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

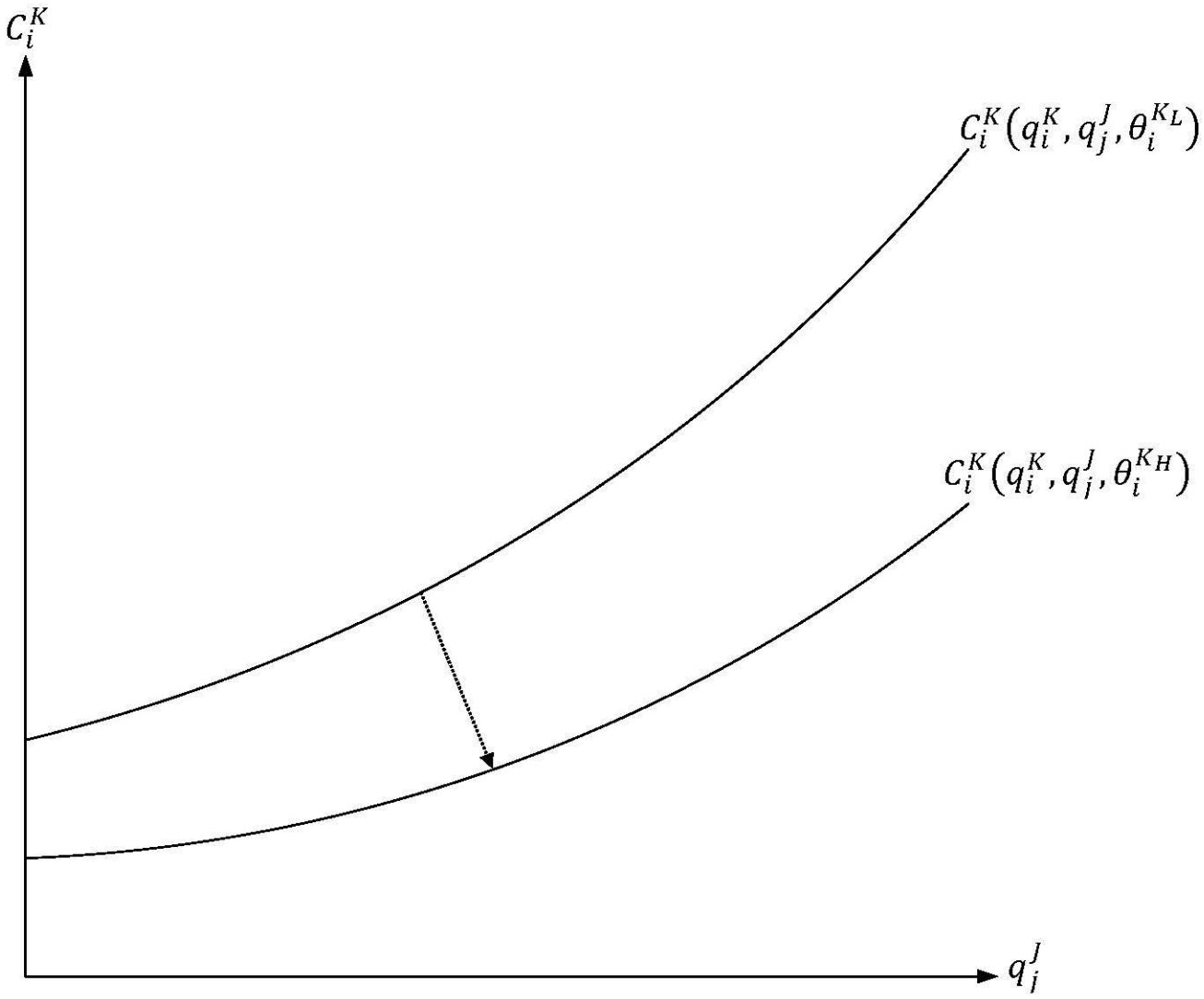
- Auctions are more efficient than flat-rate payment schemes (Lataczz-Lohmann, 2005) despite information rents (Kirwan et al., 2005).

	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 $\left\{\theta_i^C, \theta_i^M\right\} \in \Theta$; but everyone knows $\theta_i \sim F_i\left[\underline{\theta}_i, \bar{\theta}_i\right]$
- Quasilinear utility function: $U_i^K\left(q_i^K, \theta_i^K\right) = t_i^K\left(q_i^K\right) - C_i^K\left(q_i^K, q_{-i}^J, \theta_i^K\right)$
  - 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, $t_i^M\left(q_i^M\right) = p \cdot q_i^M$ where p is market price
- Social welfare function: $W_i\left(q_i\right) = V\left(q_i^C\right) - \left(1+\lambda\right) t_i\left(q_i^C\right)$
  - 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 $\left\{q_i^C, t_i^C\left(q_i^C\right)\right\}$ to solve

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

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

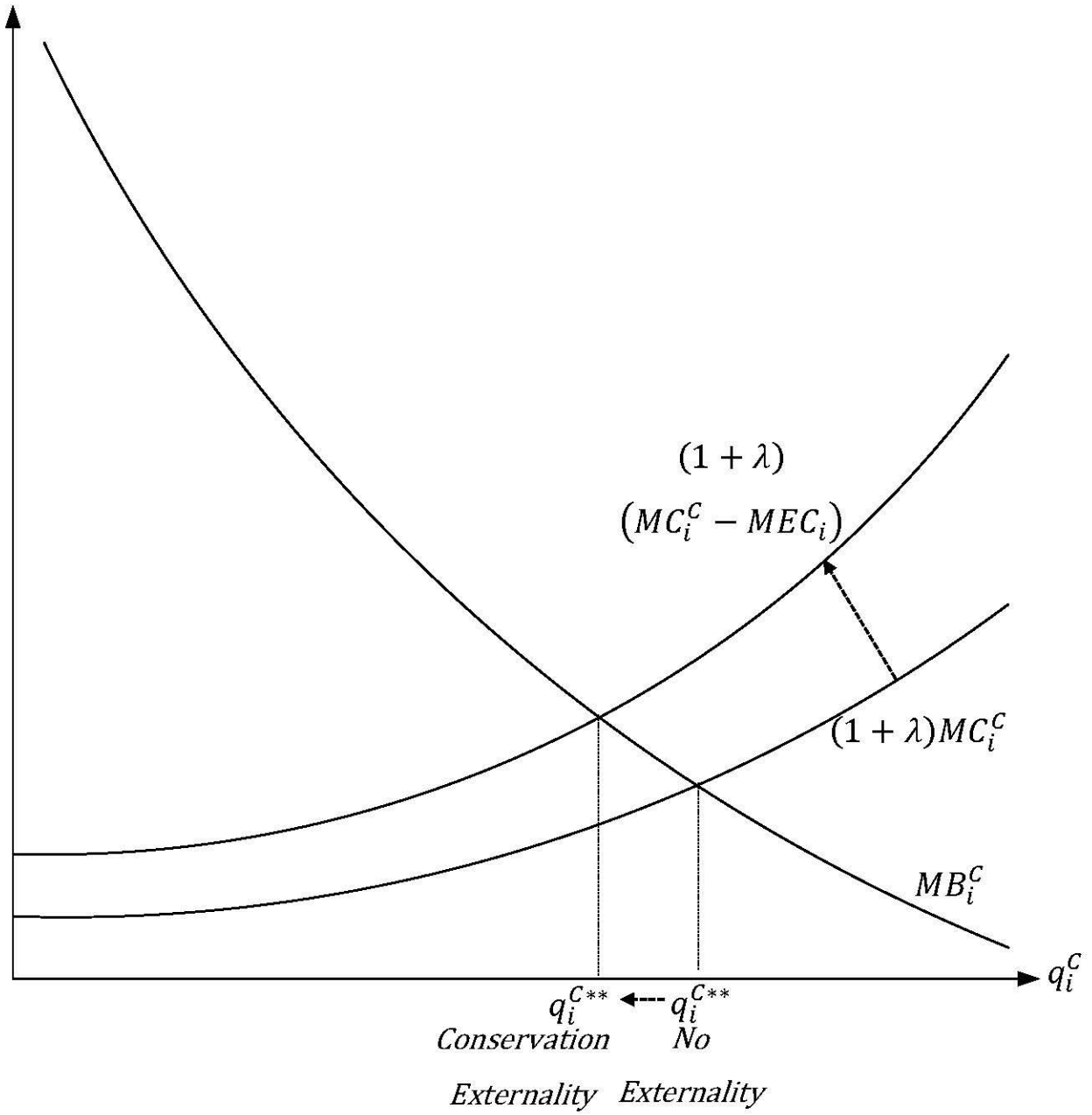
- Optimal conservation output

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

- Optimal transfer payment

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

Negative Conservation Externality on Other Bidders



Incomplete Information

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

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

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

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

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

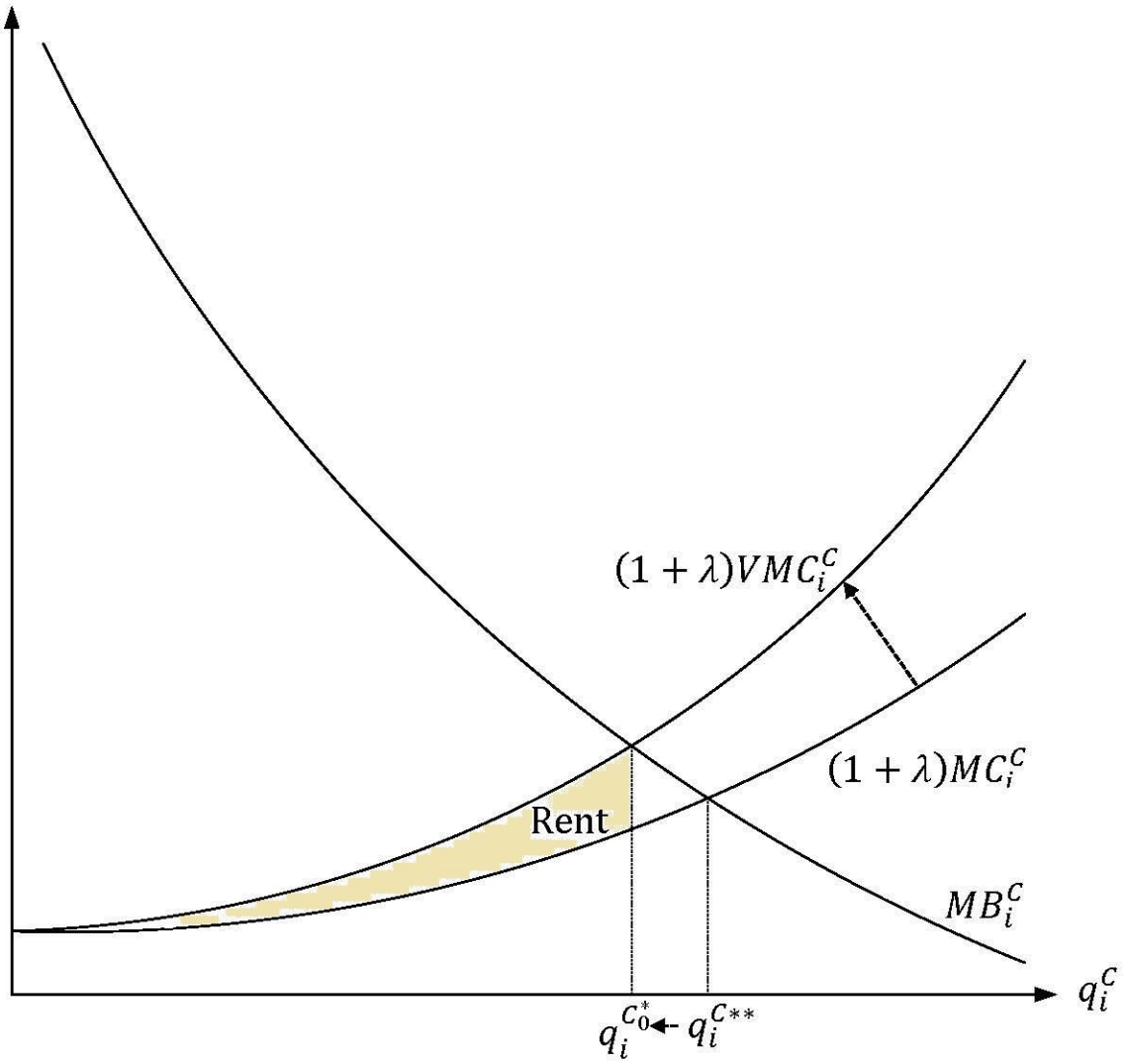
- Optimal conservation output

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

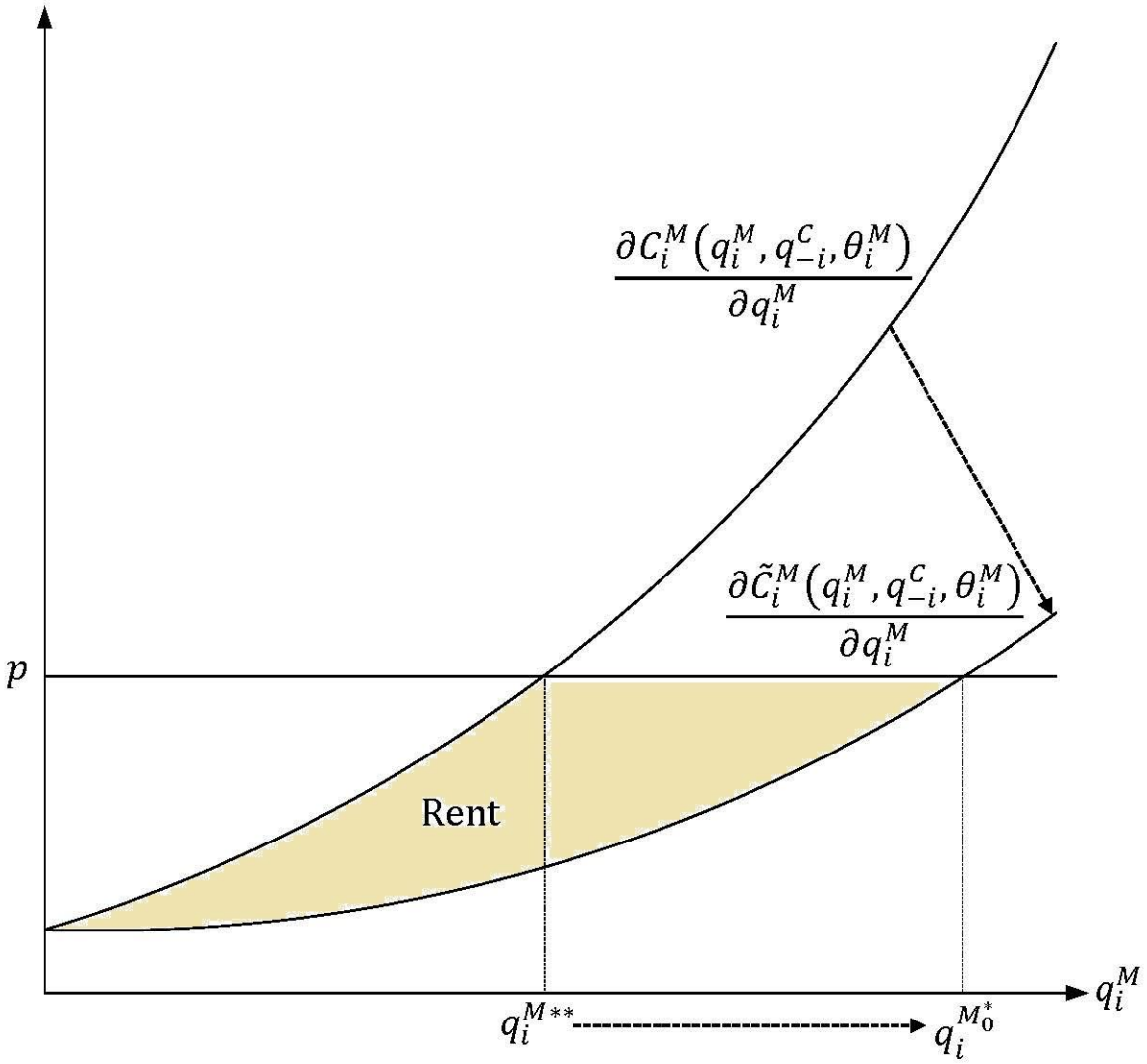
- Optimal transfer payment

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

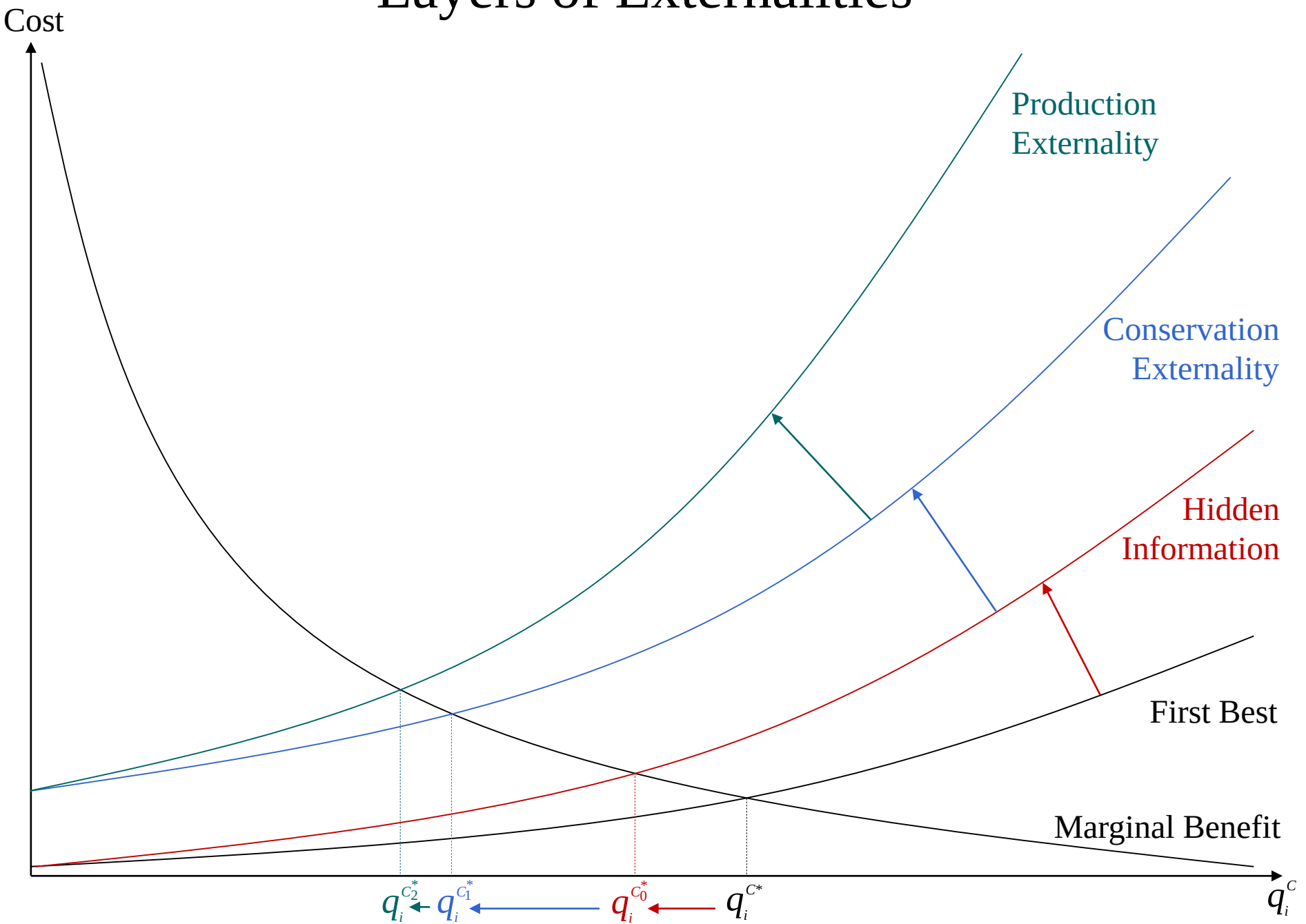
Unobservable Conservation Efficiency



Unobservable Production Efficiency



Layers of Externalities



Score Function

- Enrolls bidder *i* if his welfare contribution is positive.

$$\tilde{W}_i^D(q) = V\left(q_i^C\right) - (1+\lambda)\left[\tilde{C}_i^C\left(q_i^C, q_{-i}^M, \theta_i^C\right) + p\cdot\hat{q}_i^M - \tilde{C}_i^M\left(\hat{q}_i^M, q_{-i}^C, \theta_i^M\right)\right]$$

$$+(1+\lambda)\sum_{j\neq i}\frac{\beta_j}{\beta_i}\left[\tilde{C}_j^M\left(\hat{q}_j'^M, \left(0, q_k'^C\right), \theta_j^M\right) - \tilde{C}_j^M\left(\hat{q}_j^M, \left(q_i^C, q_k^C\right), \theta_j^M\right)\right]$$

$$+(1+\lambda)\sum_{j\neq i}\frac{\beta_j}{\beta_i}\left[\tilde{C}_j^C\left(q_j'^C, \left(\hat{q}_i^M, q_k'^M\right), \theta_j^C\right) - \tilde{C}_j^C\left(q_j^C, \left(0, q_k^M\right), \theta_j^C\right)\right]$$

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.