Compliance and Emission Trading Rules for Uncertain Estimates of Inventory Uncertainty

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Kyoto obligations

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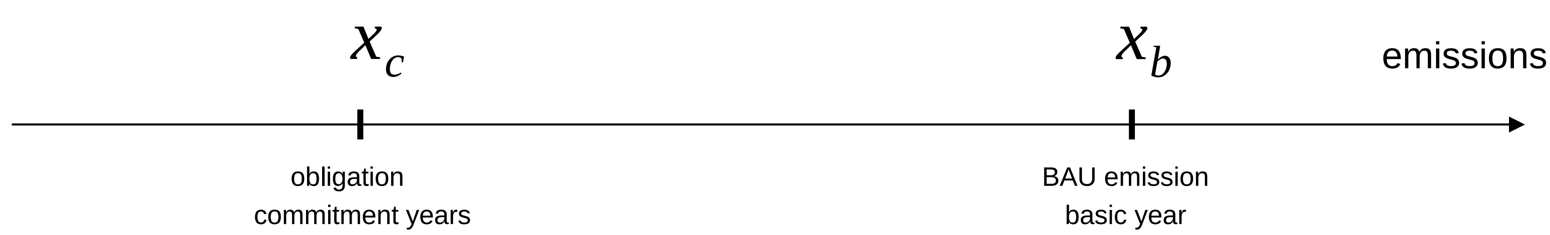
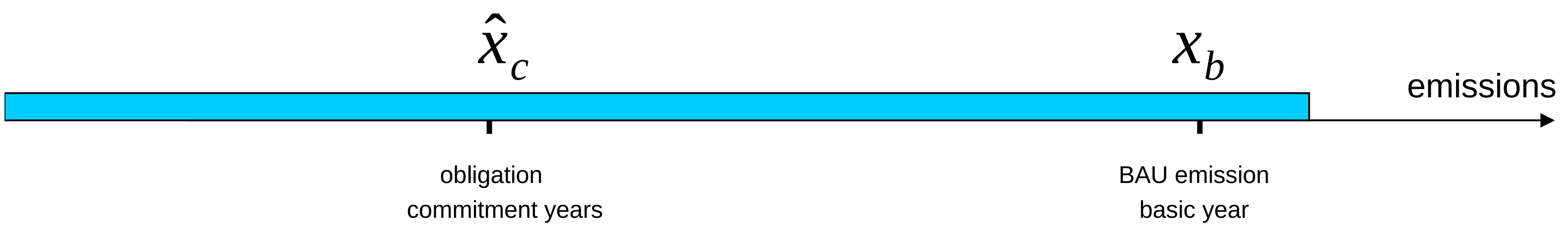
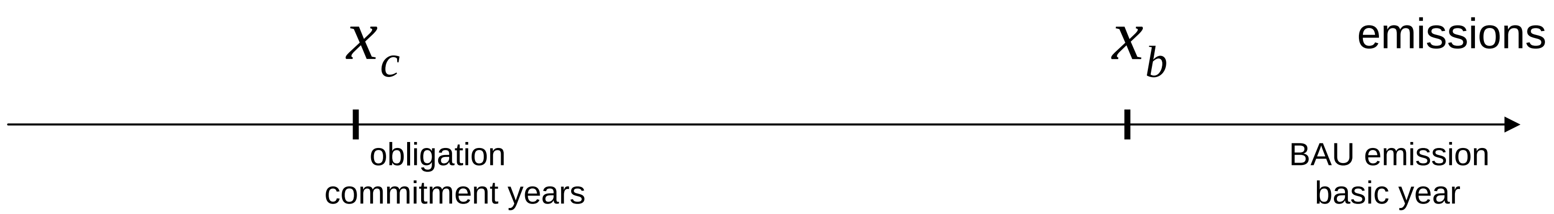
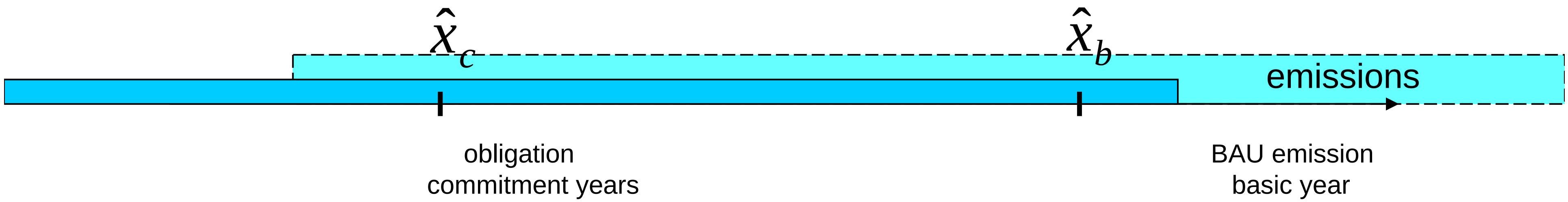




Kyoto obligations





Compliance under uncertainty (1)

$$x_c \le (1-\delta)x_b$$

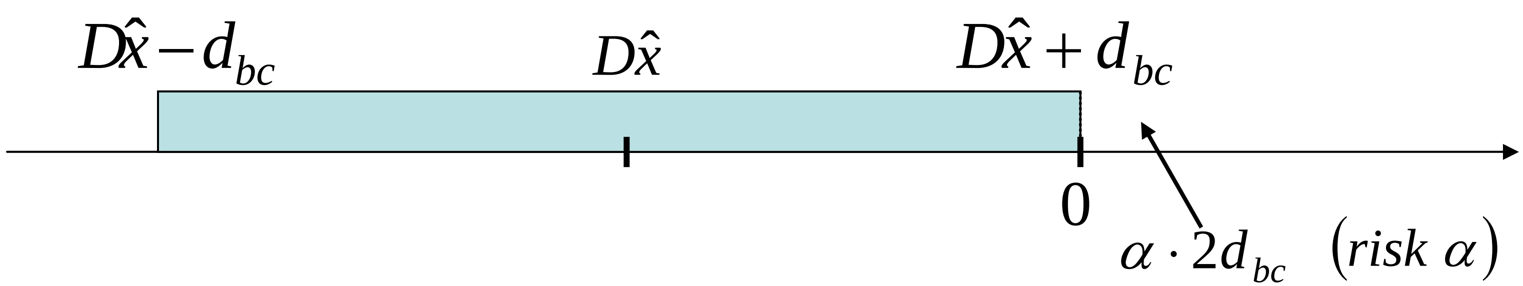
$$x_c - (1-\delta)x_b \le 0$$ exact knowledge

$$x_c \in [\hat{x}_c - d_c, \hat{x}_c + d_c] \qquad x_b \in [\hat{x}_b - d_b, \hat{x}_b + d_b]$$

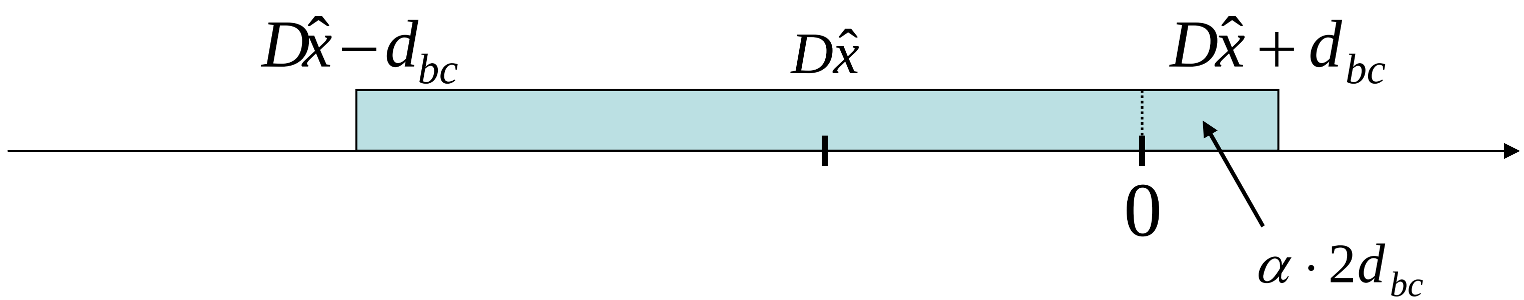
$$x_c - (1-\delta)x_b \in [D\hat{x} - d_{bc}, D\hat{x} + d_{bc}]$$

$$D\hat{x} = \hat{x}_c - (1-\delta)\hat{x}_b$$

$$d_{bc} = d_c + (1-\delta)d_b$$



Compliance under uncertainty (2)



$$\hat{x}_c - (1-\delta)\hat{x}_b + d_{bc} \leq 2\alpha d_{bc}$$

$$\boxed{\hat{x}_c} + \boxed{(1-2\alpha)d_{bc}} \leq (1-\delta)\hat{x}_b$$

modified compliance rule

inventory

unreported inventory

due to uncertainty

Emission trading

Buying party before the trade

$$\hat{x}_c^B + (1-2\alpha)d_{bc}^B \le (1-\delta)x_b^B$$

Selling party relative uncertainty

$$R_c^S = \frac{d_c^S}{\hat{x}_c^S}$$

purchased quota $\hat{E}^S$ with uncertainty $\hat{E}^S R_c^S$

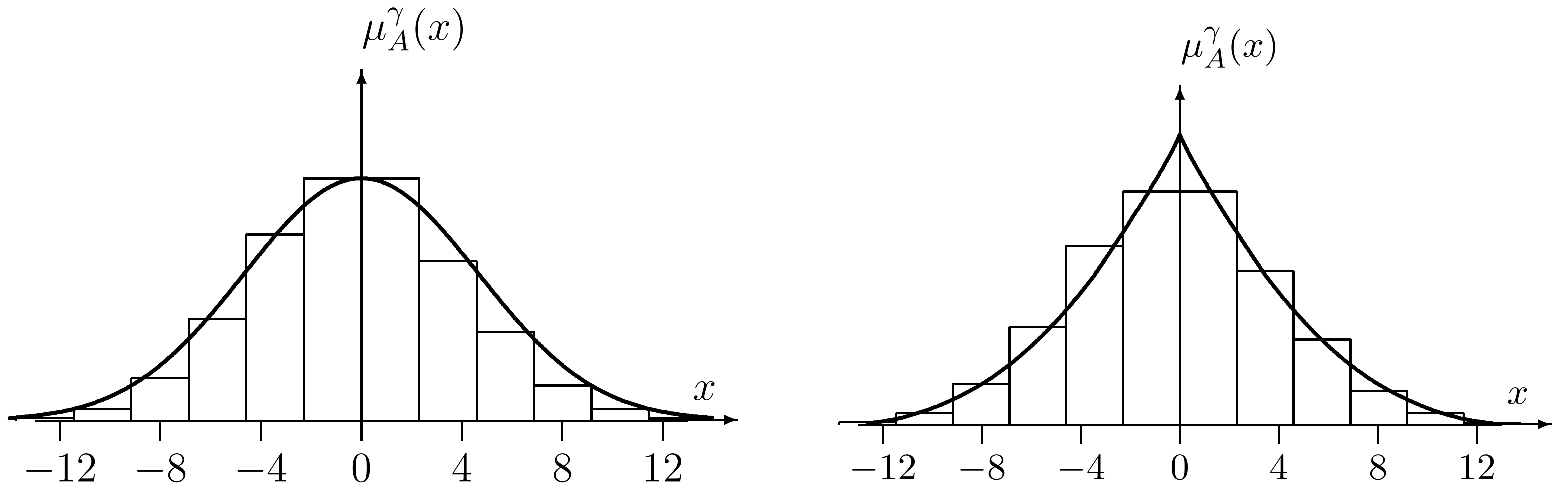
Buying party after the trade

$$\hat{x}_c^B - \hat{E}^S + (1-2\alpha)\left[d_{bc}^B + \hat{E}^S R_c^S\right] \le (1-\delta)x_b^B$$

real difference

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

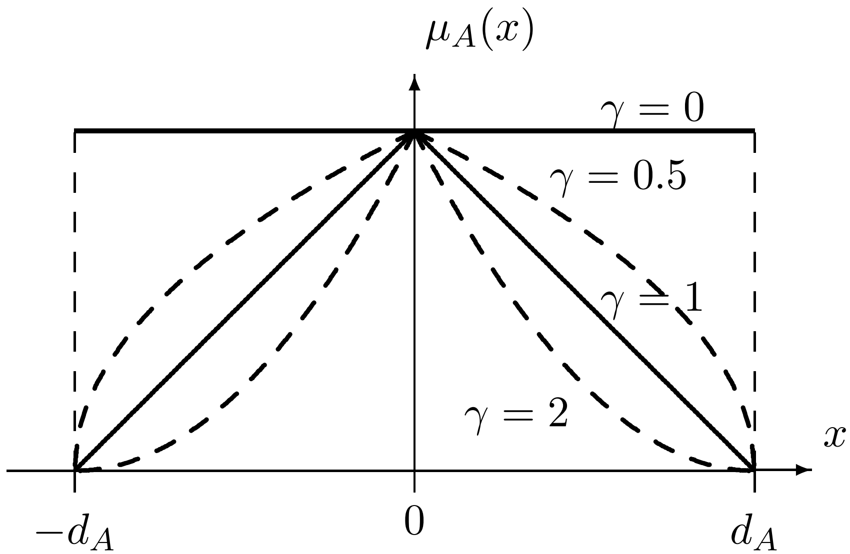
Inventory uncertainty distribution



membership function → $$\mu^\gamma(x) = C\left(1 - \frac{|x - \hat{x}|}{d}\right)^\gamma$$

$$\gamma = 2.43$$

A fuzzy number



a fuzzy number

$$\left\{x,\ \mu^{\gamma}(x)\right\}$$

Need not be symmetric

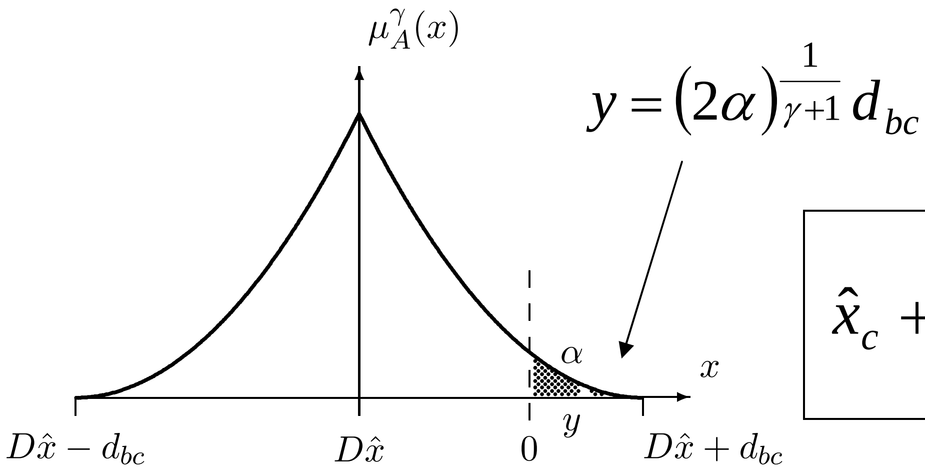
Compliance with the fuzzy numbers

$$\left\{\hat{x}_b,\quad \left(1-\frac{\left|x-\hat{x}_b\right|}{d_b}\right)^{\gamma}\right\} \qquad \left\{\hat{x}_c,\quad \left(1-\frac{\left|x-\hat{x}_c\right|}{d_c}\right)^{\gamma}\right\}$$

algebra like in the interval case

$$\left\{D\hat{x},\quad \left(1-\frac{\left|x-D\hat{x}\right|}{d_{bc}}\right)^{\gamma}\right\}$$

Compliance rule



$$\hat{x}_c + \left[1 - (2\alpha)^{\frac{1}{\gamma+1}}\right] d_{bc} \leq (1-\delta)\hat{x}_b$$

Emission trading

$$E_{eff} = \left\{1 - \left[1 - (2\alpha)^{\frac{1}{\gamma+1}}\right]\right\} \hat{E}^S$$

$E_{eff} / \hat{E}^S$ for $\alpha = 0.3$

country	δ	inter.	fuzzy				
	[%]	γ=0	γ=0.5	γ=1	γ=1.5	γ=2	γ=2.5
Austria	12	0.904	0.965	0.973	0.978	0.981	0.984
Holland	5	0.960	0.986	0.989	0.991	0.992	0.993
Norway	21	0.832	0.939	0.953	0.961	0.967	0.971
Poland	6	0.952	0.983	0.986	0.989	0.991	0.992
Russia	17	0.864	0.951	0.962	0.969	0.973	0.977
U.K.	19	0.848	0.945	0.957	0.965	0.970	0.974

Equivalence of interval and fuzzy approach (1)

Equivalence:

– the same reduction,

– the same effective emission

$$(2\alpha_I)^{1+\gamma} = 2\alpha_F$$

$$\Downarrow$$

$$\alpha_I \geq \alpha_F$$

Equivalence of interval and fuzzy approach (2)

	α_I	γ 1.5	2	2.5
α_F	0.05	0.20	0.23	0.26
	0.10	0.26	0.29	0.32
	0.15	0.31	0.33	0.35
	0.20	0.35	0.37	0.38

Conclusion

Use interval rules

with $\alpha = 0.25 - 0.30$

Thank you for attention