to the big university hospital one hour away. He replied, quite reasonably, that there was no time. I raced home and drove the kids to a friend's house.

At the hospital, an emergency-room doctor stated without preliminaries: "Bottom line -- you've had a heart attack." The enzyme tests were definitive. Fortunately there was no other detectable damage. He explained that this was the kind of heart attack, more common than one would suppose, that can leave no obvious damage. A tiny piece of plaque becomes dislodged, initiating clotting. Such an attack can be essentially self-healing once it runs its course. I gave the gruff but comfortably authoritative cardiologist the business card of V's internist and asked him to call.

V needed cardiac catheterization. This is a delicate procedure. Cardiologists and their surgical teams differ substantially in skill and in post-operative mortality. For 25 years, health-services researchers have documented that it's good to have an operation in the right hospital by the right people. Many jurisdictions have begun to publish hospital-specific and surgeon-specific rankings of observed and expected mortality rates for these procedures.

As you might imagine, ranking is a complicated subject. Hospitals complain they are penalized because they serve high-risk, complex patients. Hospitals may also game things. There is suggestive evidence that cardiac report cards encourage physicians to provide less-aggressive treatment to minority patients and others who tend to have worse outcomes. Risk-adjustment methods developed to address these concerns have spurred needed changes. A striking number of surgeons in the highest mortality categories retired or moved away when New York implemented report-card systems. A 2006 Health Affairs paper by Ashish Jha and Arnold Epstein reports: "With the release of each report card, approximately one in five bottom-quartile surgeons relocated or ceased practicing within two years." New York's post-operative mortality

rates sharply declined after ratings were published. Rankings were not the only reasons for improvement, but they helped.

Not surprisingly, high-volume facilities perform better. Surgeons get better with practice. Care teams get better at minimizing post-operative infections. Some hospitals become popular because they are good; others become good because they are popular. Which came first? If you're a patient, you don't care. There are ongoing debates over whether cardiac catheterization and other delicate services should be provided by a small number of high-volume regional centers. Probably they should, though this is hard to pull off in our decentralized and competitive system. The data also reveal surprising disparities, sometimes between adjoining hospitals or those we might otherwise consider peers.

New York State publishes risk-adjusted 30-day mortality rankings. Based on 2003–2005 data (released last February), where would you want your ambulance to go in the New York area? You might not guess that Bellevue Hospital and the Long Island Jewish Hospital performed markedly better than many more famous hospitals. You might not suspect that Montefiore-Einstein Heart Center ranked poorly in both mortality and post-operative complication.

I have presented this information to hundreds of students at leading universities. I could cite a wealth of data on many topics. Yet when V got sick, my personal databank included nothing on the hospitals near my own home. You don't comparison shop alongside a loved one's hospital gurney.

As the bedside conversation proceeded, I wondered whether to sell our house. I wasn't thinking about the sub-prime mess. I just wanted to live near a great cardiac facility. A classic analysis by Mark McLellan, Barbara McNeil, and Joseph Newhouse showed that people who happen to live near these hospitals were more likely to survive cardiac emergencies. I wish I had taken that paper to heart.

The community hospital that treated V is, by reputation, probably the best within 10 miles of us. The attending cardiologist is well respected and projected an infectious certainty about what was wrong, how to fix it, and who was in charge. I found his decisiveness reassuring. Still, I would rather have had this performed at a major academic medical center or at least done by someone I had vetted. I again rather awkwardly asked the emergency-room docs whether V should be moved. I called a friend who is a good internist who said they seemed to be doing sensible things, and there was no time to screw around moving her. Given the situation, there was nothing else to do.

The team whisked V upstairs for the angiogram. They threaded a catheter into her groin area and ran it up near the heart to examine arteries that might have been blocked. I sat pensively in the waiting area. The cardiologist shortly emerged to report that the angiogram had gone well. There was no observable tissue damage. There were no blockages. Her arteries were squeaky clean.

Days later, I looked up the local rankings. Our hospital wasn't ranked badly. Its cardiac catheterization is 40 percent cheaper than the fancy university hospital I preferred. The bad

news: Its post-operative mortality rate was 40 percent higher than that of another community hospital I never held in much regard three miles from our home.

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The various waiting rooms were especially sobering. Dozens of tight-lipped people filled them, worried, first and foremost, about their loved ones. The hospital is located in a gritty suburb. Many of the people sitting with me were surely wondering, how will I pay for this?

I wasn't worrying about money. I remember thinking: Thank God we have good insurance. At least I think we do…. Sitting in that waiting room, I was also struck by the responsibility each of us has to care for our mind and body. We are vulnerable to genetics and bad luck. Still, the intensive care unit brutally displays the consequences of poor health behaviors. Surprising numbers of young people are there, suffering and sometimes dying when this doesn't have to be.

It was hard not to notice something else. That waiting room, like so many others… was filled with people of color. Public perceptions of racial and ethnic disparities are shaped by headlines about homicide, substance abuse, infant mortality, AIDS. Mundane cardiovascular diseases exact a far heavier toll in minority communities, within which child and adult obesity have markedly worsened. I fear that waiting rooms may need more chairs.

Within a few hours after the angiogram, V was in intensive care, and we began to digest the bizarre news. Once the anesthesia wore off, she felt real chest pain but was otherwise amazingly normal. Wired up to the monitors, she was soon sitting up doing her cross-stitch, joking with my sister, asking about the kids. An infectious-disease specialist came through and treated her cold sores. Things became boring.

V stayed in that ICU for three days. A pneumatic messaging tube thwonked loudly and randomly throughout the night. Various machines would beep if V moved her arm and impinged on some tubing. On top of that, V was in pain, which the cardiologist explained later was a normal reaction to blood returning to the damaged heart areas. The effect is grueling. Sleep disruption is a prominent cause of what is charmingly labeled "ICU psychosis." Despite that, the staff provided much wonderful care. A community-hospital ICU resembles what hospital care often used to be: kind nurses in an unhurried environment where they could pay close attention to patients.

V spent her last 24 hours in that hospital on a regular floor. Fewer nurses were responsible for more sick patients. V was in pretty good shape by then. She saw her nurse one or two times, not much more. The cardiologist and the local attending shook our hands, assured V she would be fine, and sent us packing.

I was nervous but happy to bring V home. Forty-eight hours earlier, she had been wired up in a cardiac ICU; now no medical provider seemed all that interested in seeing her. We made an appointment to see the cardiologist nearly one month later. We called V's young university internist. I would have thought the words: "I had a heart attack" would provide some scheduling advantage -- apparently not. The medical center is de-emphasizing primary care. It's hard to make money on these services in a tertiary-care setting. During the 10 days before we saw the

internist, V dutifully took her medications and set about recovering from her illness and from the grueling days in the hospital. Recovery was slow. She had trouble climbing stairs, got winded a lot, and needed a lot of sleep.

Internists have taken some hits in recent years. A *New York Times* story in March noted that dermatologists earn twice as much and work 10 fewer hours per week. The Times quotes an aspiring dermatologist as saying that internal medicine is "viewed as easy because anyone can get into it." Since preventive medical care cases can be "humdrum," he said there is a "lack of respect for what they do."

***

Although that student doesn't know it, internists are the linchpin of our medical system. As described in Jerome Groopman's beautiful book How Doctors Think, physicians make sense of a disorganized jumble of data, recognize latent signs of trouble, chase down patterns when things don't look right, and help patients form a coordinated care plan. V's internist started the 30-minute appointment with a jaw-dropper: "I want to hear what happened straight from you. I should say at the outset that I don't think you've had a heart attack."

Before the appointment, he had mastered V's hospital record. That already put him miles ahead of most other doctors. It just didn't look right that a healthy gym rat would have a sudden heart attack with no warning and no detectable damage. He had a hunch, which he checked out with five or six senior colleagues. They agreed that a viral infection of the heart, viral myocarditis, was more likely.

He took an EKG, which revealed V's resting pulse of 47. She had previously been so fit that her normal heart rate was already quite low. The beta-blocker V had been prescribed was too potent, and nobody was monitoring it--making her one of many people who become sick from their medication. Mercifully, the internist tapered the beta-blocker. He also arranged for an echocardiogram in order to make a more definitive diagnosis. That echocardiogram is where this article began.

Two days after the echo, we sat in an examining room with a university cardiologist, a wonderfully effervescent, small man with a flowing gray beard and an Irish brogue. My heart initially sank when he said, "I have not read your chart. I want to hear from you." He proceeded to ask V in detail about everything that had happened. V tried to be efficient and precise to fit the confines of our visit. "Slow down," he said. "We have plenty of time. Did the cardiologist say your arteries look 'clean,' or 'squeaky clean'?"

After 15 or 30 minutes of questions, he said, "OK. I am going to stop the conversation now, and I am going to read your records." He methodically reviewed what had been written. "Your internist has written a Bible about you," he happily noted. He went through all the lab values and commented almost flirtatiously: "You have the kidneys of a young girl."

After more back-and-forth, he noted the competing hypotheses. He then looked over the echocardiogram results and said, "This is a classic presentation of viral myocarditis." He noted that a damaging heart attack would have shown a dead or damaged region, too weakened to

support the heart's syncopated beat. I cannot imagine what cardiac patients experience when they watch live movies of their own hearts in visibly damaged condition.

My own heart skipped when he said to V: "Your echo clearly shows a heart pumping poorly from the myocarditis." It wasn't just the beta-blockers that were making her winded. Her right atrium was enlarged.

As this article goes to print, V is doing well but is facing a nine-month recovery. We have one loose end. V's university-hospital record says that she is on aspirin and a blood thinner and that she is recovering from viral myocarditis. Yet if she falls ill tonight, an ambulance will deliver her to that community hospital, whose records indicate that she is a recovering heart-attack patient taking a potent dose of beta-blockers. Nothing in our health-care system reliably reconciles these different versions of reality. Everyone involved seems skittish to close this loop. What will we tell her original cardiologist? Will he worry that we will sue? Will he argue with us or with the other guy?

***

People draw their own lessons from intense experiences. Perhaps most frightening is the ease with which smart people make bad mistakes and never look back. Such findings provide a human frame through which to view many mistakes in V's care, including mine.. Medical errors seem more egregious in hindsight than they actually are. Jerome Groopman's *How Doctors Think* recounts many serious mistakes but also several heroic diagnoses made when doctors spot things others have missed. But many of these cases just don't seem that hard: the chronic anorexia that turns out to be celiac disease, the ER patient with chest pain who turns out to have unstable angina, the overlooked infected abscess. These examples are frightening because they reveal how skilled professionals go astray.

I can't say why V's doctors missed her heart infection, but I have some clues. For one thing, V's doctors never performed an echocardiogram. Such missed opportunities are common. Tejal Gandhi of Brigham and Women's Hospital and colleagues recently examined closed malpractice cases involving missed or delayed diagnoses. More than half included some failure to order an appropriate diagnostic test. This pattern may be hard to generalize. Only a tiny proportion of medical mistakes and injuries result in malpractice claims. Moreover, a missed diagnostic test is an especially provable form of malpractice.

Emergency physicians face disconcerting challenges that make them especially vulnerable to cognitive error. They must act decisively based on what is currently suspected or known. Doctors and patients both want certainty in an anxious situation. No one is reassured when the doctor says, "I'm not sure what's wrong."

The possibility of heart attack was on everyone's mind based on V's dramatic cardiac-enzyme numbers. Had we gone to the hospital first rather than to the urgent-care center, the staff might have conducted a more reflective conversation with V about the specific history of her illness. Given her urgent-care admission, V needed an immediate angiogram before that conversation could really be had. In those first few hours, heart attack was the most reasonable working hypothesis. This deadly possibility needed immediate attention.

Later, things became murkier. V's arteries and heart tissue looked fine. Her only symptoms were the bad enzyme results and continued chest and arm pain. These were consistent with a heart attack but also with other things. Healthy, 46-year-old women rarely have heart attacks that refuse to leave a trace. That pattern would later pique the curiosity of V's internist….

Given my own credentials, I'm embarrassed that I navigated this emergency relatively badly and generally felt no less bewildered than anyone else. I guess the final lessons are more personal. We must forgive ourselves, and others, for our near-misses. Then we must learn from these experiences.

4Solution KeyEarly Final Exam

SSA 456/ PPOL 460

This is a 3-hour exam. You are on your honor to work on it alone. You may make use of an 8.5 by 11 crib sheet. Please do not talk to anyone except the instructor or the course assistants about any aspect of this examination.

Some questions have been modified from a test administered by A. David Paltiel of Yale University.

The fine print:

Please show your work and explain how/why you arrived at your answer. You will receive no credit for responses that merely provide a numerical answer. Students who submit a computer-generated response should pay special attention to explaining their results.

Partial credit will be awarded generously. Be sure to attempt to answer all questions — even those that ask you to rely on a prior result that you may not have been able to obtain.

Good luck!

1. Climate change investments

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Global climate change will damage the U.S. economy in future generations. Yet efforts to reduce climate change will be costly and may not be worth it. An advocacy group reports that a one-time $100 billion investment now will produce a one-time benefit equivalent to $1 trillion in the year 2109. An economist accepts their figures, but suggests that the investment isn't worth it. Is she right?

What is $1 trillion 99 years from now worth in today's terms?

Using the usual discount rate of 3%, we take the PDV of $1 trillion 99 years from now: $1 trillion/(1.03)^99, and we find $53.6 billion.

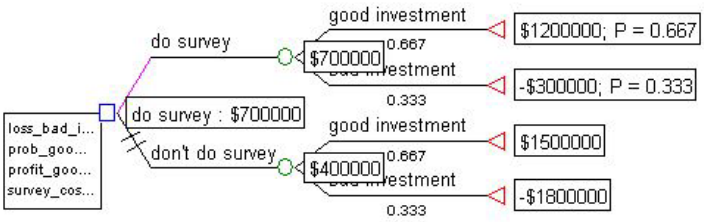
Initial investment	years	final value	r	PDV of final value
100,000,000,000	99	1,000,000,000,000	0.03	53,593,825,046

So the investment is a bad deal. It's close. If the discount rate were 2.35 percent, the investment would be worth it. Environmental economists often use a discount rate of 2% for intergenerational problems. So you could defend this investment, but it fails by the usual criteria

2. Market test

~~(Drawn from Hiller and Lieberman, p. 787).~~ HAP enterprises is considering developing and marketing a new product. The product has a 2/3 probability of being successful and a 1/3 probability of failing. If successful, expected profit is $1.5 million. If unsuccessful, the expected loss is $1.8 million. A marketing survey can be conducted that costs $300,000 to predict whether the product will be successful.

A. Suppose the test is perfectly accurate. If one is trying to maximize expected profit, draw a decision tree (with all probabilities and payoffs) you would use to figure out whether to pay for the test.



Here is the solved out tree. I did it in Treeage. Make sure you can do something like this by hand.

B. What is the maximum HAP would pay for this perfect test?

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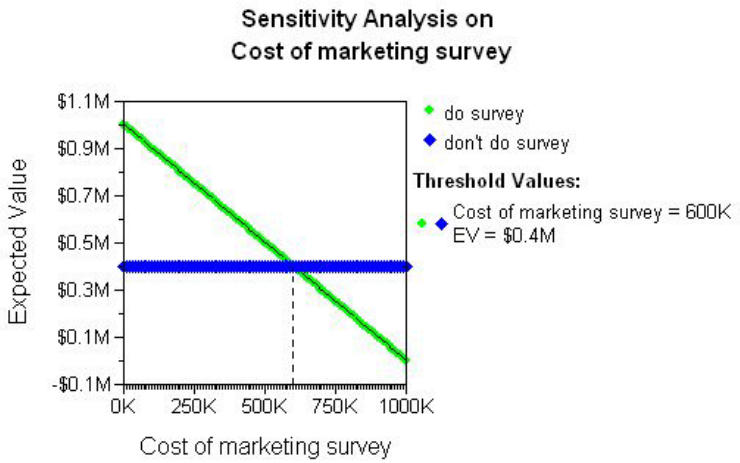
If I had treeage handy, I could do the sensitivity analysis below. But I don't need to. Because the difference in payoffs between doing the survey and not doing the survey is $300,000, I would be willing to pay $300,000 more for the test than I currently am.



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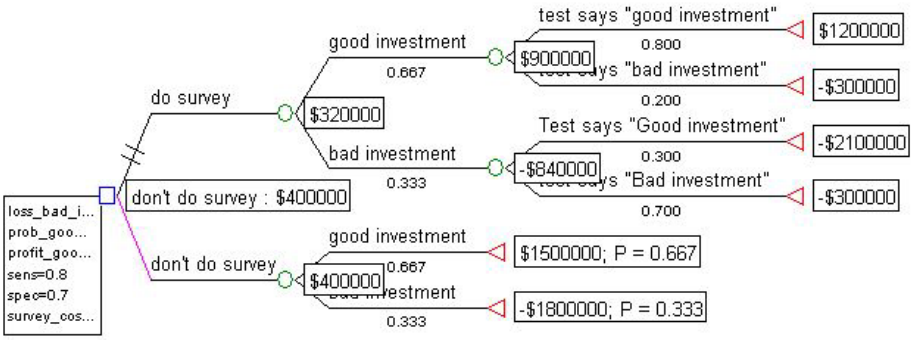
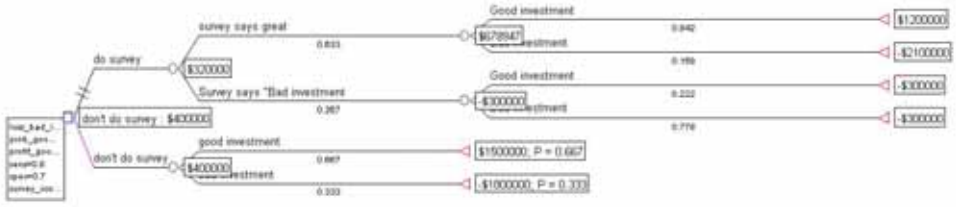
C. Actually the marketing test is imperfect. When the product would be successful, the test will indicate this 80% of the time, and will get the wrong answer 20% of the time. Conversely, when the product would be unsuccessful, the test will indicate this 70% of the time, and will get the wrong answer 30% of the time. Revise your decision tree from (A) to accommodate the imperfection of the test. If the marketing test indicates "this product will be successful," what is the probability that the test is correct?

I did the tree the way I do it:



I also did out the tree the way Elbert does.



These are equally correct. I find the top approach faster, but what do I know? ~~I only have a PhD from Harvard…~~

D. What is the maximum HAP would be willing to pay for this test?

Since the payoff of having the test is $80,000 less than not having it, the most one is willing to pay is $300,000-$80,000=$220,000.

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~~D.What is the maximum HAP would be willing to pay for this test?~~

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3. Pre-K interventions as crime prevention

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Individuals can grow up to be high-level offenders (H), low-level offenders (L), or non-offenders (N). Assume criminals begin committing their crimes on the 16th birthday. From that day forward, the social cost of crime committed by the H's is $300,000. In like fashion, the social costs of crime committed by the low-level offenders is $100,000. (We got these numbers from an analysis like that of the last problem set.)

Offenders are drawn from a population of "high-risk" youth. A community is considering a universal preschool prevention intervention that would (among its other benefits) prevent some youth from ever becoming offenders in the first place. The intervention would require an up-front investment of $5,000 per student, all spent around the time students reach the age of 4. In the pertinent community, policymakers anticipate the following outcomes, with and without the preschool program.

	No intervention	Universal pre-K
Percentage of kids who become non-offenders (N)	80%	90%
Percentage of kids who become low-level offenders (L)	10%	5%
Percentage of kids who become high-level offenders (H)	10%	5%

A. Draw a tree with all relevant probabilities and payoffs that you would use to solve this problem.

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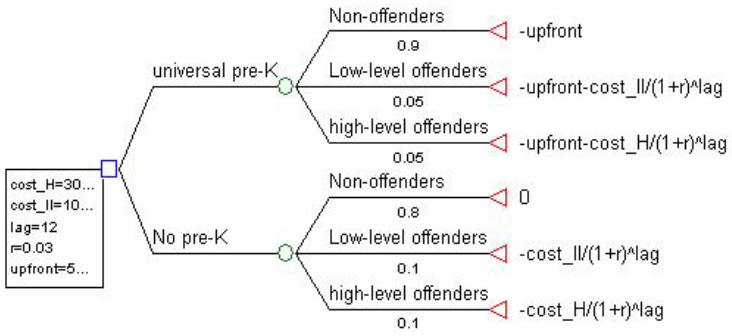
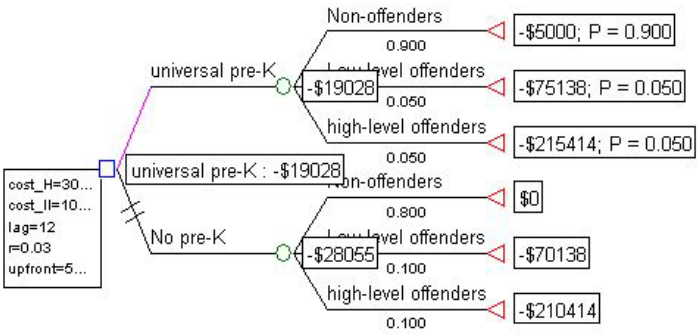


B. Assume there is a 12-year lag between the up-front investment and the beginning (if there is one) of youths' criminal career. Based solely on its value for crime reduction, is the pre-K intervention worth it?



The universal pre-K is worth it.

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4. Annual HIV testing

The UN AIDS program is considering implementing HIV testing in a developing country. The key parameters are shown below

Description	Value
Annual death rate when HIV undetected	0.1
Annual death rate among infected screened	0.03
Annual death rate among uninfected	0.015
Discount rate	0.06
Annual rate of new HIV infections among the uninfected	0.0001
Initial HIV prevalence in the population	0.0005
Quality of Life of infected person when test is detected	0.7
Quality of Life of untested infected persons	0.6
Quality of Life of uninfected persons	1
Cost of test	$20
Dollar-value of a QALY	$150,000

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Imagine (unrealistically) that the choice is between never testing and testing every year. Also ignore all treatment costs.

a. Draw (but do not solve) a decision tree with all pertinent probabilities and payoffs that you would use in solving this problem.

Here is the way this might look in Treeage. On your exam show the payoffs more clearly than I did.

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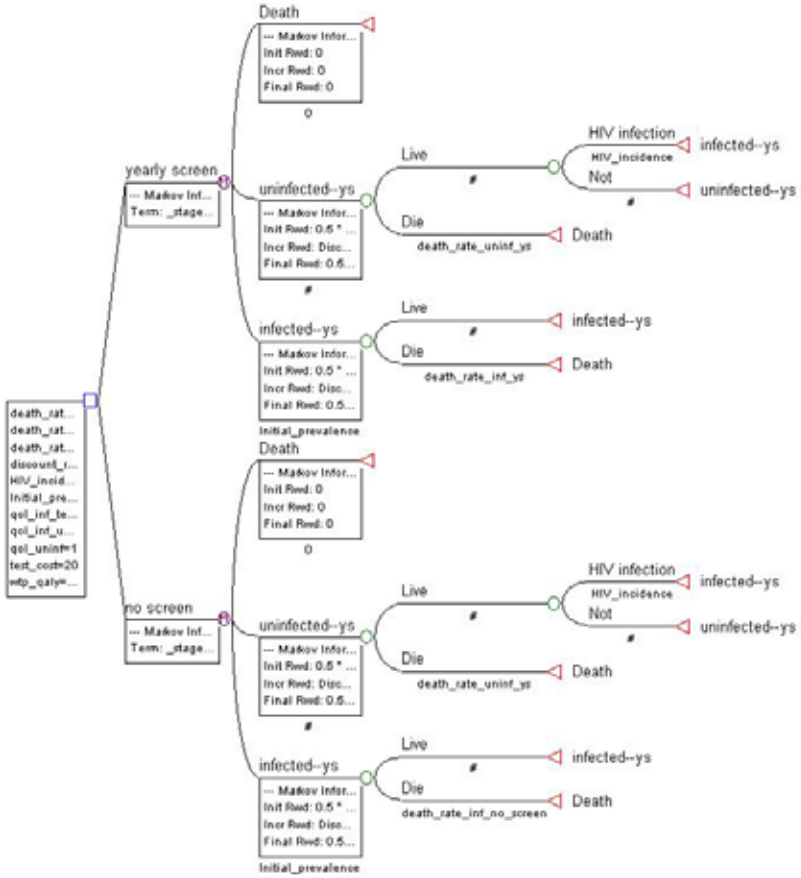
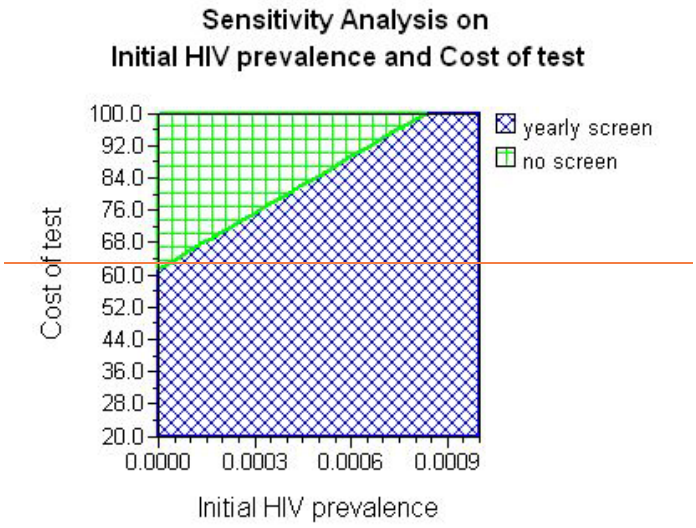


~~UNAIDS performed a cost-benefit analysis using the correct tree. The following sensitivity analyses were performed, which may be used to answer (b) and (c).~~



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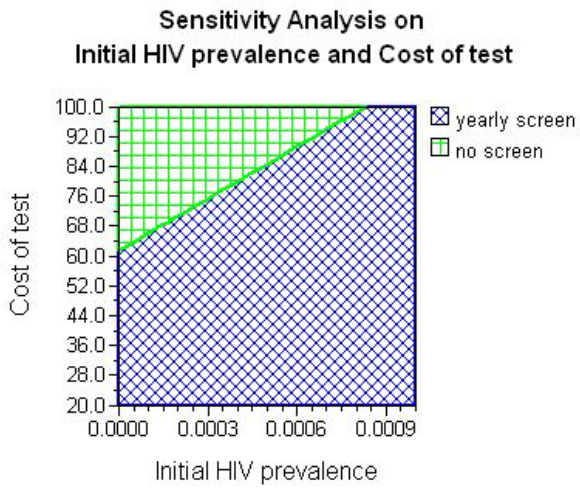

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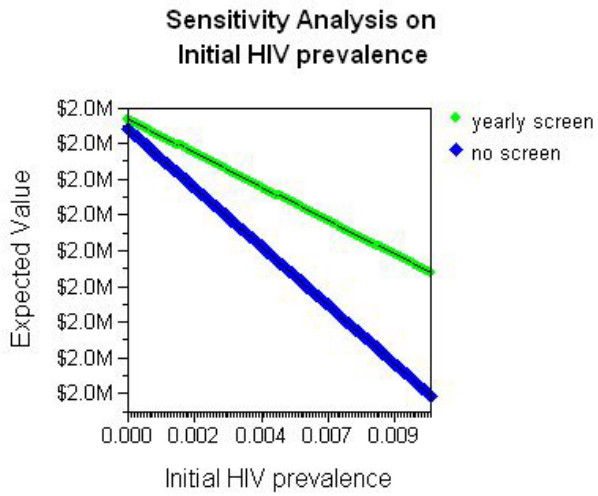

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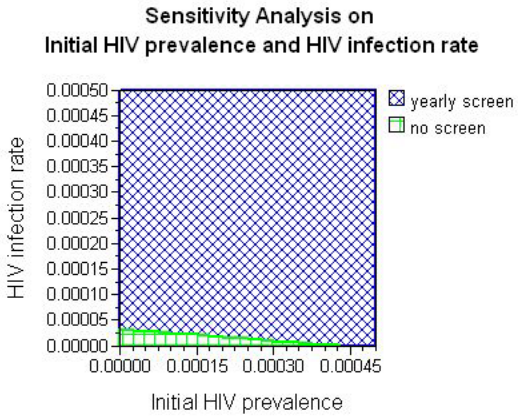
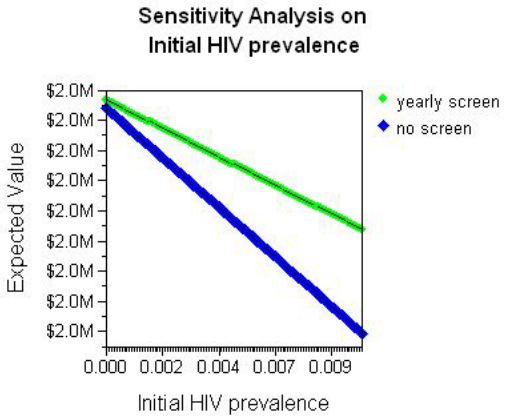


b. UN AIDS is under pressure to approve or disapprove the project. The agency feels confident about the annual rate of HIV infections. Unfortunately it doesn't really know how many people are currently infected. The director is speaking to funders tomorrow, who will vote to approve or disapprove the project. They are understandably upset that this basic information is unavailable. What should she tell them?

We wouldn't change our policy recommendation based on this parameter. The optimal policy is to do annual testing through the relevant range.



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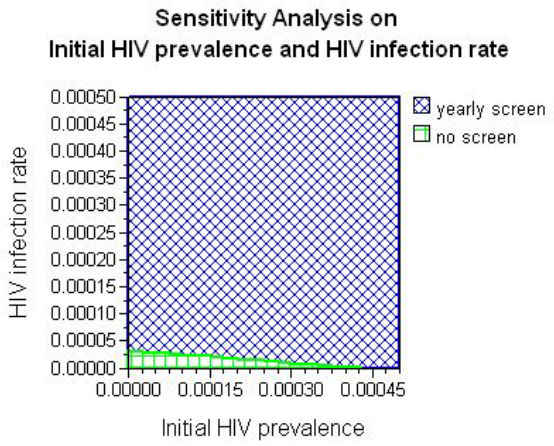
We can also see that from the two-way sensitivity analysis immediately above this section. Find the point on the vertical axis that corresponds to the 0.0001 annual prevalence, and draw a flat line the entire range of initial HIV prevalences. At every value of initial HIV prevalence, we are well inside the blue region.



c. The test turns out to be much more costly than expected. Suppose initial HIV prevalence is about 0.0003. About how much would UN AIDS be willing to pay for it?

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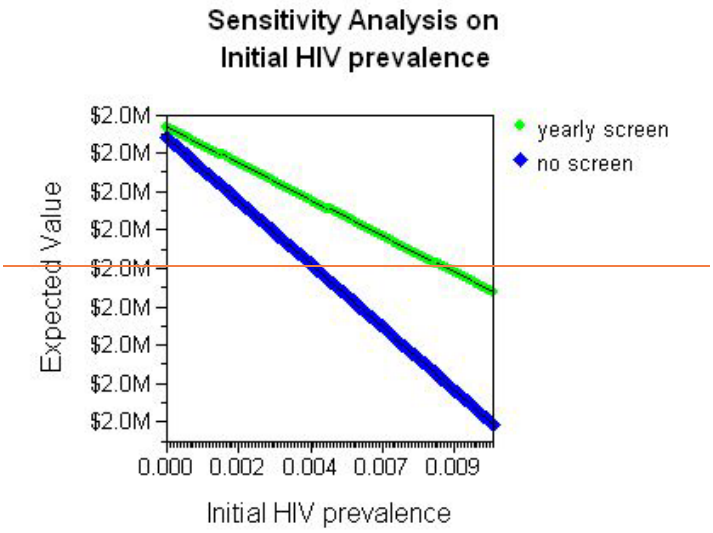

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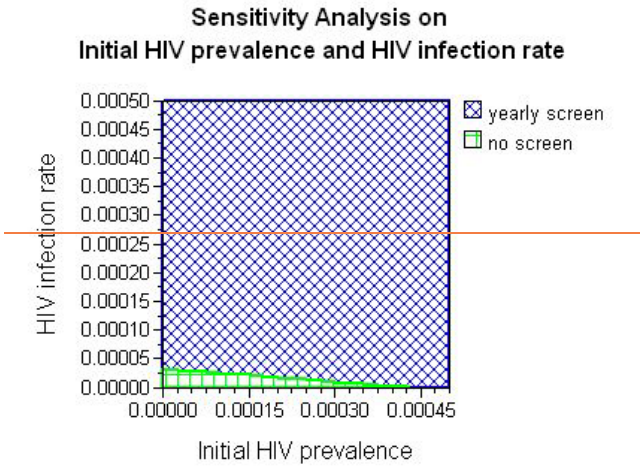

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~~c.~~*~~The test turns out to be much more costly than expected. Suppose initial HIV prevalence is about 0.0003. About how much would UN AIDS be willing to pay for it?~~*top two-way sensitivity analysis. Find 0.0003 on the horizontal axis. Now take a straightedge or your credit card and draw a vertical line to the boundary between the two regions. That's what we are willing to pay, approximately $70.*

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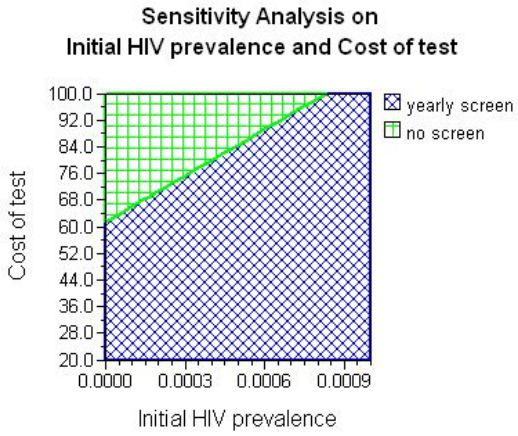

6. Vehicle Mileage Tax

Please read the attached articles on a vehicle mileage tax. Identify at least one course theme and describe how it is important to the VMT debate.

I believe that this is a pretty crummy essay question for you, since the year I included that question we had a slightly different mix of substantive topics. Good answers showed how Pigouvian taxes on externalities look within the context of cost-benefit analysis. Because drivers don't bear congestion/road wear/environmental costs,they drive too much.

I will provide a better essay question and example before the exam.

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AP Interview: LaHood eyes taxing miles driven

By JOAN LOWY – Feb 20, 2009

WASHINGTON (AP) — Transportation Secretary Ray LaHood says he wants to consider taxing motorists based on how many miles they drive rather than how much gasoline they burn — an idea that has angered drivers in some states where it has been proposed.

Gasoline taxes that for nearly half a century have paid for the federal share of highway and bridge construction can no longer be counted on to raise enough money to keep the nation's transportation system moving, LaHood said in an interview with The Associated Press.

"We should look at the vehicular miles program where people are actually clocked on the number of miles that they traveled," the former Illinois Republican lawmaker said.

Most transportation experts see a vehicle miles traveled tax as a long-term solution, but Congress is being urged to move in that direction now by funding pilot projects.

The idea also is gaining ground in several states. Governors in Idaho and Rhode Island are talking about such programs, and a North Carolina panel suggested in December the state start charging motorists a quarter-cent for every mile as a substitute for the gas tax.

A tentative plan in Massachusetts to use GPS chips in vehicles to charge motorists by the mile has drawn complaints from drivers who say it's an Orwellian intrusion by government into the lives of citizens. Other motorists say it eliminates an incentive to drive more fuel-efficient cars since gas guzzlers will be taxed at the same rate as fuel sippers.

Besides a VMT tax, more tolls for highways and bridges and more government partnerships with business to finance transportation projects are other funding options, LaHood, one of two Republicans in President Barack Obama's Cabinet, said in the interview Thursday.

"What I see this administration doing is this — thinking outside the box on how we fund our infrastructure in America," he said.

LaHood said he firmly opposes raising the federal gasoline tax in the current recession.

The program that funds the federal share of highway projects is part of a surface transportation law that expires Sept. 30. Last fall, Congress made an emergency infusion of $8 billion to make up for a shortfall between gas tax revenues and the amount of money promised to states for their projects. The gap between money raised by the gas tax and the cost of maintaining the nation's highway system and expanding it to accommodate population growth is forecast to continue to widen.

Among the reasons for the gap is a switch to more fuel-efficient cars and a decrease in driving that many transportation experts believe is related to the economic downturn. Electric cars and alternative-fuel vehicles that don't use gasoline are expected to start penetrating the market in greater numbers.

"One of the things I think everyone agrees with around reauthorization of the highway bill is that the highway trust fund is an antiquated system for funding our highways," LaHood said. "It did work to build the interstate system and it was very effective, there's no question about that. But the big question now is, We're into the 21st century and how are we going to take care of our infrastructure needs ... with a highway trust fund that had to be plused up by $8 billion by Congress last year?"

A blue-ribbon national transportation commission is expected to release a report next week recommending a VMT.

The system would require all cars and trucks be equipped with global satellite positioning technology, a transponder, a clock and other equipment to record how many miles a vehicle was driven, whether it was driven on highways or secondary roads, and even whether it was driven during peak traffic periods or off-peak hours.

The device would tally how much tax motorists owed depending upon their road use. Motorists would pay the amount owed when it was downloaded, probably at gas stations at first, but an alternative eventually would be needed.

Rob Atkinson, president of the National Surface Transportation Infrastructure Financing Commission, the agency that is developing future transportation funding options, said moving to a national VMT would take about a decade.

Privacy concerns are based more on perception than any actual risk, Atkinson said. The satellite information would be beamed one way to the car and driving information would be contained within the device on the car, with the amount of the tax due the only information that's downloaded, he said.

The devices also could be programmed to charge higher rates to vehicles that are heavier, like trucks that put more stress on roadways, Atkinson said.

LaHood's talk of mileage tax nixed

White House and Transportation spokeswoman say idea won't be used

The Associated Press

updated 2:15 p.m. CT, Fri., Feb. 20, 2009

WASHINGTON - President Barack Obama will not adopt a policy to tax motorists based on how many miles they drive instead of how much gasoline they buy, his chief spokesman said Friday.

Press secretary Robert Gibbs commented after Transportation Secretary Ray LaHood told The Associated Press that he wants to consider the idea, which has been proposed in some states but has angered many drivers.

"It is not and will not be the policy of the Obama administration," Gibbs told reporters, when asked for the president's thoughts about the policy and LaHood's remarks.

Gasoline taxes that for nearly half a century have paid for the federal share of highway and bridge construction can no longer be counted on to raise enough money to keep the nation's transportation system moving, LaHood told the AP in an interview Thursday.

"We should look at the vehicular miles program where people are actually clocked on the number of miles that they traveled," the former Illinois Republican lawmaker said Thursday.

LaHood spokeswoman Lori Irving said Friday that the secretary was speaking of the idea only in general terms, not as something being implemented as administration policy.

Most transportation experts see a vehicle miles traveled tax as a long-term solution, but Congress is being urged to move in that direction now by funding pilot projects.

The idea also is gaining ground in several states. Governors in Idaho and Rhode Island are talking about such programs, and a North Carolina panel suggested in December the state start charging motorists a quarter-cent for every mile as a substitute for the gas tax.

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A blue-ribbon national transportation commission is expected to release a report next week recommending a VMT.

The system would require all cars and trucks be equipped with global satellite positioning technology, a transponder, a clock and other equipment to record how many miles a vehicle was driven, whether it was driven on highways or secondary roads, and even whether it was driven during peak traffic periods or off-peak hours.

The device would tally how much tax motorists owed depending upon their road use. Motorists would pay the amount owed when it was downloaded, probably at gas stations at first, but an alternative eventually would be needed.

Rob Atkinson, chairman of the National Surface Transportation Infrastructure Financing Commission, the blue-ribbon group that is developing future transportation funding options, said moving to a national VMT would take about a decade.

Privacy concerns are based more on perception than any actual risk, Atkinson said. The satellite information would be beamed one way to the car and driving information would be contained within the device on the car, with the amount of the tax due the only information that's downloaded, he said.

URL: http://www.msnbc.msn.com/id/29298315/

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