# Quantitative Literacy in the News

Topics from the QM4PP project
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## Abstract

In the QM4PP project at Macalester, we used themes from the current news to help develop quantitative literacy in our students. This presentation covers some of the literacy topics we cover, deriving them from discussions of current issues such as global warming, mad-cow disease, immigration policy, and social security. It also shows some examples of how technology can help involve all students in the discussions and force them to confront some of the quantitative issues inherent in many news topics.

## Defining Quantitative Literacy

Quantitative literacy is the ability to identify, understand, and use quantitative arguments in **everyday contexts**.

Quantitative literacy describes a **habit of mind** rather than a set of topics or a list of skills.

…a person who knows calculus is not necessarily any more literate than one who knows only arithmetic. The person who knows calculus formally but cannot see the quantitative aspects of the surrounding world is probably not quantitatively literate, whereas the person who knows only arithmetic but sees quantitative arguments everywhere may be.

-Deborah Hughes-Hallett

## Mathematics in Context

If quantitative literacy is the ability to identify quantitative relationships in a range of contexts, it must be taught in context. Thus, quantitative literacy is everyone's responsibility.

Recognizing mathematics in another field requires understanding the context. A student's ability to understand a context depends heavily on the relationship of that student to the field in question. For example, nonscience students in calculus often dislike applications from physics because they do not understand that field. On the other hand, the same students may easily grasp applications from the life sciences and economics.

-Deborah Hughes-Hallett

## A Cookbook Example

Quantitative literacy is the ability to identify, understand, and use quantitative arguments in everyday contexts. –D. H.-H.

- You are given a 1½ lb roast and a recipe
  - 3½ pound loin
  - 1 lb onions
  - 1¼ lb rhubarb
  - Cook 50 minutes at 500 deg
- How do you apply your mathematical knowledge to cooking?
  - How much onion and rhubarb to use?
    - Similarity and the mathematics of proportion
  - What cooking temperature and time?
    - Linear approximation to functions? It's hopeless without context.

## We Effectively Segregate Quantitative Reasoning

- Truism: Quantitative inclinations of students vary markedly between departments.
- Truism: Some departments serve as concentration points for quantitatively disinclined students.
- Within those non-quantitative departments, what meaningful context can we give for developing useful quantitative reasoning?

## Quantitative Courses among Students in Classes, by Department.

Fraction of students in department classes.

Key: Red – took no Q courses before graduating. Tan took 1 Q course, …

## Quantitative Courses among Majors

Fraction of majors in the department.

Key: Red – took no Q courses before graduating. Tan took 1 Q course, …

## A Common Context for QL

- Items in the news, particularly matters where personal opinion needs to be balanced against the opinions of others: Public Policy.
- QM4PP --- Quantitative Methods for Public Policy
  - A prototype of a graduation requirement in quantitative literacy.
  - Disciplinary "participating courses" linked together by a core of quantitative sessions.

## Some Policy Topics

- Response to Global Warming
  - How much $CO_2$ should the US produce?
- Mad Cow Disease
  - Is the USDA testing regime adequate?
- Immigration
  - How open should our policies be?
  - Do we need better IDs to deter terrorism?
- Taxes
  - How should we change social security?

## Some News Since We Last Met

- Yesterday: Kyoto accord goes into effect, but not in the US which doesn't participate in the system.
- Last week: Pres. Bush proposes changes to Social Security system
- Last week: House of Representatives passes the "Real ID" bill.

**A slide used in one class.**

## Some Quantitative Topics that Span Policy Topics

- Rates
- Growth
- Trade-offs
- Detection
- Sampling

# Rates

## Is a big population good or bad?

- Increased drain on fixed natural resources
- Crowding, congestion, traffic
- Lower wages (supply exceeds demand)

BUT

- Larger economy => economies of scale
  - E.g., public transportation requires high density
  - Larger markets for movies, books, newspapers => diversity
- Greater specialization of workers
  - Benefits of open markets/free trade

## Is population increase good or bad?

- Depends on whether we are above or below the ideal target population.
- Too fast an increase stresses infrastructure.
- Demographic issues: age structure of population, wage structure for workers.
- Cultural issues: assimilation and tolerance
- Can we benefit from "draining the brains" and capital of other countries?
- Growing out of debt [Lincoln's proposal]
- Growth as a component of planning [adding without cutting]

## Two Questions

1. What should our population be?
2. How should we get there?
   - Birth rate
   - Death rate
   - Immigration

*Why would we want to answer (2) before we answer (1)?* If we thought the issues that shape (2) are more important than those shaping (1).

## Q1: What would be an ideal population for the US?

| | |
|---|---|
| 1) 25M | 6) 400M |
| 2) 50M | 7) 600M |
| 3) 100M | 8) 1 Billion |
| 4) 200M | 9) 1.5 Billion |
| 5) 300M | 10) 2 Billion |

## Population

- One way to estimate what our ideal population should be is to look at countries that we admire, and copy them.

3

## Populations of Largest Countries

| Country | Population | | Country | Population |
|---|---|---|---|---|
| China | 1,246,871,951 | | Turkey | 65,599,206 |
| India | 1,000,848,550 | | Iran | 65,179,752 |
| United States | 272,639,608 | | Thailand | 60,609,046 |
| Indonesia | 216,108,345 | | Ethiopia | 59,680,383 |
| Brazil | 171,853,126 | | United Kingdom | 59,113,439 |
| Russia | 146,393,569 | | France | 58,978,172 |
| Pakistan | 138,123,359 | | Italy | 56,735,130 |
| Bangladesh | 127,117,967 | | Congo, Democratic Republic of the | 50,481,305 |
| Japan | 126,182,077 | | Ukraine | 49,811,174 |
| Nigeria | 113,828,587 | | Burma | 48,081,302 |
| Mexico | 100,294,036 | | Korea, South | 46,884,800 |
| Germany | 82,087,361 | | South Africa | 43,426,386 |
| Philippines | 79,345,812 | | Colombia | 39,309,422 |
| Vietnam | 77,311,210 | | Spain | 39,167,744 |
| Egypt | 67,273,906 | | Poland | 38,608,929 |

## Persons per square km

| Country | Persons per sq km | | Country | Persons per sq km |
|---|---|---|---|---|
| Hong Kong | 6571 | | El Salvador | 282 |
| Singapore | 5540 | | Philippines | 266 |
| Gaza Strip | 3091 | | Haiti | 250 |
| Bahrain | 1015 | | Jamaica | 245 |
| Bangladesh | 949 | | United Kingdom | 245 |
| Taiwan | 685 | | Vietnam | 238 |
| Korea, South | 477 | | Germany | 235 |
| Netherlands | 466 | | Cyprus - Turkish Sector | 225 |
| Puerto Rico | 434 | | Italy | 193 |
| Lebanon | 348 | | Switzerland | 183 |
| Belgium | 337 | | Nepal | 178 |
| Japan | 337 | | Korea, North | 178 |
| India | 337 | | Pakistan | 177 |
| Rwanda | 327 | | China | 134 |
| West Bank | 286 | | Poland | 127 |
| Israel | 283 | | Denmark | 126 |

| Country | Persons per sq km | | Country | Persons per sq km |
|---|---|---|---|---|
| Indonesia | 118 | | Tanzania | 35 |
| Uganda | 114 | | Cameroon | 33 |
| Guatemala | 114 | | Eritrea | 33 |
| Kuwait | 112 | | Estonia | 33 |
| Slovakia | 111 | | Yemen | 32 |
| Hungary | 110 | | Guinea | 31 |
| **France** | **108** | | Liberia | 30 |
| Portugal | 108 | | United States | 30 |
| Malawi | 106 | | Faroe Islands | 29 |
| Serbia | 103 | | Zimbabwe | 29 |
| Egypt | 68 | | | |
| Ethiopia | 53 | | | |
| Mexico | 52 | | | |
| Iraq | 52 | | | |
| Jordan | 51 | | | |
| Somalia | 11 | | | |
| Congo, Republic of the | 8 | | | |
| Canada | 3 | | | |
| Australia | 2 | | | |

## Population Density is Uneven
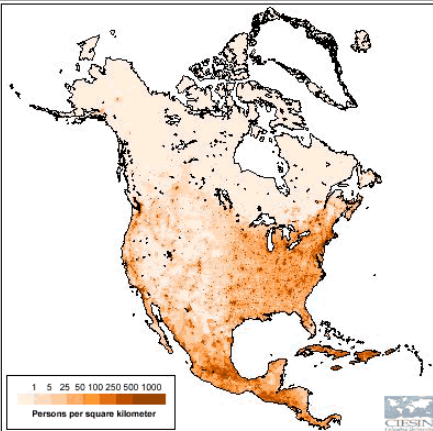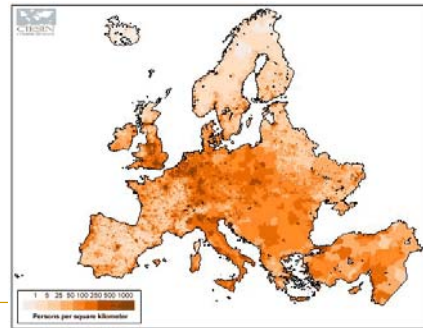


## Quality of Life is Complicated

Response and Explanatory variables.
Response: "Quality of Life"
Explanatory variables
- Population size, density, clustering, …
- Quality of land,
- Available capital, incl. human capital
- Political factors,
- ….

How do we adjust for all these things to single out the effect of population size?



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## Why do people immigrate from Mexico to the US?

Argument: Many aspects of the quality of life --- nutrition, health care, safety, risk of violence --- are summarized by the number of deaths.

Evidence: Annual number of deaths
- US:           2,600,000 deaths each year
- Mexico:        480,000 deaths each year

Does this indicate that the US is worse off than Mexico?

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Question 2:  Do you agree with the following statement: The much larger number of deaths per year in the US than in Mexico indicate that Mexico is a better place to live than the US in some important ways.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | Somewhat Disagree | Neutral | Somewhat Agree | Strongly Agree |

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## Deaths per 1000 people

- US ---        4.8 per 1000 people
- Mexico ---    8.8 per 1000 people

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Question 3:  Do you agree with the following statement: The death rate of 4.8 per 1000 (per year) in the US versus 8.8 per 1000 (per year) in Mexico indicate that the US is a better place to live than Mexico in some important ways.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | Somewhat Disagree | Neutral | Somewhat Agree | Strongly Agree |

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## Deaths per 1000 people - Corrected

- US ---        8.8 per 1000 people
- Mexico ---    4.8 per 1000 people

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Question 4:  Do you agree with the following statement: The death rate of 8.8 per 1000 (per year) in the US versus 4.8 per 1000 (per year) in Mexico indicate that the Mexico is a better place to live than the US in some important ways.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | Somewhat Disagree | Neutral | Somewhat Agree | Strongly Agree |

## What's misleading about deaths/1000 people (per year)?

- Total deaths per year is misleading because it reflects to some extent the population size.
- Deaths/1000 (per year) is a rate: it adjusts for population size.
- What does it not adjust for?
  - Age structure of the population. Mexico has a population that is much younger than the US.

## Age Structure of Population
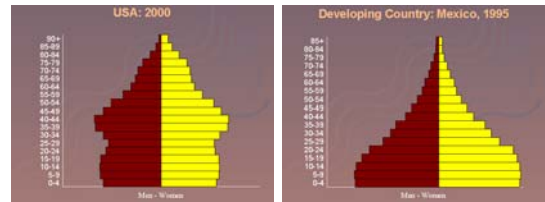


| Country | Mortality Rate | Birth Rate | Life Expectancy | |
|---|---|---|---|---|
| | | | Male | Female |
| Mexico | 4.8 | 25.0 | 69.0 | 75.2 |
| US | 8.8 | 14.3 | 73.0 | 79.7 |
| Gaza | 3.8 | 48.2 | 72.0 | 75.0 |
| Israel | 6.2 | 19.8 | 76.7 | 80.6 |
| UK | 10.6 | 11.9 | 74.7 | 80.2 |
| Latvia | 15.8 | 8.6 | 61.2 | 73.7 |
| Russia | 15.0 | 9.6 | 58.8 | 71.7 |
| Haiti | 14.0 | 32.6 | 49.5 | 53.9 |

G-7 countries
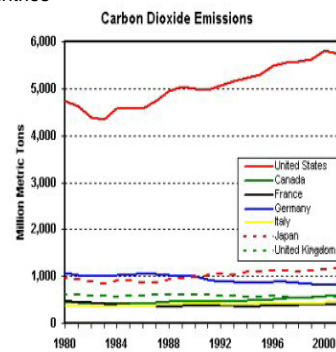


## What Fraction of Global $CO_2$ Production is Due to US?

1. 10%
2. 20%
3. 30%
4. 40%
5. 50%
6. 60%
7. 70%
8. 80%

## The Largest Producers of $CO_2$

1998 (Millions of Metric Tons of Carbon)

- United States    1495
- China    740
- Russia    405
- Japan    288
- India    253
- Germany    227
- United Kingdom    147
- Canada    138

Question: As a matter of basic fairness, the US should cut its energy-related CO2 production by
- 1: 10%      2: 20%      3: 30%
- 4: 40%      5: 50%      6: 60%
- 7: 70%      8: 80%      9: 90%

## Per Capita Emissions of $CO_2$

- United States              5.5 tons/year
- China                            0.6
- Russia                           2.8
- Japan                            2.3
- India                             0.3
- Germany                       2.8
- United Kingdom            2.5
- Canada                         4.6

## $CO_2$ Production adjusted for GDP
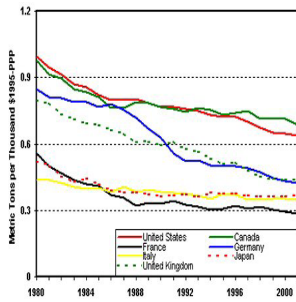


## Shadow Prices
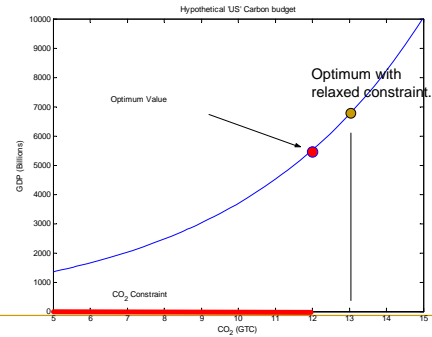


## Trading Constraints
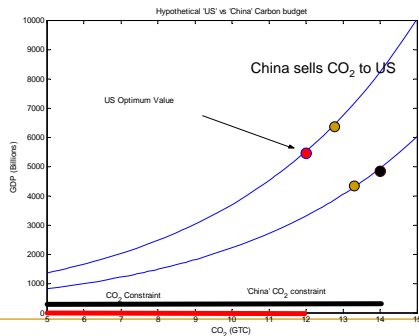


## Wind Power at Macalester

- No fuel use
- No pollution
- No $CO_2$
- A positive symbol?

Vs

- Expense
- A negative symbol?

## What fraction of Macalester's electricity does the turbine produce?

1) 0.001% of our electricity use
2) 0.01%
3) 0.1%
4) 1%
5) 10%
6) 100%

St. Paul, Minn. — The 90-foot-tall tower topped with sleek, silver blades looks like the wind turbines that dot Minnesota's prairies. But this one stands on the edge of the Macalester college football field, surrounded by a densely populated urban neighborhood.

Macalester's Tom Welna read a long list of thank-you's at the switch-flipping ceremony, including one to the St. Paul Zoning Committee. "The zoning committee went out on a limb and trusted that we were not erecting a noisy eyesore in a perfectly good neighborhood. And speaking of perfectly good neighborhoods, I also want to thank the many neighbors who called in, wrote in letters of support for this project," Welna said.

The college's graduating class of 2003 is raising money to pay for the tower's installation. "I think its a powerful symbol of where we need to go, and it's an icon for the school and the neighborhood, and it should generate more than just electricity," Dan Moring, a Macalester senior, said.

Other speakers agreed that the turbine was largely symbolic. It would take 300 such turbines to generate all the electricity the college needs. But speakers said the turbine will also be a useful study tool. It will generate data on how much electricity is produced at different windspeeds and it will provide a focus for discussion of wind-power issues.

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The Macalester turbine is one of only a handful of urban wind turbines nationwide. The turbine and tower plus the equipment to hook it into the grid cost $40,000. The cost was paid for by Minnesota's largest utility, Xcel Energy. Xcel's Laura McCarten says the company has been a nationwide leader in wind energy issues, and strong supporter of alternative energy.

"From windpower on both a large and small scale, to windpower, to photovoltaics to fuel cell technology, we work to foster the growth of alternative energy sources, and to prepare for a more environmentally friendly future," McCarten said.

But another speaker at the event questioned whether Minnesota really is headed toward the environmentally friendly future touted by Xcel.

Andrew Lambert is a 2001 graduate of the Unversity of Minnesota who now works with a group called the Green Institute to develop renewable energy. Lambert pointed to bills in the state House and Senate to allow Xcel to expand its nuclear waste storage. The expanded storage would allow the company to keep its two nuclear plants operating long into the future.

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"This presents an enormous disincentive for renewable energy development by continuing to supply a large chunk of the market with nuclear power. We can do better. We're smarter than that. Aldo Leopold said, 'A thing is right when it tends to preserve the integrity, stability and beauty of the biotic community. It is wrong if it tends otherwise.' Procuring electricity from renewable resources like solar, fuel cells and wind turbines like this is clearly the right thing to do," Lamber said.

Macalester spokesman Welna said afterwards that Lambert had been asked to speak because the senior class had requested someone to speak on energy in a broader sense. He said the college, "suspected but didn't know specifically" that the topic of nuclear waste storage would be raised. Welna says the college has an open and flexible tradition, and respects academic freedom.

"I truly do not believe that this is a choice that if you want renewables, you have to shut the nuclear plants down," countered Xcel's Laura McCarten. "They co-exist, they should co-exist, they can co-exist, and with the plans that we have to add even more windpower, as we sit here today over 800 megawats by 2007, we'll continue to have one of the strongest programs in the nation."

Critics say Xcel has added windpower only because the state legislature required it to as part of a law allowing it to expand its nuclear storage in the early 1990s. If the company is denied permission for more nuclear storage, it plans replace its nuclear plants with two conventional power plants, one fired by coal, and the other by natural gas.

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## Fuel and capital costs of generation

- Generates up to 10KWH.
- Wind fluctuates. Average generation is about 0.3% of College's electricity.
- We pay $600,000/year for electricity, so the turbine saves $1800/year.

- Cost approx. $55,000
- NPV of $1800/year over 40 years @5 % is $31,374.

Conclusion: Wind generation is economically almost viable even at this scale!

Large scale turbines are much more cost effective.

So why isn't it everywhere?

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The College currently spends about $600,000 per year on electricity:

$330 per student per year.

How much would you be willing to charge every student to eliminate $CO_2$ production due to Macalester energy use? (Not covered by financial aid.)

1) $5 per year
2) $10 per year
3) $50 per year
4) $100 per year
5) $200 per year
6) $500 per year

## Buying our way out of Electricity $CO_2$ production

- XCEL energy sells Wind power: roughly 30% increase in electricity cost.
- To buy the wind-turbine equivalent electricity from XCEL would cost $600/yr, compare to $2700/year cost of turbine ($55,000 total cost of turbine @ 5%/yr endowment draw rate).

## Windsource adds about 30% to energy charges

- Corresponds to approximately doubling fuel costs.

Cost to College: $100 per student

- College is committed to meeting the full need of all admitted students.
- 70% of students receive need-based aid.
- So, $100 per student per year corresponds to a tuition increase of $100/.3 : **$333 dollars per year**

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- What if everyone did this?

- We couldn't. For technical reasons wind would be limited to about 20% of electricity consumption and that comes with a huge investment.

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## CBS News on Mad Cow Disease

Risk To Humans

Mad cow disease is a concern because scientists believe that eating brain or spinal matter from an infected cow can cause a TSE in humans called "variant" Creutzfeldt-Jakob disease. A total of 153 people worldwide have been reported to have contracted this form of the illness, according to the federal Centers for Disease Control and Prevention. Most cases occurred during an outbreak in Great Britain in the 1980s.

Separately, about 250 people in the United States alone are diagnosed with "classic" CJD, a disease doctors have known about for 80 years. The cause of classic CJD is unknown 85 percent of the time. The remaining cases are either caused by inheriting a genetic mutation or acquired through medical procedures that used contaminated equipment or tissues.

The two forms of CJD differ in several ways: in the age of their victims, the speed in which they kill and the initial symptoms. "Classic" CJD has been found in both vegetarians and meat-eaters. And it is important to note that neither is a communicable disease -- and you can't "catch" it from someone else.

April 28, 2004,
http://www.cbsnews.com/stories/2004/04/28/earlyshow/contributors/melindamurphy/main6
14154.shtml

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## More from CBS news

So it's safe to eat meat?

Federal officials say American beef is safe despite the latest mad cow diagnosis, noting that the prions that cause both mad cow disease and variant CJD have not been found in cow muscle tissue, which is the source of roasts, steaks and other beef cuts.

In 2002, California scientists reported that mice exposed to prions did accumulate them in muscle. They called for a major effort to look for prions in muscle of infected livestock. But other researchers have found that muscle tissue from infected cows couldn't spread disease when put into other animals.

Processed meats are slightly riskier to eat. Meat such as ground beef, hot dogs, taco meat, and luncheon meats are made from several sources of meat. They are obtained by machines, known as advanced meat recovery systems, that strip flesh from the spines and other awkwardly shaped parts of the cow. Some tests have detected tissue from the central nervous system in samples of beef products. However, many meat companies remove the spine and brain before slaughter.

Such tissues are not supposed to be in meat products in the United States unless they are labeled. Industry officials say Agriculture Department tests on beef products found incidental amounts of central nervous system cells.

Consumers with other food safety questions can phone the toll-free USDA Meat and Poultry Hotline at 1-888-MPHotline.

Question 8:  Based on the information available, what is the risk of vCJD death for a typical beef-eating person in the US?

About the same as dying from:

1. Sky diving
2. smoking cigarettes
3. driving a car.
4. E. coli infection from hamburger
5. flying in commercial airplanes.
6. living in a brick house rather than a wood-frame house

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## Various Estimates of Deaths from vCJD

- Researchers can only guess how many people have been infected. Mathematical models predict 136,000. Other researchers suggest that about 10,000 cases would be a more realistic estimate. Either number is a tragedy." (Eyeball-to-eyeball with mad cow disease – Dr. George Johnson On Science)
- "Experts previously estimated that anywhere between a few hundred to 100,000 people in Britain could eventually get the fatal brain-wasting illness, variant Creutzfeldt-Jakob disease.
  Now new research published by the Royal Society, Britain's academy of scientists, forecasts that as few as 10 additional people and as many as 7,000 could get the illness by 2080. Variant CJD has killed 132 people so far – 122 of them in Britain... and the incubation period is unknown. Scientists believe it may be longer than 30 years." (Scientists lower mad cow epidemic estimate – CNN – 02/28/2003)
- "Scientists believe as many as 3,800 victims, mostly aged 30 or under, could be involved… The study – carried out at Derriford Hospital in Plymouth and published today in the Journal of Pathology – examined 12,674 appendix and tonsil tissues removed during routine surgery and stored at hospitals." (Why nearly 4,000 young Britons could have CJD without knowing – Daily Mail (London) – Jenny Hope – 05/21/2004)

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Eaten mad cows and dead people in GB/year

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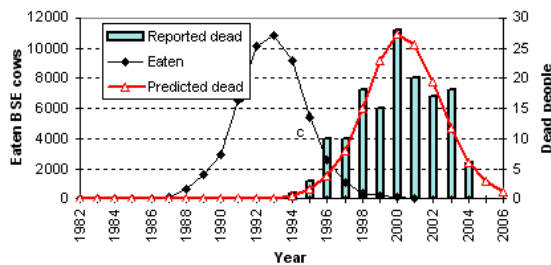
## Mad Cow Numbers

As of December 1, 2003, a total of 153 cases of vCJD had been reported in the world: 143 from the United Kingdom, six from France, and one each from Canada, Ireland, Italy, and the United States (note: the Canadian, Irish, and U.S. cases were reported in persons who resided in the United Kingdom during a key exposure period of the U.K. population to the BSE agent).

Almost all the 153 vCJD patients had multiple-year exposures in the United Kingdom between 1980 and 1996 during the occurrence of a large UK outbreak of bovine spongiform encephalopathy (BSE, commonly known as mad cow disease) among cattle.

There has never been a case of vCJD that did not have a history of exposure within a country where this cattle disease, BSE, was occurring.

The BSE epidemic in the United Kingdom reached its peak incidence in January 1993 at almost 1,000 new cases per week. The outbreak may have resulted from the feeding of scrapie-containing sheep meat-and-bone meal to cattle. There is strong evidence and general agreement that the outbreak was amplified by feeding rendered bovine meat-and-bone meal to young calves.

From:http://www.cdc.gov/ncidod/diseases/cjd/cjd_fact_sheet.htm

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**Evaluation of the Potential for Bovine Spongiform Encephalopathy in the United States**
Joshua T. Cohen, Keith Duggar, George M. Gray, Silvia Kreindel
Harvard Center for Risk Analysis
Harvard School of Public Health
http://www.aphis.usda.gov/lpa/issues/bse/risk_assessment/mainreporttext.pdf

Despite the potential for the consumption of high risk-tissues and the contamination of low-risk tissues, our results indicate that only small amounts of infectivity are available for human consumption. The import of one infected animal yields in an average of 2.7 cattle oral ID50s for potential human exposure over a 20 year period, while the import of ten infected cattle results in an average of 35 cattle oral ID50s this period. These results can be put into context by comparing them to potential exposure in the UK where it is estimated almost one million cattle were infected over a 15 to 20 year period. If the UK population was potentially exposed to only one cattle oral ID50 from each of these animals, potential human exposure in the UK would dwarf our projections for the U.S. At this time, just over 100 cases of variant Creutzfeldt-Jakob disease (the human TSE linked to BSE) have been identified in the UK, although projections range from a few hundred to tens of thousands of eventual cases. If cattle oral ID50s available for human consumption is a good indicator of possible disease risk, it is unlikely the UK experience would be duplicated in the U.S. p. 98

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## What to Compare this to?

**Like Your Burgers on the Raw Side?**
**E. Coli May Give You a Raw Deal: Death**
By Joel R. Cooper, The Medical Reporter © 1995

If you think you can only get E. coli 0157:H7 (Escherichia coli) from undercooked hamburger meat served in restaurants, think again. The infection, which causes diarrhea (often bloody) and abdominal cramps and sometimes even acute kidney failure resulting from hemolytic uremic syndrome (HUS), has also been traced to home-prepared hamburgers. Roast beef, unpasteurized milk, apple cider, and municipal water have also been shown to carry E. coli. A recent article in the New York Times reported E. coli in salami making people sick, too. Apparently, the infection can be spread from person-to-person in child day care centers and pre-school settings as well as in nursing homes and hospitals.

What exactly is E. coli? It's a bacteria commonly found in cattle feces which can be spread by people and animals. According to CDC (Centers for Disease Control and Prevention) estimates, up to 20,400 cases of E. coli infection and **500 deaths from E. coli disease occur annually in the United States.** Nearly three-quarters of all cases are directly linked to ground beef.

## How Much Should I Be Willing to Spend to Save Electricity?

Buy an efficient refrigerator instead of an inefficient one:
- Save approx. 100 kWh per year.
- Life span of fridge approx. 20 years

1) Nothing
2) $10
3) $50
4) $100
5) $150
6) $200
7) $500
8) $1000
9) They should pay me!



## Marginal versus Average Costs of Electricity Production

- Utility companies need to add capacity in order to meet a growing demand.
- New generators cost more per watt-hr than old ones. (Pollution limits, siting difficulties, …)
- They can only charge an average rate for electricity.

## Incentive to Balance Demand with Supply

## Saving with Light Bulbs

What fraction of domestic electricity use would be saved if each household replaced two 100 watt bulbs with high-efficiency alternatives?

1) Less than 1%
2) About 1%
3) About 5%
4) About 10%
5) About 20%



## How can we best use our resources to reduce $CO_2$ production?

- Over the 40 years that the generator will be on campus, it will displace 1,000,000 kWh, equivalent to 150 tons of $CO_2$.
- On the market for $CO_2$ emissions rights, 1 ton of CO2 costs about $10.

In order to reduce $CO_2$, should we:
- Build more turbines on campus?
- Buy wind energy from XCEL?
- Buy $CO_2$ production rights from Russia, then bury them?

## Average vs Marginal Rates

- We measure change by examining two quantities, x and y, in two different conditions.
- On a graph of y vs x, this gives us two points on a curve.
- The rate is the slope of the curve.
- Should the two different conditions be similar or very different?

## Example: Income Tax Owed

- y -- income taxes owed
- x -- total income
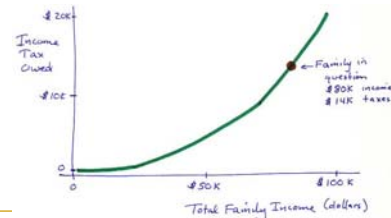
## What is the tax rate?

- Average rate: $14K/$80K = 17.5%
- Marginal rate: 33%



## Which is the right one to use?

It depends on the purpose.

- Marginal rates accurately describe the response to small changes in the system.
  Example: is it worthwhile to work an overtime shift?
- Average rates describe big changes in the system.
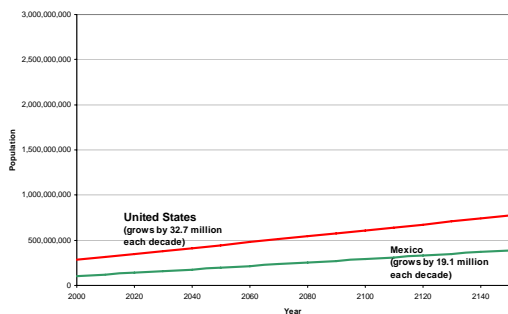  Example: should we shift to a flat tax?

## Growth

In the 1990's, the United States grew by 32.7 million people. Over the same time, Mexico grew by 19.1 million people. If each country continues to grow at the same pace, when will Mexico be larger than the United States?
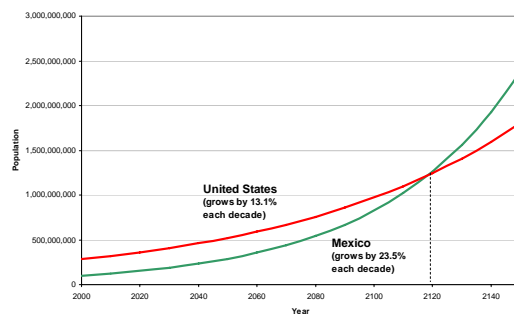
A) Never.
B) 2010.
C) 2060.
D) 2120.
E) 2200.
F) Some time… but who knows when?





Projected U.S. and Mexico populations (linear)

United States (grows by 32.7 million each decade)

Mexico (grows by 19.1 million each decade)



Projected U.S. and Mexico populations (exponential)

United States (grows by 13.1% each decade)

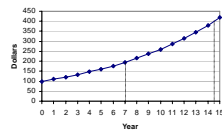Mexico (grows by 23.5% each decade)

## Slide 1

### The Rule 0f 70

To find an estimate of doubling time, apply the following formula:

$$Doubling\ time = \frac{70}{annual\ growth\ rate}$$

**Example:**

10% annual return

Doubling time = 70 / 10 = **7 years**



## Slide 2

YT A15

### College Endowments Post Solid Gains in '04

#### Universities Still Feeling Pressure After Losses of Previous Years

**By GREG WINTER**

Buoyed by a healthy stock market, university endowments posted robust earnings in 2004, but not enough to compensate fully for the losses of previous years and to enable the kind of spending that many institutions depend on to run their campuses, according to the most recent annual survey by the National Association of College and University Business Officers.

Endowments — the financial stockpiles that help determine an institution's financial health and often pay for crucial aspects of academia, including some professors and scholarships — brought in an average 15.1 percent return during the 2004 fiscal year. It was one of the largest average returns since the mid- to late 1990's, and it came as a huge relief after declines in 2001 and 2002, followed by only a modest rebound in 2003.

**Investment Rebound**

One-year return rates on investments for college endowments.
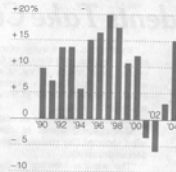


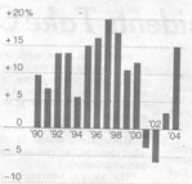Source: National Association of College and University Business Officers

ties say the additional money has not been enough to offset recent cuts in state contributions.

With strong investment returns and a capital campaign to help it along, the University of Michigan's endowment grew by about $700 million, or 20 percent, during the 2004 fiscal year. That would seem to dwarf the $44 million in cuts from the state that the university says it has faced in the last two years. But because Michigan, like most careful institutions, imposes strict rules on spending from its endowment, it would have had to raise about $880 million just to make up for the loss in state money.

"We got pretty close, but we didn't quite do that," said Timothy P. Slottow, Michigan's chief financial officer. "Even if we did, the substitutes for state money are difficult to come by."

## Slide 3



Taking into account the return on investments over the entire period from 1990 to 2004, how much did college endowments grow?

1) Quadrupled

2) Tripled

3) Doubled

4) 50% growth

5) 25% growth

6) No growth

7) Decline

## Slide 4

**Growth of college endowments**



## Slide 5
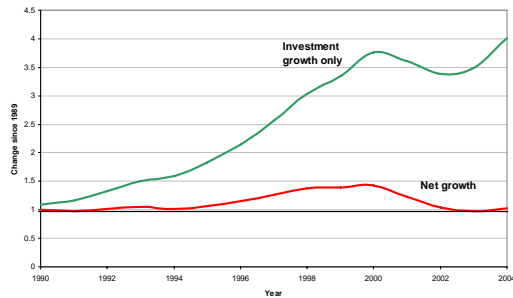
| Year | Investment Growth | Draw | Expense | Inflation | NET |
|---|---|---|---|---|---|
| 1990 | 1.095 | 0.05 | 0.005 | 0.04 | 1.000 |
| 1991 | 1.070 | 0.05 | 0.005 | 0.04 | 0.975 |
| 1992 | 1.135 | 0.05 | 0.005 | 0.04 | 1.040 |
| 1993 | 1.135 | 0.05 | 0.005 | 0.04 | 1.040 |
| 1994 | 1.055 | 0.05 | 0.005 | 0.04 | 0.960 |
| 1995 | 1.150 | 0.05 | 0.005 | 0.04 | 1.055 |
| 1996 | 1.170 | 0.05 | 0.005 | 0.04 | 1.075 |
| 1997 | 1.200 | 0.05 | 0.005 | 0.04 | 1.105 |
| 1998 | 1.180 | 0.05 | 0.005 | 0.04 | 1.085 |
| 1999 | 1.105 | 0.05 | 0.005 | 0.04 | 1.010 |
| 2000 | 1.120 | 0.05 | 0.005 | 0.04 | 1.025 |
| 2001 | 0.960 | 0.05 | 0.005 | 0.04 | 0.865 |
| 2002 | 0.940 | 0.05 | 0.005 | 0.04 | 0.845 |
| 2003 | 1.030 | 0.05 | 0.005 | 0.04 | 0.935 |
| 2004 | 1.150 | 0.05 | 0.005 | 0.04 | 1.055 |
| **TOTAL** | **4.013** | | | | **1.027** |

## Slide 6

For a 20 year old worker earning an average wage, what percentage of her annual income must she save in order to retire at age 65?

A) 1%

B) 5%

C) 10%

D) 25%

E) 35%

F) 50%

**The New York Times**
nytimes.com

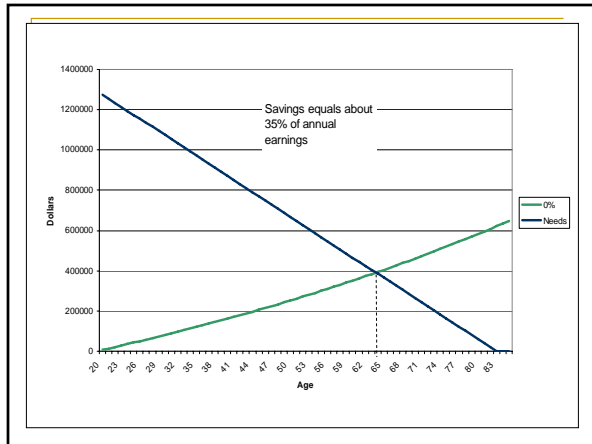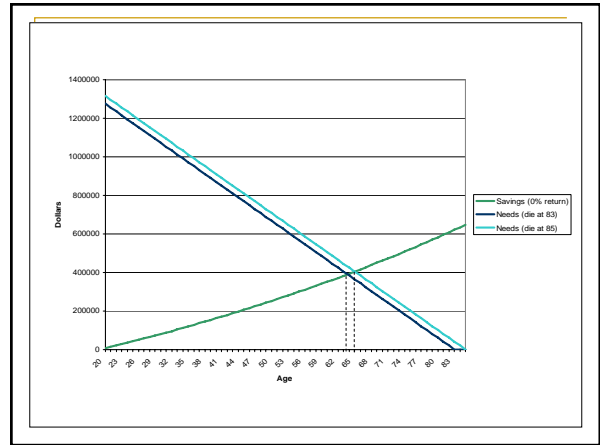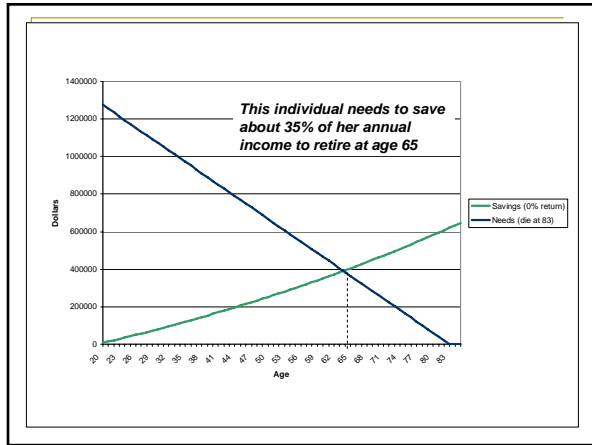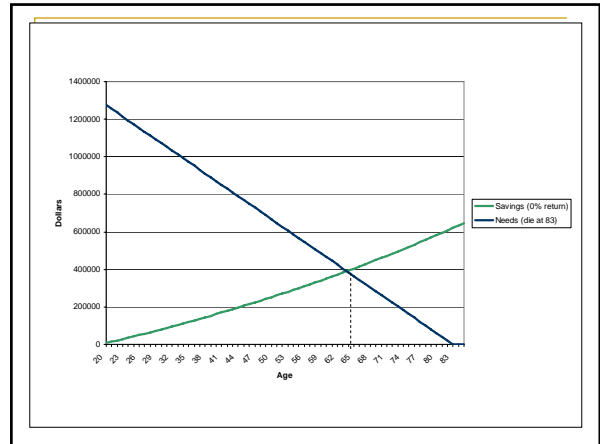### In Overhaul of Social Security, Age Is the Elephant in the Room

**WASHINGTON, June 11 -** Americans turning 65 this year can expect to live, on average, until they are 83, four and a half years longer than the typical 65-year-old could expect in 1940. And government actuaries predict that American life spans will just keep growing.

This demographic trend - by 2040, the average 65-year-old will live to about 85 - has major financial implications for Social Security and major political implications for the lawmakers now trying to overhaul the system.

### White House Lowers a Bit Its Forecast for '05 Growth

**WASHINGTON, June 8 -** The Bush administration predicted on Wednesday that economic growth would be slightly slower and inflation slightly higher this year than it expected six months ago. …

The White House forecast also assumes that the Federal Reserve will raise interest rates very little in the next four years. It assumes that rates on three-month Treasury bills will remain below 4 percent through 2009.

---

*Chart: Dollars vs. Age — Savings (0% return), Needs (die at 83)*

---

*Chart: This individual needs to save about 35% of her annual income to retire at age 65 — Savings (0% return), Needs (die at 83)*

---

*Chart: Savings (0% return), Needs (die at 83), Needs (die at 85)*

---

*Chart: Savings equals about 35% of annual earnings — 0%, Needs*

---

*Chart: Savings equals about 35% of annual earnings — 0%, 1%, 2%, 3%, Needs*

15

## CO2 Production adjusted for GDP



## Trade-offs
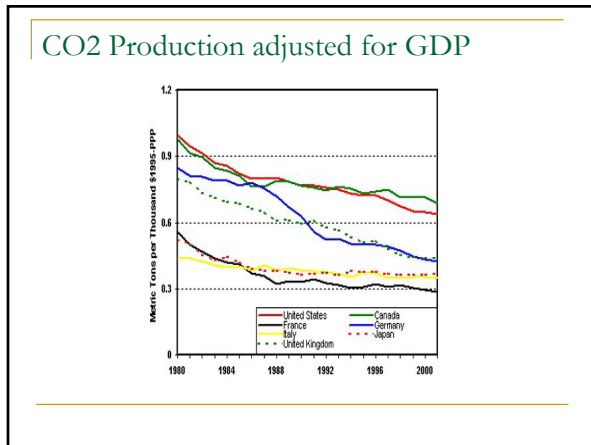
Question: What's an appropriate target for US $CO_2$ cuts compared to other G-7 countries?

- 1: 10%      2: 20%      3: 30%
- 4: 40%      5: 50%      6: 60%
- 7: 70%      8: 80%      9: 90%
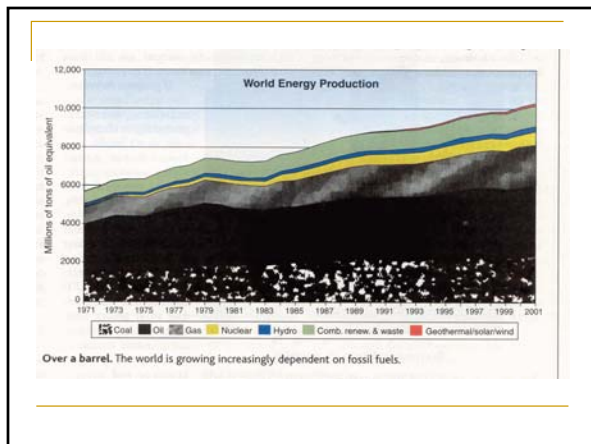


| Share  in electricity production | | |
|---|---|---|
| | **Denmark** | **France** |
| Coal | 51.6 | 6.2 |
| Oil | 12.5 | 2 |
| Gas | 23.5 | 1.4 |
| Nuclear | 0 | 75.8 |
| Hydro | 0.1 | 13.9 |
| Wind+Photo | 7.8 | 0.1 |
| Biomass | 4.5 | 0.6 |

Sweden is another low-CO2 production country.  Electricity is mainly produced by a mix of nuclear (45%) and hydro-electric (45%).

## Disadvantages to Hydro power?

- Cost of development
- Limited availability for geographical reasons
- Environmental --- Is the cure sometimes worse than the disease?

  file:///B:/Courses/QA/2004Fall/Sept-23-2004/impactsofhydroelectricdevelopment.htm
  http://www.the-tree.org.uk/TreeTalk/1Autumn2002/impactsofhydroelectricdevelopment.htm

## Quick Quiz

- Consider 4 policies, labeled A,B,C, & D
- Each policy is evaluated on two outputs: black and green.
- Next slide shows a plot of the values of the black and green outputs for each of the 4 policies.

- Which is the best policy?
- Which policies are better than others?

## Which is the best policy?
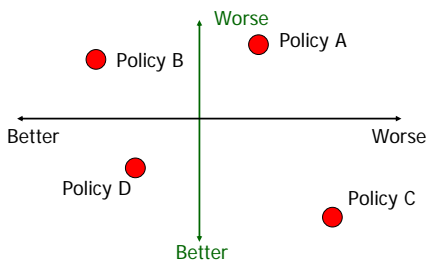


A – 1 ;   B – 2 ;   C – 3;   D – 4;

## Answer to Quiz

- A is clearly worse than B or D.
- A might be better or worse than C.
- C might be better or worse than B or D.
- B might be better or worse than D.
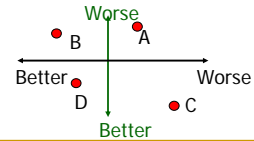


## Multiple Outputs have no Optimium (in general)

The word "best" has no mathematical meaning when there is more than one output.

## But Not All Situations Are Hard



Policy B is the best; it dominates the others.

## More Terminology

**Incommensurate.** Two quantities are incommensurate when they cannot be directed compared. Example: Inches and Liters. Example: Human rights & GDP. $CO_2$ & GDP.

**Domination.** One policy dominates another when all the outputs are better than the outputs for another policy.
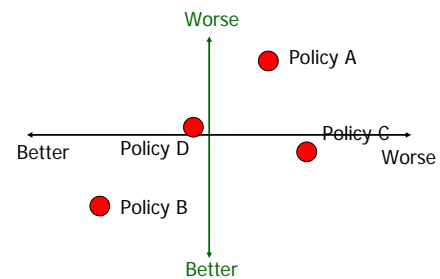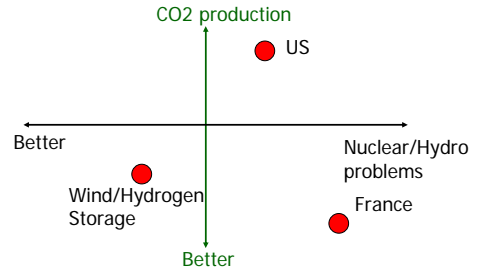
## Some Policy Choices in Global Warming



A – 1 ;    B – 2 ;    C – 3;    D – 4;

## Multiple Outputs Lead to Suboptimal Policies

- When there is a single output we can optimize the policy.
- When there are multiple (conflicting) outputs the selected policy will not be optimal for all outputs.
- We tend to compromise, making each output somewhat sub-optimal.
- In comparing two systems (e.g., public v. private schools), it's important to look at all the outputs and not just a single one.
- Race cars and bicycles compare differently when evaluated on different scales.  I prefer a bicycle for my purposes but that doesn't mean a bicycle is better for all purposes.

## Dealing with Trade-Offs

- Make trade-offs explicit; acknowledging them
- Look for dominating policy
- Talk in other people's terms
- Ignore the trade-off
- Reduction to a single goal: bottom line, loss function, present value
- Conversion via a market price
- Conversion via shadow prices

## Acknowledging Multiple Outputs

- per capita GDP
- total GDP (buying our way out of debt)
- Wages (employees want them high, employers low)
- Finding labor for jobs not desired by US citizens
- Providing refuge or asylum
- Increasing population diversity
- Providing support for domestic retirees
- Avoiding environmental effects/congestion
- Attracting "desirable" people to the US
- Keeping out undesirables
- ESL teaching load in schools

## Multiple outputs for global warming

- Avoiding climate change
- Keeping high GDP
- Allowing developing countries to develop.
- Non-CO2 environmental issues
  - Nuclear proliferation, accidents
  - Damage due to hydro-electric projects
- Security implications of reliance on oil.

18

## Look for Dominating Policy

- Best solution by all measures. But there may not be such a policy.
- Simplify: Ignore policies that are dominated by others.
- **Pareto optimality**: accept only policies that dominate the status quo. Unfortunately, this gives the status quo a privileged status.

## Pareto Optimality in Global Warming

Kyoto puts CO2 constraints on many countries including US, but not including China and India.

This isn't a pareto optimal change, since the change effectively transfers wealth from the Kyoto countries to China and India.

## Ignore the Trade-Off

Choose one output. Optimize policies for that.

- Example: majority rule. Effective, but crude.
- Example: split the difference. Give something to everyone.

## Reduction to a Single Output

- "Bottom Line" in business, or stock price
- Present Value when comparing today with the future. (Covered in cost/benefit class session.)
- Value of a human life when evaluating safety policies.
- Reduction of immigration policy to issues of race.
- Reduction of immigration policy to labor availability.
- Reduction of immigration policy to asylum issues or to social security issues or to …

## Reduction to a single output in Global Warming

- **President Bush**: Emphasize uncertainties in the projections. Maybe global warming isn't happening or isn't caused by $CO_2$.
- **Some environmentalists**: Ignore GDP-related issues.
- **Hollywood**: Amplify risks of global warming to make it a simple matter of survival.

## Child seats on Airplanes
from St. Paul Pioneer Press, Sun. 1 Feb, 2004, Travel Section p. 106

Q: We are flying to Europe with our 1½-year-old and have purchased a seat for her. We are confused about the rules regarding car seat use on planes.

A: You don't need a child restraint seat for children under age 2 on airplanes. Alison Duquett, a spokeswoman for the Federal Aviation Administration, said, "The FAA does not require parents to use a child restraint seat. **However, we strongly encourage it**."

## Airline Child Safety (cont.)
## Lives vs Money or Lives vs Lives

"The issue of whether children under 2 should be permitted to sit on parents' laps while flying has been debated for years.  The American Academy of Pediatrics and the government's National Transportation Safety Board are among the groups that have been lobbying the FAA to mandate child-safety restraints aboard airliners.  The FAA has responded by strongly recommending that parents use child-restraint systems but has not adopted the rule, citing arguments, including the results of a recent study, that conclude that such a law may cause an increase in deaths if parents switch from air to car travel to avoid paying for the extra plane ticket.  Most airlines offer discounts of up to 50 percent on seats for children younger than 2.  Children in laps travel free."

---

## Global Warming Reduction Questions

- What is the $ value of the damage due to global warming?  How does this compare to the costs of reducing $CO_2$ emissions?
- Suppose we could fully nuclearize electricity production worldwide but at a (hypothetical) cost in lives/year.  Would this be worthwhile?

---

## Reducing $CO_2$ by Half through Nuclear Energy

What's the most you would pay?

1) 10 lives per year
2) 100 lives per year
3) 1000 lives per year
4) 10,000 lives per year
5) 100,000 lives per year
6) 1,000,000 lives per year

---

## A Social Dilemma

www.nytimes.com
**The New York Times**
ON THE WEB

March 20, 2002

### Tiny Heart Devices Reduce Death Rate, but Cost Is Concern

By GINA KOLATA

Researchers have found that they can sharply reduce the death rate in high-risk heart attack patients with small but costly devices that are tucked under the skin of the chest and can avert potentially fatal heart rhythms.

The devices, implantable defibrillators, sense when the heart's rhythm is going awry and administer a small electric shock to the heart to bring its fluttering rhythm back to normal, preventing sudden death. The new study found that the device was effective in patients whose hearts were so damaged from heart attacks that they could no longer pump blood effectively.

---

## ICDs (continued 2)

Implantable defibrillators are routinely used for a relatively small group of patients who, like Vice President Dick Cheney, have demonstrable heart-rhythm disturbances. The new study showed that the devices are effective in a much larger group of people who have had serious heart attacks that placed them at risk for heart-rhythm disturbances, but may not have had such problems yet.

The device costs about $20,000, though, and the operation to insert it, another $10,000. With 400,000 new patients a year who could benefit, and an additional three million patients who have already had serious heart attacks who could be helped, some doctors wonder who is going to pay.

Dr. Douglas Zipes, president of the American College of Cardiology, said he and other physicians were bracing for a surge of calls from patients who would want the device.

---

## ICDs (continued 3)

"It's a difficult situation," Dr. Zipes said. "We're looking at changes that could easily rupture the health care budget."

The study, which was reported yesterday at the annual meeting of the American College of Cardiology and will be published tomorrow in The New England Journal of Medicine, found that after an average of 20 months, 19.8 percent of those patients who did not have the devices died, compared with 14.2 percent of those who had them, a 30 percent difference in the death rate.

"There's no question — it's a big effect," said Dr. David Faxon, the president of the American Heart Association. "It's very significant. It offers hope for a large group of patients who have a very bad outlook. Before, we didn't have a good therapy for them."

## ICDs: the Trade-off

For every 20 such patients given an ICD, on average one life will be saved.

- Cost: $30,000 x 20 = $600,000 per life
- What else could we do with $600,000? Drug treatment programs, head start, highway safety, pre-natal care.
- What is the added survival time?
- Personal versus societal decisions:

Dr. Zipes said he planned to implant defibrillators in patients who should be helped and argue with their insurers later.

"Very honestly, if it were I or my father or a loved one, I'd want them to get it," he said.

---

Question: How much should the government be willing to spend to provide implantable cardioverters-defibrillators?

1) $50,000 per saved life
2) $200,000 per saved life
3) $400,000 per saved life
4) $600,000 per saved life
5) $800,000 per saved life
6) $1,000,000 per saved life
7) Don't be crass, Kaplan. You shouldn't put a dollar value on life.

---

Question: Would your answer to the previous question have changed if you took into account the age of the ICD recipient?

1) No. The value of a life doesn't depend on age.
2) No. We told you not to be crass, Kaplan. Now stop it.
3) Yes. It's reasonable to spend less on an older person.
4) Yes. It's reasonable to spend more on an older person.

---

## Value of a Human Life (non-crass version)



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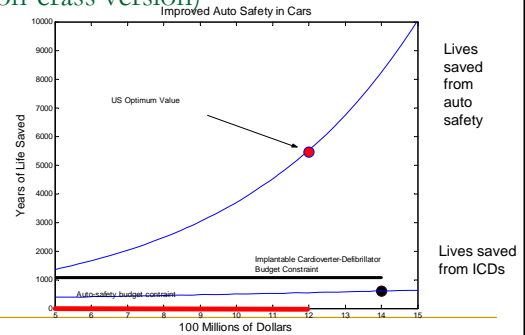
Question: Given these (hypothetical) data on lives saved in auto safety or from ICDs, would you reduce the ICD budget in favor of auto safety?

1) Yes, reduce the budget a lot, until the shadow prices balance.
2) Yes, reduce the budget a little, but not too much.
3) No, keep things they way they are. That's Pareto optimal
4) No, don't keep trying to put a $ value on life, Kaplan. You are soooo crass.

---

## A Social Dilemma Game

Each of us can choose to play either strategy C or D. Our payoff depends both on which strategy we choose as an individual, and what strategy others choose.

D-players get $1 for every C player.

C-players get $1 for every C player - $20

Example: If 15 of 30 choose D, then each D player gets $15. Each C player **pays** $5.

1 --- C player

5 --- D player

## What should we do to get people to cooperate?

- Play the game again, but two students get to address the class beforehand.

[Moral exhortations to cooperate, but mainly this draws attention to the advantages of defecting to those students who didn't think about it.]

## Peer-pressure

- Play the game again, but with a show of hands for C and D, not the anonymous clickers.

[Much more effective at getting people to cooperate, because the defectors have to pay in other ways.]

## Real situations in which this dilemma arises.

Origin of the dilemma:

The individual benefits are different and conflicting with the group benefits, even though both are denominated in dollars.

- Vaccination
- Driving at the speed limit
- Goods held in common: clean air, clean water, $CO_2$ capacity, space, quiet. "The Tragedy of the Commons."
- Paying taxes honestly
- Financial aid at Macalester

## Detection

New York *Times*, September 28, 2004 D.G. McNeil

**Moist Nose Shows Promise in**

**Tracking Down Cancers**

British researchers have trained dogs to detect bladder cancer by sniffing human urine, opening up the possibility that dogs - or electronic noses modeled on their snouts - may one day be used to detect the disease.

The study, published in the British medical journal BMJ on Saturday, is the first to demonstrate scientifically that dogs can detect cancer through smell, its authors said.

The study, done at Amersham Hospital in Buckinghamshire, England, was small; **six dogs sniffed at 54 urine samples** after weeks of training.

As a group, they were only about **41 percent accurate**. That is far below what is considered acceptable on most medical tests, but the idea is in its infancy.

Dog tests might eventually be cheap and work early, and they also might be useful in poor countries, scientists said.

*A dog named Tangle works his way along a line of urine samples during his search for one from a patient with bladder cancer. Tangle has been taught to lie down by a positive sample.*

Suppose another research group announced a test that was 95 percent accurate? Compare the new test to the dog test (which was 41% accurate).

1. The new test would be **much better**.
2. The new test would be **somewhat better**.
3. The new test might be **better or worse**.
4. The new test would be **somewhat worse**.
5. The new test would be **much worse**.

## Slide 1

**Terror no-fly list singled out Kennedy**

**Senator was stopped 5 times at airports**

Sara Kehaulani Goo, Washington *Post* Friday, August 20, 2004

**Washington** -- Sen. Edward "Ted" Kennedy said Thursday that he was stopped and questioned at airports on the East Coast five times in March because his name appeared on the government's secret "no-fly" list.

Federal air security officials said the initial error that led to scrutiny of the Massachusetts Democrat should not have happened even though they recognize that the no-fly list is imperfect. But privately they acknowledged being embarrassed that it took the senator and his staff more than three weeks to get his name removed.

A senior administration official, who spoke on condition he not be identified, said Kennedy was stopped because the name "T. Kennedy" has been used as an alias by someone on the list of terrorist suspects.

## Slide 2

Imagine that the Travel Security Administration developed an ID-card reading system that is 99.9% accurate for detecting terrorists.

1. Impossible, but I would support it.
2. Impossible, and I would not support it.
3. Might be possible, but I would support it.
4. Might be possible, but I would not support it.
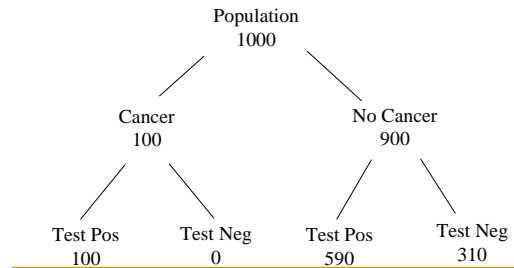


## Slide 3

# BSE/Mad Cow Disease

- In some countries, e.g., UK, Japan, Switzerland, all slaughtered cattle are tested for BSE.
- The US tests about 1% of cattle, and these are mostly the "downers."
- *As the test improves, how accurate does it have to be before you would encourage the US government to use it more widely?*

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|
| 50% | 75% | 90% | 95% | 99% | 99.9% | 99.999% | 99.9999% |

## Slide 4

### Dog Sniffing Cancer Test:

**41% accurate**

```
                    Population
                      1000
                  /          \
            Cancer            No Cancer
             100                900
           /      \           /        \
     Test Pos  Test Neg   Test Pos   Test Neg
       100        0         590         310
```

## Slide 5

### Dog Sniffing Cancer Test:

**95% accurate, but worse than the 41% test**

```
                    Population
                      1000
                  /          \
            Cancer            No Cancer
              25                 975
           /      \           /        \
     Test Pos  Test Neg   Test Pos   Test Neg
        0         25         25         950
```

## Slide 6
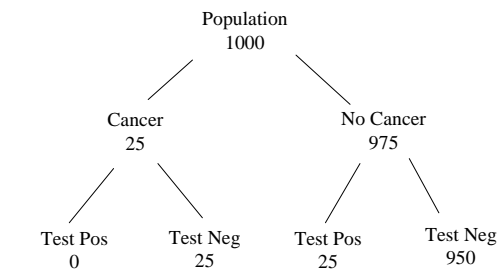
# A Canonical Summary

- **Sensitivity: A/(A+C)**
  For the + objects, what is the probability of a correct test result.
- **Specificity: D/(B+D)**
  For the – objects, what is the probability of a correct test result.
- **Prevalence: (A+C)/n**
  What fraction of the objects are +.
- **Total count:**
  **n=A+B+C+D**

```
                     Population
                        N
                   /          \
          Diseased            Healthy
        N*prevalence        N*(1-prev)
        /        \          /        \
     Pos        Neg      Pos        Neg
     Test       Test     Test       Test
      A          C        B          D
```
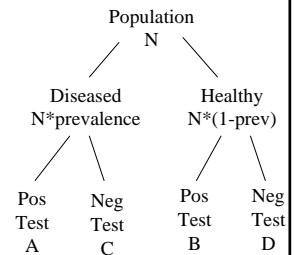
## Transportation Security Administration

- A secret no-fly list established after 9/11 by security, intelligence, and law-enforcement agencies contains the names of known or suspected terrorists.
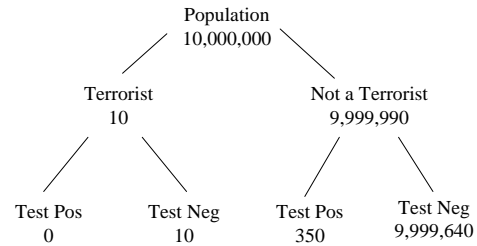
- How does it work? Ticket agents compare the name on the ID card to the list. The government does not make public the names or total number of people on the list, which officials say is constantly updated.

- This system is more than 99% accurate.

---

## Transportation Security Administration No-Fly List:
### 99.9% accurate

Population
10,000,000

Terrorist
10

Not a Terrorist
9,999,990

| Test Pos | Test Neg | Test Pos | Test Neg |
|----------|----------|----------|----------|
| 0 | 10 | 350 | 9,999,640 |

---

## Is this a good test, since it is 99.9% accurate?

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree |

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## Mad-Cow Disease

**Expert Warned that Mad Cow Was Imminent**
*New York Times, Dec.25, 2003*
Ever since he identified the bizarre brain-destroying proteins that cause mad cow disease, Dr. Stanley Prusiner, a neurologist at the Univ. of California at San Francisco, has worried about whether the meat supply in America is safe....
This nation should immediately start testing every cow that shows signs of illness and eventually every single cow upon slaughter, he said he told Ms. Veneman. Japan has such a program and is finding the disease in young asymptomatic animals.

**Plan for Sharp Rise in Mad Cow Testing Gets Mixed Reaction**
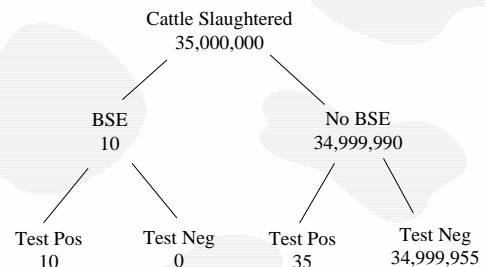*New York Times, March 17, 2004*
The Agriculture Department's plan for a tenfold increase in testing for mad cow disease was greeted yesterday with a mixture of optimism and skepticism.

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## Should we test all cows? Why test just the "downer" cows?

- US 100 million cattle. Japan 4 million
- US 35 million slaughtered each year. Japan 1.2 million
- Japan tests all cows. Found 3 cases in 3 years.
- Testing all cattle would raise price of beef by 2-3 cents per pound.
- Mad cow transmitted by eating nervous-system tissue. Can also occur spontaneously.
- Disease more likely in older cows. Cows with severe disease display strong symptoms: downers.
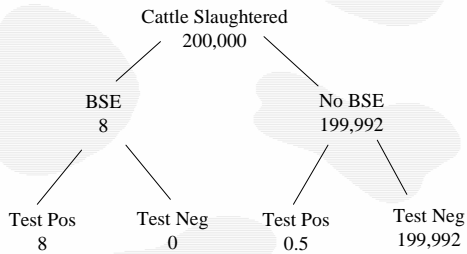
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## Comprehensive BSE testing in US:
### 99.9999% accurate

Cattle Slaughtered
35,000,000

BSE
10

No BSE
34,999,990

| Test Pos | Test Neg | Test Pos | Test Neg |
|----------|----------|----------|----------|
| 10 | 0 | 35 | 34,999,955 |

## Slide 1

**Restricted BSE testing in US (High risk population with 80% of cases):**

99.9999% accurate.

Cattle Slaughtered
200,000

BSE
8

No BSE
199,992

Test Pos
8

Test Neg
0

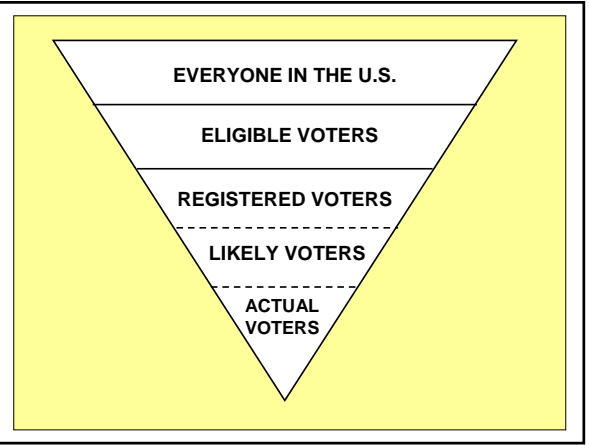Test Pos
0.5

Test Neg
199,992

## Slide 2

Sampling & Polling

## Slide 3

The New York Times
nytimes.com

**Bush Leads. Make That Kerry. Why Can't the Pollsters Agree?**

…But pollsters, who insist that they have the best intentions, say **the differences in their surveys only highlight the difficulties this year in determining who is going to vote**, no small task at a time of unusually high voter interest and many new voter registrations. And how pollsters set about figuring that out, they say, can make all of the difference in how the results are presented on television and in newspapers.

**Why does it matter who is going to vote?**

## Slide 4

EVERYONE IN THE U.S.

ELIGIBLE VOTERS

REGISTERED VOTERS

- - - - - - - - - - - - - - - - - - -

LIKELY VOTERS

- - - - - - - - - - - - -

ACTUAL VOTERS

## Slide 5

If you voted in the 2004 United States presidential election, who did you vote for?

1. John Kerry / John Edwards
2. George W. Bush / Dick Chaney
3. Ralph Nader / Peter Miguel Camejo
4. Other

## Slide 6

**Actual Results**

*CNN.com*

| Bush / Cheney | Kerry / Edwards | Nader / Camejo |
|---|---|---|
| *51* | *48* | *1* |

GEORGE W. BUSH     JOHN KERRY     RALPH NADER

## USA Today/CNN/Gallup Poll

(October 22-24, 2004)

Now, suppose that the presidential election were being held today, and it included … Who would you vote for?

| Bush / Cheney | Kerry / Edwards | Nader / Camejo | Other / Undecided |
|---|---|---|---|
| 51 | 46 | 1 | 2 |

*For results based on the total sample of likely voters, one can say with 95% confidence that the margin of sampling error is ±3 percentage points.*

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# MARGIN OF ERROR



Flip a coin 10 times

Record the number of heads

Do it again

The number of heads could very well be different, even though the experiment was identical to the first

You could get 10 heads, but this is unlikely

**Margin of error gives you a "reasonable" estimate of how much another random sample is expected to differ from the one you are looking at.**

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**A margin of error is often described using percentages:**

*"For results based on the total sample of National Adults, one can say with 95% confidence that the margin of sampling error is ±3 percentage points."*

### POINT 1:

**The percentages tell you the range over which the result might vary due to sampling variability**

\* This has nothing to do with sampling bias

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**The margin of error should always be accompanied by a confidence level:**

*"For results based on the total sample of National Adults, one can say with 95% confidence that the margin of sampling error is ±3 percentage points."*

### POINT 2:

**This confidence level tells you that in 95% of a large number of samples the result would be within 3 percentage points of this result.**

\* It might be phrased as a "confidence interval"

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## USA Today/CNN/Gallup Poll

(October 14-16, 2004)

| Bush / Cheney | Kerry / Edwards | Nader / Camejo | Other / Undecided |
|---|---|---|---|
| 51 | 46 | 1 | 2 |

*For results based on the total sample of likely voters, one can say with 95% confidence that the margin of sampling error is ±3 percentage points.*

*Pollsters believe that in 95% of samples, between 48% and 54% of voters would vote for Bush and between 43% and 49% of voters would vote for Kerry*