

GCET20

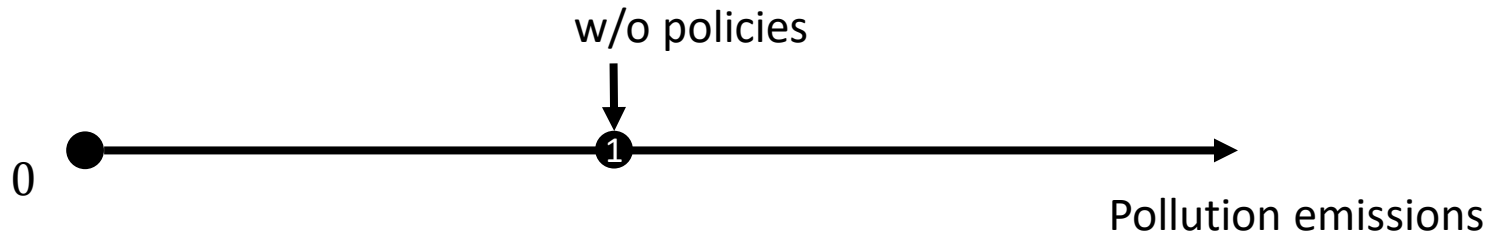
Comparing the efficiency of the alternative  
environmental policies under the moral  
formation

Eiji SAWADA

Faculty of Economics, Kyushu Sangyo University, Japan

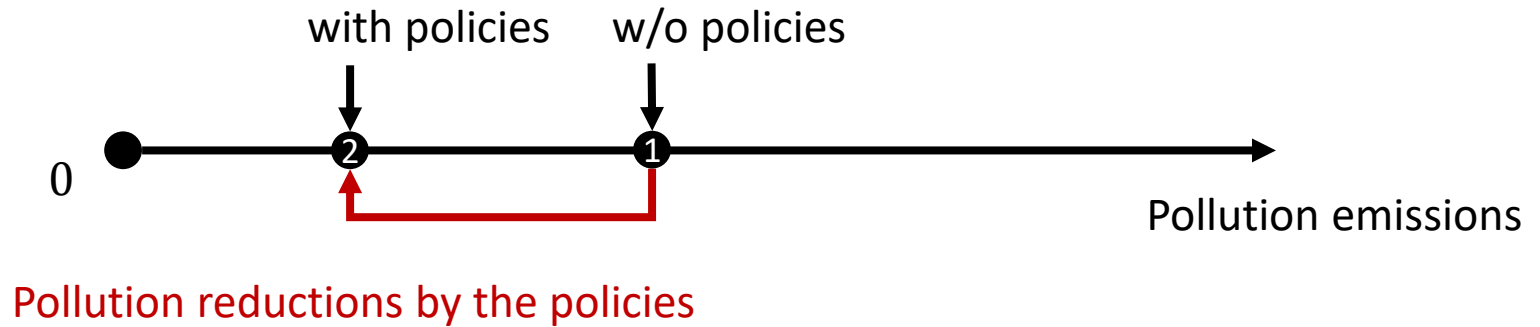
# No pollution reductions w/o policies?

Many studies assume that



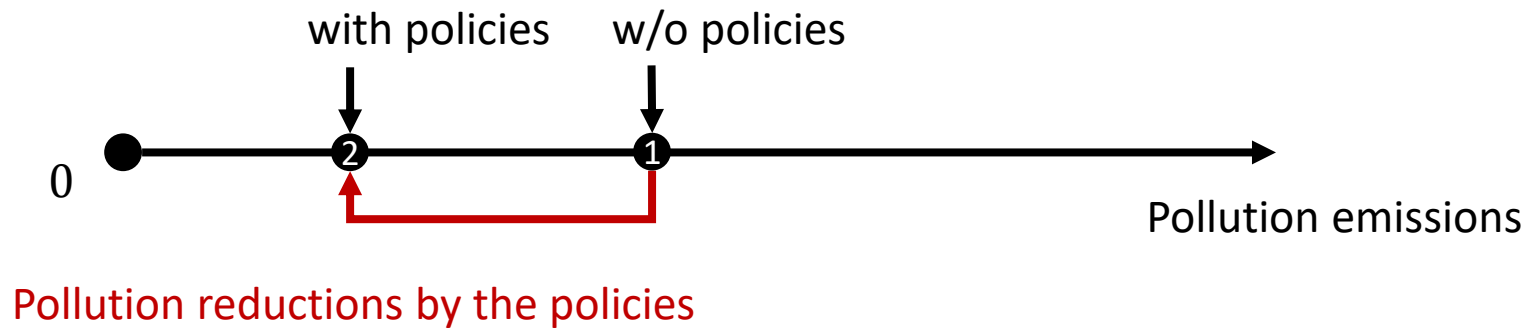
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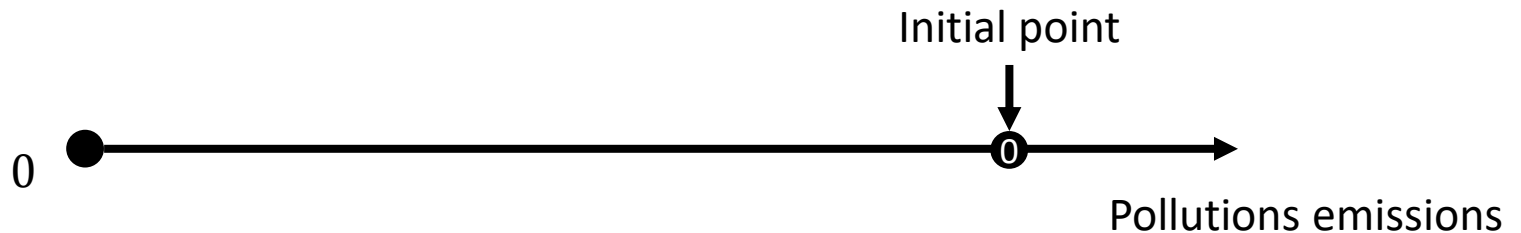


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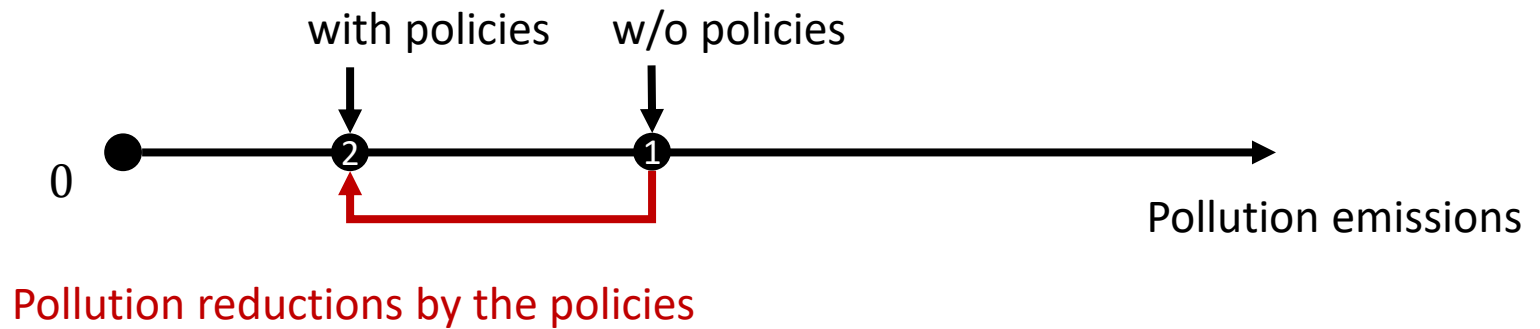


But actually,

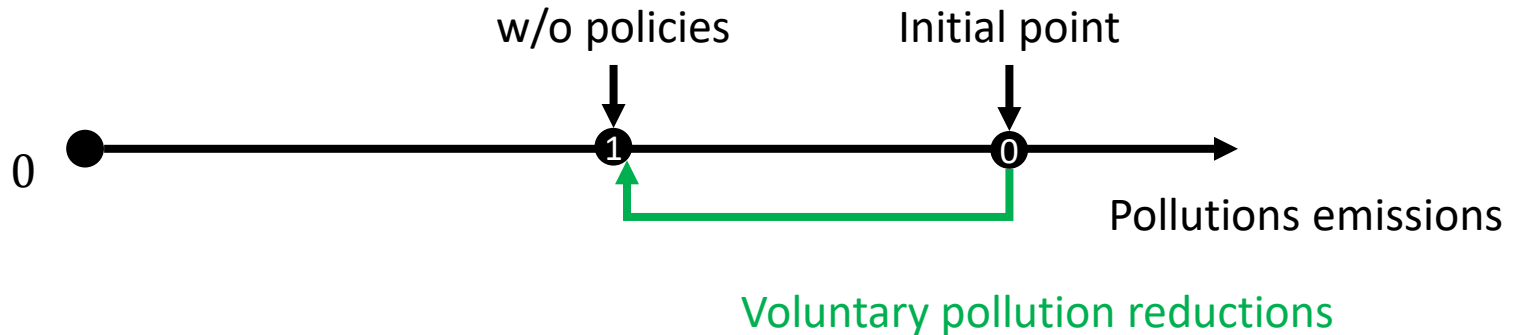


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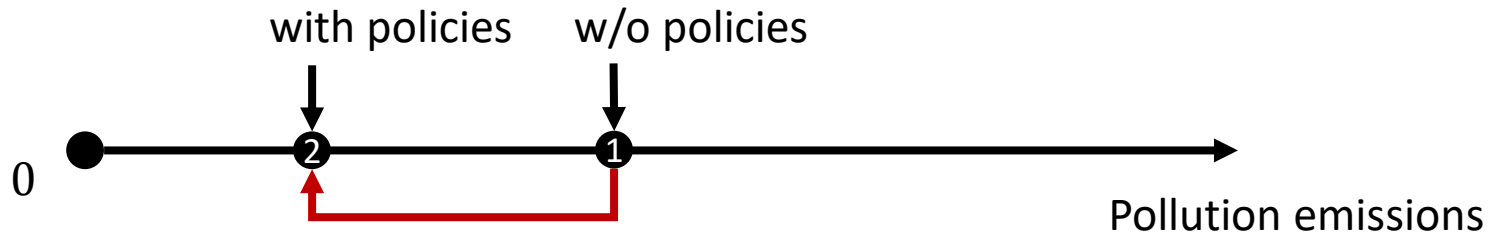


But actually,



# No pollution reductions w/o policies?

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Pollution reductions by the policies

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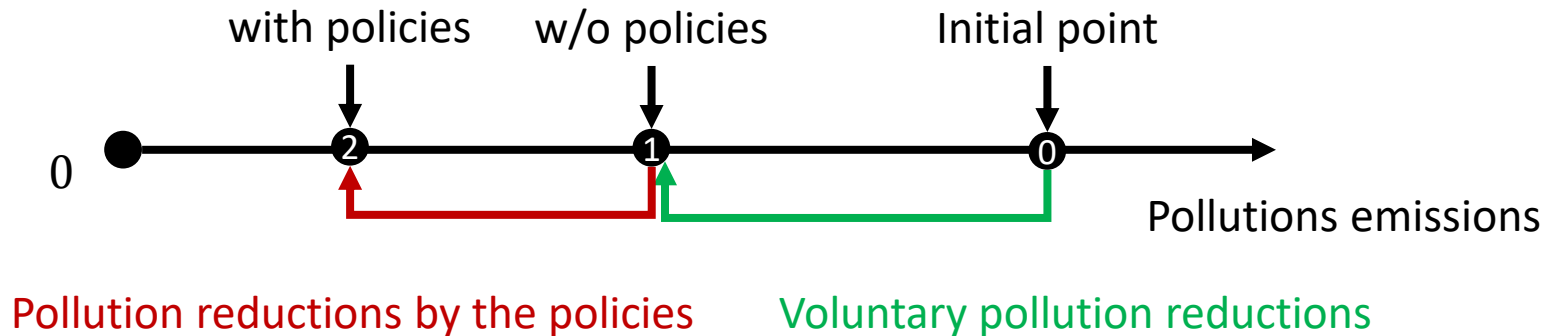
Pollution reductions by the policies

Voluntary pollution reductions

# Brekke et al. (2003)

showed that the policy intervention could change the voluntary actions as well as giving the additional incentives.

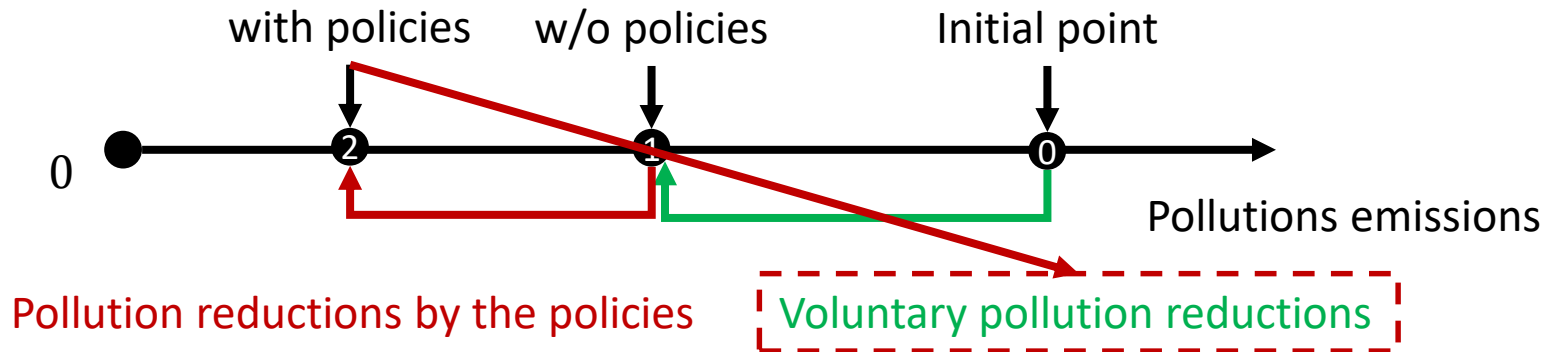
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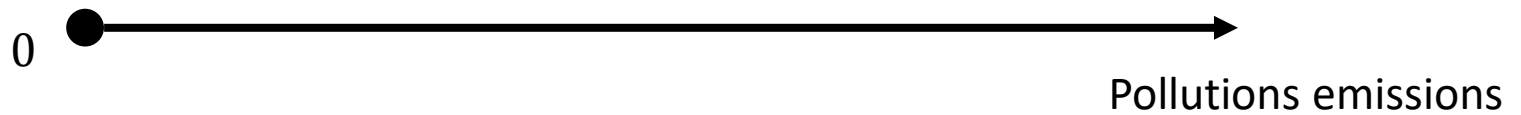
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# Crowding out of the voluntary actions

Pollution reductions by the policies < Crowding out

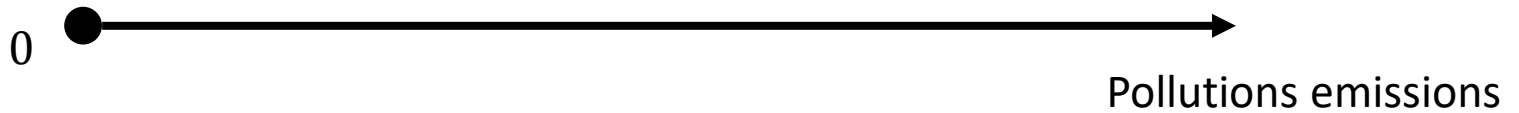


Pollution reductions by the policies

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# Crowding out of the voluntary actions

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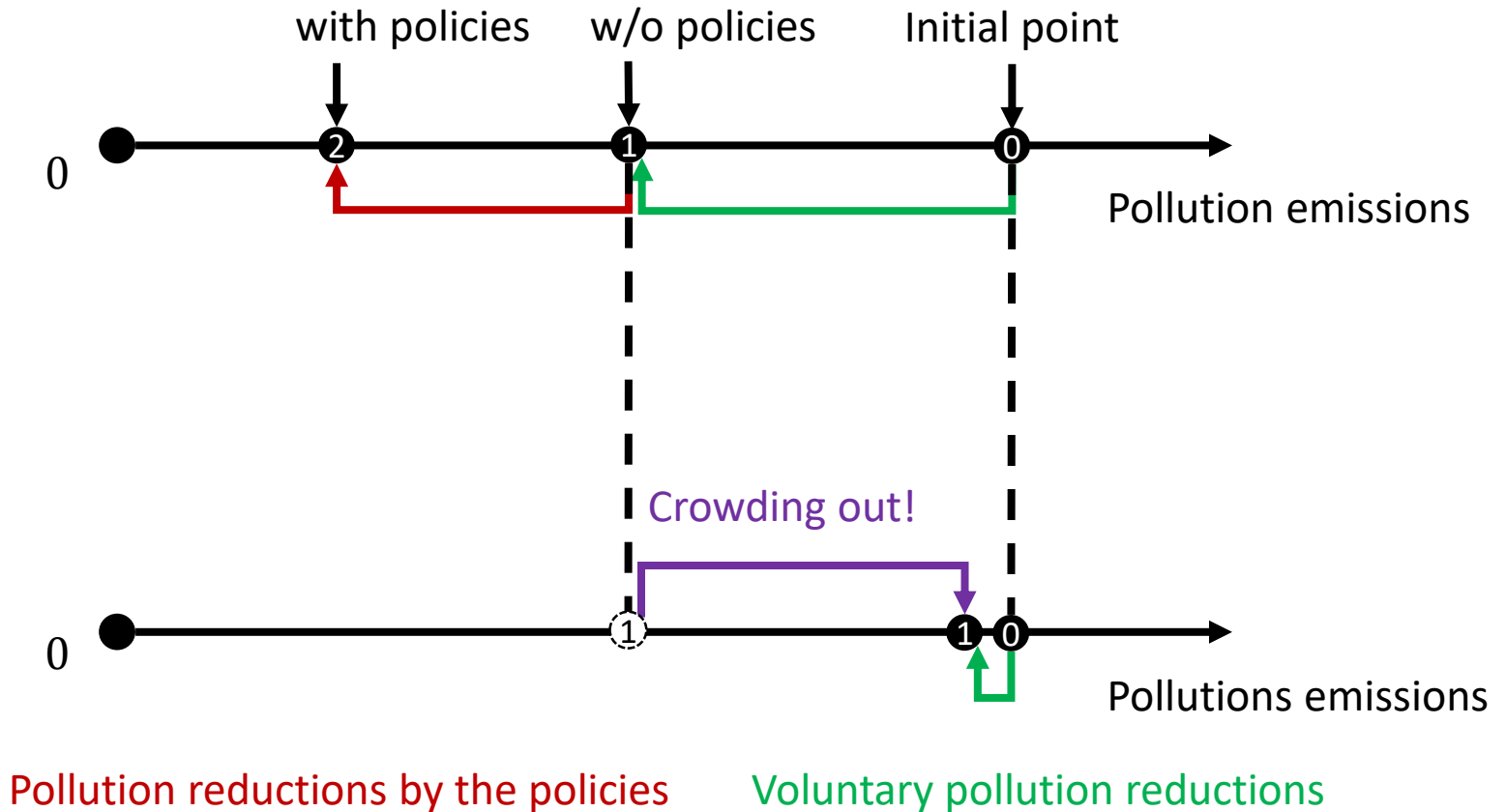


Pollution reductions by the policies

Voluntary pollution reductions

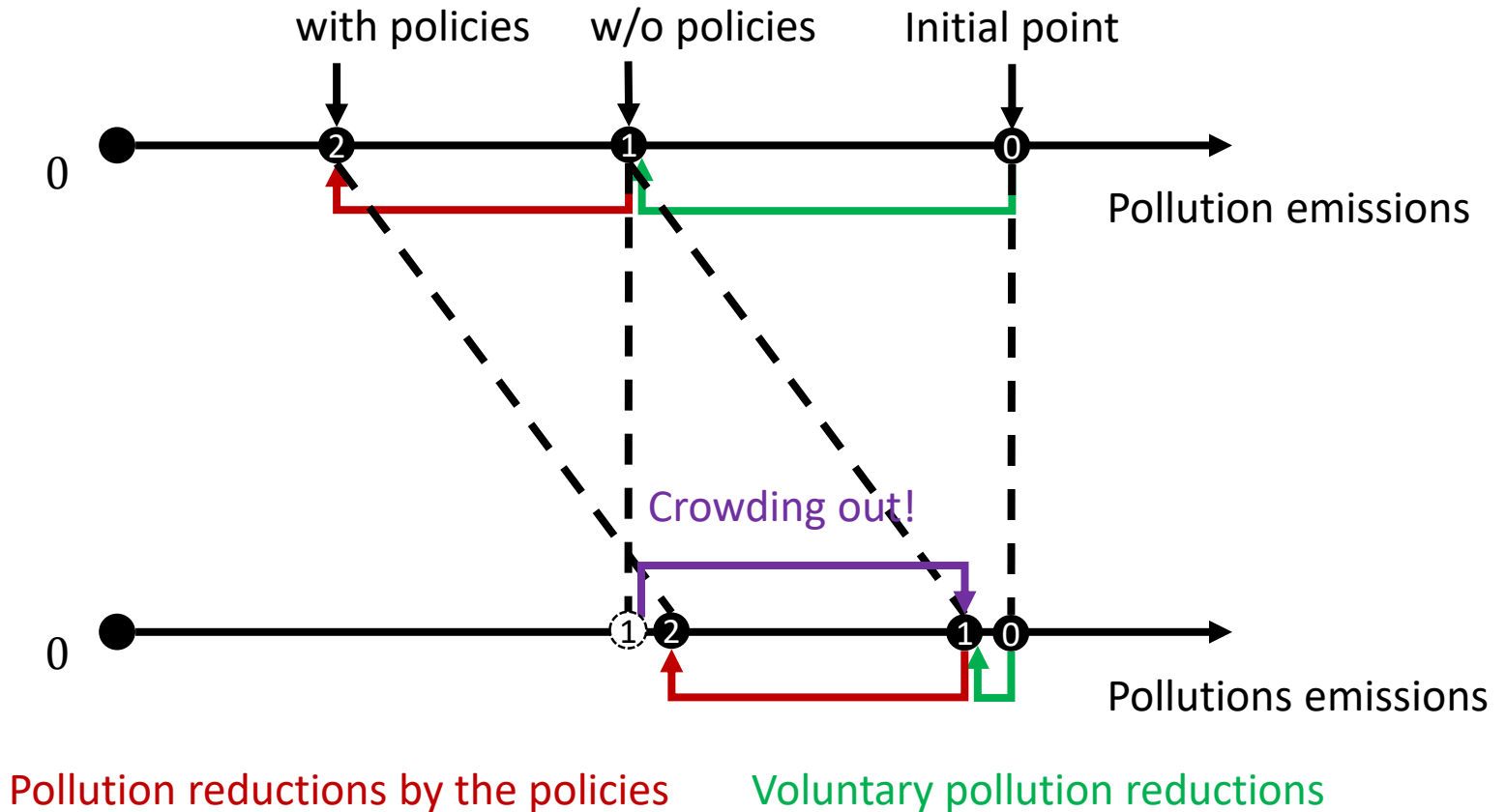
# Crowding out of the voluntary actions

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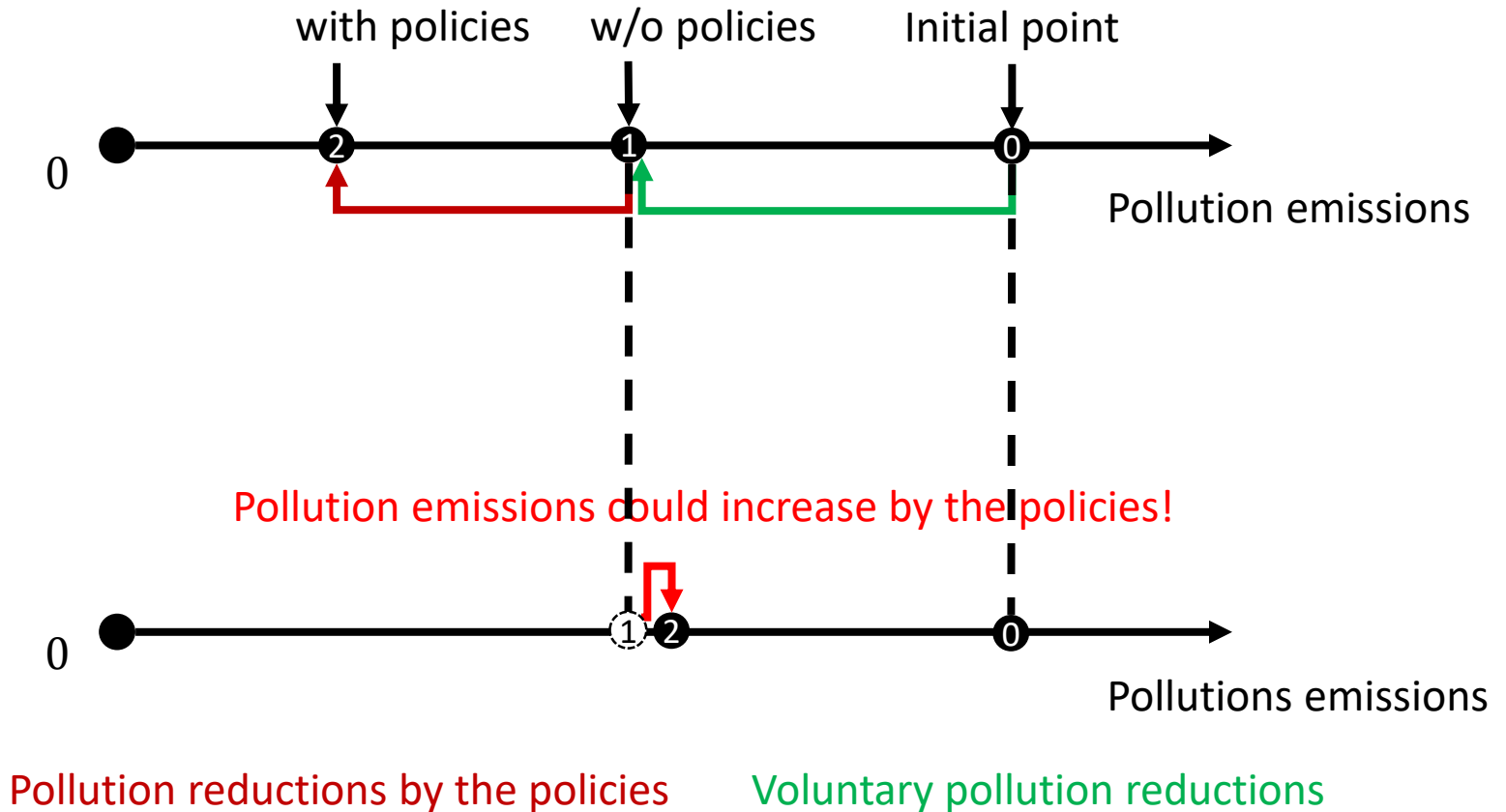
# Crowding out of the voluntary actions

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# Crowding out of the voluntary actions

Pollution reductions by the policies < Crowding out



# This research

examines the further properties of such crowding out effect by the numerical illustrations.

- ① How and when do environmental policies become disincentives for pollution reductions?
- ② How does such crowding out effect differ among alternative environmental policies?

# A Simple Economic Model

$N$  economic agents choose the pollution emissions maximizing their net private benefit:

$$\max_{z_i} B_i(z_i) - C_i(z_i), \text{ for } i = 1 \cdots N$$

Social optimality problems is to choose the pollution emissions maximizing the total net private benefit minus environmental damage:

$$\max_{z_i} \sum_{i=1}^N (B_i(z_i) - C_i(z_i)) - D(Z)$$

$$Z = \sum_{i=1}^N z_i$$

$B_i(z_i)$ ,  $C_i(z_i)$  and  $D(Z)$  are the C2 functions and  $B_i' > 0$ ,  $B_i'' < 0$ ,  $C_i' > 0$ ,  $C_i'' > 0$ ,  $D_i' > 0$ ,  $D_i'' > 0$ .

# Environmental taxes

- We do not consider the optimal emissions tax.
- We assume that the tax rate on the pollution emissions is **half of the optimal emissions tax**.

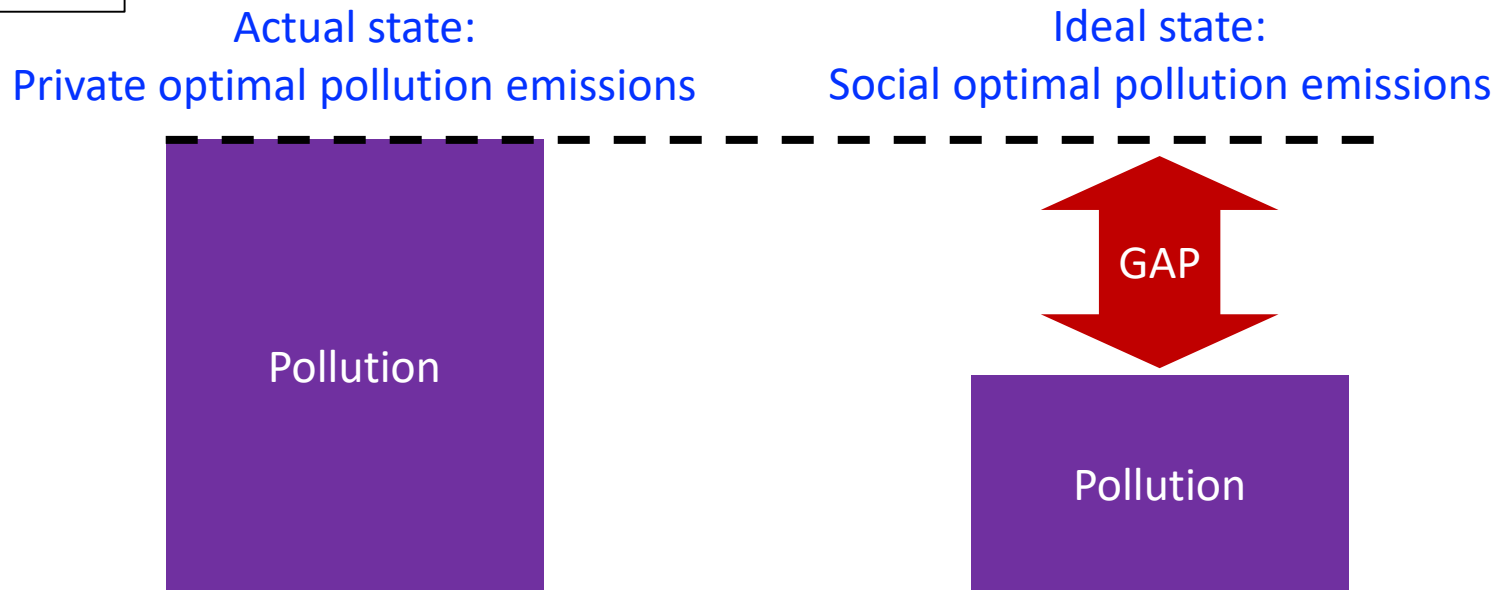
$$t = \frac{t^*}{2}$$



# Moral formation

We define the moral cost based on the gap between some values of private optimum and social optimum following the idea of Brekke et al. (2003).

Example



# Some options for moral cost definition

## ① Pollution emissions

Private optimal level with and w/o policies      Social optimal level

w/o policies       $M_i^*(z_i) = m_i(\bar{Z}^* - \bar{Z}^0)^2 z_i$

with policies       $M_i^T(z_i) = m_i(\bar{Z}^T - \bar{Z}^0)^2 z_i$

## ② Net private benefit

Private optimal level with and w/o policies      Social optimal level

w/o policies       $M_i^*(z_i) = m_i(NPB^* - NPB^0)^2 z_i$

with policies       $M_i^T(z_i) = m_i(NPB^T - NPB^0)^2 z_i$

Under the optimal policy  $M_i^*(z_i) = M_i^T(z_i) = 0$

# Crowding out effect

Crowding out effect:

$$CO_i =$$

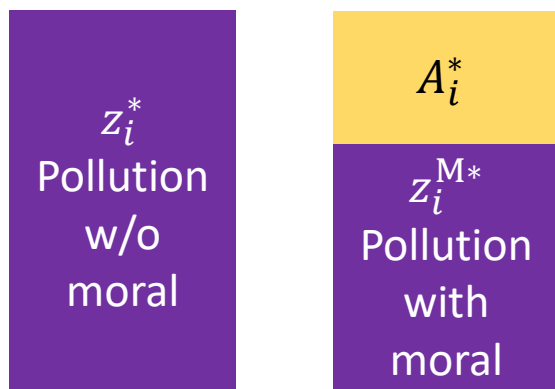
# Crowding out effect

Crowding out effect:

$$CO_i =$$

w/o policies

Voluntary pollution reductions



$$z_i^* = \operatorname{argmax}_{z_i} B_i(z_i) - C_i(z_i)$$

$$z_i^{M*} = \operatorname{argmax}_{z_i} B_i(z_i) - C_i(z_i) - M_i^*(z_i)$$

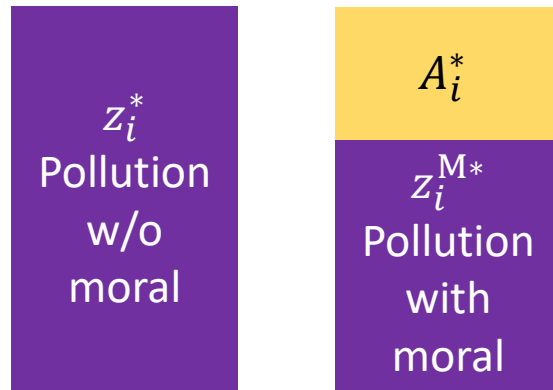
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Crowding out effect:

$$CO_i =$$

w/o policies

Voluntary pollution reductions



with policies

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$$z_i^* = \operatorname{argmax}_{z_i} B_i(z_i) - C_i(z_i)$$

$$z_i^{M*} = \operatorname{argmax}_{z_i} B_i(z_i) - C_i(z_i) - M_i^*(z_i)$$

$$z_i^T = \operatorname{argmax}_{z_i} B_i(z_i) - C_i(z_i) - tz_i$$

$$z_i^{MT} = \operatorname{argmax}_{z_i} B_i(z_i) - C_i(z_i) - tz_i - M_i^*(z_i)$$

# Crowding out effect

Crowding out effect:



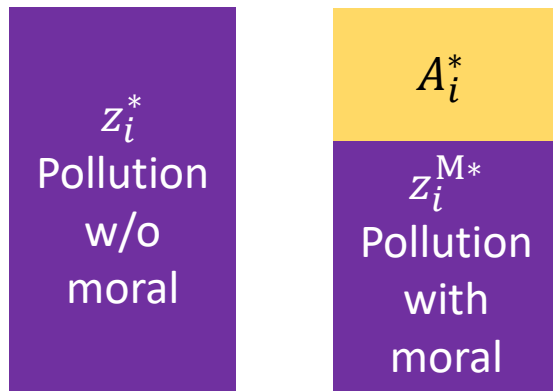
$$CO_i = A_i^* - A_i^T$$

w/o policies

with policies

Voluntary pollution reductions

Voluntary pollution reductions



$$z_i^* = \operatorname{argmax}_{z_i} B_i(z_i) - C_i(z_i)$$

$$z_i^{M*} = \operatorname{argmax}_{z_i} B_i(z_i) - C_i(z_i) - M_i^*(z_i)$$

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$$z_i^{MT} = \operatorname{argmax}_{z_i} B_i(z_i) - C_i(z_i) - tz_i - M_i^*(z_i)$$

# Numerical illustrations

We specify the functions as following:

Private benefit of pollution emissions  $B_i(z_i) = b_i z_i^{\frac{1}{2}}$

Private cost of pollution emissions  $C_i(z_i) = c_i z_i$

Environmental damage  $D(Z) = dZ^2, Z = \sum_{i=1}^N z_i$

# We focus on the two parameters:

- ① Growing technology (increasing  $b_i$ )

$$B_i(z_i) = b_i z_i^{\frac{1}{2}}$$

- ② Environmental education (increasing  $m_i$ )

$$M_i^*(z_i) = m_i (Z^* - Z^0)^2 z_i$$

$$M_i^T(z_i) = m_i (Z^T - Z^0)^2 z_i$$



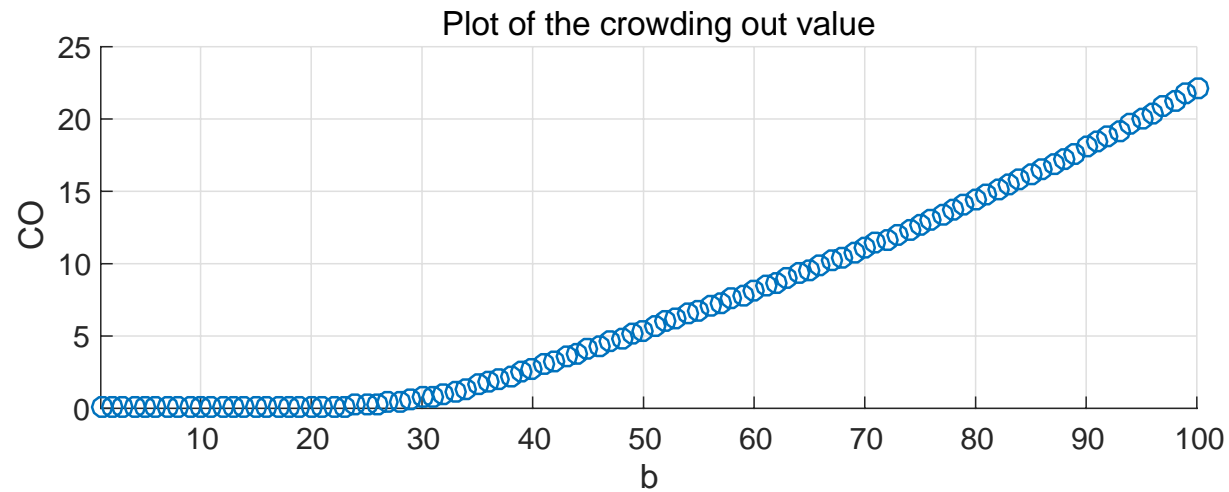
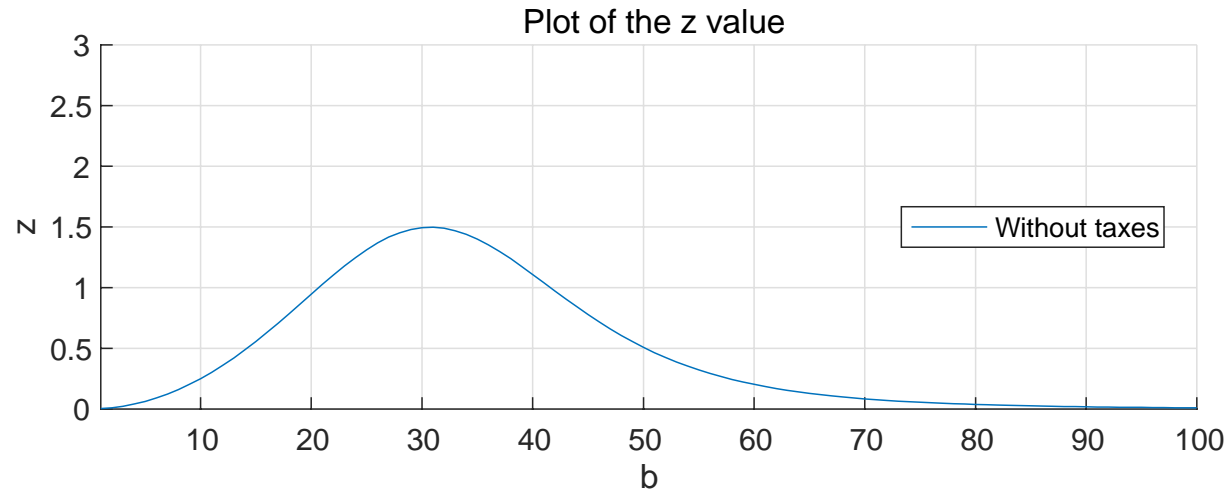
# Result 1

- Environmental policy: Taxes
- Moral formation: Pollution emissions

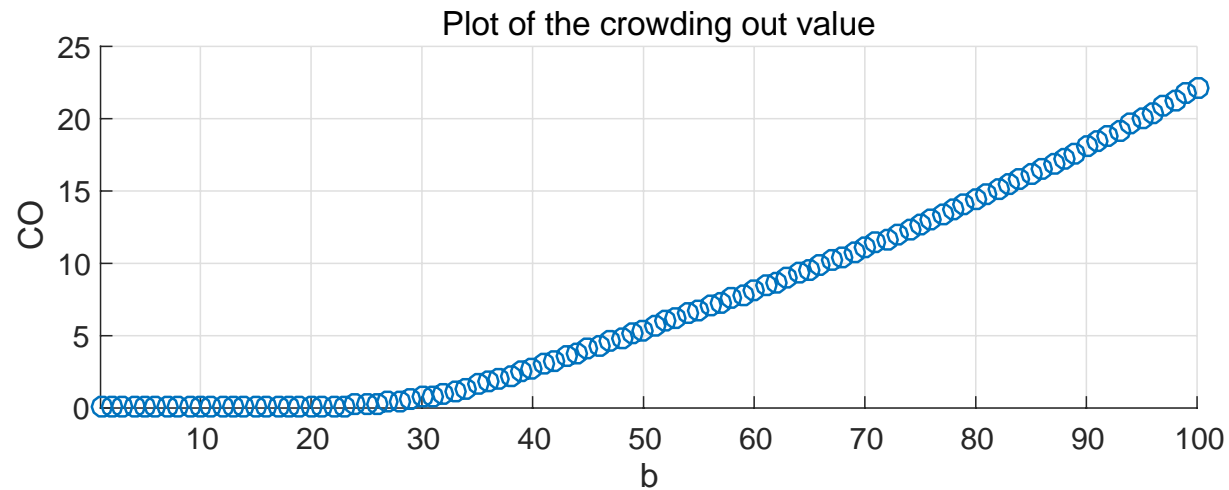
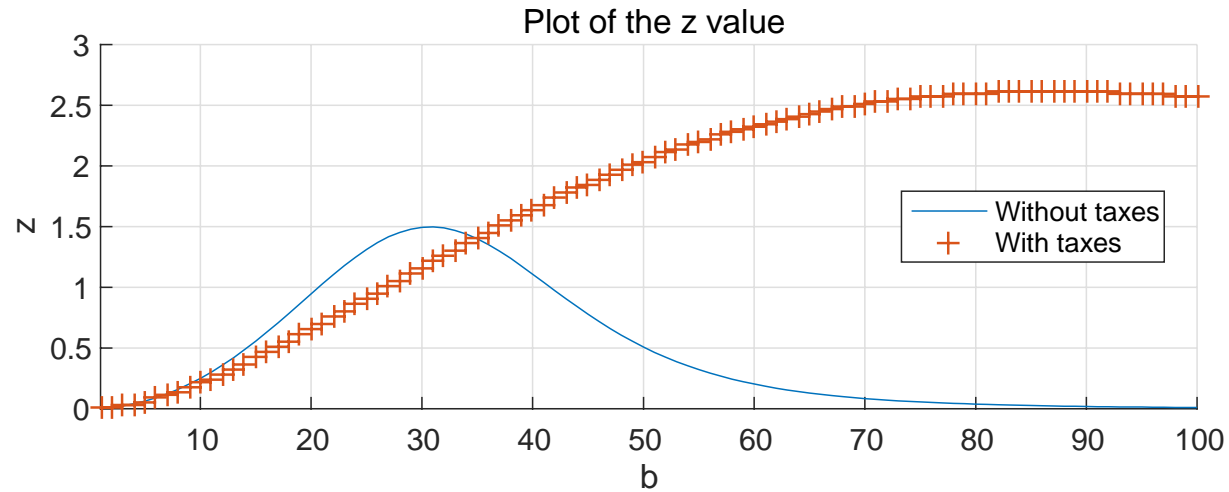
## Effect of the growing technology (increasing $b$ )

b

$$(b, c, d, m) = (1 \cdots 100, 10, 5, 1)$$

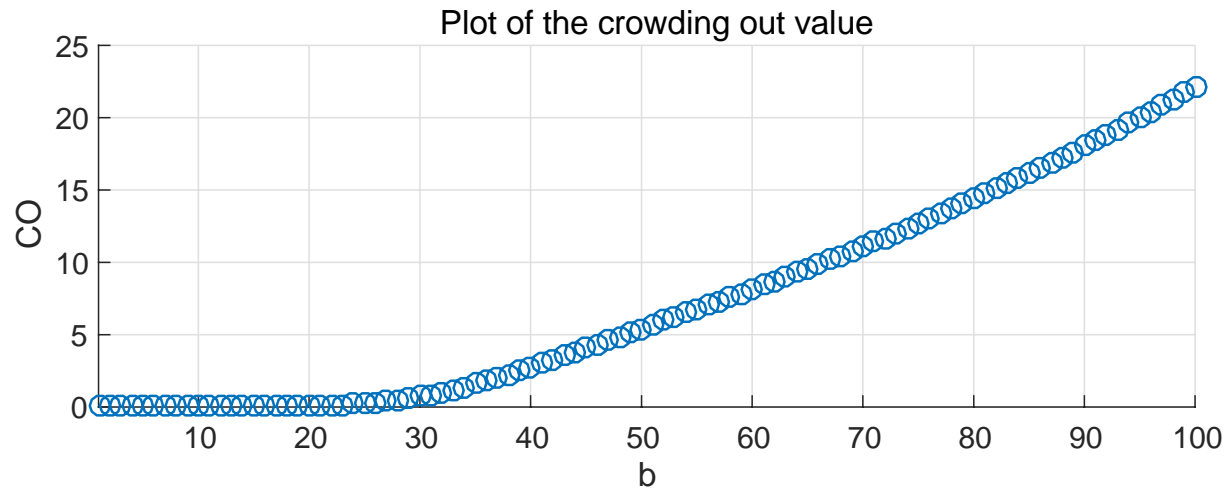
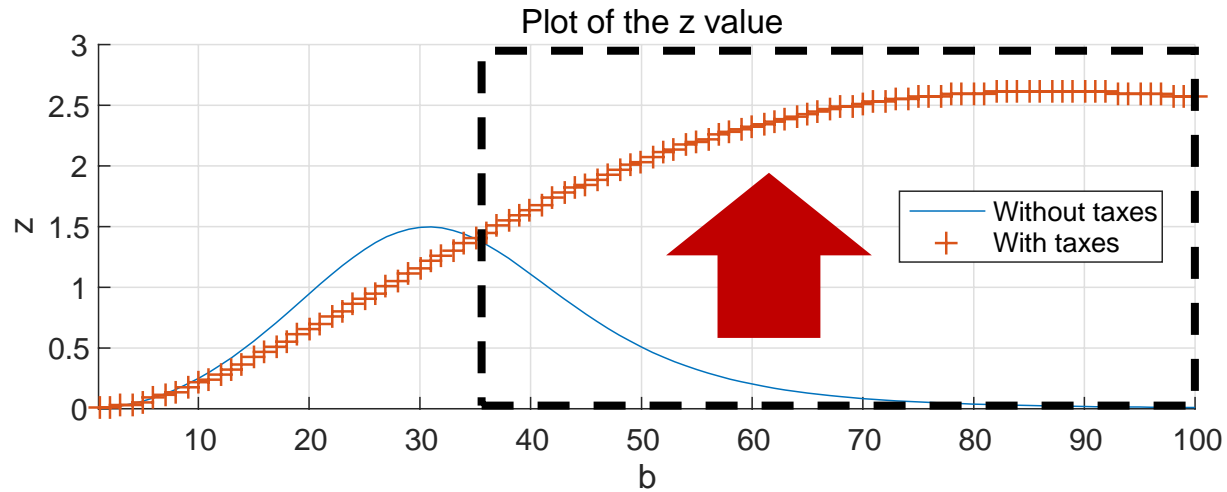


$$(b, c, d, m) = (1 \cdots 100, 10, 5, 1)$$



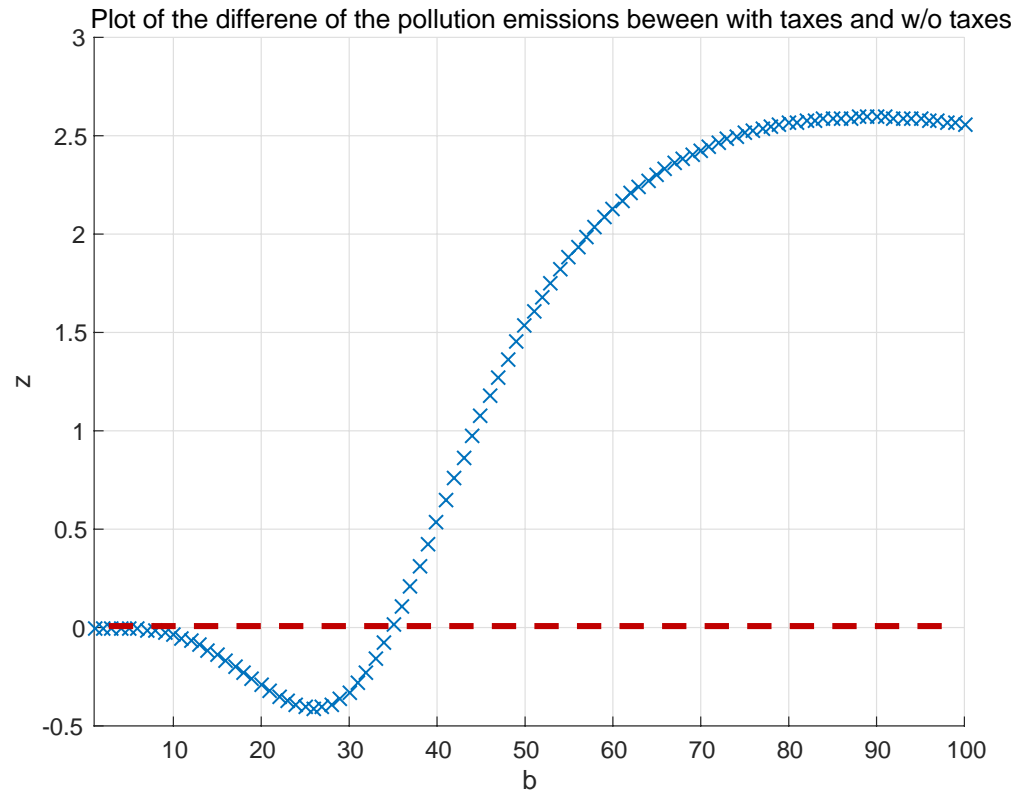
$$(b, c, d, m) = (1 \cdots 100, 10, 5, 1)$$

Environmental taxes increase the pollution emissions.



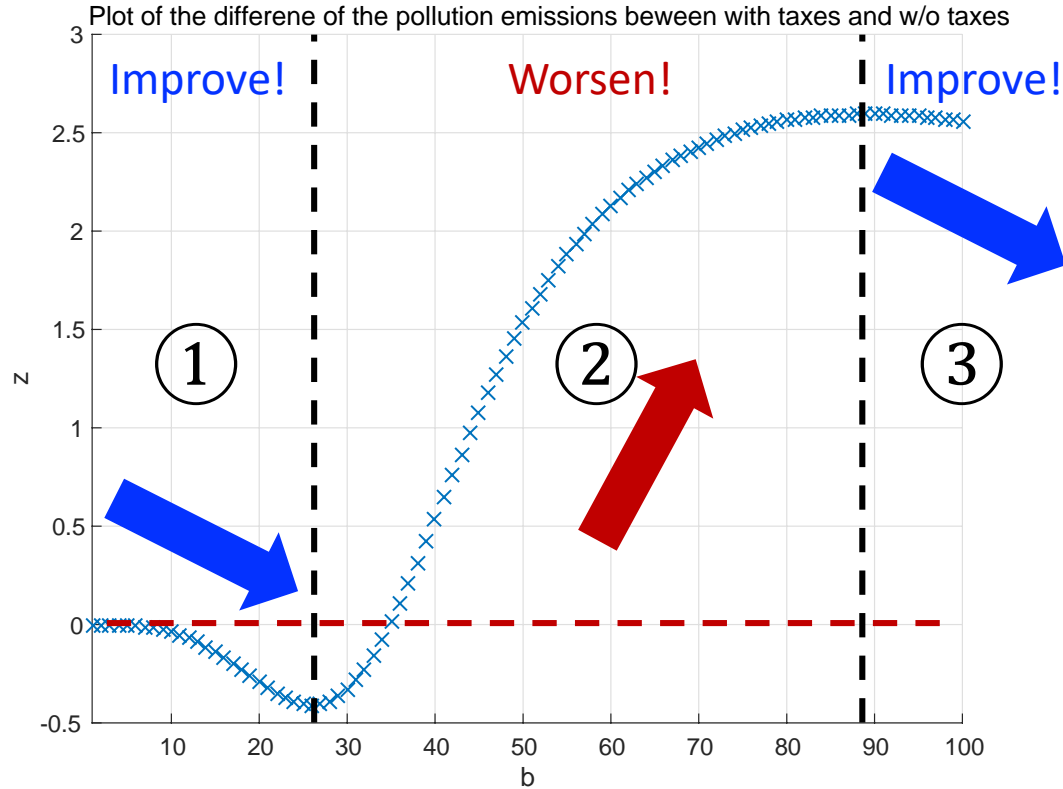
$$(b, c, d, m) = (1 \cdots 100, 10, 5, 1)$$

Pollution emissions change by the environmental taxes



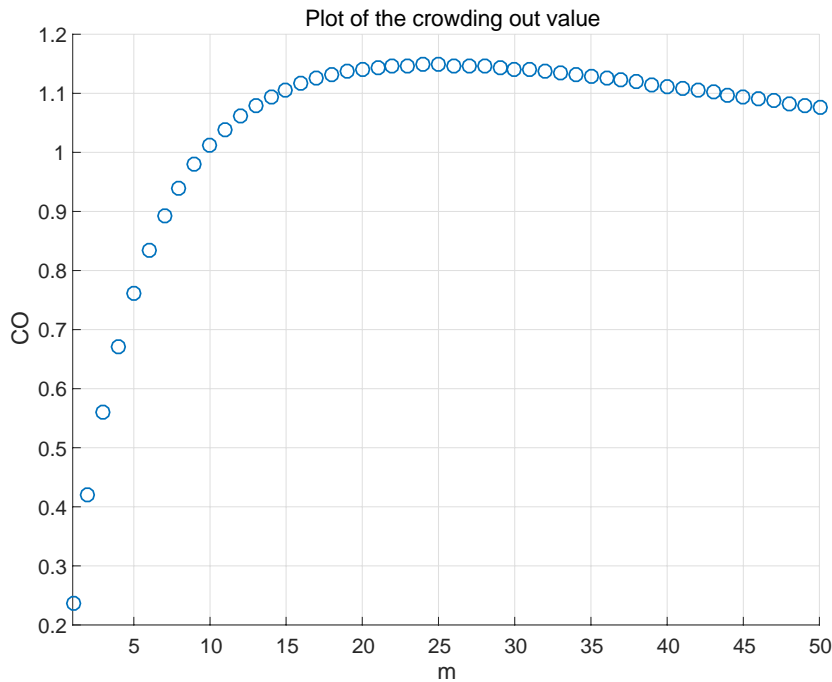
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Pollution emissions change by the environmental taxes



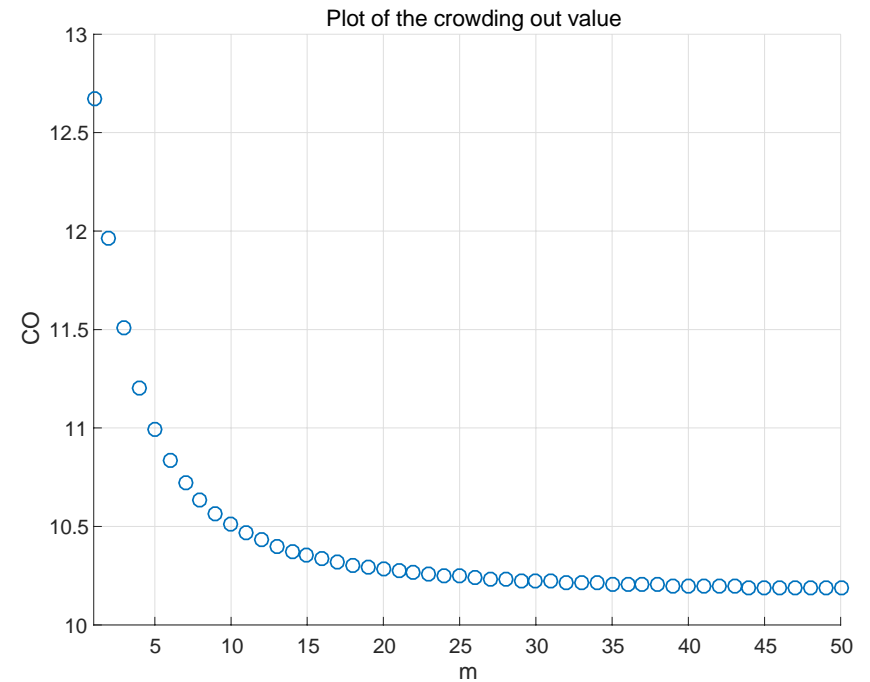
Relatively developing countries

$$(b, c, d, m) = (25, 10, 5, 1 \dots 50)$$



Relatively developed countries

$$(b, c, d, m) = (75, 10, 5, 1 \dots 50)$$



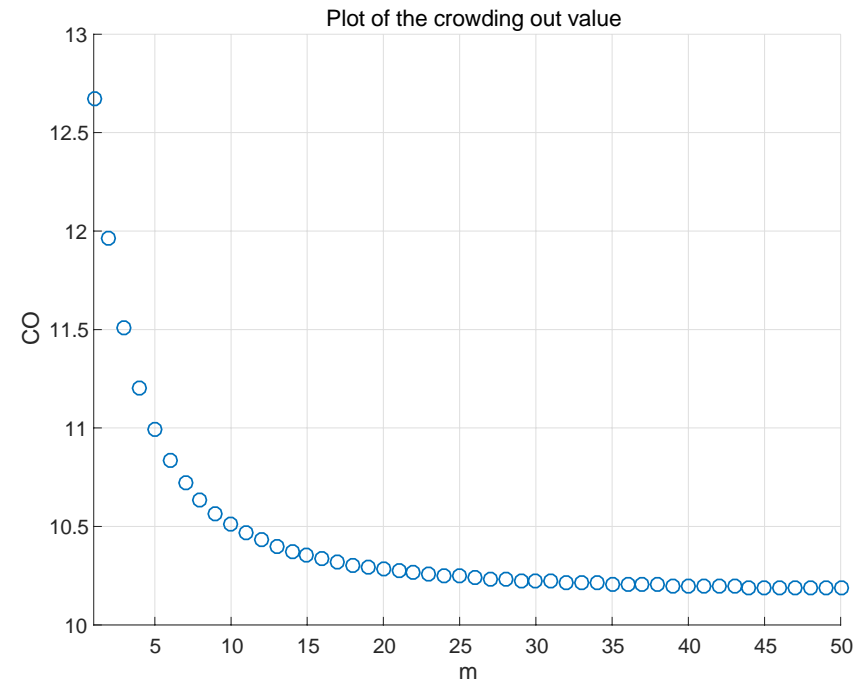
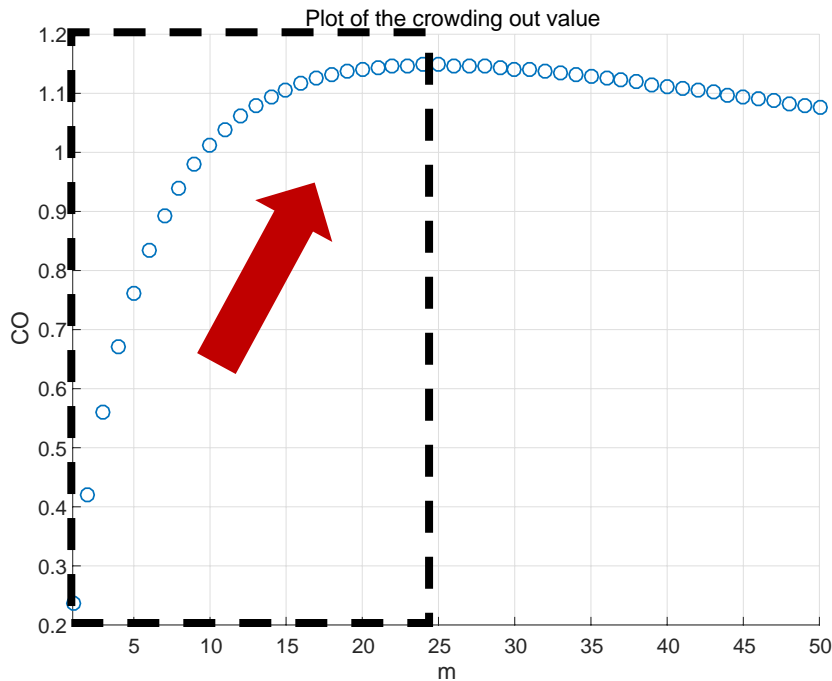
Relatively developing countries

$$(b, c, d, m) = (25, 10, 5, 1 \dots 50)$$

Relatively developed countries

$$(b, c, d, m) = (75, 10, 5, 1 \dots 50)$$

Environmental education increase the crowding out.





# Summary 1

If considering the moral cost, then

- Environmental policies could result in increasing pollution emissions by the crowding out effect.
- Growing technology could both improve and worsen the facility of environmental policies.
- In developing countries, environmental education could increase the magnitude of the crowding out effect and could increase the pollution emissions.

# Taxes versus Subsidies

Taxes

$$-tz_i$$

Subsidies

pollution reductions

$$+s(z_i^* - z_i)$$

$$= -sz_i + sz_i^*$$

Only difference is existence of lump-sum subsidies.

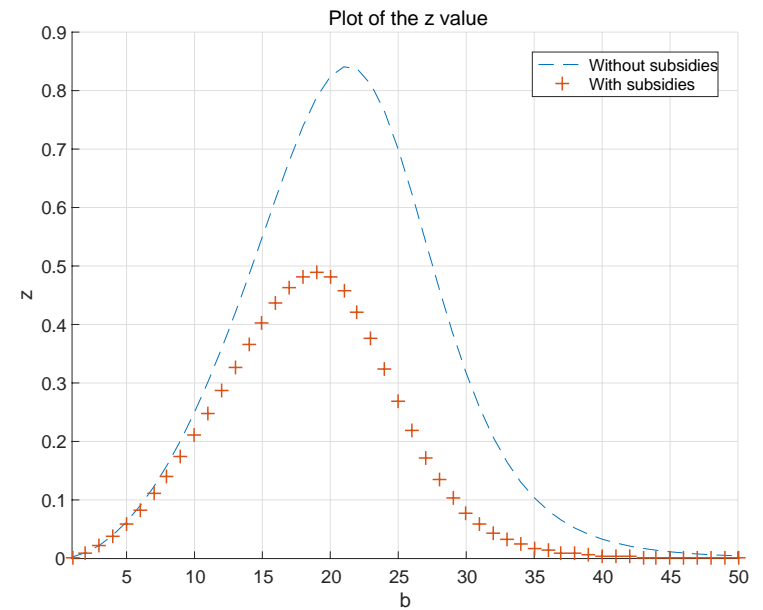
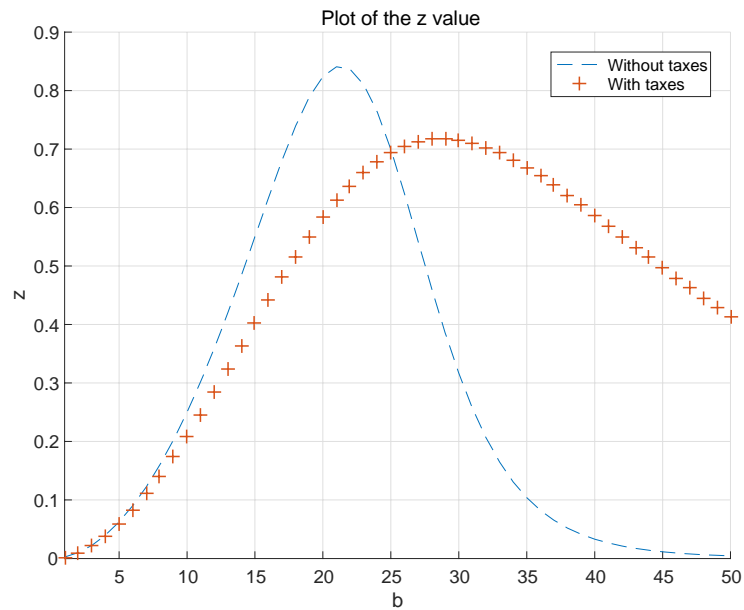
# Result 2

- Environmental policy: Taxes and Subsidies
- Moral formation: Net private benefit

$$(b, c, d, m) = (1 \cdots 50, 10, 5, 1)$$

### Taxes

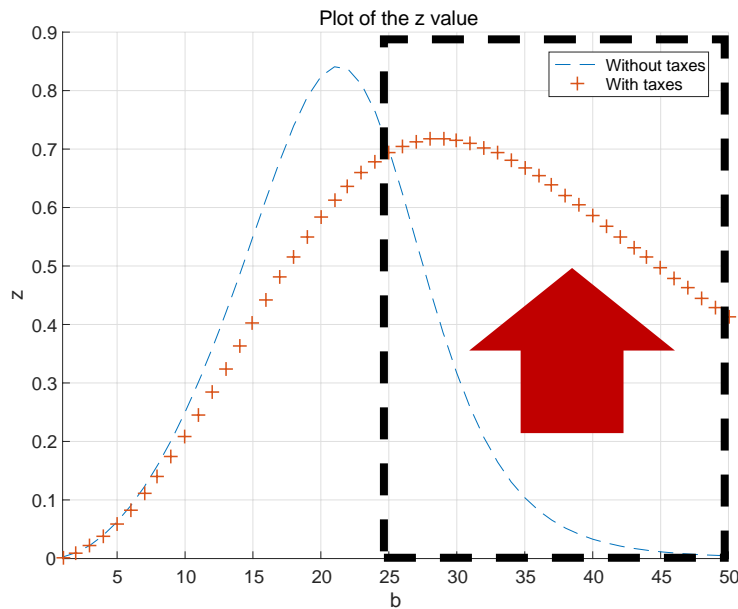
### Subsidies



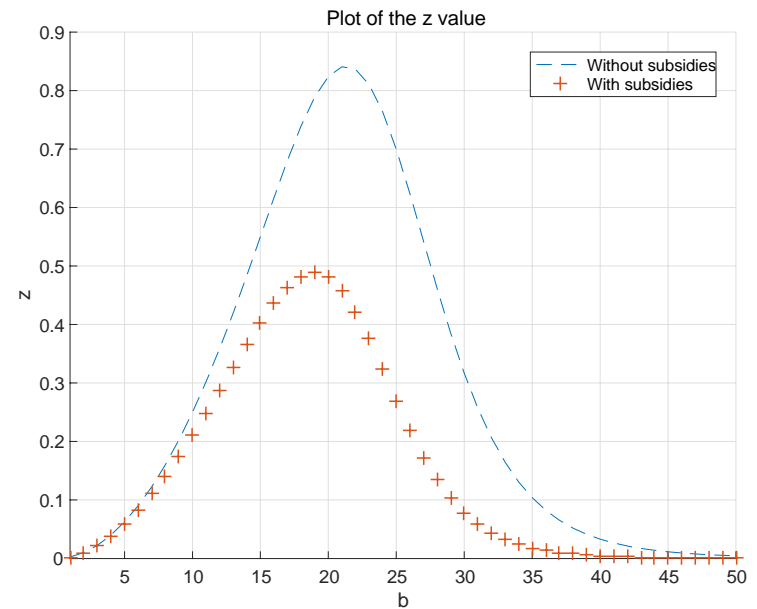
$$(b, c, d, m) = (1 \cdots 50, 10, 5, 1)$$

## Taxes

could increase pollution emissions!



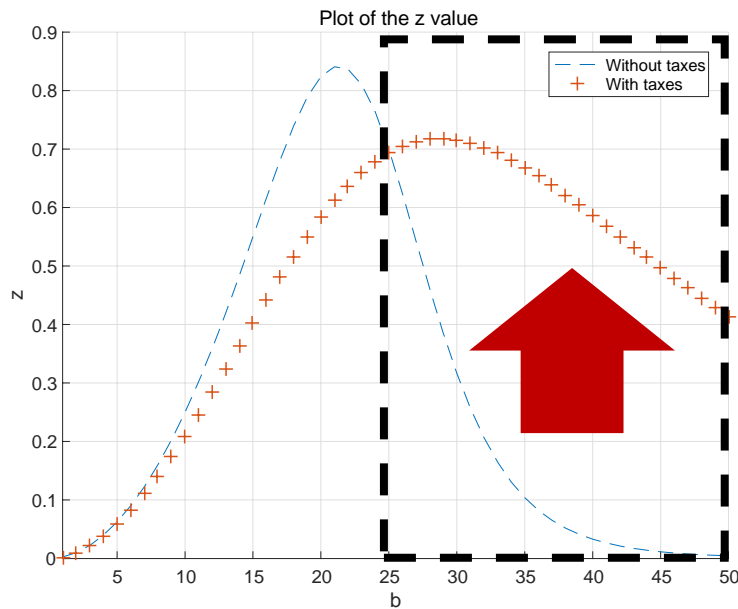
## Subsidies



$$(b, c, d, m) = (1 \cdots 50, 10, 5, 1)$$

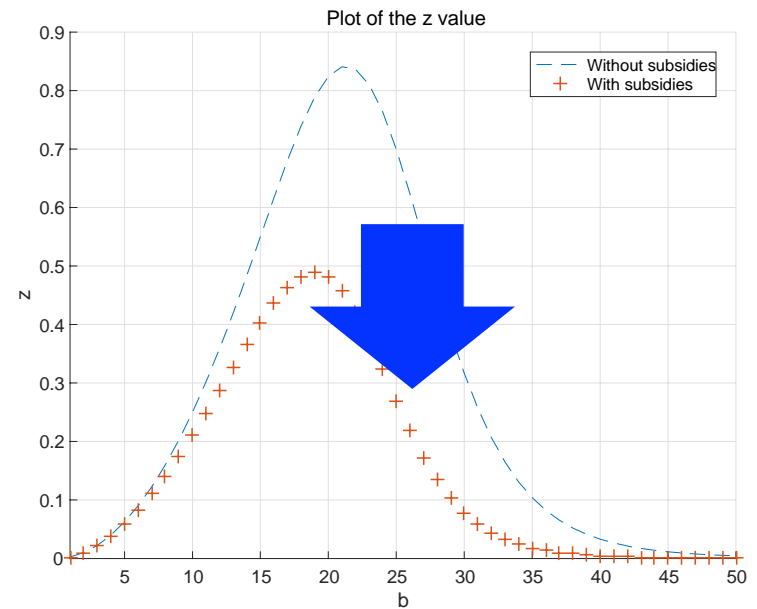
### Taxes

could increase pollution emissions!



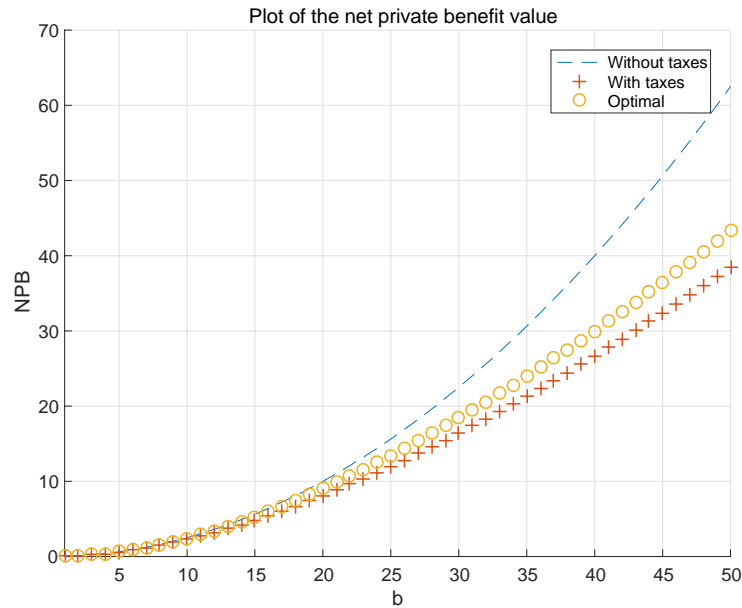
### Subsidies

always result in pollution reductions!

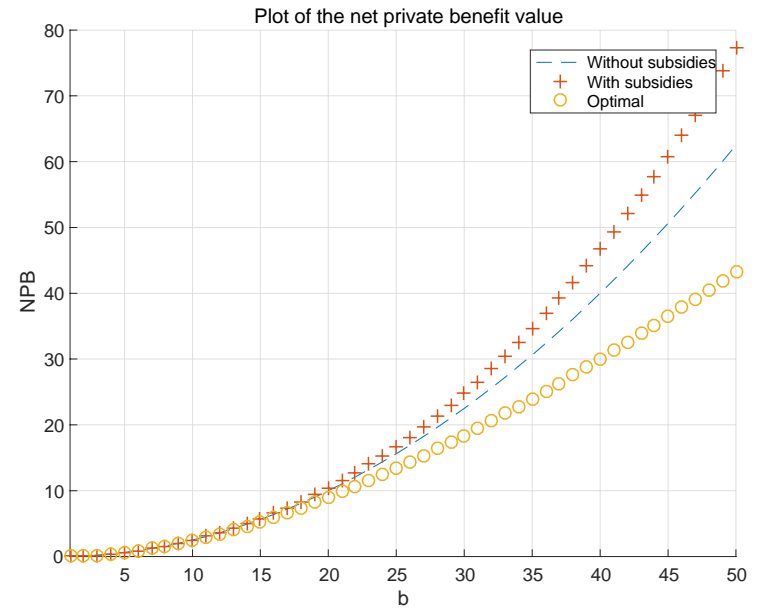


$$(b, c, d, m) = (1 \cdots 50, 10, 5, 1)$$

## Taxes



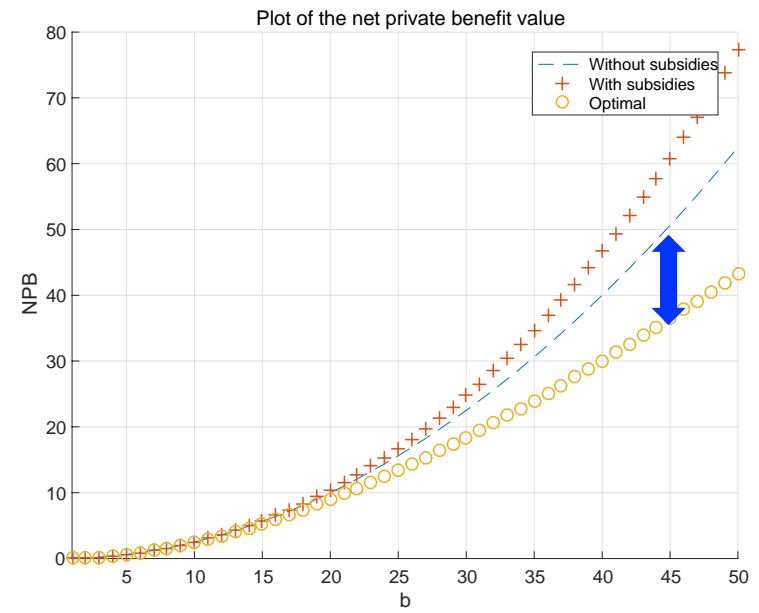
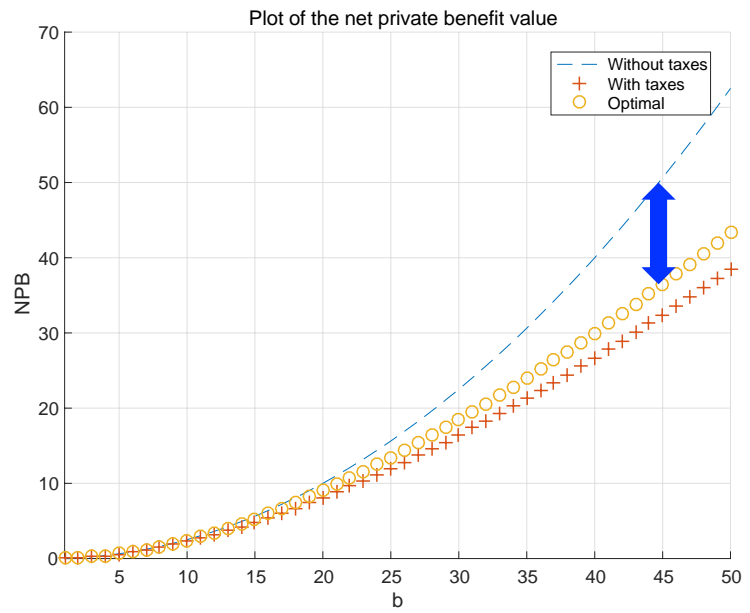
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## Taxes

## Subsidies



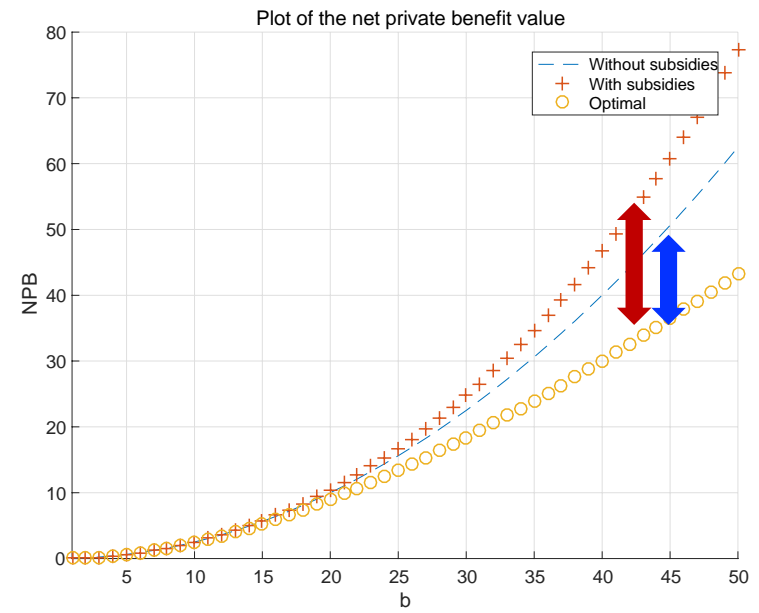
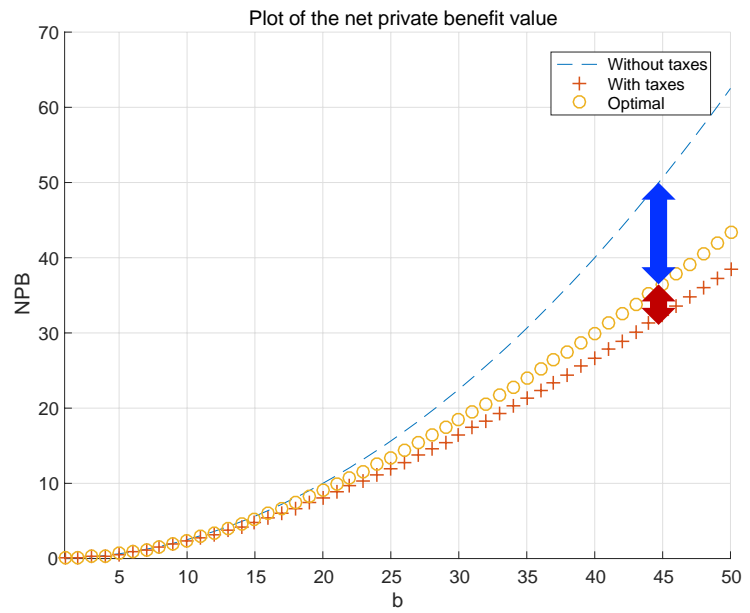
The gap between private and optimal level w/o policies.



$$(b, c, d, m) = (1 \cdots 50, 10, 5, 1)$$

## Taxes

## Subsidies



The gap between private and optimal level w/o policies.

The gap between private and optimal level with policies.

# Summary 2

- The crowding out effect is different between environmental taxes and subsidies.
- Under the given set up, environmental subsidies always decrease the pollution emissions, while environmental taxes could increase the pollution emissions.

# Remaining issues

1. General analysis not depending on the numerical calculation.
2. Case studies and empirical analysis.
3. Further understanding of the human decision making.

We need your cooperation!

## References

- [1] J. Andreoni, Impure altruism and donations to public goods: A theory of warm-glow giving, *The economic journal*, vol. 100, pp. 464-477 (1990)
- [2] K. A. Brekke, S. Kverndokk, K. Nyborg, An economic model of motivation, *Journal of Public Economics*, vol. 87, pp. 1967-1983 (2003)