Externalities

Key Ideas

What is an externality?

Externalities create opportunities for Pareto improving policy

Externalities require "active" and ongoing policy interventions

The optimal (*second best*) policy intervention involves trade-offs

Externalities

Person A's action imposes an *externality* on person B if A's action affects B's payoffs

Suppose Person A can take action a or not take action a

Person A's action a imposes a *negative externality* on Person B if B's payoff is always lower when A does a than when A does not do a

- Positive externalities are defined analogously

The General Principle

People do not *internalize* their externalities

- Externalities do not influence decision making

Relative to the utilitarian optimum

- Too little of actions with positive externalities
- Too much of actions with negative externalities

The Policy Challenge

Get people to internalize their externalities

- Persuasion
- Subsidies/taxes
- Regulation
- Decentralized mechanisms

Weight the benefits of internalizing externalities against the costs of the policy intervention

What is a Public Good?

Non-excludable: If I have access to the good, so do you

Non-rival: My use of the good does not diminish your access to it

Examples

Clean air

National defense

Protection from asteroids

Knowledge

The Model

$N > 1$ people each decide how much effort to contribute

Player i's contribution is e_i

Public good production technology is additive

$$G = e_1 + e_2 + \ldots + e_N$$

i's cost of effort is e_i^2

Best Responses

Player $i's$ best response to $\mathbf{e}_{-i}$ is found by solving:

$$\max_{e_i} \overbrace{e_1 + e_2 + \ldots + e_i + \ldots + e_N}^{\text{Public Goods}} - \overbrace{e_i^2}^{\text{Costs}}$$

First-order condition

$$1 - 2e_i^* = 0$$

$$\text{BR}_i(\mathbf{e}_{-i}) = \frac{1}{2}$$

Because of the additive technology, player i's best response actually doesn't depend on what anyone else is doing

- This wouldn't be true if efforts were complements

Nash Equilibrium

The unique equilibrium is all players choose effort $\frac{1}{2}$

Player i's equilibrium payoff is:

$$N \times \frac{1}{2} - \left(\frac{1}{2}\right)^2 = \frac{2N-1}{4}$$

The First Best

The profile of efforts that maximize the utilitarian welfare is called the *first best*

The utilitarian welfare is

$$N \times \sum_{i=1}^{N} e_i - \sum_{i=1}^{N} e_i^2$$

The equilibrium efforts are not the first best because people do not internalize their positive externalities

Finding the First Best

If each player chooses the same effort ($\hat{e}$), each individual's payoff is:

$$\overbrace{N \times \hat{e}}^{\text{Public Goods}} - \overbrace{\hat{e}^2}^{\text{Costs}}$$

The first best solves:

$$\max_{\hat{e}} N\left(N \times \hat{e} - \hat{e}^2\right)$$

$$N\left(N - 2e^{FB}\right) = 0$$

$$e^{FB} = \frac{N}{2}$$

Social Dilemma

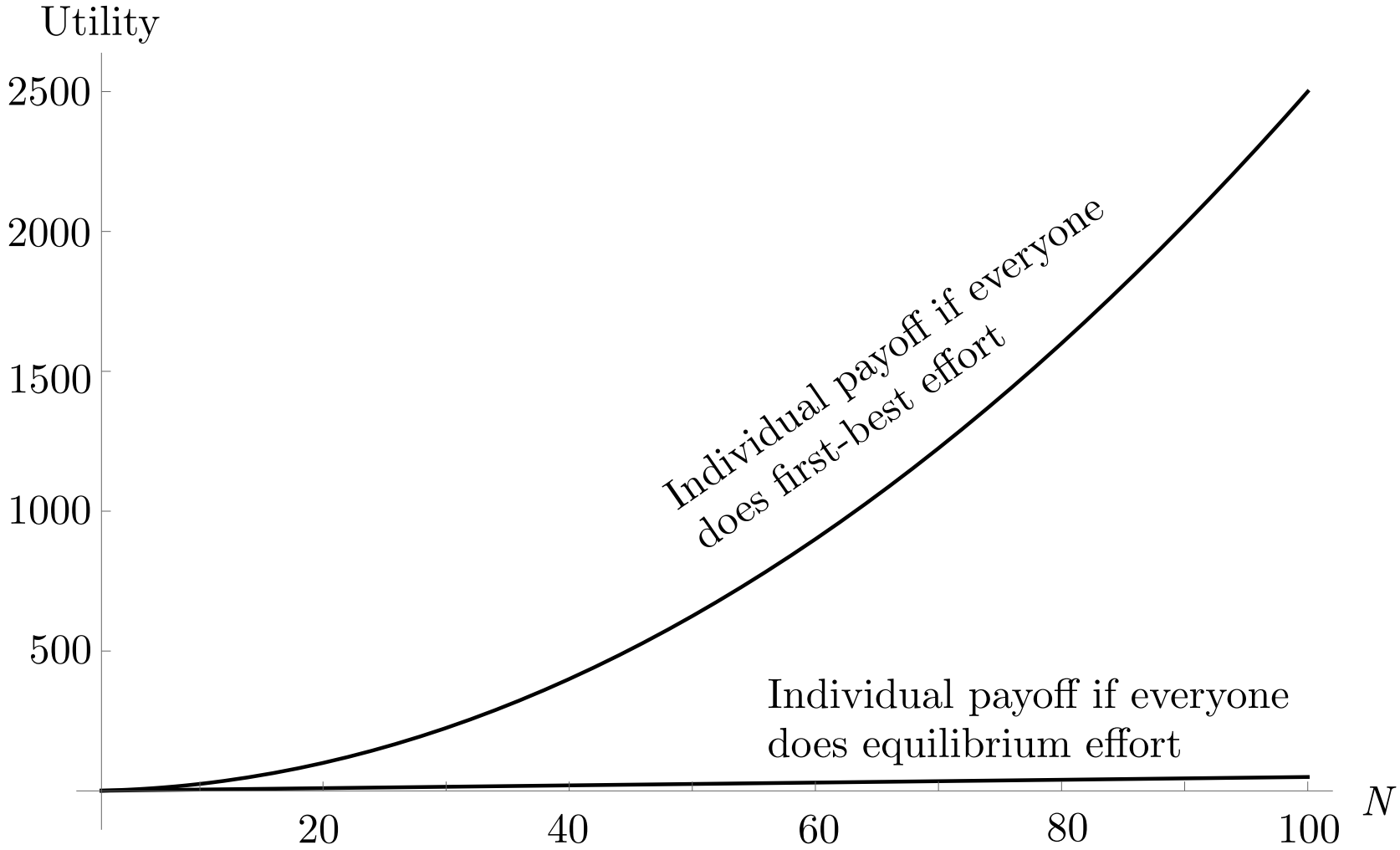
Equilibrium effort by each individual is $\frac{1}{2}$

- Individual payoff is $\frac{2N-1}{4}$

The first best is for each individual to exert effort $\frac{N}{2}$

- Payoff would be $N \times \frac{N}{2} - \left(\frac{N}{2}\right)^2 = \frac{N^2}{4}$

Each individual is better off if all individuals exert more effort. This is especially true as society gets big.


Utility
2500
2000
1500
1000
500
Individual payoff if everyone
does first-best effort
Individual payoff if everyone
does equilibrium effort
20
40
60
80
100
N

Policy Responses

The fundamental problem is the failure to internalize externalities

Policy makers must look for instruments to get people to internalize externalities

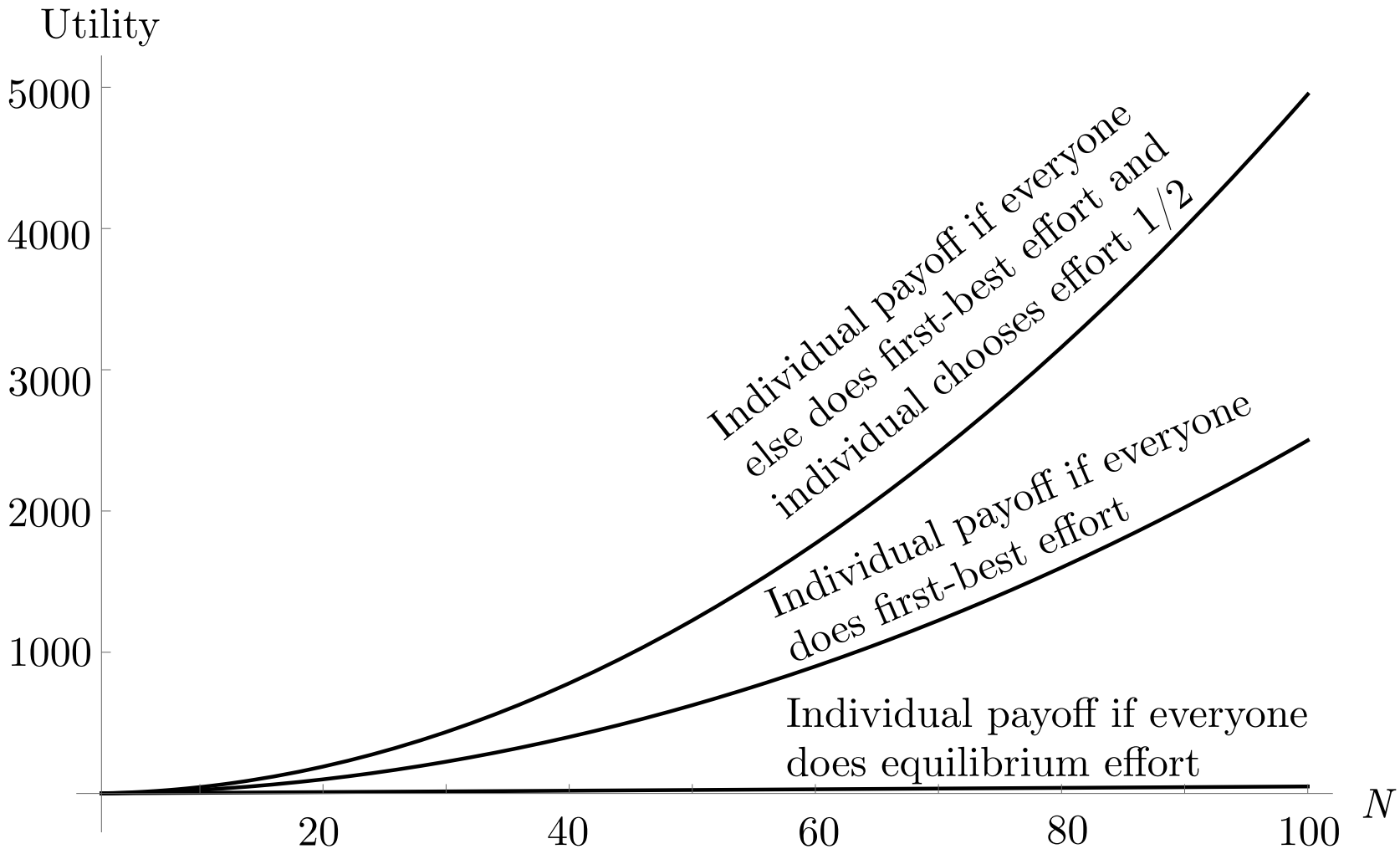
They must also pay attention to any unintended consequences of using those instruments

Free Riding

Even though payoffs are higher if everyone does first-best effort, no individual has an incentive to behave in this socially optimal way

Each individual has an incentive to free ride, even if everyone else does social optimum

$$(N-1) \times \frac{N}{2} + \frac{1}{2} - \left(\frac{1}{2}\right)^2 = \frac{2N^2 - 2N + 1}{4} > \frac{N^2}{4}$$


Utility
5000
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Individual payoff if everyone
else does first-best effort and
individual chooses effort 1/2
Individual payoff if everyone
does first-best effort
Individual payoff if everyone
does equilibrium effort

Pigovian Subsidies in Public Goods Game

Suppose provide a subsidy, σ, for each unit of effort

Subsidy must be funded with inefficient taxation

It costs tax payers $\tau > 1$ dollars for each dollar of revenue the government collects

Each member of society pays an equal share of the tax burden to fund subsidies for everyone other than herself

Best Response to Subsidy

$$\max_{e_i} e_1 + e_2 + \ldots + e_i(1+\sigma) + \ldots + e_N - e_i^2 - \frac{\tau\sigma \sum_{j \neq i} e_j}{N-1}$$

First-order condition

$$1 + \sigma - 2e_i^* = 0$$

$$\text{BR}_i(\mathbf{e}_{-i}, \sigma) = \frac{1+\sigma}{2}$$

To achieve the first-best level of effort choose $\sigma = N - 1$

- People fully internalize externalities
- This is *not* the socially optimal subsidy

Direct Regulation vs. Pigovian Intervention

Informational requirements

Monitoring

Flexibility

In either case, requires ongoing intervention

The Idea

Any policy lever government pulls to address one issue has spillover effects in another domain

Good policy balances these benefits and costs

The *second best* policy is the socially optimal intervention, given all the constraints and effects

When policy effects other domains, it is rarely socially optimal to achieve the first best in the given domain

An Example

Monopolist in a polluting industry

Break monopoly to improve consumer surplus

Also increases production, which imposes externalities

Optimal policy with respect to market power may not be perfect competition because of constraint from the pollution domain

Second-Best Defined

The *second-best policy* is the policy that maximizes the utilitarian social welfare, taking into consideration all the various effects of the policy.

The *second-best action* is the action players are induced to take when the second-best policy is implemented.

Finding the Second-Best Subsidy

Take the equilibrium effort as a function of the subsidy, σ, as given

Given the equilibrium effort induced by a given subsidy, σ, calculate the utilitarian social welfare as a function of σ

Find the σ that maximizes that social welfare

- The σ that does so is the second-best subsidy and the effort it induces is the second-best effort.

Individual Welfare under Subsidy

Recall, given a subsidy σ, each individual will choose effort

$$\text{BR}_i(\mathbf{e}_{-i}, \sigma) = \frac{1+\sigma}{2} \equiv e^{*,\sigma}$$

To fund the subsidy, each individual must pay a taxes of

$$\frac{(N-1) \times e^{*,\sigma} \times \sigma \times \tau}{N-1} = e^{*,\sigma} \times \sigma \times \tau$$

$$u_i(\sigma) = \overbrace{N \times e^{*,\sigma}}^{\text{Public Goods}} + \overbrace{e^{*,\sigma} \times \sigma}^{i\text{'s subsidy}} - \overbrace{\left(e^{*,\sigma}\right)^2}^{i\text{'s cost}} - \overbrace{e^{*,\sigma} \times \sigma \times \tau}^{i\text{'s tax burden}}$$

Utilitarian Welfare

Utilitarian welfare from subsidy σ is

$$U(\sigma) = N \times u_i(\sigma)$$

Substituting for $e^{*,\sigma} = \frac{1+\sigma}{2}$

$$U(\sigma) = N\Bigg[\overbrace{N\left(\frac{1+\sigma}{2}\right)}^{\text{Public Goods}} + \overbrace{\left(\frac{1+\sigma}{2}\right)\sigma}^{i\text{'s subsidy}} - \overbrace{\left(\frac{1+\sigma}{2}\right)^2}^{i\text{'s cost}} - \overbrace{\left(\frac{1+\sigma}{2}\right)\sigma\tau}^{i\text{'s tax burden}} \Bigg]$$

The Second Best

The second-best subsidy solves

$$\max_{\sigma} U(\sigma)$$

$$\sigma^{SB} = \frac{N-\tau}{2\tau-1}$$

$$e^{*,\sigma^{SB}} = \frac{1+\frac{N-\tau}{2\tau-1}}{2} = \frac{N-1+\tau}{2(2\tau-1)}$$

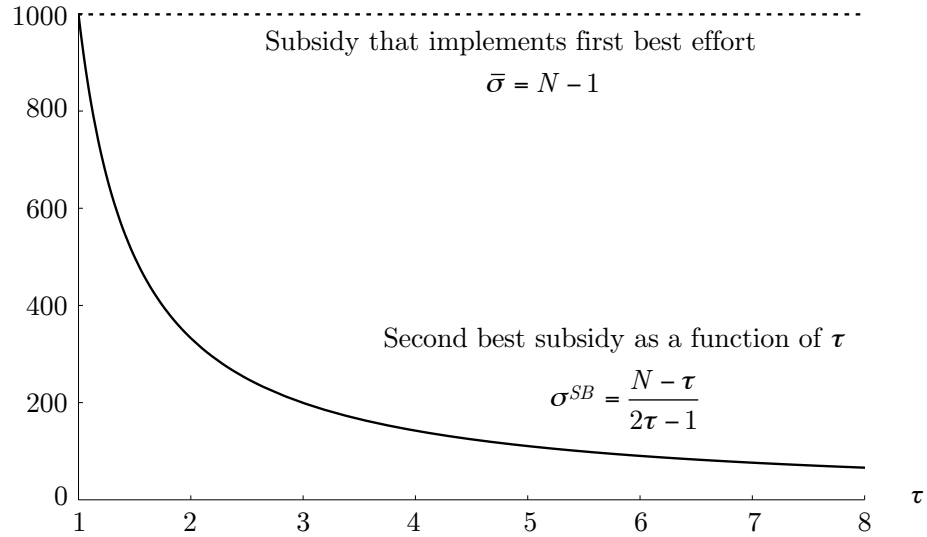
Four Points

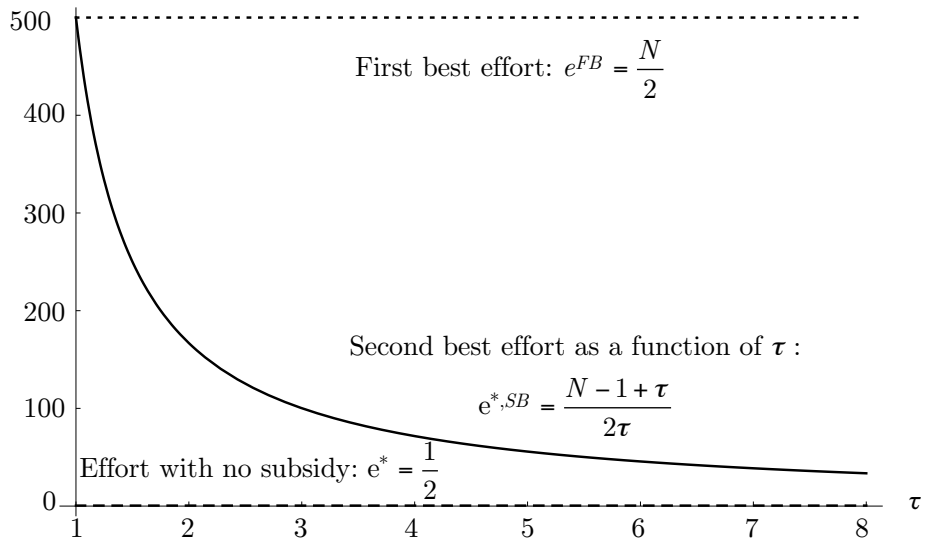
The more people, the larger is the second-best subsidy because externalities are more important

The larger is τ, the smaller is the second-best subsidy because the inefficiencies of funding it loom large

Second-best subsidy is less than the subsidy that induces the first-best effort

$$\frac{N-\tau}{2\tau-1} < N-1$$


1000
800
600
400
200
0
1
2
3
4
5
6
7
8
τ
Subsidy that implements first best effort
$\bar{\sigma} = N - 1$
Second best subsidy as a function of τ
$\sigma^{SB} = \frac{N - \tau}{2\tau - 1}$


500
400
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0
1
2
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8
τ
First best effort: $e^{FB} = \frac{N}{2}$
Second best effort as a function of τ :
$e^{*,SB} = \frac{N - 1 + \tau}{2\tau}$
Effort with no subsidy: $e^{*} = \frac{1}{2}$

Four Points

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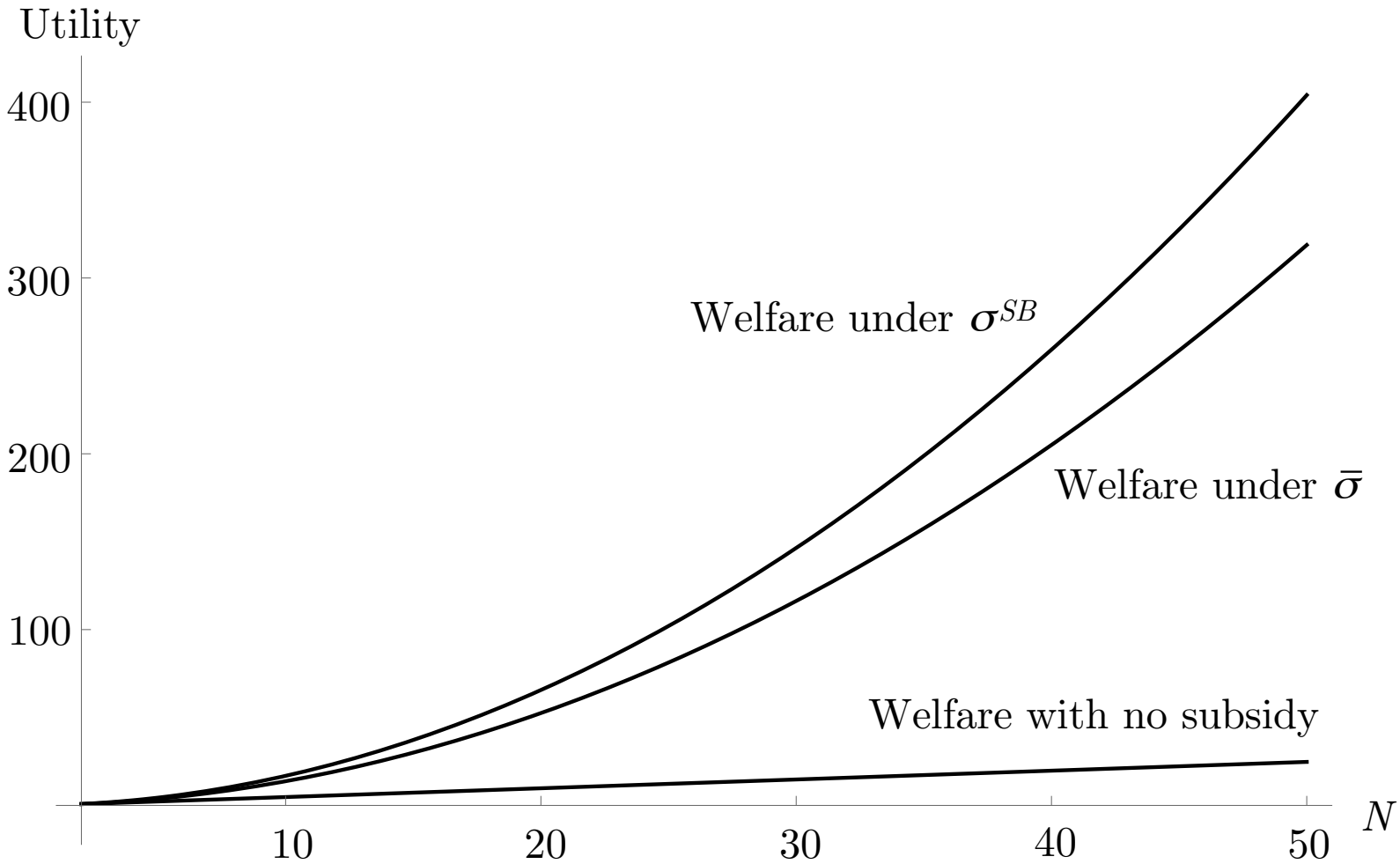
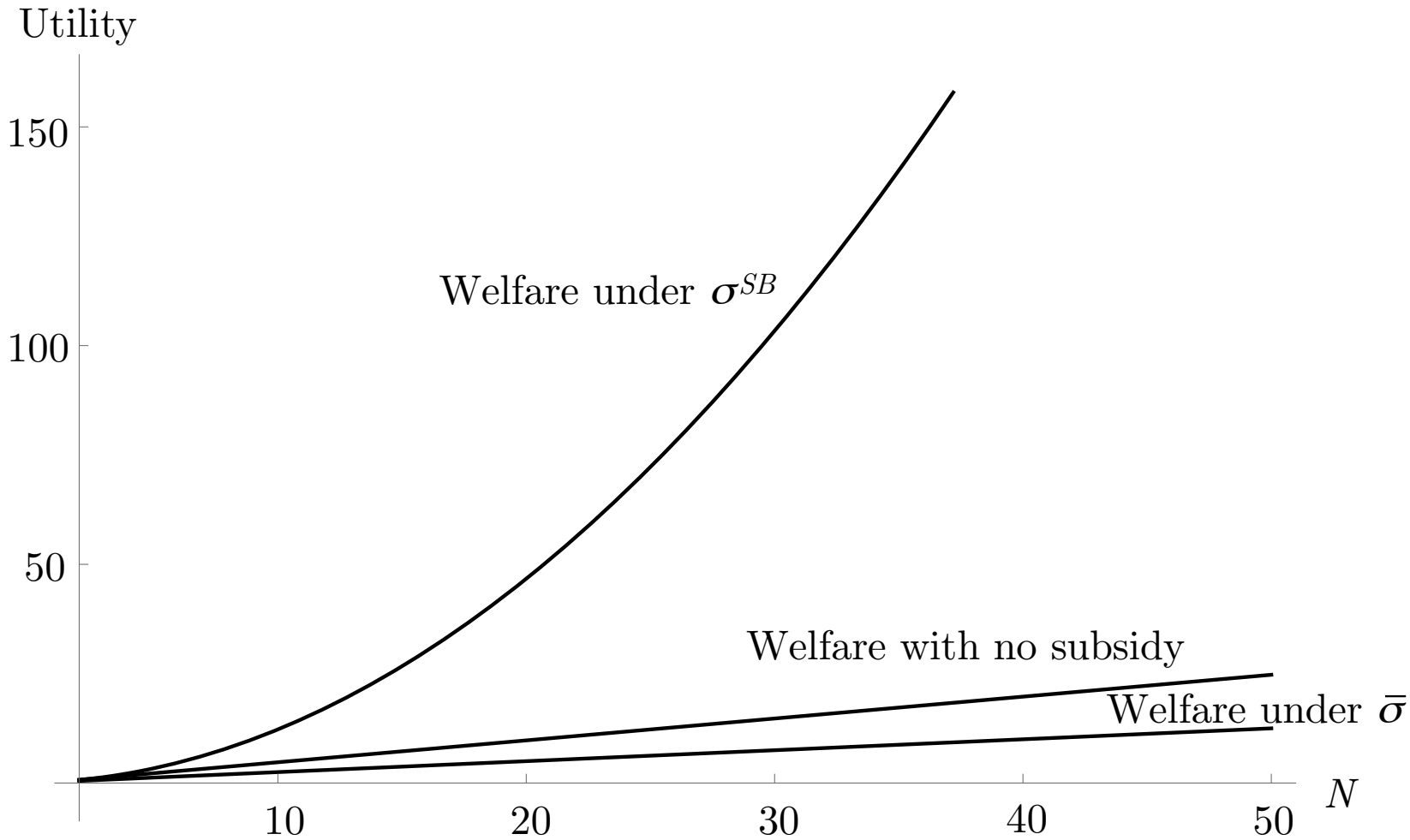
$$\frac{N-\tau}{2\tau-1} < N-1$$

For any $\tau > 1$, welfare is higher under second-best subsidy than under either no subsidy or subsidy that induces first-best effort


Utility
400
300
200
100
Welfare under σ^{SB}
Welfare under $\bar{\sigma}$
Welfare with no subsidy
10
20
30
40
50
N

$\tau = 1.25$


Utility
150
100
50
Welfare under σ^{SB}
Welfare with no subsidy
Welfare under $\bar{\sigma}$
10
20
30
40
50
N

$\tau = 1.5$

Take Aways

Externalities create Pareto inefficiency

Policy can improve situation by incentivizing people to (partially) internalize their externalities

Policy intervention must be active and ongoing

If policy has other costs, the socially optimal policy (second best) does not achieve complete internalization of externalities