

Output-based allocations in pollution markets with uncertainty and self-selection

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Motivation

- EU-ETS pillar of the EU Climate Policy (50% EU CO₂);
- Carbon markets spreading (California-Quebec-Ontario, RGGI, China, New Zealand);
- Two critical issues for their design:
 - how to allocate permits (auctions, grandfathering, output-based)
 - how to deal with carbon price variations (price corridor, market stability reserve).
- Both issues are linked: Could free allocations be used to deal with price uncertainty?

Motivation for output based allocations (OBA)

- OBAs receiving increasing attention: California, EU, New Zealand
- permits are allocated according to firms' output, so
 - they represent a production subsidy, and
 - total number of permits in the market no longer fixed
- two reactions
 - subsidy usually justified by carbon leakage or market power
 - in California the cap is kept fixed (adjust grandfathered or auctioned allocations)

Main results (plan of the talk)

- OBA need only be justified on demand and cost uncertainty (no need of leakage or market power)
- the overall permits cap should be flexible
- optimal OBA design solves a trade-off between output inefficiency and cap flexibility (keeping permit price closer to marginal harm)
- the optimal OBA rate is increasing in sector (demand/supply) volatility
- self-selection problem: room for lobby and misreporting, but can be solved with menus of lump-sum permits and OBA rates
- numerical simulations: gains from optimal OBA can be substantial

Literature

- prices vs quantities: Weitzman (1974), Roberts and Spence (1976)
- indexed (e.g., to GDP) allocation: Newell and Pizer (2008), Branger and Quirion (2014)
- intertemporal trading: Rubin (1996), Ellerman and Montero (2007)
- OBA and leakage: Fischer and Fox (2007, 2012), Monjon and Quirion (2011), Meunier et al. (2014)
- OBA and market power: Fischer (2011), Fowlie et al. (2015)
- pollution regulation under asymmetric information: Spulber (1988), Montero (2008)

Model - One sector

- consumers demand output q according to $P(q, \theta) = S'(q, \theta)$, where θ is a demand shock
- output is supplied by a sector of mass 1 of identical firms
- each firm produces output q and pollution e according to $C(q, e, \eta)$, where η is a supply shock
- environmental harm is $D(e)$, so welfare in a given state θ and η is

$$W(q, e, \theta, \eta) = S(q, \theta) - C(q, e, \eta) - D(e)$$

- q and e are equilibrium variables that depends on the environmental policy

OBA regulation and equilibrium

- An OBA scheme is defined as $\{\bar{e}, \alpha\}$, where
- \bar{e} is the number of permits to be auctioned off and α is the OBA rate, so total emissions (the cap) are

$$e = \bar{e} + \alpha q$$

- Timing: (1) the regulator picks \bar{e} and α , (2) shocks θ and η are realized, and (3) firms choose q and e so as to maximize

$$\pi = pq - C(q, e, \eta) - re + \alpha r q$$

where r is the equilibrium price of permits and $p = P(q, \theta)$.

- in equilibrium

$$p = C_q - \alpha r \text{ and } r = -C_e$$

Proposition 1

- Consider a permits market with $\alpha = 0$ and \bar{e} such that $D'(\bar{e}) = \mathbb{E}[r]$. If in that market we observe a positive correlation between permit prices and output, then it is optimal to introduce a positive OBA rate, $\alpha > 0$.
- More precisely, the optimal OBA scheme $\{\bar{e}, \alpha\}$ in that case satisfies the pair of equations

$$\mathbb{E}[r - D'(e)] = \alpha \mathbb{E}[D'(e)q\bar{e}]$$

$$\alpha = \text{cov}(r - D'(e), q) \left(\mathbb{E}[D'q\alpha] - \mathbb{E}[q]\mathbb{E}[D'q\bar{e}] \right)^{-1}$$

Intuition for Proposition 1

- Suppose the regulator sets $\alpha = 0$, it is optimal to set $\mathbb{E}[r] = D'(\bar{e})$ and let permit prices move around $D'(\bar{e})$...

- the impact on (expected) welfare of introducing a very small OBA rate $\alpha \approx 0$

$$\tilde{W}_\alpha(\bar{e}, \alpha) = \mathbb{E}[-\alpha r q_\alpha + (r - D'(e))e_\alpha]$$

- the first term is the subsidy effect (always negative) and the second term is the flexibility effect

- since $e = \bar{e} + \alpha q$, $e_\alpha = q + \alpha q_\alpha$, so when $\alpha \approx 0$

$$\tilde{W}_\alpha(\bar{e}, \alpha = 0) = \mathbb{E}[(r - D'(\bar{e}))q] = \text{cov}(r, q)$$

- when $\text{cov}(r, q) > 0$:
- the gains from increasing pollution when prices are high is greater than the losses of increasing pollution when prices are low, or

$$(r_H - D'(\bar{e}))q_H > (D'(\bar{e}) - r_L)q_L$$

- the result in Proposition 1 is very general
 - It still applies if the regulator implements a hybrid permit scheme with a price floor and ceiling
 - It also applies to multiple sectors in which the only abatement technology is output reduction

A two-sector simple example

- two sectors $i = 1, 2$
- production costs are normalized to zero
- no abatement technology: $e = q$
- sector 2 is more volatile than sector 1:

$$P_1 = a - q_1 + \theta_1$$

$$P_2 = a - q_2 + \theta_2$$

where $\mathbb{E}[\theta_i] = 0$, $\mathbb{E}[\theta_i^2] = \sigma_i^2 > 0$, and $\sigma_2 > \sigma_1$

- environmental harm: $D(e) = he$

What is the optimal OBA design?

- the sector with higher volatility (sector 2) gets a larger OBA rate. The optimal OBA scheme $\{\bar{e}, \alpha_1, \alpha_2\}$ is given by

$$\alpha_1 \in [0, 1)$$

$$\frac{\alpha_2 - \alpha_1}{1 - \alpha_1} = 1 - [(\Delta^2 + 1)^{1/2} - \Delta] > 0$$

$$\bar{e} = \frac{1}{2}(a - h)(2 - \alpha_1 - \alpha_2)$$

where $\Delta = [\sigma_2^2 - \sigma_1^2]/2h^2 > 0$.

- intuition.** suppose $\alpha_1 = \alpha_2 = 0$: total output is fixed, $q_1 + q_2 = \bar{e}$, but it splits across sectors according to shocks
- this output adjustment leads to changes in permit prices r and, ultimately, to a covariance between permit prices and output in each individual sector

Self-selection problem

- Since sector profit is increasing in the OBA rate, sector 1 may pretend to be sector 2 (adverse selection problem) or lobby for the OBA rate of sector 2
- regulator can solve this self-selection problem with a menu of permit-allocation options: $\{\alpha_1, \hat{e}_1\}$ and $\{\alpha_2, \hat{e}_2\}$, where α_j is the OBA rate in option $j = 1, 2$ and \hat{e}_j is the number of free lump-sum permits
- implementation of the optimal OBA scheme requires to satisfy
 - budget balance: $\hat{e}_1 + \hat{e}_2 < \bar{e}$ and
 - self-selection:

$$\mathbb{E}[\pi_i(\theta_i, r, \alpha_i) + r\hat{e}_i] \geq \mathbb{E}[\pi_i(\theta_i, r, \alpha_j) + r\hat{e}_j]$$

Numerical exercises

- evaluate gains from implementing OBA
 - no OBA solution (fixed cap)
 - OBA and flexible cap (our proposal)
 - OBA and fixed cap
- illustrate the self-selection problem
- use two-sector example: $a = 1$, $h = 1/4$, $\sigma_1 = 0$ and $\sigma_2 \in [0, 1/2)$.

Figure 1: The optimal policy as a function of the uncertainty

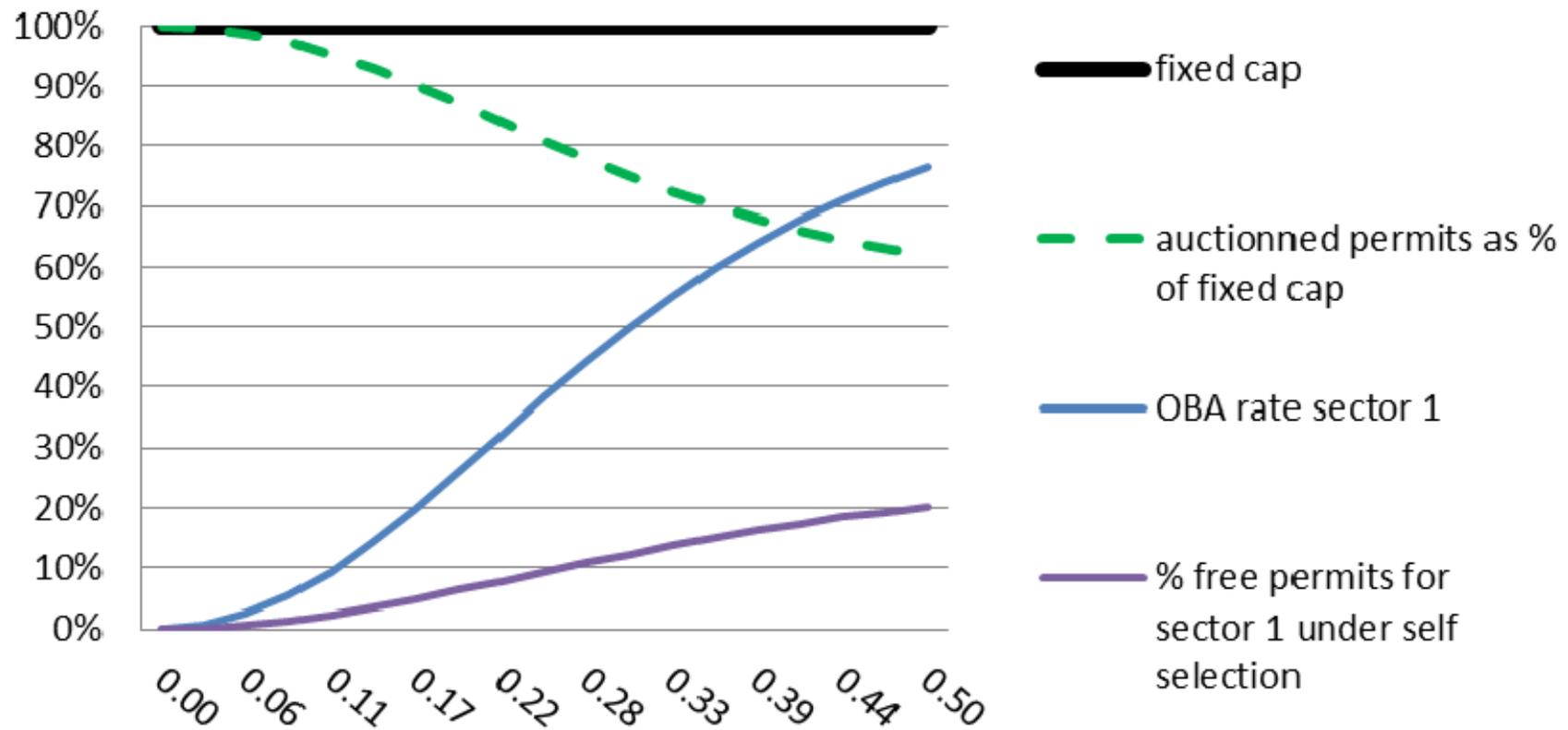


Figure 2: Average welfare

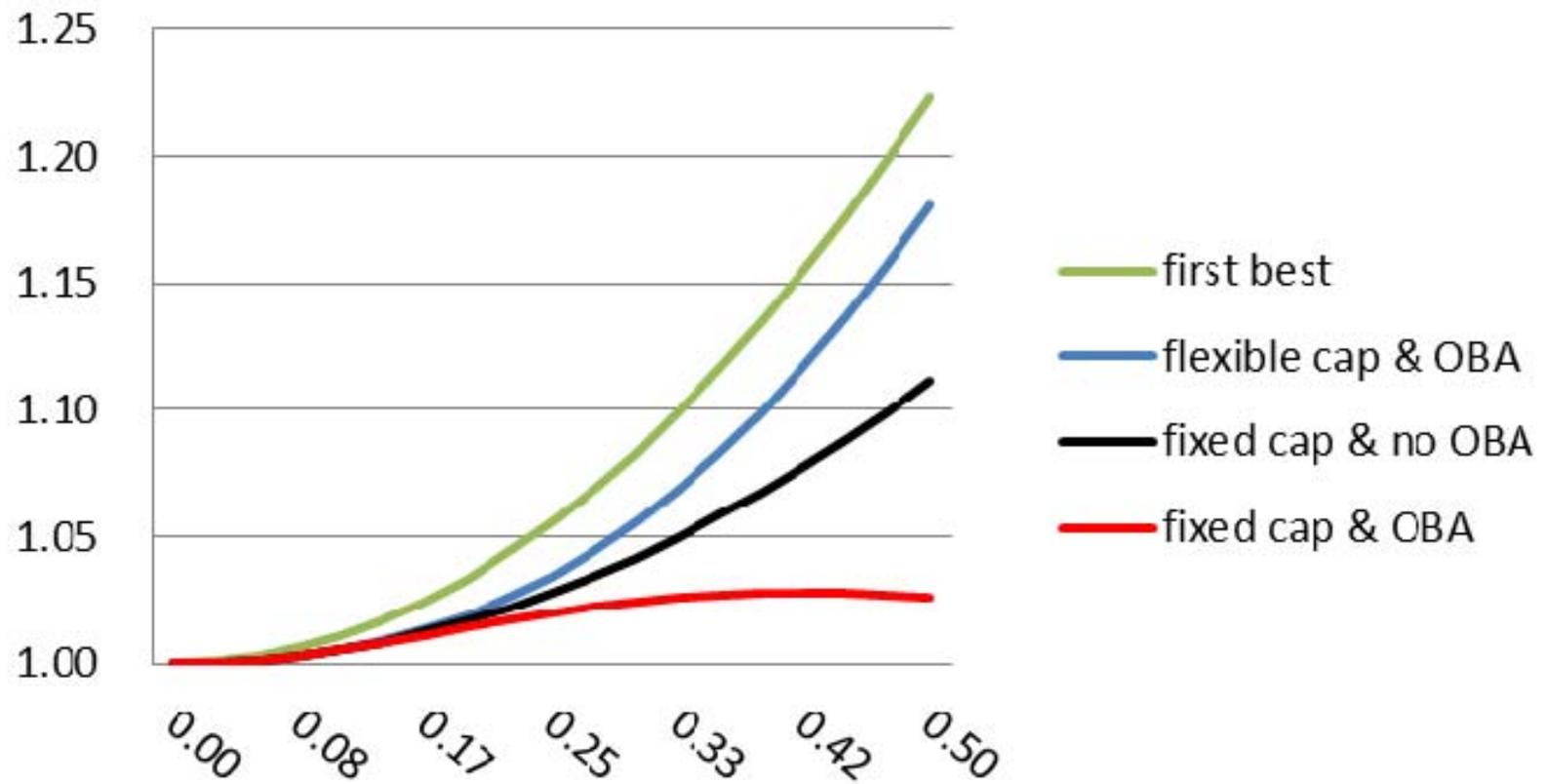


Figure 2a: Average welfare in sector 1

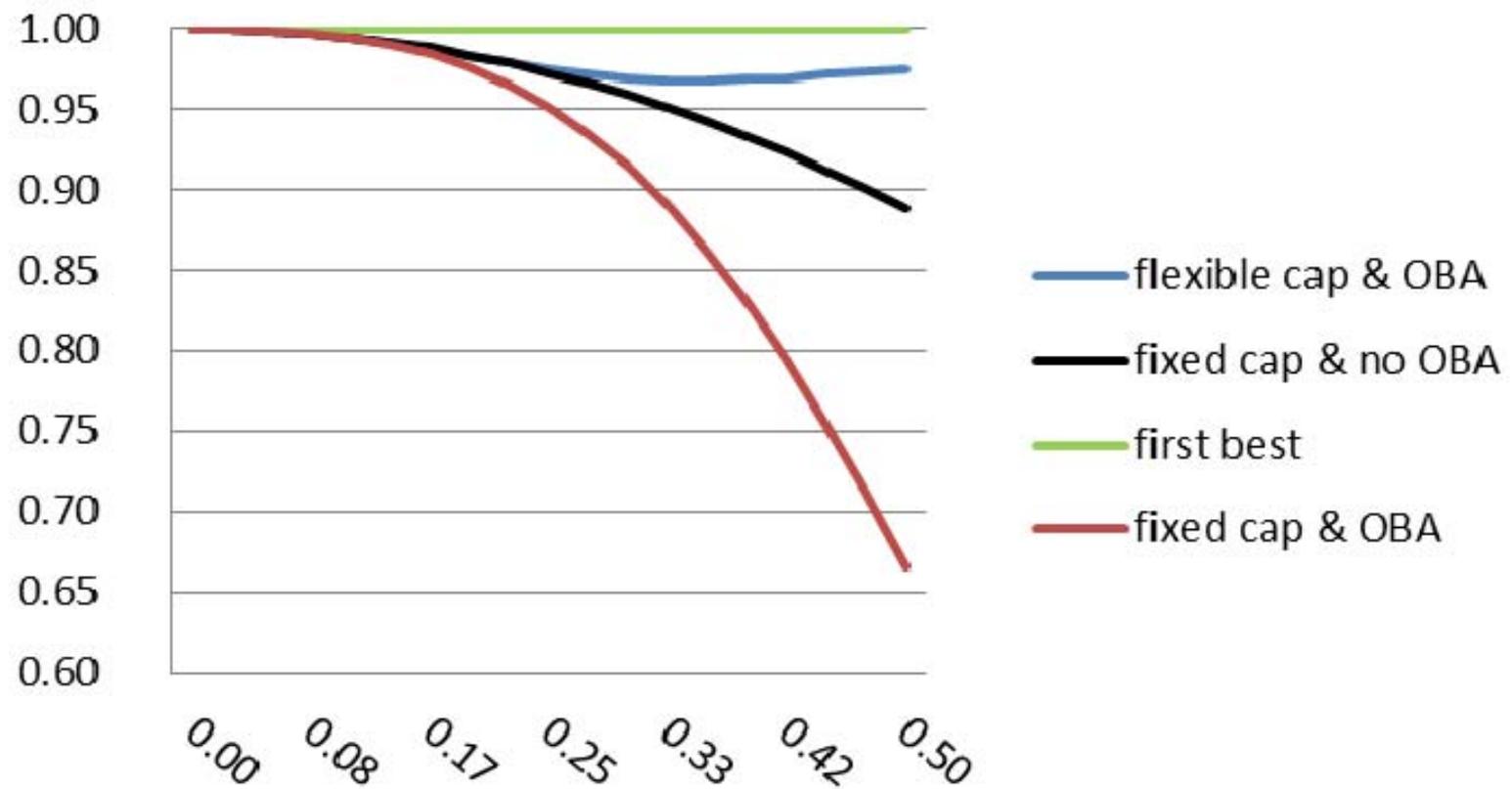


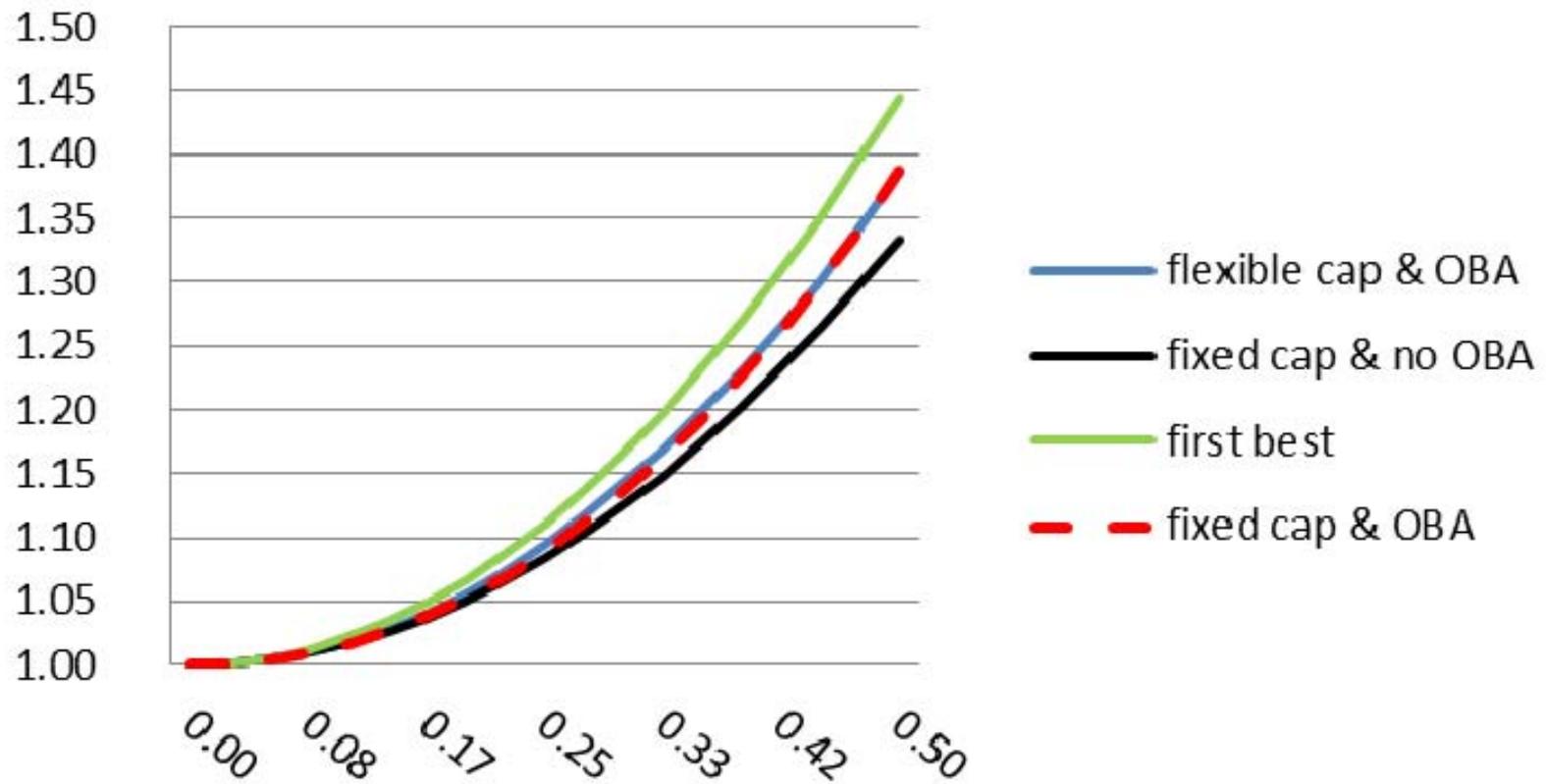
Figure 2b: Average welfare in sector 2

Figure 3: Emissions for flexible cap versus fixed cap

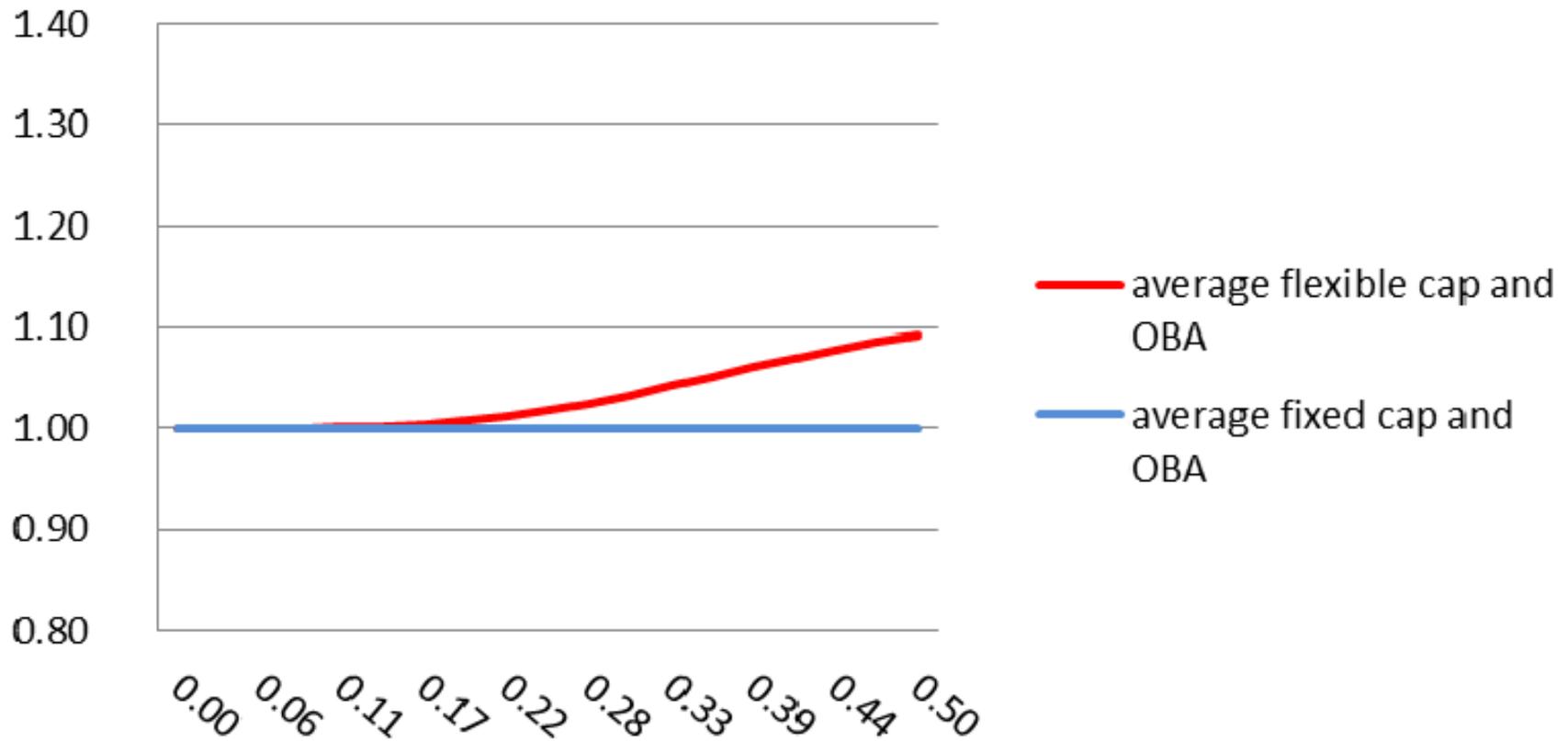
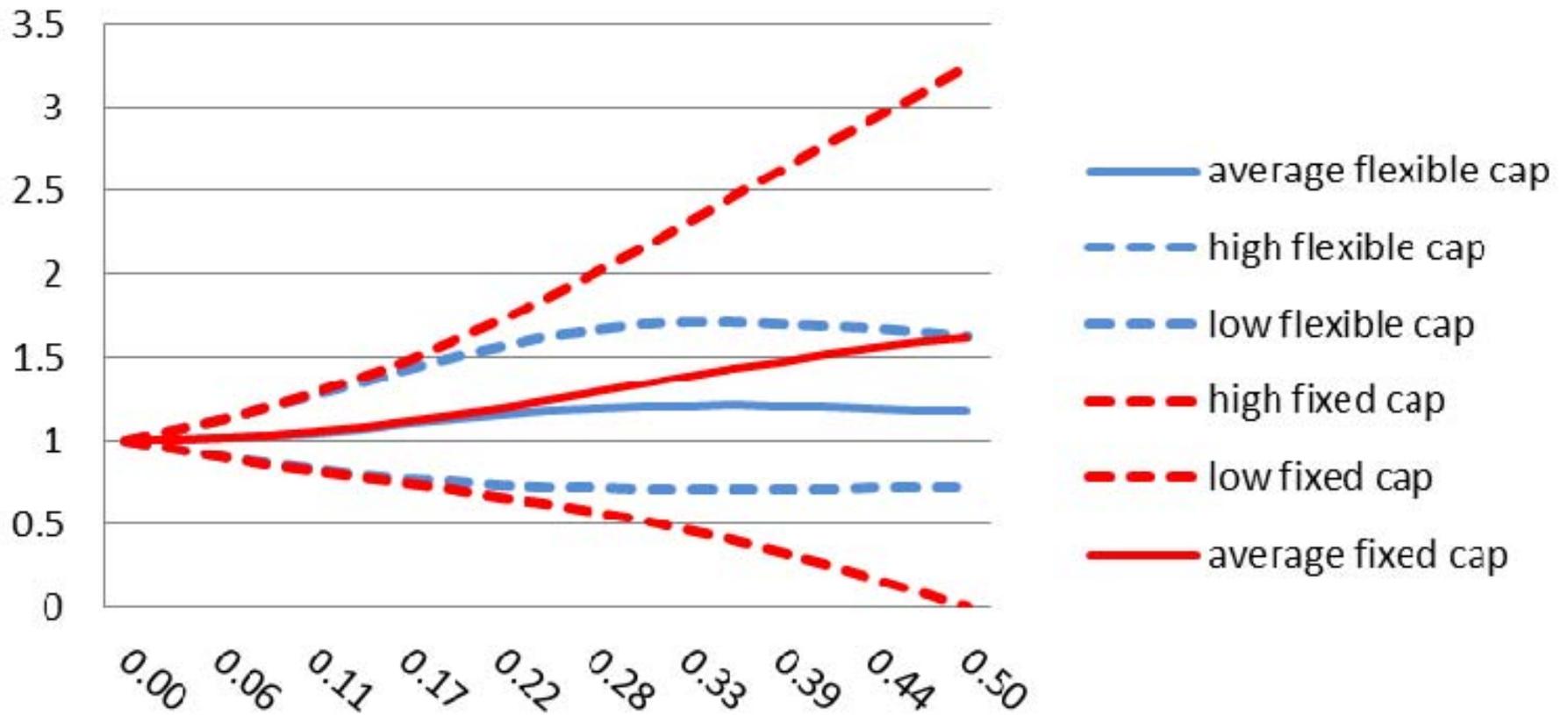


Figure 4: Permit prices for flexible cap versus fixed cap



Conclusions

- Output-based allocation schemes can be effective to handle price volatility, but if well designed (i.e., flexible cap)
- Because OBA rates will vary across sectors, regulator must handle a self-selection problem by allocating some permits in a lump-sum fashion
- (future work: explore the best OBA design when either or both budget-balance and self-selection constraints don't hold at the optimal OBA scheme)