

Conservation Procurement Auctions with Bidirectional Externalities

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Question

- How to design optimal procurement mechanisms for Conservation Reserve Program (CRP) when bi-directional externalities exist between the bidders and the non-bidders?

Motivation

The literature mainly considers unidirectional externality from the winners on the outside options/ reservation utilities of non-winners.

Conservation
Projects



Market
Activities

Negative Externality on Market Activities

- Wetland rehabilitation invites migratory birds
- ⇒ Increase the risks of avian influenza outbreak



Motivation

However, the external effects of outside options on the implementation costs of conservation projects are not considered.

Conservation
Projects



Market
Activities

Negative Externality on Conservation

- Farming draws water from aquifers
- ⇒ More costly to rehabilitate wetlands



Contribution

- Introduce bi-directional externalities to procurement auctions whereby the procurer can decide the project allocations by accounting for the directionality and effects of externalities.
- Output-reducing effect of externalities are cumulative and are more pronounced under incomplete information.

Literature

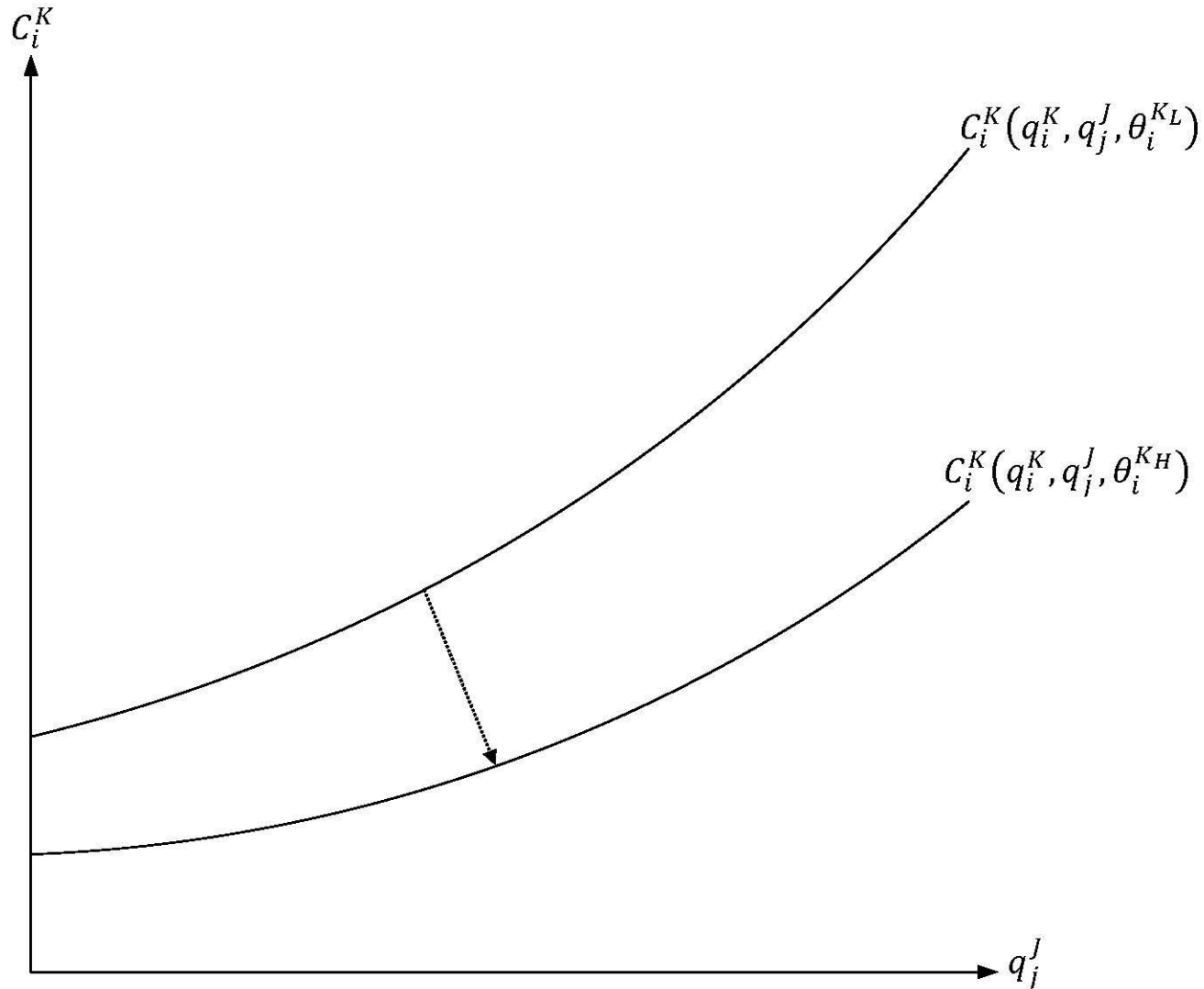
- Auctions are more efficient than flat-rate payment schemes (Latacz-Lohmann, 2005) despite information rents (Kirwan et al., 2005).

	Unidirectional Externality	Bidirectional Externalities
Unidimensional Type	Jehiel et al. (1996, 1999, 2000) Espínola-Arredondo (2008) Figueroa & Skreta (2011)	This Paper
Bidimensional Types	Che (1993) Branco (1997) Rochet and Stole (2003)	This Paper

Model

- Bidder i observes $\{\theta_i^C, \theta_i^M\} \in \Theta$; but everyone knows $\theta_i \sim F_i[\underline{\theta}_i, \bar{\theta}_i]$
- Quasilinear utility function: $U_i^K(q_i^K, \theta_i^K) = t_i^K(q_i^K) - C_i^K(q_i^K, q_{-i}^J, \theta_i^K)$
 - convex cost in output q_i^K attenuated by efficiency θ_i^K
 - cost augmented by negative externalities from others q_{-i}^J
 - for market activities, $t_i^M(q_i^M) = p \cdot q_i^M$ where p is market price
- Social welfare function: $W_i(q_i) = V(q_i^C) - (1 + \lambda)t_i(q_i^C)$
 - value function increasing and concave in conservation q_i^C
 - λ is the shadow cost of raising public funds

Attenuation of Negative Externality by Efficiency



Complete Information

- The procurer chooses $\{q_i^C, t_i^C(q_i^C)\}$ to solve

$$\max_{\{q_i^C, t_i^C(q_i^C)\}_{i=1}^N} \sum_{i=1}^N \beta_i \left[V(q_i^C) - (1 + \lambda) t_i^C(q_i^C) \right]$$

$$\text{s.t.} \quad U_i^C(q_i^C(\theta_i^C), \theta_i^C) \geq U_i^M(q_i^M(\theta_i^M), \theta_i^M) \quad \forall \{\theta_i^C, \theta_i^M\} \in \Theta \quad (\text{IRC}_i)$$

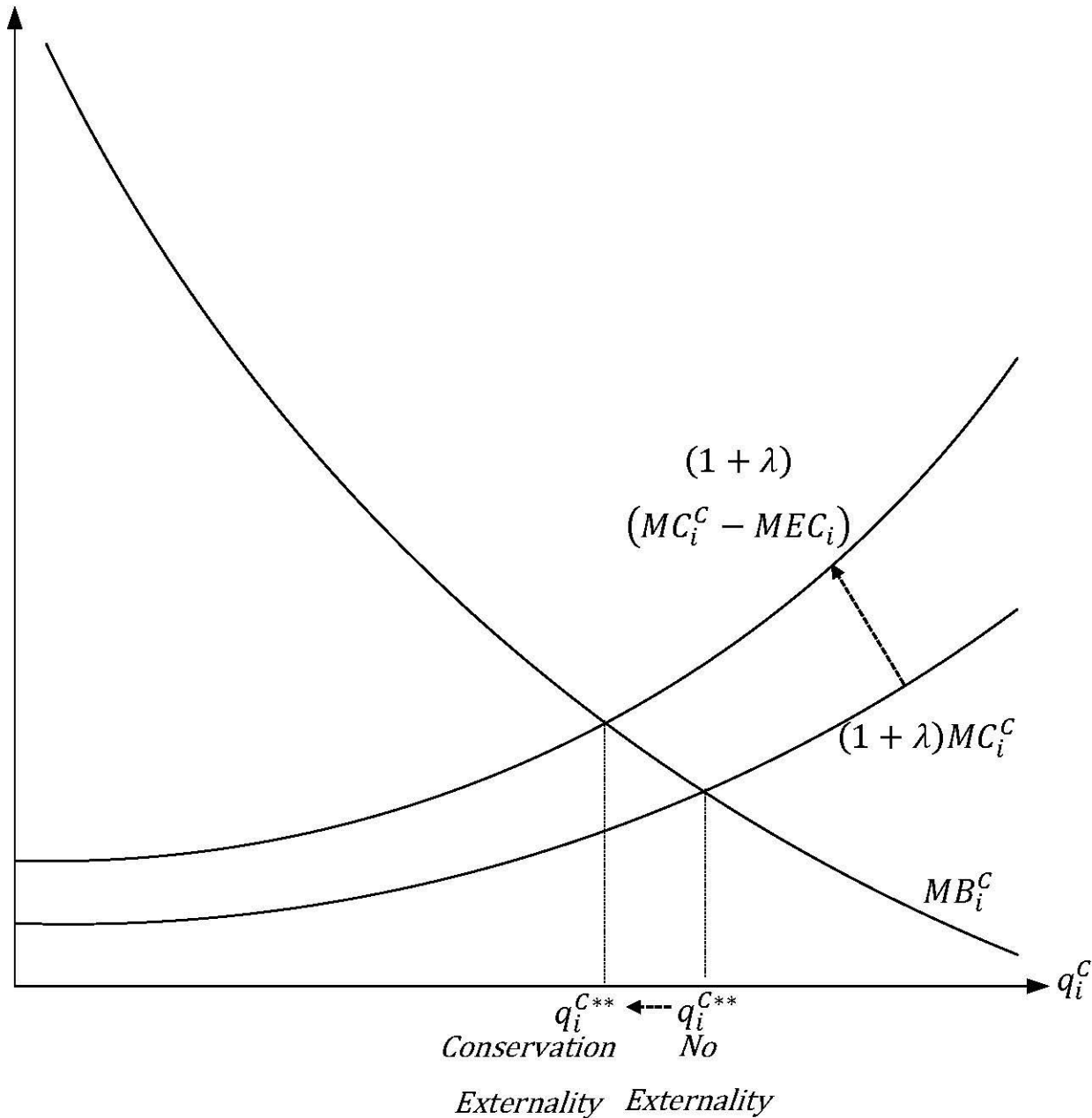
- Optimal conservation output

$$MB_i(q_i^C) = (1 + \lambda) \left[MC_i(q_i^C, q_{-i}^M) - MEC_i(q_{-i}^M, q_i^C) \right]$$

- Optimal transfer payment

$$t_i^C(q_i^C) = C_i^C(q_i^C, q_{-i}^M, \theta_i^C) + p \cdot \hat{q}_i^M - C_i^M(\hat{q}_i^M, q_{-i}^C, \theta_i^M)$$

Negative Conservation Externality on Other Bidders



Incomplete Information

- Using the DRM, the procurer chooses $\{q_i^C, t_i^C(q_i^C)\}$ to solve

$$\max_{\{q_i^C, t_i^C(q_i^C)\}_{i=1}^N} \sum_{i=1}^N \beta_i \left[V(q_i^C) - (1 + \lambda) t_i^C(q_i^C) \right]$$

s.t.
$$U_i^C(q_i^C(\underline{\theta}_i^C), \underline{\theta}_i^C) \geq U_i^M(\bar{q}_i^M(\bar{\theta}_i^M), \bar{\theta}_i^M) \quad (\underline{\text{IRC}}_i)$$

$$U_i^C(q_i^C(\theta_i^C), \theta_i^C) \geq U_i^C(\hat{q}_i^C(\hat{\theta}_i^C), \hat{\theta}_i^C) \quad \forall \theta_i^C, \hat{\theta}_i^C \in \Theta^C$$

$$U_i^M(q_i^M(\theta_i^M), \theta_i^M) \geq U_i^M(\hat{q}_i^M(\hat{\theta}_i^M), \hat{\theta}_i^M) \quad \forall \theta_i^M, \hat{\theta}_i^M \in \Theta^M \quad (\text{BIC}_i)$$

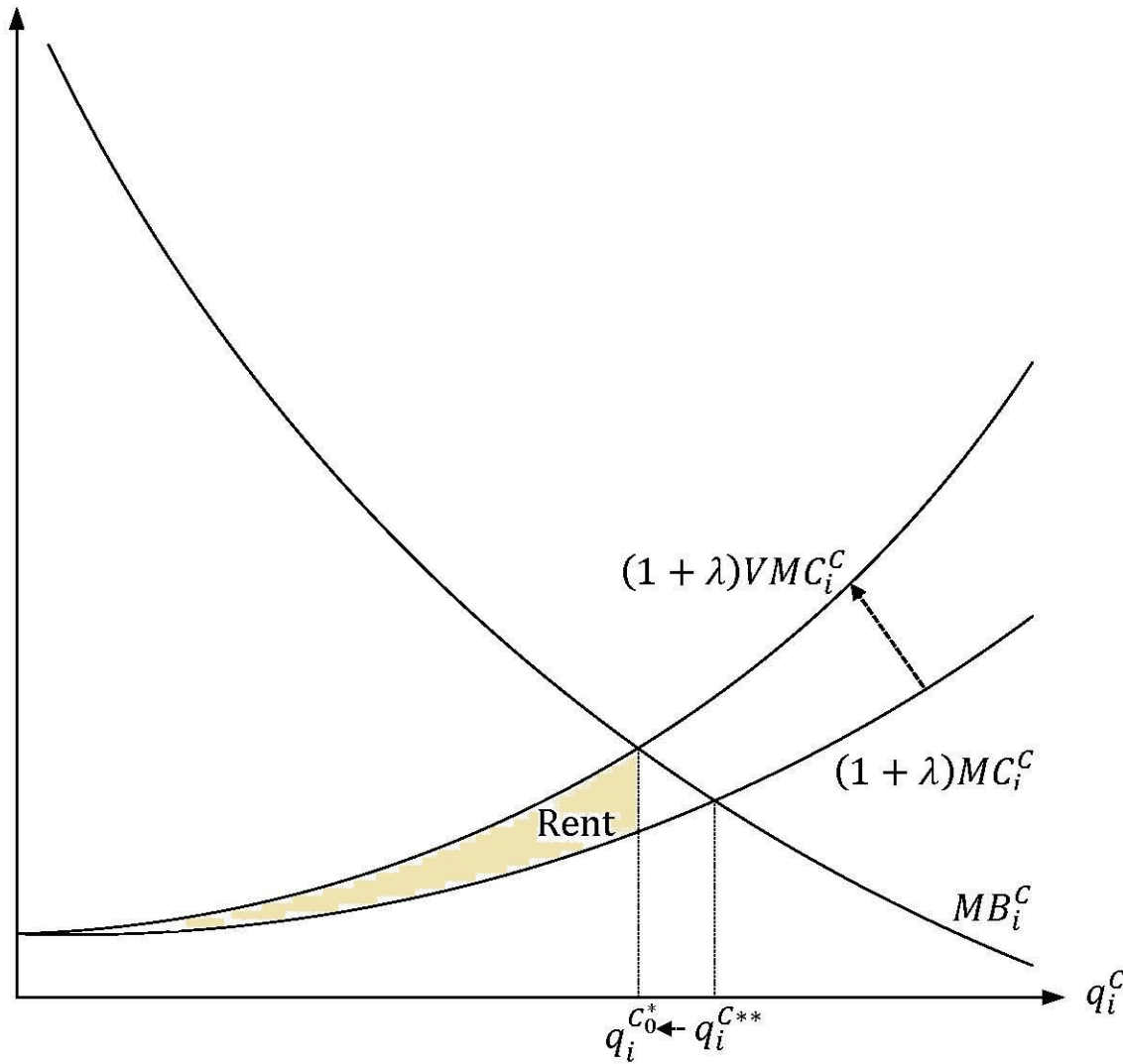
- Optimal conservation output

$$MB_i(q_i^C) = (1 + \lambda) \left[VMC_i(q_i^C, q_{-i}^M) - VEC_i(q_{-i}^M, q_i^C) \right]$$

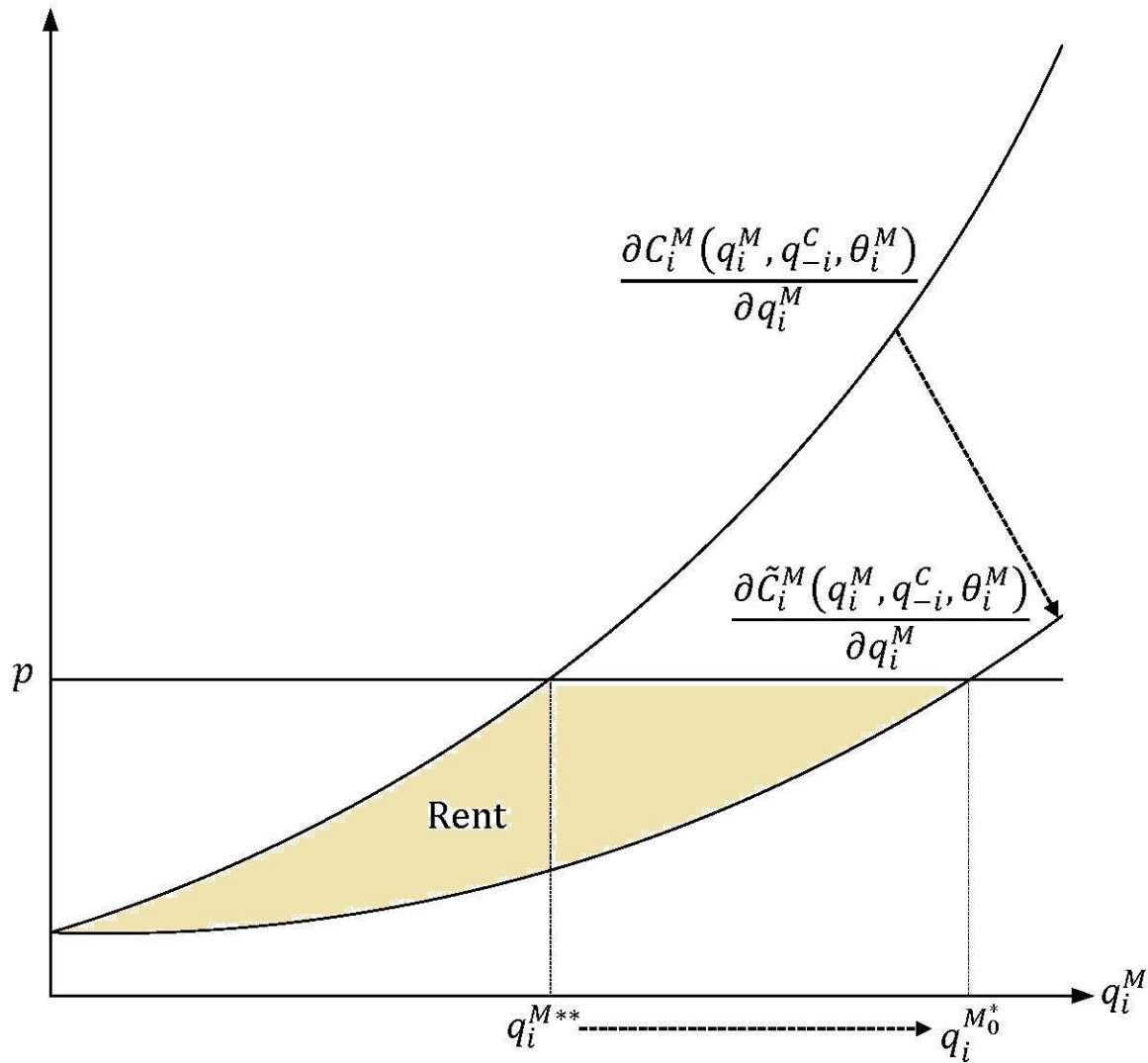
- Optimal transfer payment

$$t_i^C(q_i^C) = \tilde{C}_i^C(q_i^C, q_{-i}^M, \theta_i^C) + p \cdot \hat{q}_i^M - \tilde{C}_i^M(\hat{q}_i^M, q_{-i}^C, \theta_i^M)$$

Unobservable Conservation Efficiency

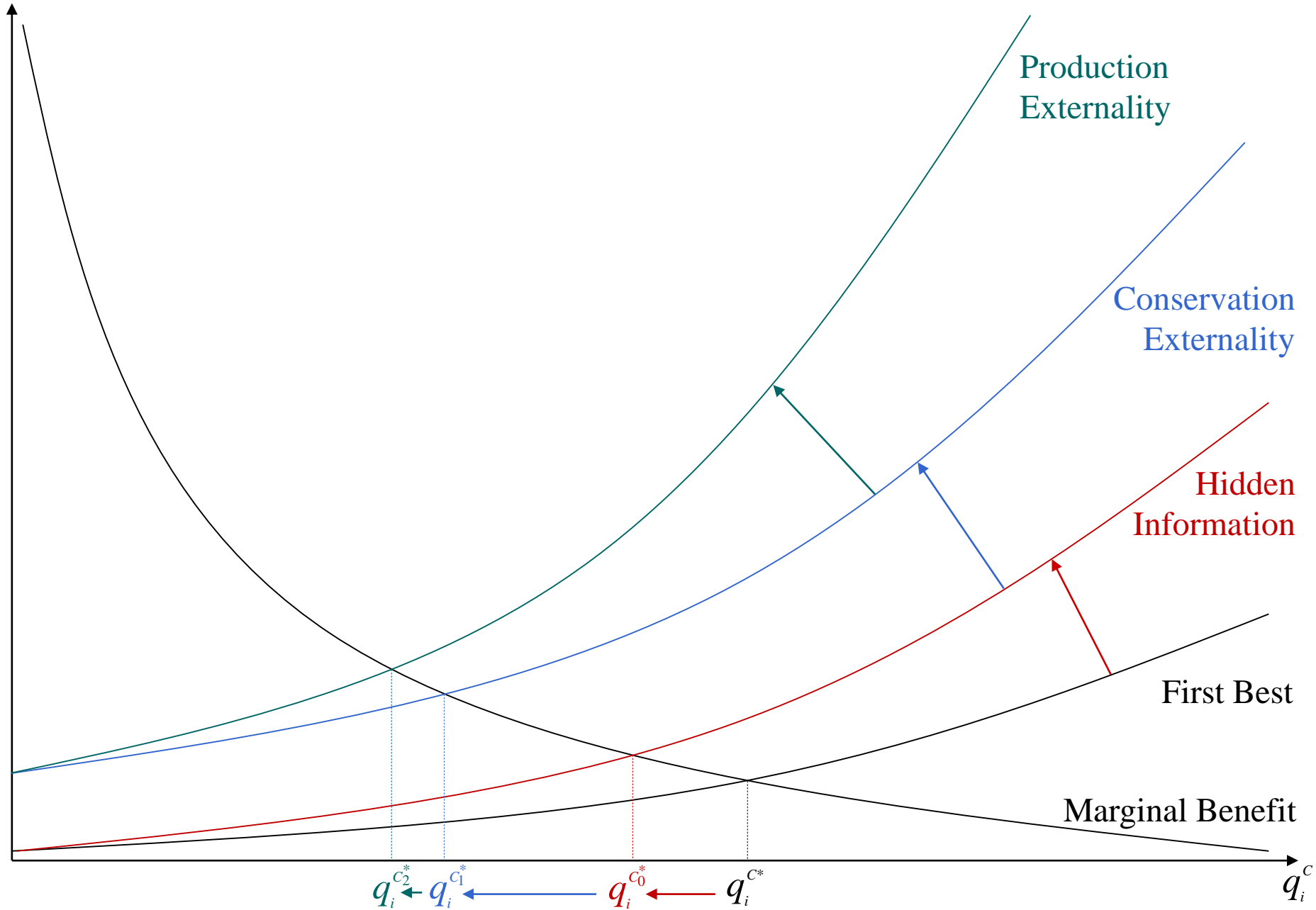


Unobservable Production Efficiency



Layers of Externalities

Cost



Score Function

- Enrolls bidder i if his welfare contribution is positive.

$$\begin{aligned} \tilde{W}_i^D(q) = & V(q_i^C) - (1 + \lambda) \left[\tilde{C}_i^C(q_i^C, q_{-i}^M, \theta_i^C) + p \cdot \hat{q}_i^M - \tilde{C}_i^M(\hat{q}_i^M, q_{-i}^C, \theta_i^M) \right] \\ & + (1 + \lambda) \sum_{j \neq i} \frac{\beta_j}{\beta_i} \left[\tilde{C}_j^M(\hat{q}_j^M, (0, q_k^C), \theta_j^M) - \tilde{C}_j^M(\hat{q}_j^M, (q_i^C, q_k^C), \theta_j^M) \right] \\ & + (1 + \lambda) \sum_{j \neq i} \frac{\beta_j}{\beta_i} \left[\tilde{C}_j^C(q_j^C, (\hat{q}_i^M, q_k^M), \theta_j^C) - \tilde{C}_j^C(q_j^C, (0, q_k^M), \theta_j^C) \right] \end{aligned}$$

1. His conservation benefits less his transfer payment.
2. His conservation externality on the other bidders.
3. His (stopping of) production externality on the other bidders.

Conclusion

- The procurer's lack of information would generate greater inefficiencies in the presence of bi-directional externalities.
- Positive externalities stimulate more conservation output, and that positive and negative externalities offset each other.
- In the case of high transfer payments and significant negative externalities, conservation output may be reduced to zero.

Extension

- Collect and analyze datasets on conservation procurement auctions to quantify the bi-directional external effects.
- Imperfect competition and market for heterogeneous goods.
Also simultaneous market activities and conservation projects.
- Consider how the different components in an ecosystem and the market interact when developing conservation projects.