2020年度寡占理論 (2)
A Comparison between Emission Intensity and Emission Cap Regulations

今日の講義の構成

(a) 超低炭素社会

(b) 原単位規制・排出量規制

(c) An Advantage of Emission Intensity Regulation for Emission Cap Regulation in a Near-Zero Emission Industry

お知らせ

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報告論文情報

Title
A Comparison between Emission Intensity and Emission Cap Regulations

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Low Emission Economy

Low Emission Society

(1) Bio Society

(2) Hydrogen Society （水素社会）

(3) Electrification Society （電化社会）

Bio Society

Bio fuel

Bio-power generation

Problems

Cost is high. (Higher than the costs of PV and Wind).

Food versus fuel→the dilemma regarding the risk of diverting farmland or crops for biofuels production to the detriment of the food supply.

Biofuels production may promote deforestation, local pollution, and/or global warming.

Hydrogen Society

Hydrogen from renewable, nuclear, or fossil fuel (coal, natural gas or oil) + Carbon Capture and Storage (CCS) or Carbon Capture and Utilization (CCU)

(Henceforth, CCS+CCS=CCSU)

Fuel cell vehicles (FCV)

Cogeneration by fuel cell

Hydrogen generation

Problems～Cost is high.

Electrification Society

Oil, Gas, Coal → Electricity

Decarbonization of the power supply

Conventional Fuel Thermal⇒Nuclear, Renewable, Fuel Thermal +CCSU

Electrification + Decarbonization of the power supply

⇒Ultra Low-Carbon Economy

Hydrogen and Bio can also play important roles in electrification society.

Near-Zero Emission Society

ICPP: almost zero net emission by 2050

Japan: 80% reduction of CO_2 by 2050

To meet this standard,

(a) High level of energy saving,

(b) Electrification

(c) The emission of current heavy emission industries such as electric power supply, steal, cement, must be close to zero.

Zero Emission of Electricity Industry

Renewable

Nuclear

Fuel Thermal + CSSU⇒I strongly doubt the cost efficiency of CCS in Japan.

electric power demand-supply adjusting reservation capacity →Hydrogen from renewable, Bio thermal, Pumped-storage hydropower, Battery, DR(Demand Response)

Zero Emission of Steal Industry

Coal →Hydrogen from renewable

or

CCSU

Blast Furnace(高炉)→Electric Furnace(電炉)

Third Basic Energy Plan in 2010

The Japanese government formulated the third basic energy plan in 2010.

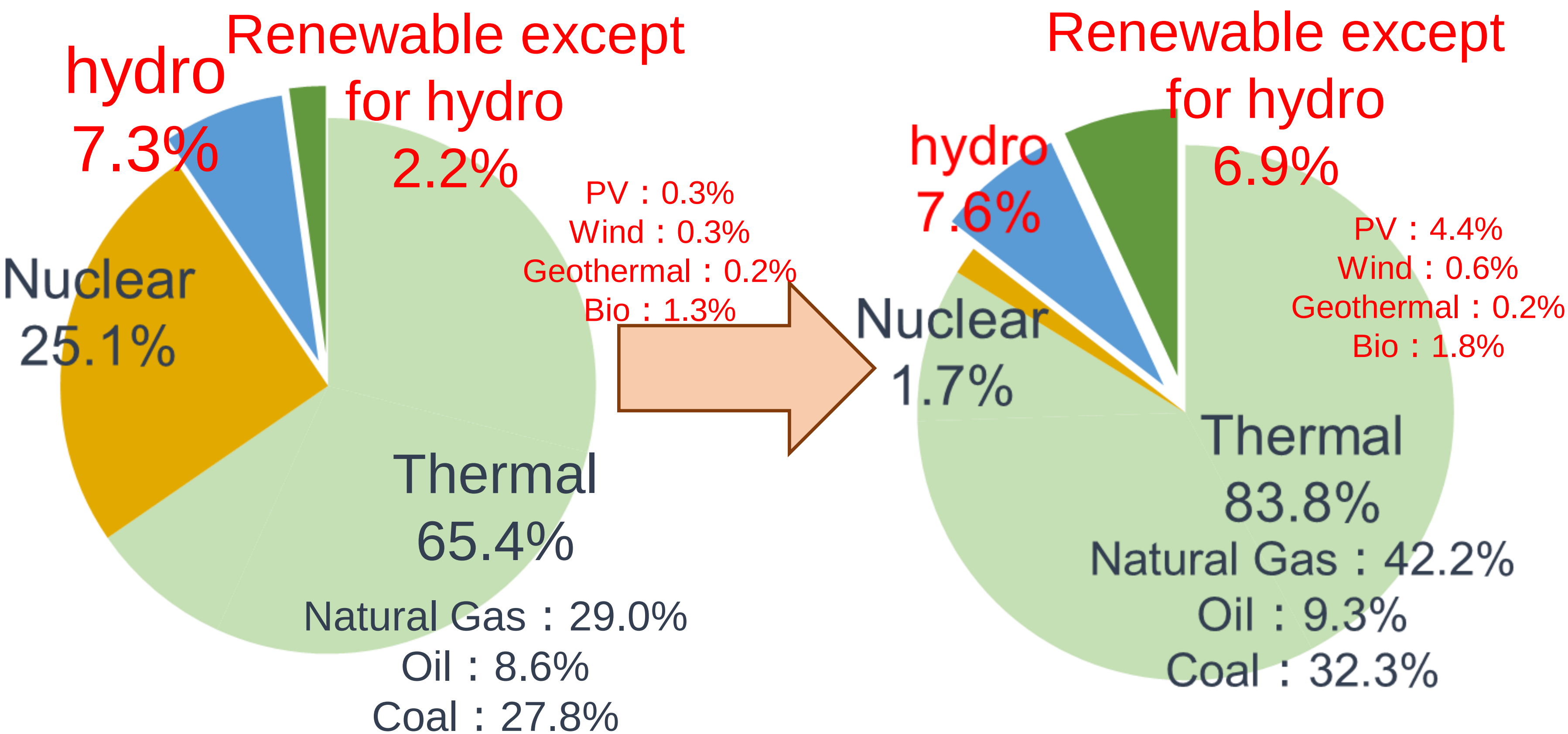
To reduce CO_2 emissions drastically, the government planned to depend on zero-emission stations by 70% (restrict thermal power stations by 30%) by 2030.

50% nuclear power stations, 20% renewable power stations (such as hydroelectric power, PV(photovoltaics, solar power), wind, geothermal, and bio.)

Electric Power Source Configuration in Japan

<2010> renewable＝9.5%

<2016> renewable=14.5%



Third Basic Energy Plan in 2010

In 2010, around 10% was generated from renewables, but around 80% of it is from large-scale hydroelectric power.

The Basic Energy Plan intended to increase renewables except for large-scale hydroelectric power six fold.

In 2010, around 25% was generated from nuclear. The government planed to double this by 2030.

Fourth Basic Energy Plan in 2014

After the accidents at Fukushima I Nuclear Power Station, the government was forced to completely renew the Basic Energy Plan.

In 2014, the target level of nuclear power changed from 50% to 20%, and from 20% to 22-24% for renewable energy.

Why is the target level for renewable energy so low?

Support for Renewable Energy

A Feed-in Tariff (FIT) was adopted after the earthquake.

At the first stage, the price for PV is about 0.4$/kW, more than four times larger than the market price. This price is fixed for 20 years. In other words, the entrants who have obtained a license can sell at 0.4$/kW for 20 years without price risk.

⇒Many firms rushed into the market. It substantially raised the electricity consumption price. (In 2017, it directly raised electricity price by 0.026$/kW, around 15% , this figure will be higher in 2018 and thereafter.)

Obstacle for Renewable Energy

Due to network capacity constraints, many projects of renewable energy stopped. Huge investments for network are required to restart the projects, which will further raise the electricity price.

The cost of PV in Japan was extremely high, around two times higher than the international price such as in European countries.

⇒The government lowered the FIT price, especially for PV, to meet the international standard cost. Moreover, it introduced auction for large scale PV, and will expand for smaller scale PV, Offshore and Onshore wind, Bio, and Geothermal. FIT will be replaced with FIP.

Renewable Energy and Electric Power Market System Reform

Many rules on connecting renewable energy to the grid are distorted, which raises the cost for new entrants.

Therefore, huge subsidy though FIT is required to increase renewable energy production, but it is not sustainable.

We now recognize that further development of electric power market system reform eliminating unnecessary regulations regarding connection, improving market efficiency, and restricting anticompetitive actions of incumbents reduces the cost of renewable energy, and these actions must be completed.

Emission Intensity Regulation

Emission Cap versus Emission Intensity

Emission Cap Regulation ~ Restriction of Total Emission

Emission Intensity Regulation ~ Restriction of Total Emission per Output (Restriction of Unit Emission)

Emission Cap Regulation (Emission Tax) versus Emission Intensity Regulation

Japanese government traditionally prefers emission intensity regulation to emission cap regulation, but it is repeatedly criticized by other governments and environment protection group.

Firm has a weaker incentive to reduce its output level under emission intensity regulation than emission cap regulation.

Carbon Pricing

Carbon Tax that is equal to the marginal damage of CO_2 emission (Pigovian Tax) internalizes the negative externality and yields the first-best outcome under perfect competition.

Introducing the carbon tax in electric power market may be an obstacle for electrification because it raise the electricity price and harm the competitive advantage of electricity over gas, oil, and so on.

However, it provides a strong incentive for reducing emission intensity and is useful for decarbonization in the industry.

To mitigate the former defect, EPA planned to use tax revenue to reduce the electricity price.

An Advantage of Emission Intensity Regulation for Emission Cap Regulation in a Near-Zero Emission Industry

Joint work with Kosuke Hirose

Efficiency of Emission Intensity Regulation

Under perfect competition, emission cap regulation can yield the first best, but emission intensity regulation can not (because output level becomes excessive for social welfare).

However, this property may be desirable under imperfect competition.

In this study, we show that emission intensity regulation dominates emission cap regulation in near-zero emission society.

The Model

Symmetric Cournot oligopoly. Emission level is given exogenously.

Firms choose their output and emission abatement.

⇒We restrict our attention to the symmetric equilibrium.

(Because we impose the classical stability condition,

the unique equilibrium is symmetric.)

Notations

q_i: output quantity of firm i (i=1,2,…,n)

P(Q): demand function

$C(q_i)$: production cost function

x_i: abatement level of firm i

$K(x_i)$ abatement cost function

$E_i := g(q_i) - x_i$:emission level

$\bar{E}$: targeted emission level

$\alpha_i := E_i/q$: emission intensity

$\underline{\alpha}$: emission intensity that yields $E_i = \bar{E}$

$\eta(\sum_{i=1}^{n} E_i)$:social cost of the emission

$\pi_i := P(Q) - C(q_i) - K(x_i)$: profit of the firm

$W := CS + \sum_{i=1}^{n} \pi_i - \eta(\sum_{i=1}^{n} E)$

Notations

superscript EI: the equilibrium outcomes under emission intensity commitment.

superscript EC: the equilibrium outcomes under emission intensity cap

superscript B: busyness as usual level

Assumptions

P(Q) is decreasing for P>0.

C'(q) $\geqq$ 0, C''(q) $\geqq$ 0

K'(x) $\geqq$ 0, K''(q) >0, K(0)=K'(0)=0.

q'(q) >0, g''(q) $\geqq$ 0

$\bar{E} \in (0, E^B)$

The standard stability condition

Comparison of the Output Level

Result 1: The equilibrium output is larger under emission intensity regulation than under emission cap regulation, that is, $q^{EI}(\bar{E})>q^{EC}(\bar{E})$

In the second stage, given α, the emission cap is proportional to its output⇒the firm has a stronger incentive to expand its output.

⇒ consumer welfare is greater under emission intensity regulation.

Note that the resulting emission level is same between emission cap regulation and emission intensity regulation by assumption.

Comparison of the Profit

Proposition 1

Emission cap regulation yields higher profit than does emission intensity regulation. (i.e., $\pi^{EC}(q^{EC}(\bar{E}), \bar{E}) > \pi^{EI}(q^{EI}(\bar{E}), \underline{\alpha})$.)

Emission cap regulation yields greater profit than emission intensity regulation.

Under emission intensity regulation, expecting larger equilibrium output, the government imposes a stricter regulation than under the emission cap regulation in order to keep the resulting emission level.

Welfare Comparison

Emission intensity commitment is better for consumer.

Emission cap is better for the producer (Proposition 1).

It is ambiguous which is better for social welfare.

However, we find two cases that yield clear results,

the case in which $\bar{E}$ is close to E^B

and the case in which $\bar{E}$ is close to 0.

Almost Zero Emission Case

Proposition 2

If $\bar{E}$ is sufficiently close to zero, emission intensity regulation yields greater welfare than does emission cap regulation.

In the almost zero emission industry, emission intensity regulation is better for social welfare.⇒It is reasonable to use this measure in electricity industry.

Intuition behind Proposition 2

If $\bar{E}$ =0, output expansion effect under emission intensity commitment disappears. therefore, two yield the same output level and abatement level.

A marginal increase in $\bar{E}$ increases the output level and the degree of it is larger under emission intensity commitment (Lemma 1).

Given $\bar{E}$, under emission cap, the output level is suboptimal (too small) because the social cost of increasing in output ($\eta' g' + C'$) is lower than that of private cost ($\eta' g' + C' - P' q$). Therefore, emission intensity that yields larger output is better for social welfare.

Business as Usual Case

Proposition 3

If $\bar{E}$ is sufficiently close to E^B.

Emission intensity commitment yields greater welfare than does emission cap commitment.

In the regulation is very weak, emission intensity commitment is better for social welfare.

Intuition behind Proposition 3

If $\bar{E} = E^B$, the commitment is not binding and two yield the same output level (the level without regulation) and abatement level (zero).

A marginal decrease in $\bar{E}$ increases the abatement level and the degree of it is larger under emission intensity commitment.

Given $\bar{E}$, under emission cap, the abatement level is suboptimal (too small). Therefore, emission intensity that yields higher abatement level is better for social welfare.

Other Cases

Propositions 2 and 3 state that in two polar cases, emission intensity yields greater welfare. Then, naturally we guess that for any $\bar{E} \in (0, E^B)$ emission intensity yields greater welfare. However, this conjecture is incorrect.

In two polar cases, $x^* > x^{EI} > x^{EC}$, where x^* is the second best abatement level.

Result 1 implies $x^{EI} > x^{EC}$. Therefore, as long as $x^* > x^{EI}$, emission intensity commitment is closer to the second best level, and yields greater welfare. However, it is possible that $x^* < x^{EI}$ holds. In this case, it is possible that emission cap yields greater welfare.

Other Cases

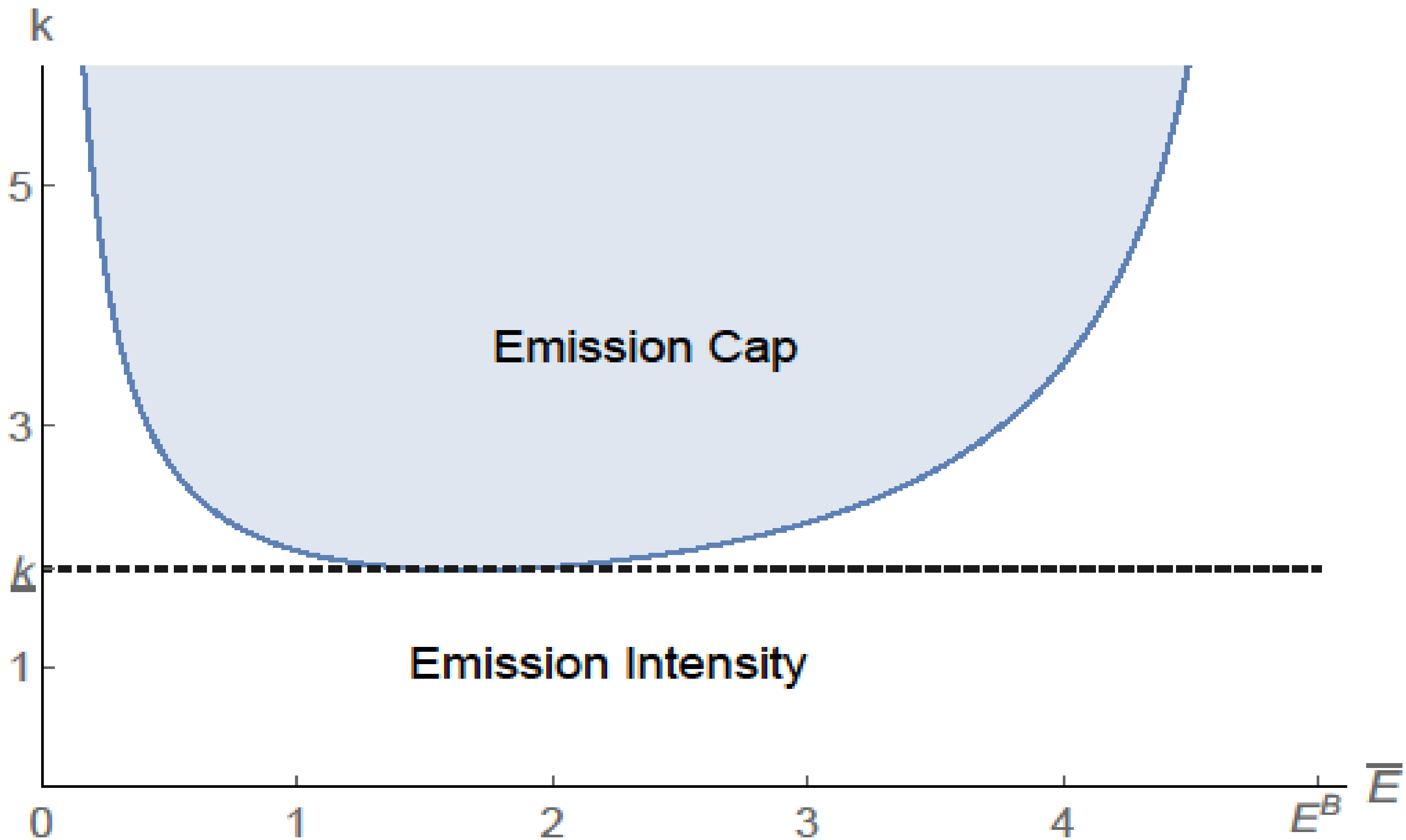
Proposition 4

Suppose that P=a-bq, C=0, g=eq, and $K=kx^2/2$. Then,

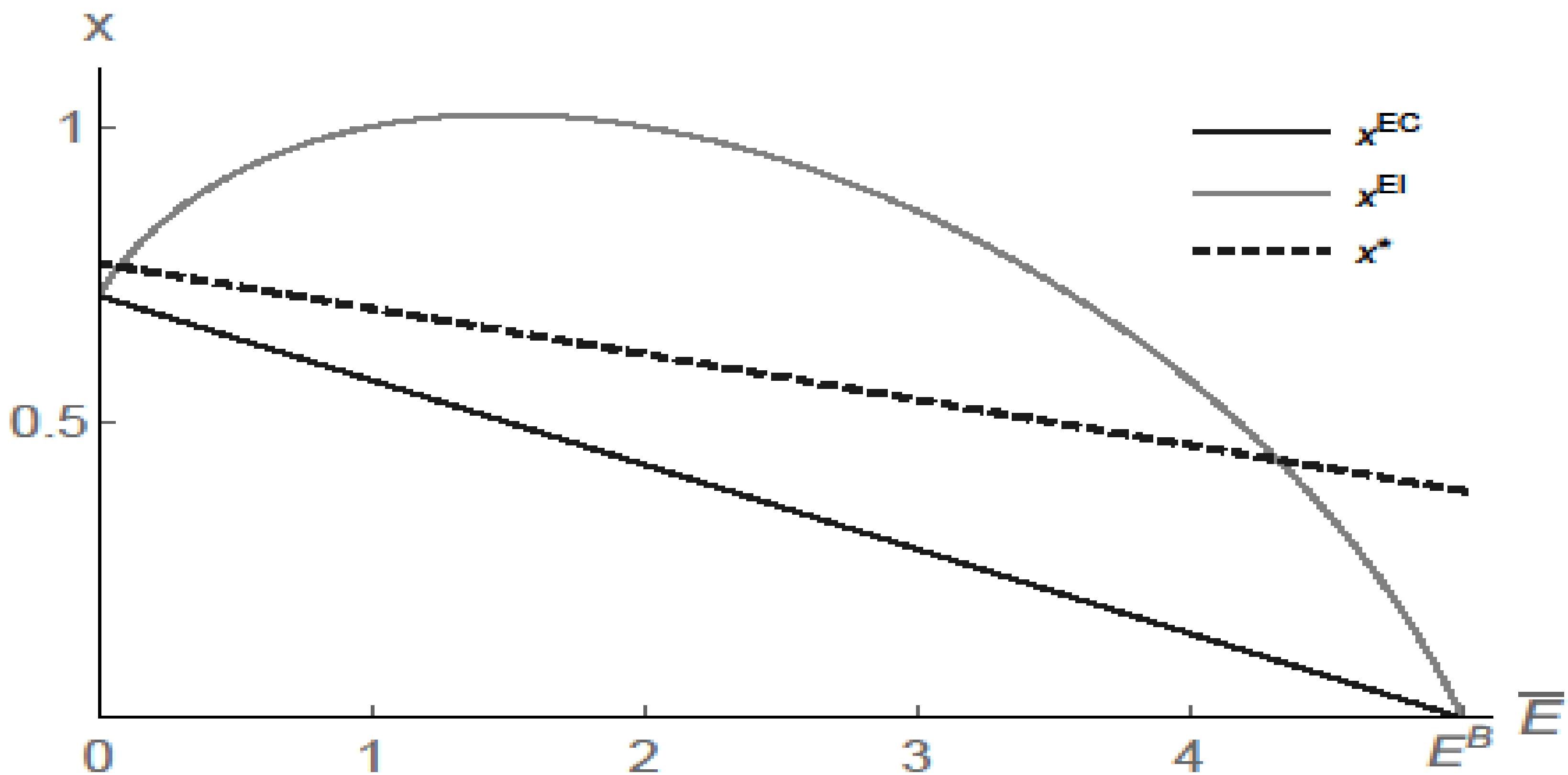
$W^{EI}>(<) W^{EC}$ if $k <(>) \tilde{k}$

Emission cap can yields greater welfare.

Area for the Advantage of Emission Cap Commitment



Comparison of the abatement level among the second best, emission cap, and emission intensity cases



Emission Abatement

Propositions 5

(i) x^* and x^{EC} are decreasing in $\bar{E}$.

(ii) x^{EI} may be increasing in $\bar{E}$.

More strict regulation may reduce abatement investment

~ Gutirrez and Teshima (2018)

Other my works on emission intensity regulations

(1) Noncooperative and Cooperative Environmental Corporate Social Responsibility, accepted by Journal of Institutional and Theoretical Economics (co-authored with Kosuke Hirose and Sang-Ho Lee).

(2) The Equivalence of Emission Tax with Tax-Revenue Refund and Emission Intensity Regulation.

Economics Letters, vol 182, pp. 126-128, September 2019 (co-authored with Hiroaki Ino).

Other my works on emission intensity regulations (unpublished)

(3) Optimality of Emission Pricing Policies Based on Emission Intensity Targets under Imperfect Competition (co-authored with Hiroaki Ino).

(4) Promoting Green or Restricting Gray?: An Analysis of Green Portfolio Standards (co-authored with Hiroaki Ino).

Thank you very much for your kind attention

非常感謝