ECONOMIC EFFICIENCY AND THE ENVIRONMENT

LESSON OBJECTIVES

01

Define and compare gross and net benefits

02

Identify socially optimal environmental quality

03

Compare static vs. dynamic efficiency

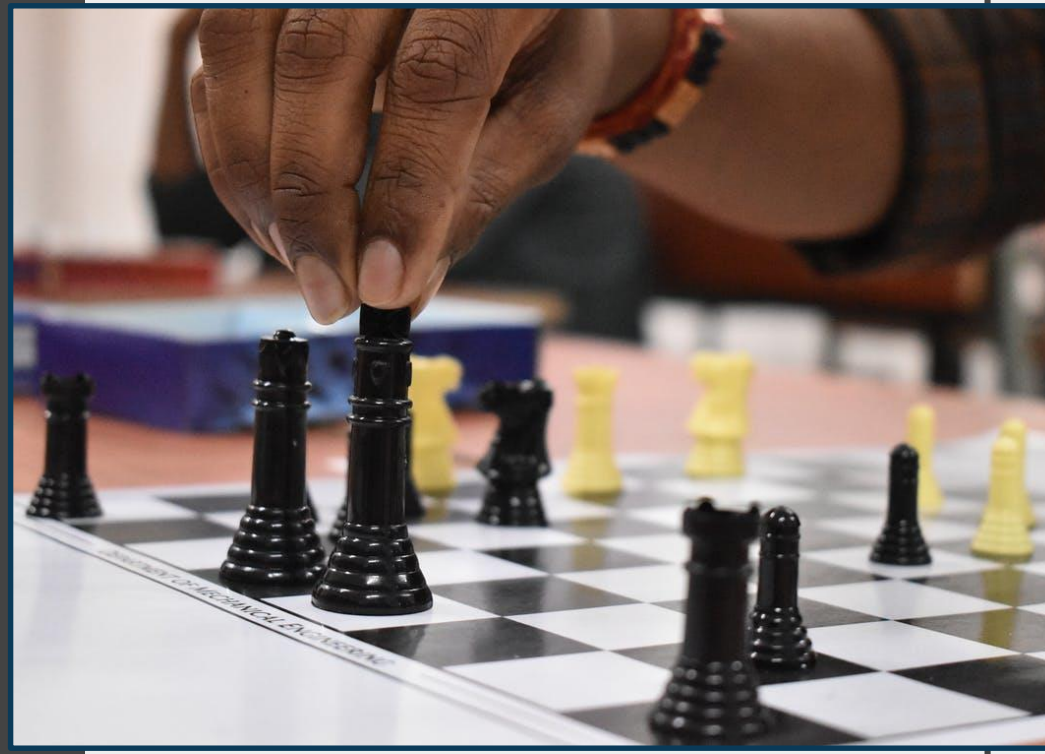
QUESTION OF THE DAY

If hybrid cars use less gas and thus cost less to drive, why doesn't everyone drive a hybrid?

01

DEFINE GROSS AND NET BENEFITS

HOW DO PEOPLE MAKE DECISIONS?



You and a friend go to see Atlanta United play and you are trying to decide where to sit…


VISITOR
HOME
FALCONS
FALCONS
- CLUB LEVEL
- VIP CLUB LEVEL
- LOWER 100 LEVEL
- MIDDLE 200 LEVEL
- UPPER 300 LEVEL
- ACCESSIBLE
ticketmaster

YOUR FRIEND ASKS HOW MUCH YOU WOULD BE WILLING TO PAY FOR A TICKET.

Seat location	Willingness to pay (WTP)
300 level	$50
200 level	$90
100 level	$120
Club	$150

YOU VALUE THE CLUB LEVEL THE MOST, SO SHOULD YOU GET IT?

Seat location	WTP	Price
300 level	$50	$30
200 level	$90	$60
100 level	$120	$100
Club	$150	$250

WHAT TICKET SHOULD YOU GET?

Seat location	WTP	Price	Net Benefit
300 level	$50	$30	($50-30 =) $20
200 level	$90	$60	$30
100 level	$120	$100	$20
Club	$150	$250	$-100

Optimal ticket is determined by **net benefit**, not gross benefit.

PROBLEM

WHAT ABOUT POLLUTION?

POLLUTION DAMAGES

There are many air pollutants with known environmental and health impacts.

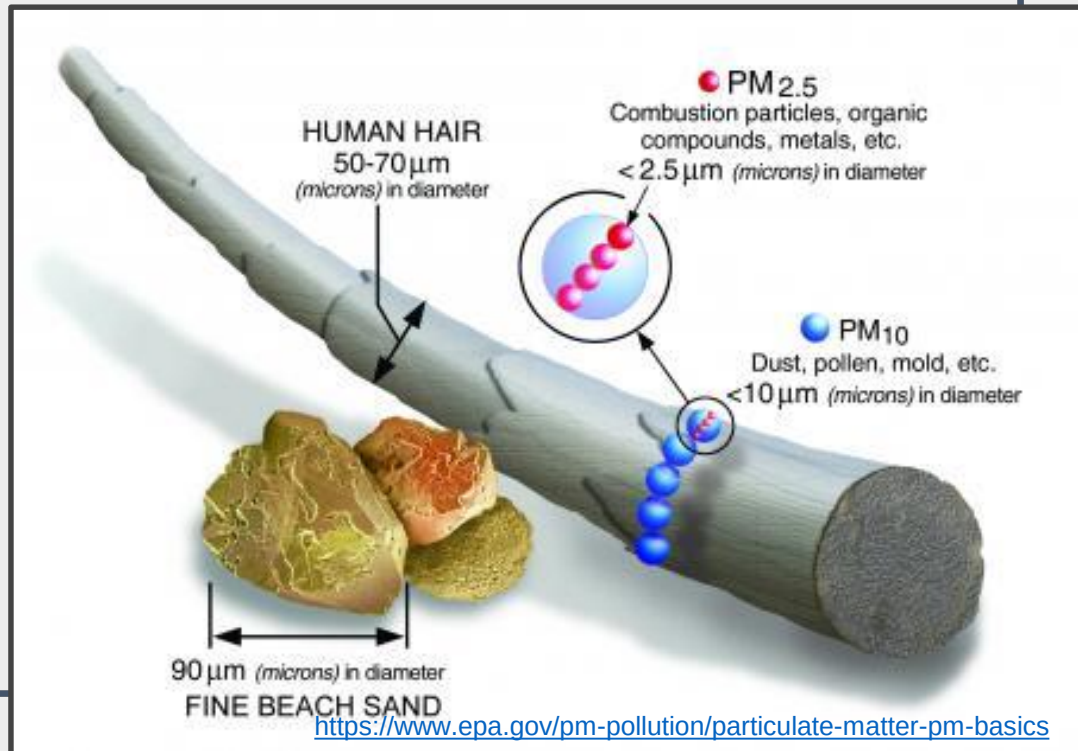
The US Clean Air Act (CAA) covers six:

- Ground-level ozone (O_3)
- Particulate Matter (PM_{10}, $PM_{2.5}$, PM_1)
- Carbon Monoxide (CO)
- Lead (Pb)
- Sulfur Dioxide (SO_2)
- Nitrogen Dioxide (NO_2)

https://www.epa.gov/criteria-air-pollutants

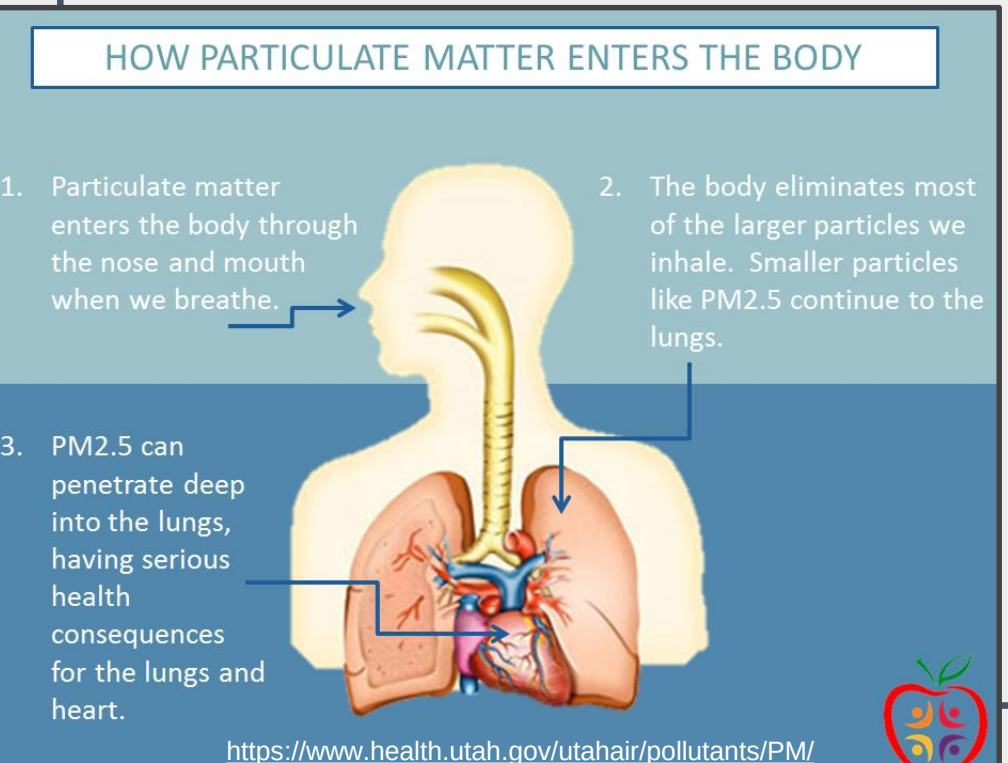
CONSIDER PARTICULATE MATTER...

- Mix of microscopic dust and liquid
- Can come from varied sources, such as construction or smokestacks
- Can form in the atmosphere



https://www.epa.gov/pm-pollution/particulate-matter-pm-basics

PM CAN HAVE SERIOUS HEALTH AND ENVIRONMENTAL EFFECTS



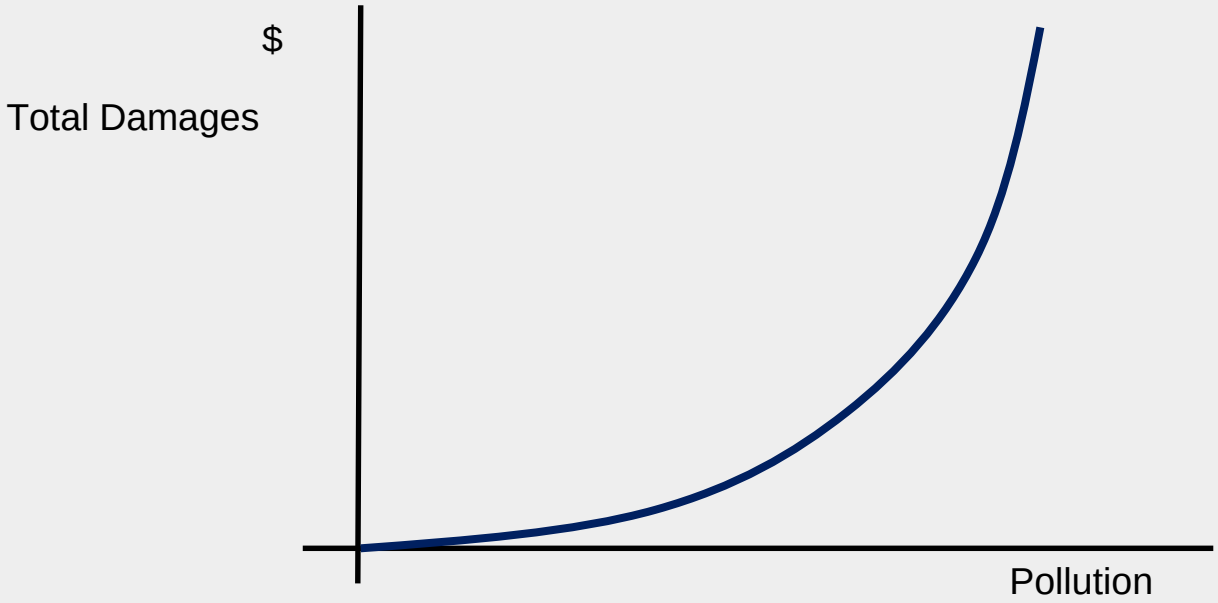
Health Effects

- Cardiovascular
- Respiratory

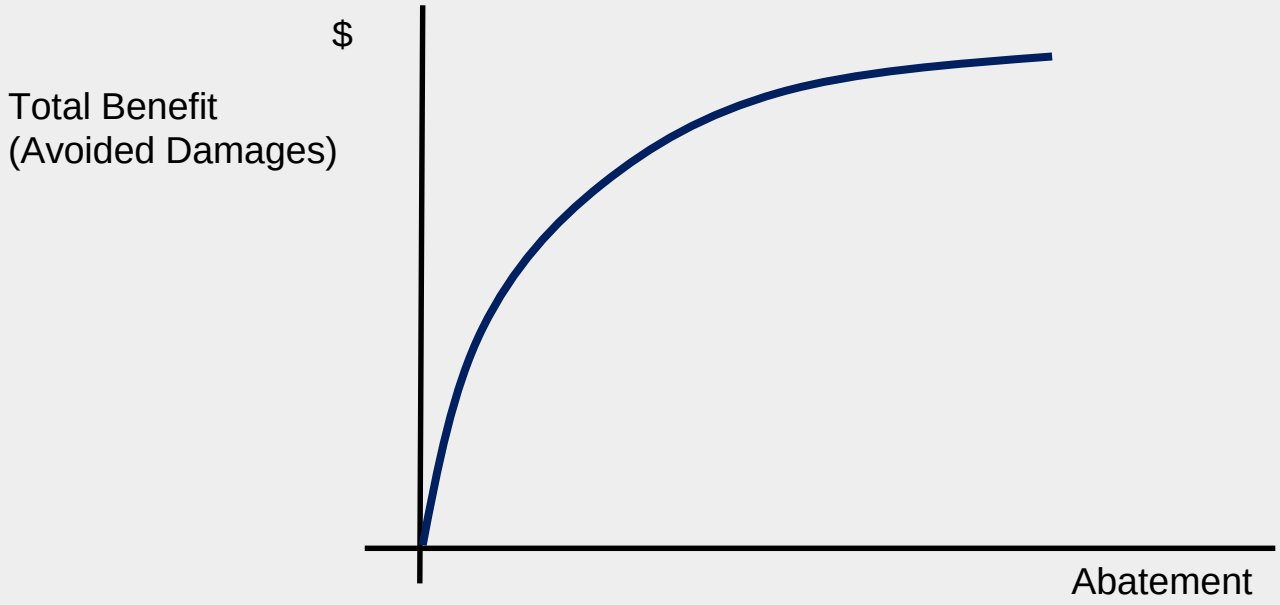
Environmental Effects

- Air Pollution (Haze)
- Damage soil and water quality

WHAT ARE THE SOCIAL COSTS OF PM?



WHAT ARE THE SOCIAL BENEFITS OF AVOIDED PM?



PM POLLUTION CLEARLY HAS NEGATIVE EFFECTS

So, should we try to reduce PM pollution to 0?

What else do we need to consider?

ABATEMENT IS NOT FREE!

POSSIBLE COSTS

Opportunity cost of reducing output

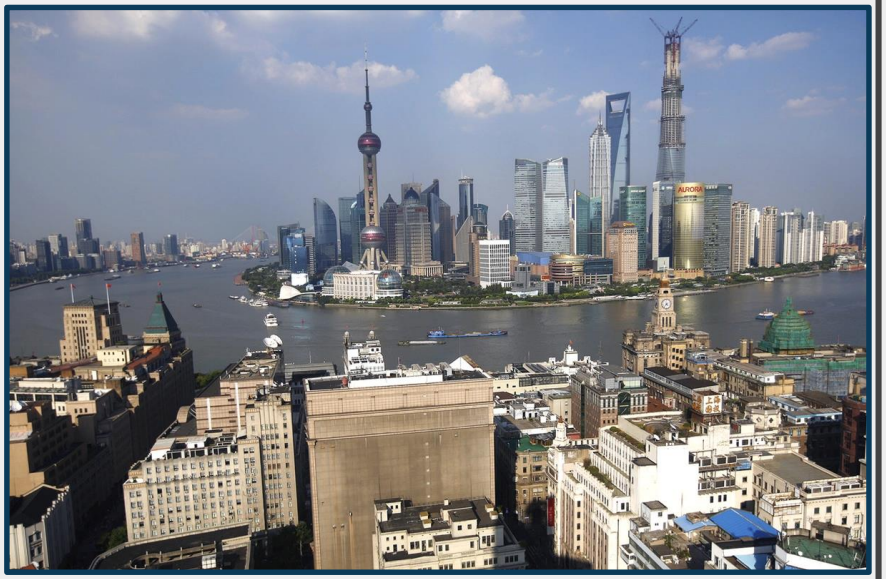
Increased cost of cleaner production process

Cost of cleaning technology

SHANGHAI

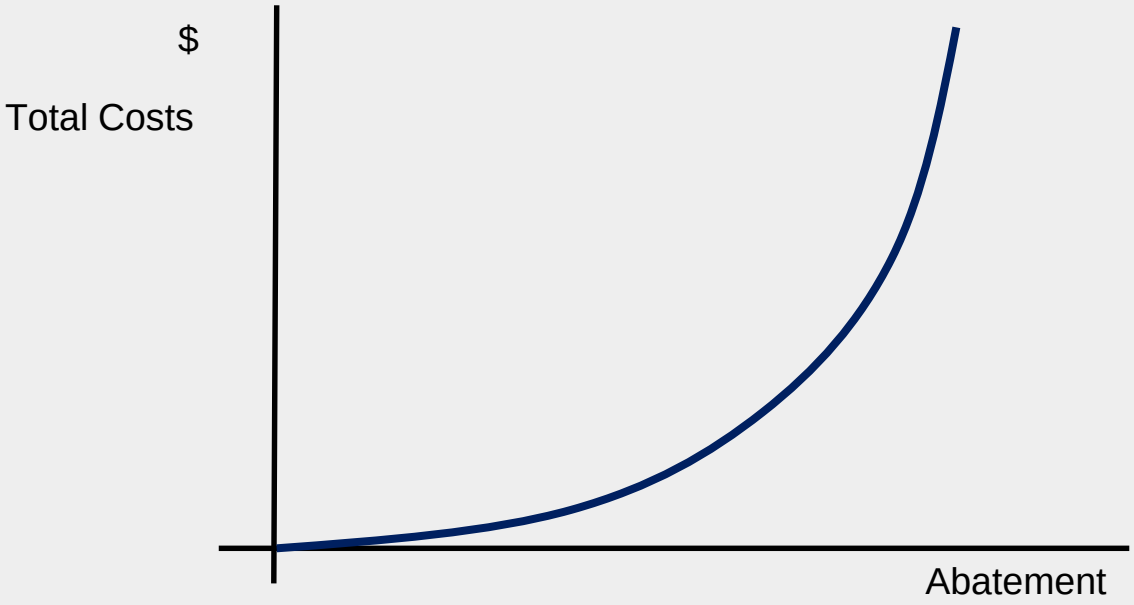
1987

2013



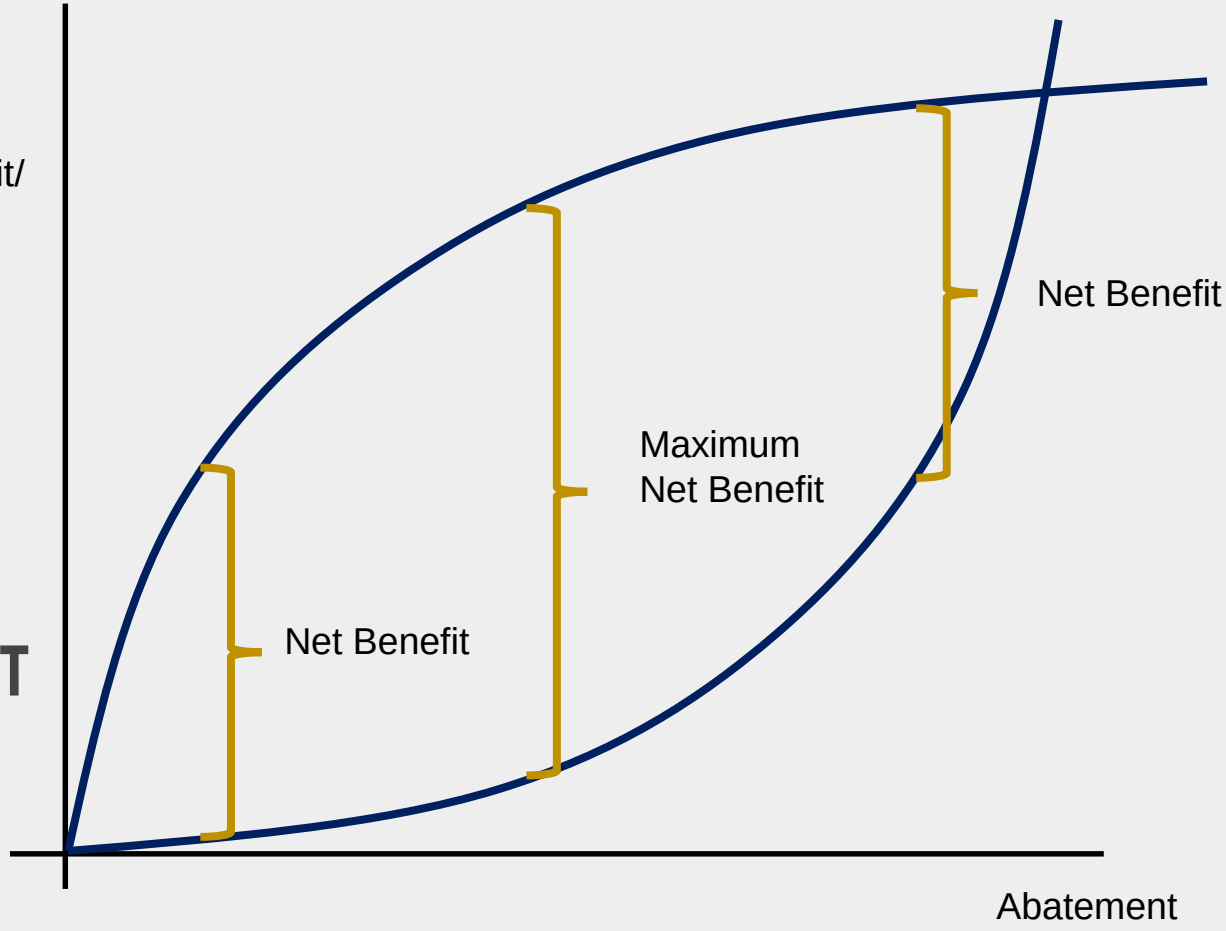
https://www.theatlantic.com/photo/2013/08/26-years-of-growth-shanghai-then-and-now/100569/

COSTS OF ABATEMENT



WHAT'S THE NET BENEFIT?

WHERE IS NET BENEFIT MAXIMIZED?



02

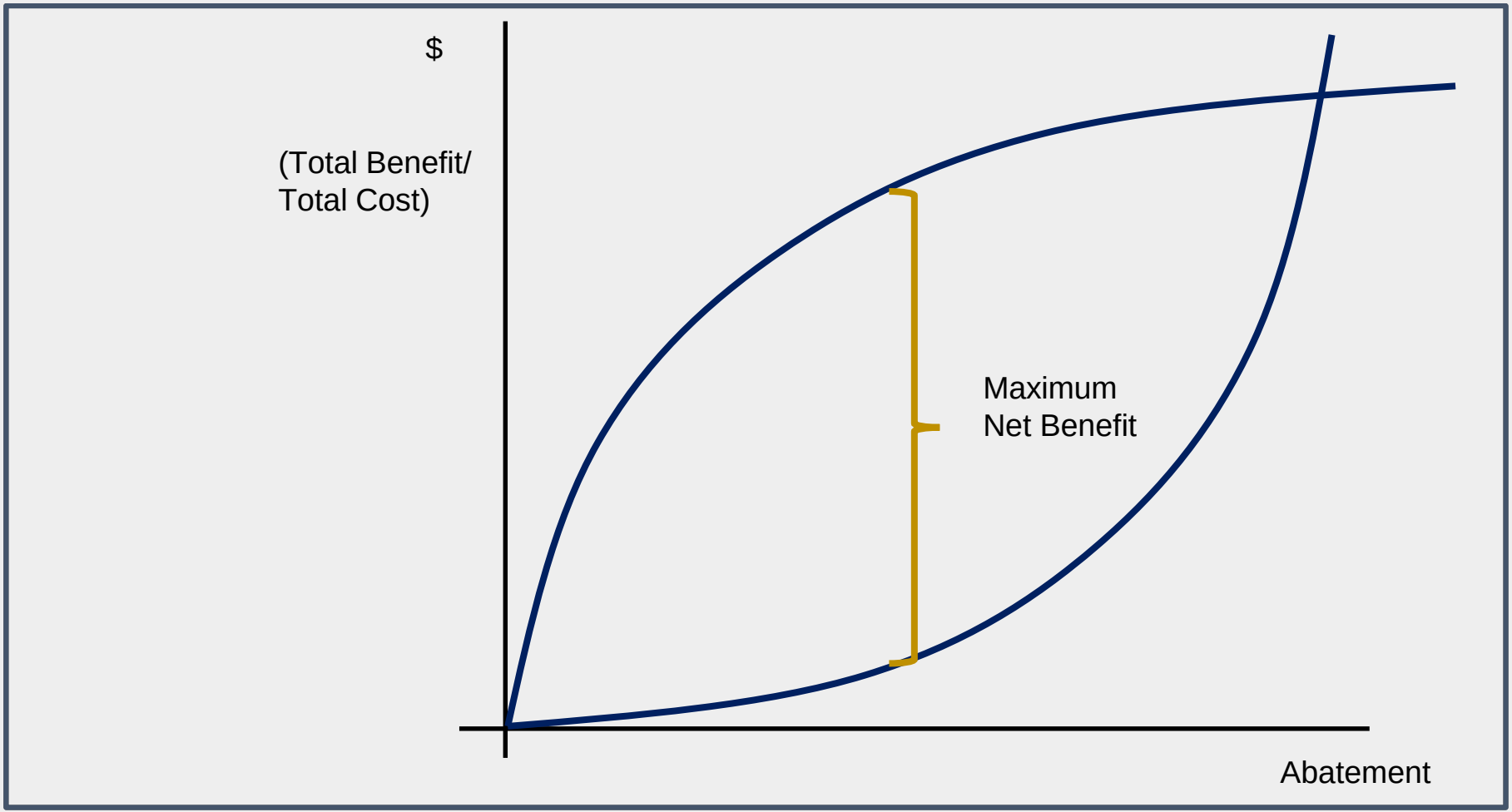
IDENTIFY SOCIALLY OPTIMAL ENVIRONMENTAL QUALITY

ECONOMIC EFFICIENCY

WHAT IS ECONOMIC EFFICIENCY?

Allocate scarce resources in a way that maximizes net benefit.

Notice, efficient level of abatement is not 100%


$
(Total Benefit/
Total Cost)
Maximum
Net Benefit
Abatement

ECONOMIC EFFICIENCY

Economic Efficiency ≠ Engineering Efficiency

ATTENDANCE ACTIVITY

Which Honda CRV should you buy?
CVT Standard: $25,000, 30 MPG
Hybrid: $28,000, 38 MPG
Price of gas: $2.00
Expected Mileage: 80,000 miles

No extra WTP from warm glow (benefits are identical)

ATTENDANCE ACTIVITY

Which Honda CRV should you buy?

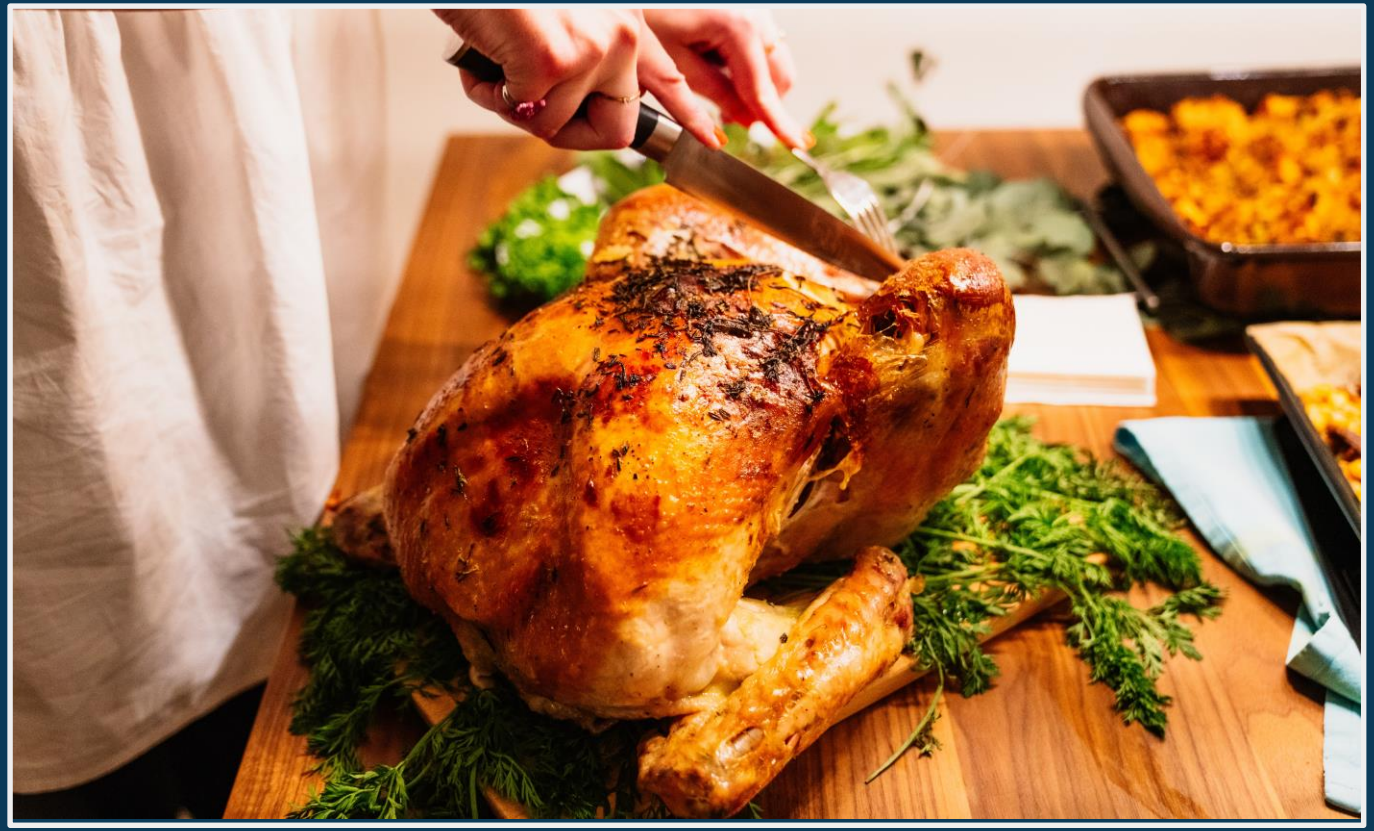
Model	Price ($)	Gas Mileage (MPG)	Gas Price ($/G)	Expected Mileage (Miles)	Total Gas Cost ($)	Total Cost ($)
CVT Standard	25,000	30	2	80,000	80,000/30*2 = 5,333	25,000 + 5,333 = 30,333
Hybrid	28,000	38	2	80,000	80,000/38*2 = 4,211	28,000 + 4,211 = 32,211

HOW DO ECONOMISTS IDENTIFY "OPTIMAL DECISIONS"

EFFICIENCY MAXIMIZES TOTAL NET BENEFIT

PROBLEM?

HOW DO ECONOMISTS FIND THIS?



HOW DO YOU CHOOSE WHAT TO GET FROM ALL THE DELICIOUS FOOD?

DO YOU CALCULATE TOTAL NET BENEFIT OF ALL THE OPTIONS AND THEN PICK THE LARGEST?

OR

DO YOU EAT A LITTLE OF EVERYTHING...THINK... GET SECONDS OF SOME STUFF...THINK...GET THIRDS

THINKING AT THE MARGIN

- 1st Serving
  - This is delicious…
- 2nd Serving
  - This is good…
- 3rd Serving
  - I'm full…
- 4th Serving
  - I should've stopped at 3…

Keep eating more until the marginal benefit (enjoyment) equals the marginal cost (feeling stuffed)

Equimarginal principle states total net benefit is maximized where MB=MC

EQUIMARGINAL CONDITION FOR EFFICIENCY

Marginal benefit (Demand curve)

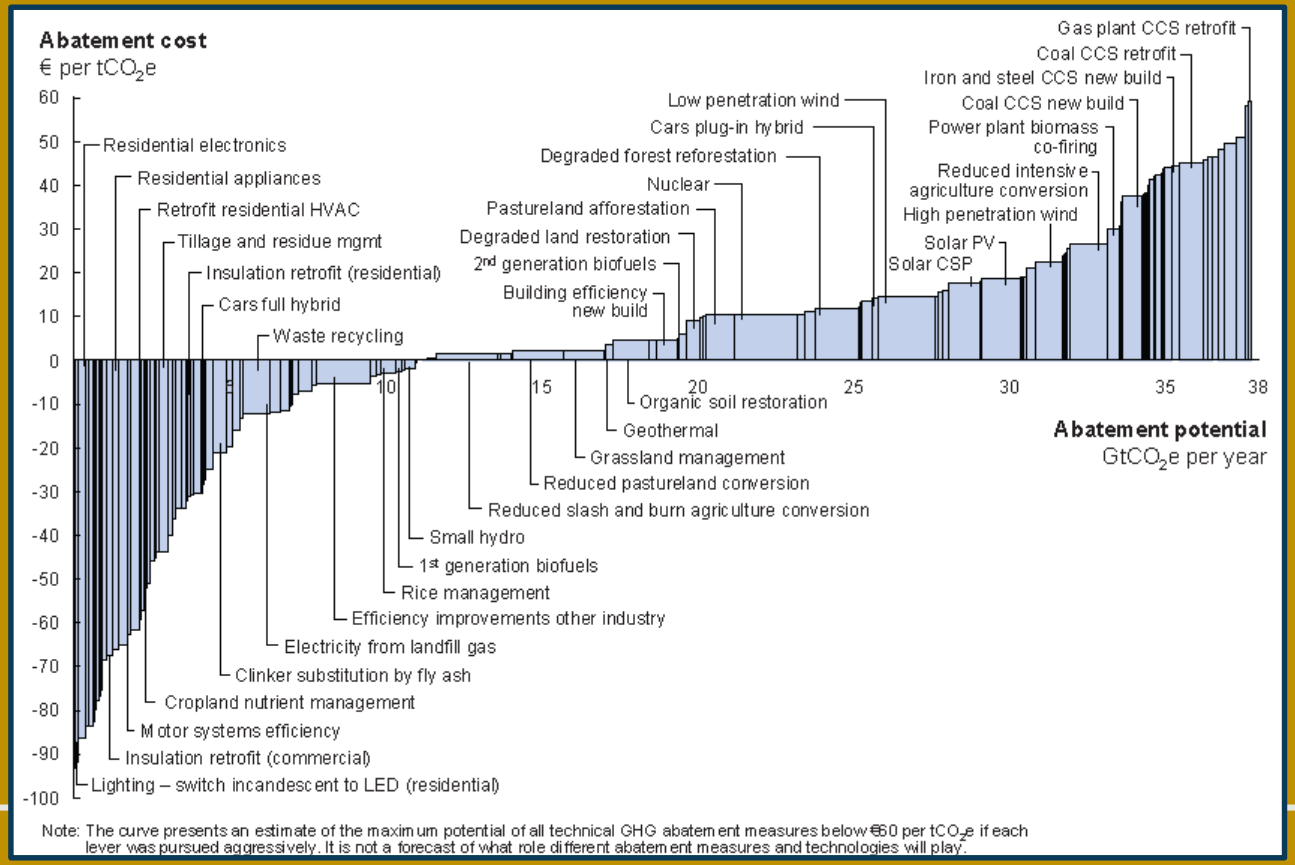
- Maximum willingness to pay for an addition unit

Marginal cost (Supply curve)

- Minimum willingness to accept for an additional unit

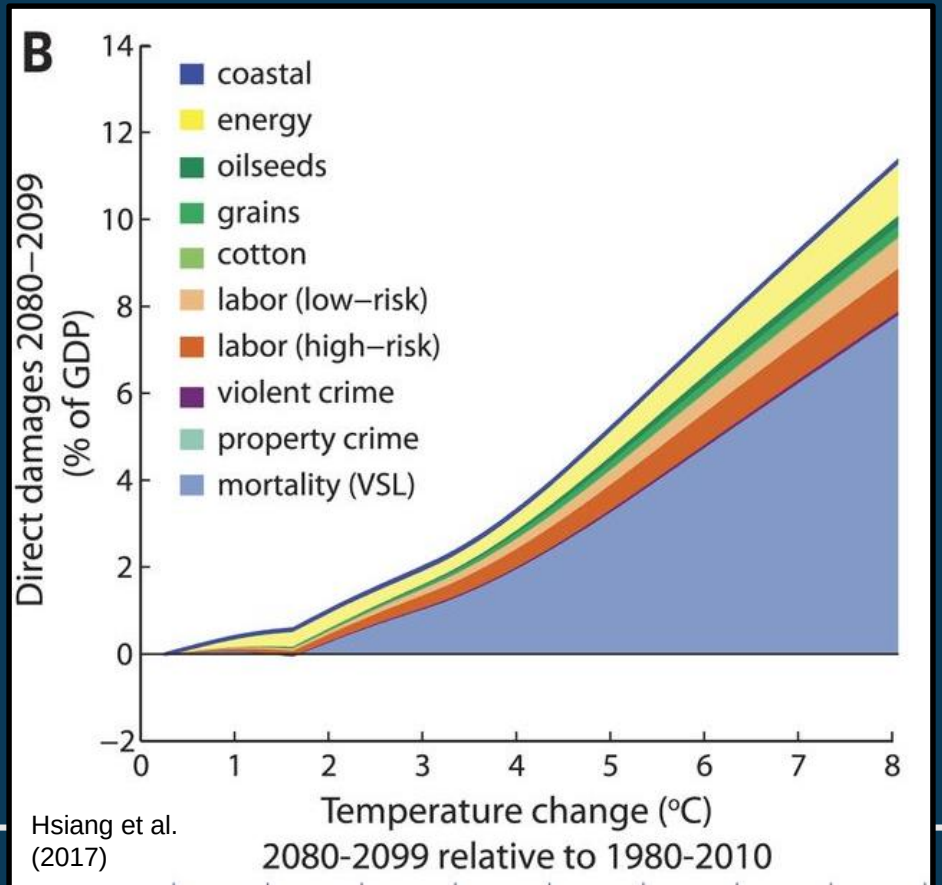
ECONOMISTS, LIKE REAL PEOPLE, THINK AT THE MARGIN

APPLIED TO CLIMATE CHANGE...

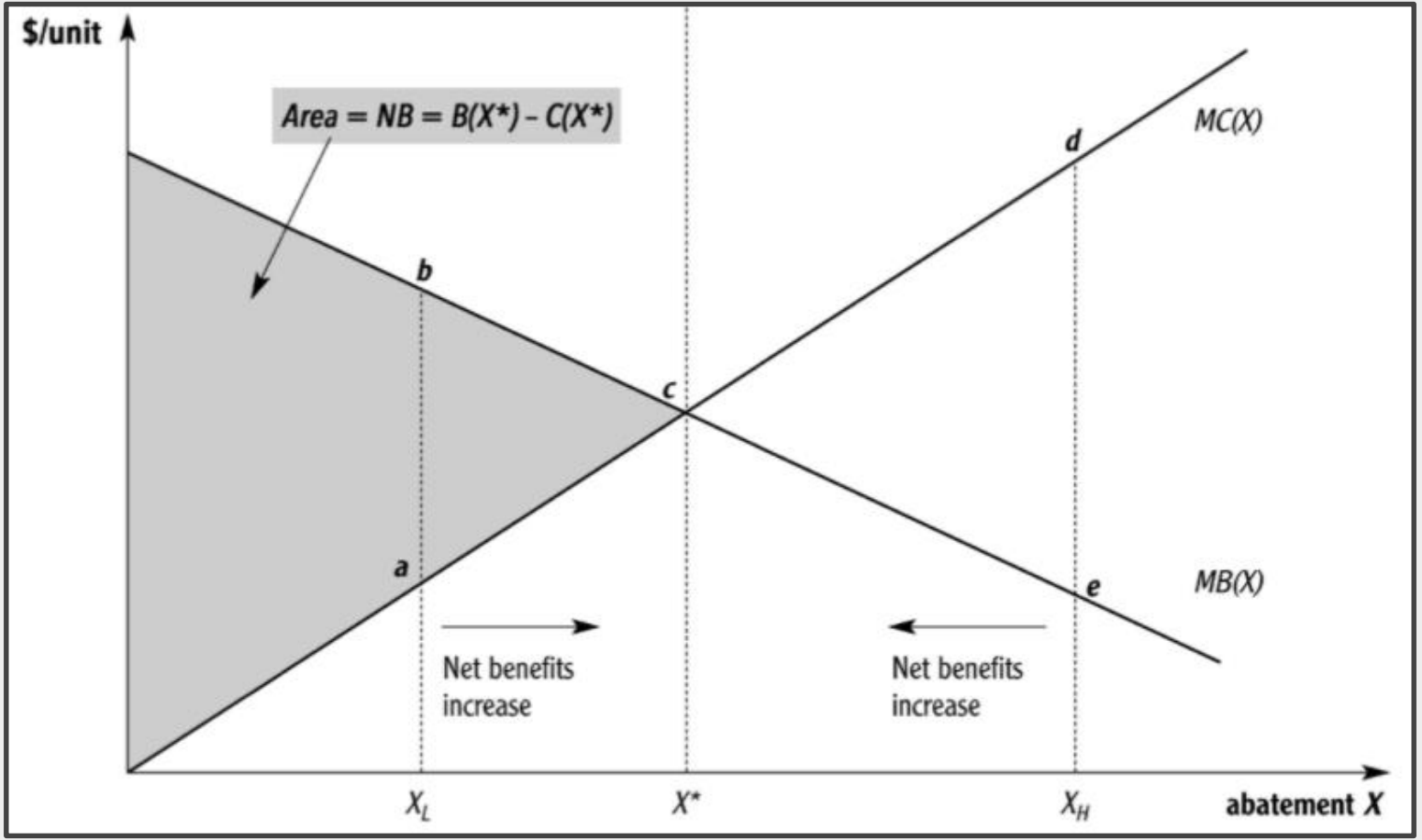


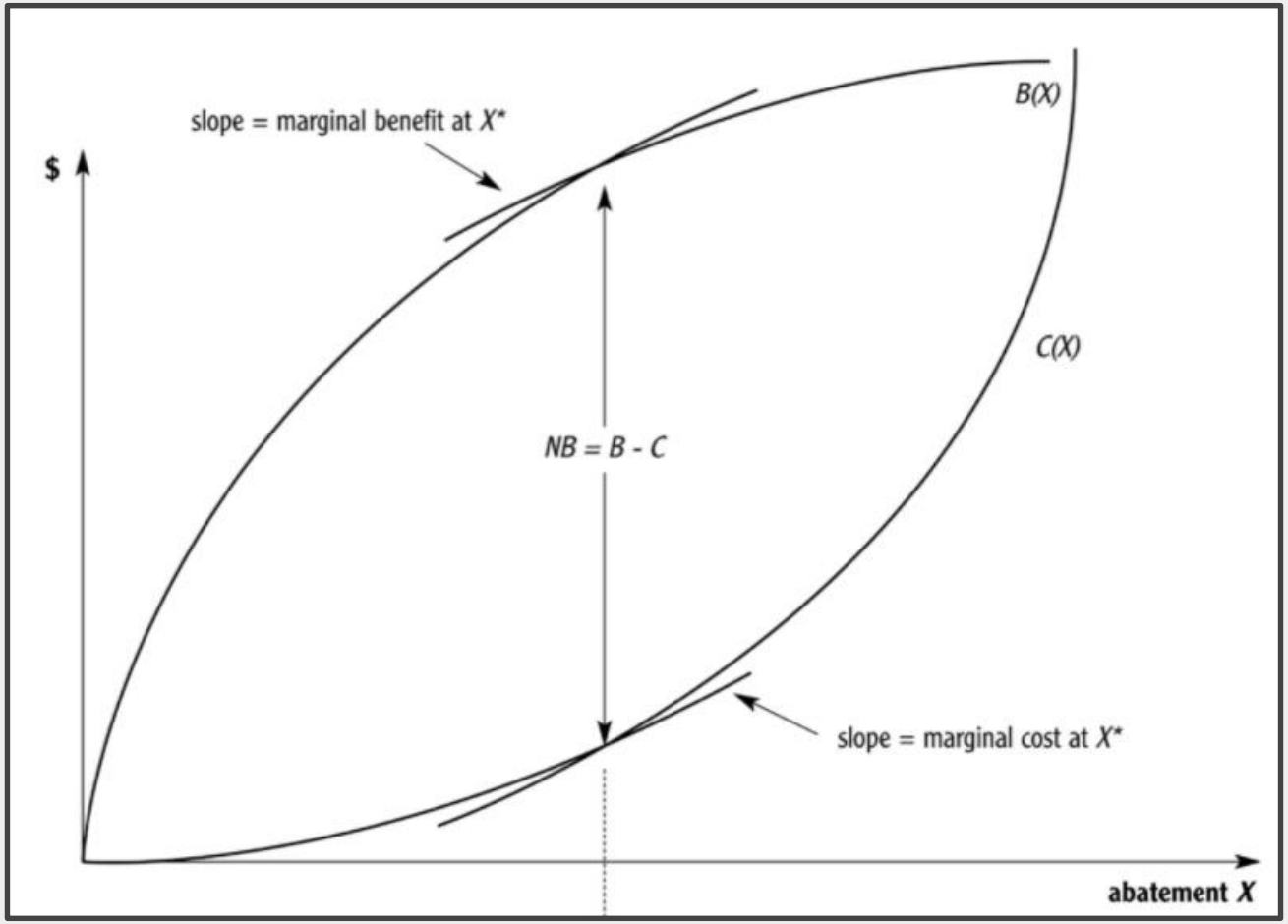
Note: The curve presents an estimate of the maximum potential of all technical GHG abatement measures below €60 per tCO_2e if each lever was pursued aggressively. It is not a forecast of what role different abatement measures and technologies will play.

APPLIED TO CLIMATE CHANGE...



Hsiang et al. (2017)


$/unit
Area = NB = B(X*) – C(X*)
MC(X)
d
b
c
a
e
MB(X)
Net benefits increase
Net benefits increase
X_L
X^*
X_H
abatement X


slope = marginal benefit at X*
B(X)
$
C(X)
NB = B - C
slope = marginal cost at X*
abatement X

03

COMPARE STATIC VS. DYNAMIC EFFICIENCY

WHAT IF DECISIONS ARE DYNAMIC?

BENEFITS AND COSTS OF EATING MASHED POTATOES ARE EXPERIENCED INSTANTANEOUSLY

STREAM OF BENEFITS AND COSTS FOR ENVIRONMENTAL PROBLEMS OFTEN OCCUR AT DIFFERENT POINTS IN TIME

DYNAMIC PROBLEM:

What if I asked you for $1000 and told you I'd give you back $1001 right away?

What if I asked you for $1000 and told you I'd give you back $1001 in 1 year (I'll even adjust for inflation)?

What about $1002? $1003?...

DISCOUNT RATE

YOU HAVE SOME CONSUMPTION RATE OF INTEREST OR DISCOUNT RATE

$$r = 1 - FV/PV$$

r – your discount rate
FV – future value
PV – present value

Why is r>0?

- Prefer instant gratification
- Expect to be richer in the future
- Could invest money today and earn a rate of return

Together, these describe the *time value of money*

HOW DO WE DEFINE ECONOMIC EFFICIENCY IN A DYNAMIC SETTING?

Costs of abatement

Benefits of avoided climate damages

How can we compare the marginal costs to the marginal benefits?

We can use the discount rate, r, to calculate present values

$$FV = PV(1 + r)^t$$

$$PV = \frac{FV}{(1 + r)^t}$$

DYNAMIC EFFICIENCY RULE

In a dynamic setting, we apply the dynamic efficiency rule.

Maximize net present value (NPV):

$$\text{NPV} = \sum_{t=0}^{T} \frac{B_t}{(1+r)^t} - \sum_{t=0}^{T} \frac{C_t}{(1+r)^t} = \sum_{t=0}^{T} \frac{B_t - C_t}{(1+r)^t}$$

DYNAMIC EFFICIENCY RULE

Maximizing NPV is the same as finding the point where the PV of marginal benefit equals the PV of marginal cost

ATTENDANCE ACTIVITY

Which Honda CRV should you buy?
CVT Standard: $25,000, 30 MPG
Hybrid: $28,000, 38 MPG
Price of gas: $2.00 (constant over time)
Expected Mileage: 80,000 miles evenly over 8 years
Discount rate of 5%

Assume in real dollars
No extra WTP from warm glow

ATTENDANCE ACTIVITY

Which Honda CRV should you buy?

MODEL	PRICE ($)	GAS MILEAGE (MPG)	GAS PRICE ($/G)	EXPECTED MILEAGE (MILES)	TOTAL GAS COST ($)	TOTAL COST ($)
CVT Standard	25,000	30	2	80,000	$\sum_{t=0}^{7} \frac{\left(\frac{10{,}000}{30} * 2\right)}{(1+0.05)^t} = 4{,}524$	25,000 + 4,524 = 29,524
Hybrid	28,000	38	2	80,000	$\sum_{t=0}^{7} \frac{\left(\frac{10{,}000}{38} * 2\right)}{(1+0.05)^t} = 3{,}572$	28,000 + 3,572 = 31,572

QUESTION OF THE DAY

If hybrid cars use less gas and thus cost less to drive, why doesn't everyone drive a hybrid?

PROBLEM

What discount rate should we use?

Higher discount rate -> less weight on the future

SOLUTION?

DISCOUNT RATES?

Choice of discount rate can have a large impact, especially for problems with a long time horizon (eg. Climate change)

	Present value of $1,000			
	T years from now			
Discount rate	*T* = 10	*T* = 50	*T* = 100	*T* = 200
1%	$905	$608	$370	$137
2%	$820	$372	$138	$19
3%	$744	$228	$52	$2.7
5%	$614	$87	$7.6	$0.06
7%	$508	$34	$1.2	$0.001
10%	$386	$8.5	$0.07	$0.00001

ONE SCHOOL OF THOUGHT SUGGESTS WE USE MARKET RATE OF RETURN...

If returns to a project or policy are less than other investments, can do better by choosing alternative and let future generation choose what to do with the returns

Should be determined based on judgements around rate of time preference and inter-generational equity

ANOTHER SCHOOL OF THOUGHT SUGGESTS THE DECISION IS NORMATIVE...

TYPICALLY, WE APPLY MULTIPLE DISCOUNT RATES AND COMPARE OUTCOMES ACROSS THEM.

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Identify socially optimal environmental quality

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Compare static vs. dynamic efficiency