Greenhouse gas emission uncertainty in compliance proving and emission trading

Zbigniew Nahorski[1], **Joanna Horabik**[1], **Matthias Jonas**[2]

[1]Systems Research Institute
Polish Academy of Sciences
Warsaw, Poland

[2]International Institute
for Applied Systems Analysis
Laxenburg, Austria

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Overview

- Proving compliance under uncertainty
  1. Problem formulation
  2. Undershooting
  3. Adjustment of the target level
- Emission trading under uncertainty
  1. Effective traded emission
  2. Effective emission permits

Compliance proving

	real (unknown) emission	estimated emission
basic year	$x(t_b)$	$\hat{x}(t_b)$
commitment year	$x(t_c)$	$\hat{x}(t_c)$
	$x(t_c) - (1-\delta)x(t_b) \leq 0$	$\hat{x}(t_c) - (1-\delta)\hat{x}(t_b)$?

δ – fraction of emission to be reduced

Interval uncertainty

$\pm\Delta$ - uncertainty interval

$$\hat{x}(t_b) - \Delta_b \leq x(t_b) \leq \hat{x}(t_b) + \Delta_b$$

$$\hat{x}(t_c) - \Delta_c \leq x(t_c) \leq \hat{x}(t_c) + \Delta_c$$

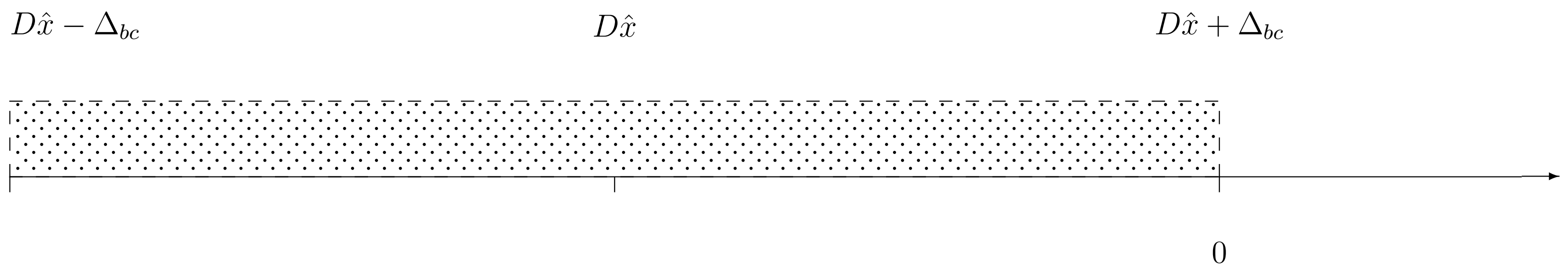
$$\Downarrow$$

$$D\hat{x} - \Delta_{bc} \leq x(t_c) - (1-\delta)x(t_b) \leq D\hat{x} + \Delta_{bc}$$

$$D\hat{x} = \hat{x}(t_c) - (1-\delta)\hat{x}(t_b)$$

$$\Delta_{bc} = \Delta_c + (1-\delta)\Delta_b$$

Undershooting (full credibility)

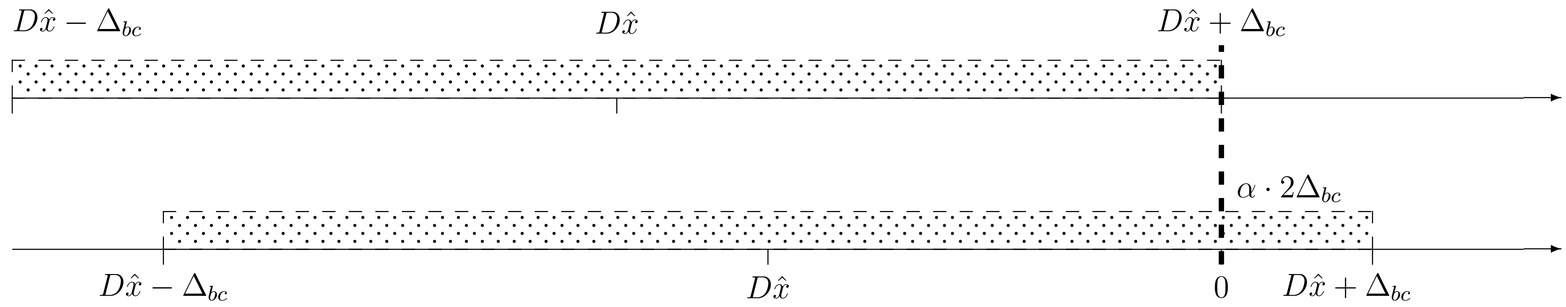


$$D\hat{x} + \Delta_{bc} = \hat{x}(t_c) - (1-\delta)\hat{x}(t_b) + \Delta_{bc} \leq 0$$

or

$$\hat{x}(t_c) + \Delta_{bc} \leq (1-\delta)\hat{x}(t_b)$$

Compliance with risk α (partial credibility)



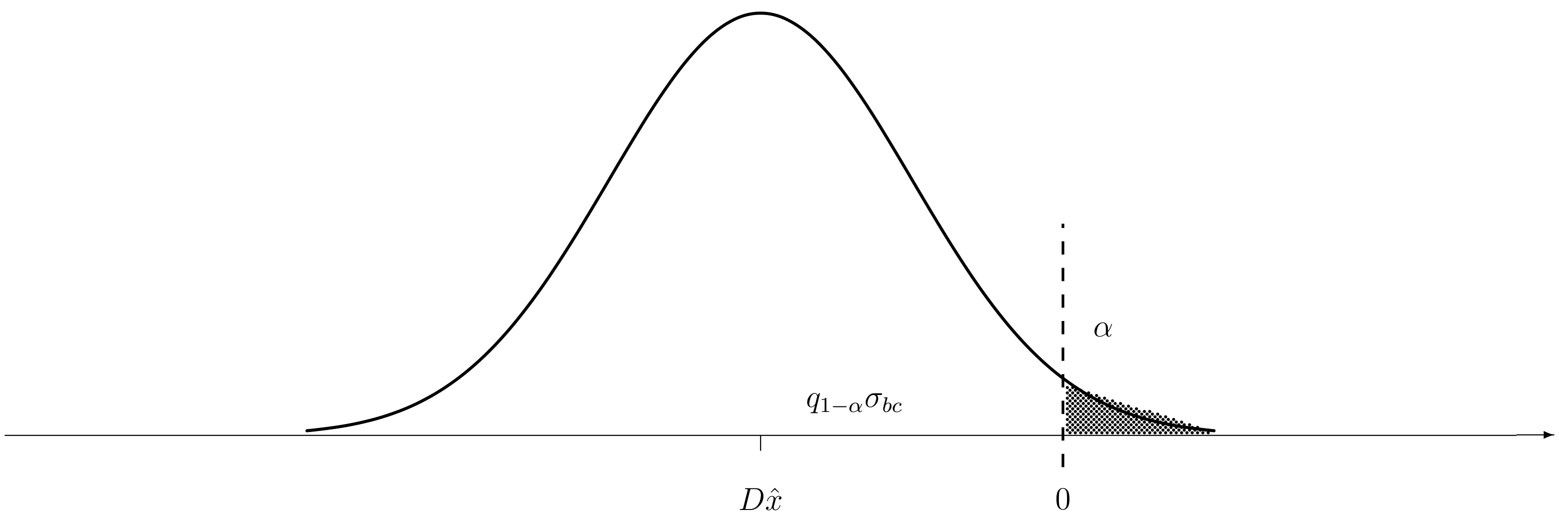
$$\hat{x}(t_c) + (1 - 2\alpha)\Delta_{bc} \leq (1 - \delta)\hat{x}(t_b)$$

α – assumed risk that the party is non-compliant

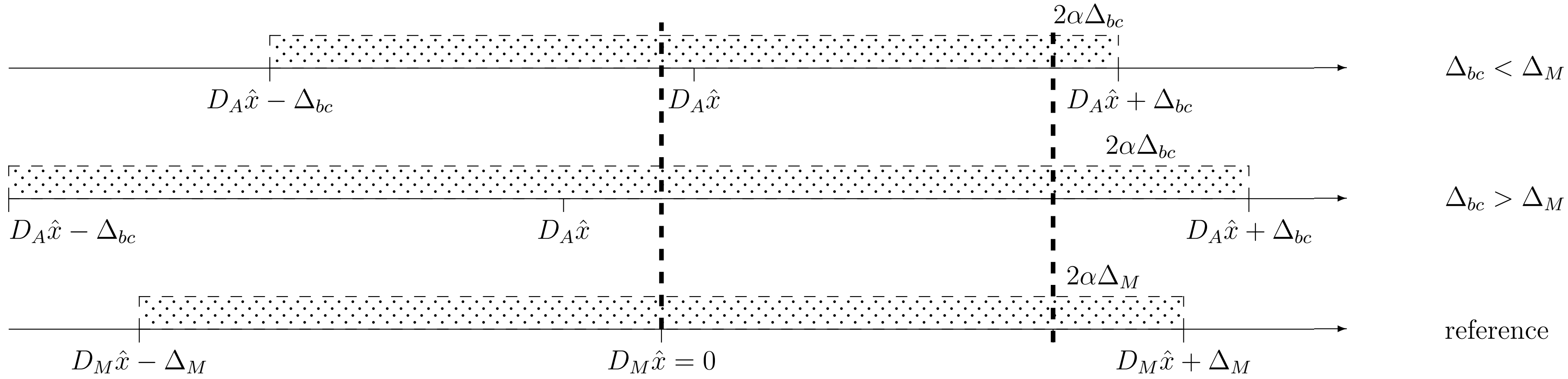
$$\hat{x}(t_c) \leq \Big(1 - \delta - (1 - 2\alpha)R_{bc}\Big)\hat{x}(t_b)$$

$R_{bc} = \frac{\Delta_{bc}}{\hat{x}(t_b)}$ – relative uncertainty

Stochastic type uncertainty



Adjusted target level



$$\hat{x}(t_c) \leq \Big(1 - \delta - (1 - 2\alpha)(R_{bc} - R_M)\Big)\hat{x}(t_b)$$

$R_{bc} = \frac{\Delta_{bc}}{\hat{x}(t_b)}$ $\qquad R_M = \frac{\Delta_M}{(1-\delta)\hat{x}(t_b)}$ – relative uncertainties

Choice of R_M

mean relative uncertainty

$$R_M = \frac{1}{N} \Sigma_{i=1}^{N} R_{bc}^{(i)}$$

mean absolute uncertainty

$$R_M = \frac{\Sigma_{i=1}^{N} \hat{x}^(i)(t_b) R_{bc}^{(i)}}{\Sigma_{i=1}^{N} \hat{x}^{(i)}(t_b)}$$

Emission trading – the selling party

- ^{S} – the selling party
- $\hat{x}^S(t_c)$ – emission at the commitment year
- $R_c^S = \frac{\Delta_c^S}{\hat{x}^S(t_c)}$ – relative uncertainty
- $\hat{E}^S$ – the unit of emission, e.g MtonCO$_2$
- $\hat{E}^S R_c^S$ – uncertainty of the unit of emission
- $n\hat{E}^S$ – n units of emission sold to other party
- $n\hat{E}^S R_c^S$ – uncertainty of n units of emission sold to other party

Emission trading – the buying party

- ^{B} – the buying party
- $\hat{x}^{B}(t_c)$ – emission at the commitment year
- $\Delta^{B}_{bc} = \Delta^{B}_{c} + (1 - \delta^{B})\Delta^{B}_{b}$ – uncertainty of compliance condition
- $\hat{x}^{B}(t_c) - n\hat{E}^{S}$ – emission balance after trade
- $\Delta^{B}_{bc} + n\hat{E}^{S}R^{S}_{c}$ – uncertainty of compliance condition after trade

Effective traded emission

Condition before the trade

$$\hat{x}^B(t_c) + (1-2\alpha)\Delta_{bc}^B \leq (1-\delta^B)\hat{x}^B(t_b)$$

Condition after the trade

$$\hat{x}^B(t_c) - n\hat{E}^S + (1-2\alpha)[\Delta_{bc}^B + n\hat{E}^S R_c^S] \leq (1-\delta^B)\hat{x}^B(t_b)$$

difference $\Longrightarrow$ effective traded emission

$$nE_{eff} = n\hat{E}^S - n(1-2\alpha)\hat{E}^S R_c^S = n\hat{E}^S[1-(1-2\alpha)R_v^S]$$

Conversion of one unit

$$E_{eff} = \hat{E}^S[1-(1-2\alpha)R_c^S]$$

Effective tradable permits

$\hat{E}$ – the emission permit

E_{eff} – the tradable permit

$\hat{x}(t_c)$ – the allotted emission

$\hat{x}(t_c)[1-(1-2\alpha)R_c] = l(t_c)$ – the tradable permits

Compliance proving condition – undershooting with risk α

$$l(t_c) \leq [1-\delta-2(1-2\alpha)R_c]l(t_b)$$

Compliance proving condition – adjustment of the target level

$$l(t_c) \leq [1-\delta-(1-2\alpha)(2R_c-R_M)]l(t_b)$$

Compliance proving and trading scheme

Before: Decision on choice of parameters, like δ, α, R_M

1. emission in the (consecutive) base year: $\hat{x}(t_b)$
2. tradable permits in the base year: $l(t_b) = \hat{x}(t_b)[1 - (1 - 2\alpha)R_b]$
3. allotted tradable permits in the commitment year:

$$l(t_c) = [1 - \delta - (1 - 2\alpha)(2R_c - R_M)]l(t_b)$$

4. allotted emission in the commitment year: $\hat{x}(t_c) = \frac{l(t_c)}{1-(1-2\alpha)R_c}$

Permits $l(t_c)$ traded on normal basis

Conclusions (1)

1. The approach solves the "credibility problem" by reducing different quality inventories to common level.
2. The approach reduces the uncertainty in observation problem to the well known "classic" permit trading with simple recalculation of the (estimated) emissions to effective permits and vice versa.
3. The approach is flexible – it has few parameters, which can be appropriately tuned.

Conclusions (2)

4. The approach encourages further investigations on documenting and decreasing uncertainty in inventories.
5. The approach can be readily adapted to trade between different activity plants with scattered uncertainties.
6. The approach requires additional agreements between parties, which may partially change those done so far.