Optimal Government Auction Design for Offshore Wind Procurement

Can transmission subsidies spur competition?

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Outline

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Defining the Problem

Procurement of Offshore Wind

Procurement Auctions – the bidders bid to sell the developments. The auctioneer selects the lowest bidder.

Issues with procurement:

- Limited entry
- Asymmetric information
- Relatively new technology
  - Near-shore and deep offshore wind
- Significant investment
  - Belgium – investing $200 million to expand transmission capacity by 1.5GW
  - The Netherlands— up to $1.1 billion for 4 GW additional capacity
  - The U.K. – over $15 billion to add 25 GW additional transmission capacity

Proposed Solution

Price -preference policy based on truthful cost revelation.

Replicate the effects of providing a transmission subsidy to deep offshore wind and implement by discrimination based on bids.

1. **New technology deployment**— promote further penetration of offshore wind technology
2. **Low entry –** encourage entry and competition between developers
3. **Adverse selection –** mitigate the adverse selection problems and reduces payment and budgetary burden

Literature Review

Auction Design

- Klemperer (1998, 1999, 2000)
- Bulow and Klemperer (1996)

Revelation Principle and Auction Mechanism

- Myerson (1981)
- Maskin and Riley (2000)

Subsidizing a Disadvantaged Bidder

- McAfee and McMillan (1985, 1989)
- Rothkopf, Harstad and Fu (2003)

Taxation and MC of Public Funds

- Snow and Warren (1996)
- Dahlby (2006)

Research Approach

What is the appropriate auction mechanism design and the optimal discrimination policy required to mitigate competitive issues in offshore wind deployment?

- **Auction Design** – What is the most suitable auction type for this case? How will the policy be implemented?
- **Auction Mechanism and Implementation** – What is auction mechanism that can accommodate the proposed policy?
- **Welfare**– What are the welfare implications of the proposed policy? How does welfare change if society incurs a cost of raising public funds?
- **Auctioning Renewable Energy in Practice** – What are the practical considerations for successful policy implementation?

Auction Design

Select Appropriate Approach

Select between

a) First Price Sealed Bid

b) Second Price Sealed Bid

c) Ascending

d) Descending

Revenue Equivalence Theorem: auctioneer can expect the same surplus regardless of the auction type under certain conditions.

Additional Considerations in Design:

1. Discourage collusion
2. Prevent Entry Deterrence and predation

Auction Type Selection: FPSB

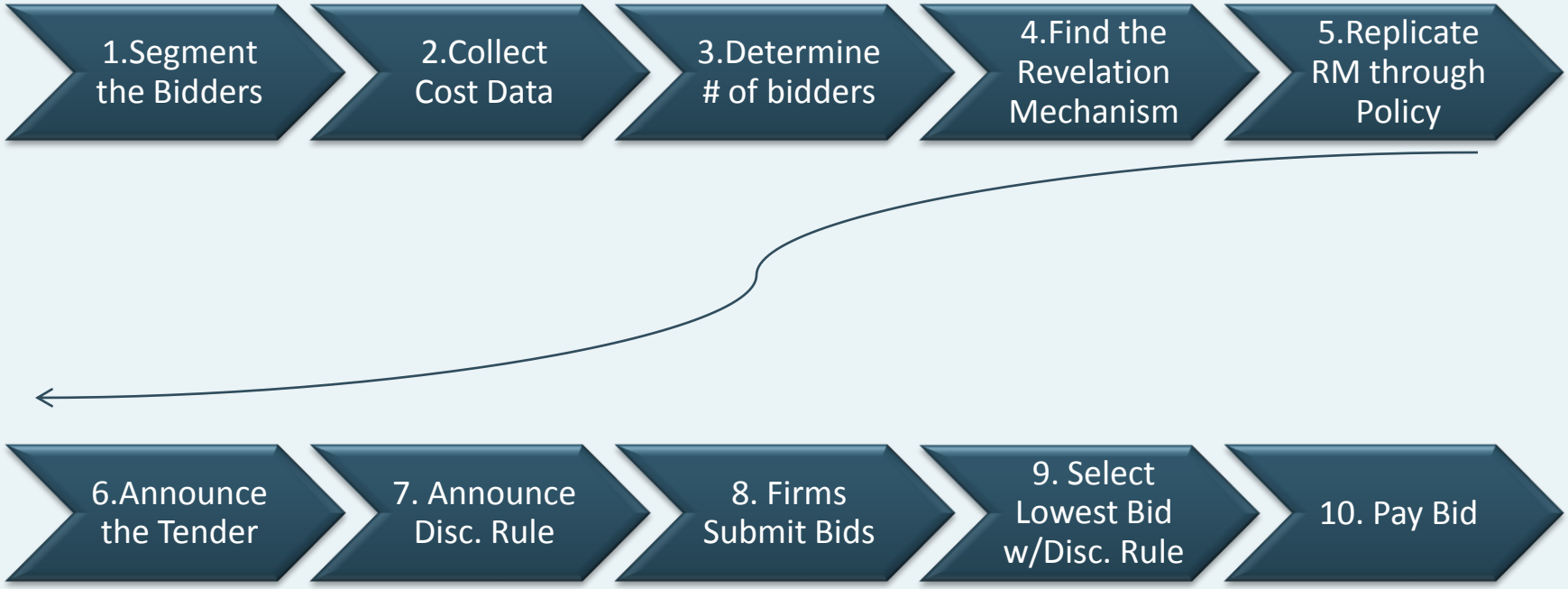
	First Price Sealed Bid	Ascending
Encourage Entry	⊕ Weaker bidders have a chance ⊕ Strategic uncertainty: bidders cannot learn the extent of asymmetry; less entry deterrence ⊖ Susceptibility to "winner's curse"	⊕ Winner's curse is less ⊖ The smallest advantage makes the stronger bidder win(less entry) ⊖ Strategic behavior to intimidate weaker bidders
Discourage Collusion	⊖ Can easily see market divisions ⊕ No possibility of signaling ⊕ No possibility to detect and punish ⊕ More entry makes collusion hard	⊖ Can easily see market divisions ⊖ Can easily signal the divisions ⊖ Can detect and punish ⊖ Limited Entry
Minimize Payment	⊕ aggressive bidding ⊖ The less efficient bidder may win ⊖ Winner's curse limits profitability and slows deployment	⊕ Signaling makes bidding more aggressive ⊕ The most efficient bidder wins ⊖ Limited entry lowers revenue
Long Term	⊕ no opportunities to signal diminishes collusion in case of additional bidding rounds or multiple unit purchases	⊖ Signaling increases collusive opportunities during additional rounds

Identify an Appropriate Mechanism

- **Information Asymmetry** – each bidder is more informed about own cost than the rivals or the government
- **Information Rent** – the bidders can misrepresent their costs and collect a profit

Revelation Principle: By providing an advantage to the higher cost deep offshore wind developer, the government can spur competition and decrease payment

Implement the Policy



Auction Mechanism and Implementation

Model Overview

- Two bidders, $i = 1,2$, deep offshore and near-shore types, respectively.
- Each firm has a cost c_i that is private.
- The government and other bidder perceive the cost by drawing from a probability distribution G_i .
- The lowest and the highest possible costs are represented by $c_i^{\ell} < c_i < c_i^{h}$.
- The government maximizes its value net of payment $V(q) - P$.

Virtual Costs and Information Rents

Virtual Cost

The cost the government must pay to prevent the firms from lying about cost.

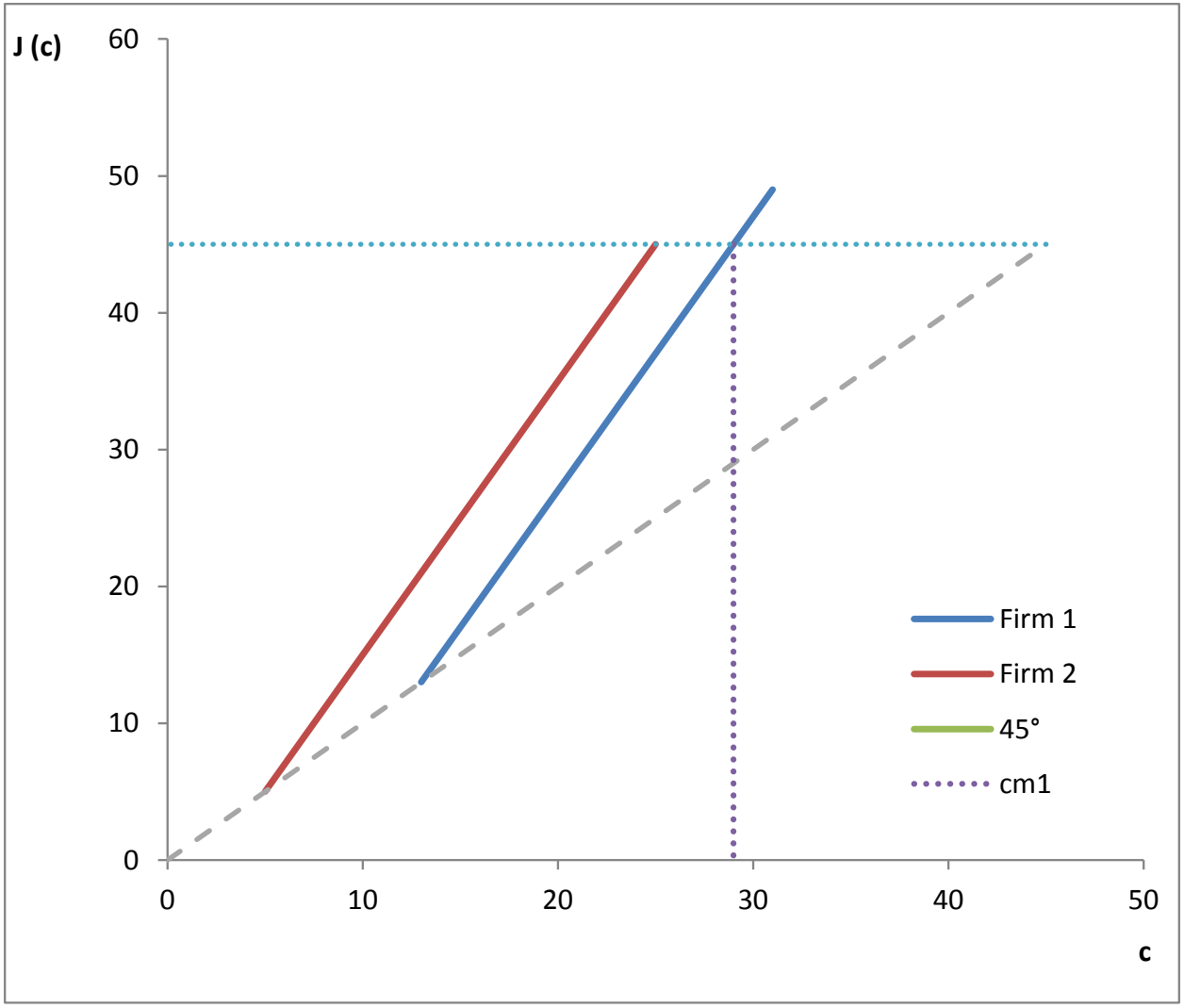
$$J_i(c_i) = c_i + \frac{G_i(c_i)}{g_i(c_i)}, \quad i = 1,2.$$

Information Rent

The profit the firm can receive due to private information about costs.

$$\frac{G_i(c_i)}{g_i(c_i)}, \quad i = 1,2.$$

Perceived Costs



Discrimination

- The government wishes to invoke the revelation principle by discriminating between bidders

$$z(c_1) < c_2$$

- The government is indifferent between the two bidders when

$$J_1(c_1) = J_2(z(c_1))$$

- Then, optimal discrimination function is

$$z(c_1) = c_1 + \frac{G_1(c_1)}{g_1(c_1)} - \frac{G_2(z(c_1))}{g_2(z(c_1))}.$$

Winning Probabilities

- The firms bid according to their strategies $B_i(c_i) = b_i$
- Probabilities of having the bid accepted are

$$H_1(\mathrm{c}_1^*) = 1 - G_2(z(\mathrm{c}_1^*))$$

$$H_2(\mathrm{c}_2^*) = 1 - G_1(\mathrm{z}^{-1}(\mathrm{c}_2^*))$$

- To find the equilibrium bid we need to define the highest cost the firm can have and have a zero probability of winning:

$$c_1^m = \min\{c_1^h, z^{-1}(c_2^h)\}$$

$$c_2^m = \min\{c_2^h, z(c_1^h)\}$$

Bidding Equilibrium

- To find the equilibrium bid, we take a derivative of profit

$$\pi = B_i(c_i^*) - c_i^*.$$

$$E(\pi) = \pi H_i(b_i).$$

$$\frac{d}{dc}\pi = B'_i(c_i^*) - 1 = 0$$

- Integrating the bid derivative up to the cost cm1 we find the equilibrium bid

$$B_i(c_i^*) = -H_i^{-1}(c_i^*) \int_{c_i^*}^{c_i^m} c\, H_i'(c_i) dc.$$

Discrimination Rule

- To find the bid discrimination rule that replicates the mechanism above:

$$B_2(z(c_1)) = \delta\left(B_1(c_1^*)\right).$$

- Plugging in the equilibrium bid, the Discrimination Rule is

$$\delta\left(\int_{c_1^*}^{c_1^m} -c_1 \frac{H'_1(c_1)}{H_1(c_1)}\,dc\right) = \int_{c_1^*}^{c_1^m} -z(c_1)\frac{H'_2(c_1)}{H_2(c_1)}\,dc.$$

Welfare Implications

Value and Welfare

Implicit reservation price

- To find the value of the project we define

$$V(q) = minJ_i(c_i).$$

Welfare under Costless Transfer

- If the government can collect funds without incurring a social cost, then the government tries to minimize cost.

Welfare under non-zero Marginal Cost of Public Funds

- If the government incurs a MCPF when collecting revenues, then the government minimizes the total payment.

Welfare: Costless Transfer

Welfare Objective Function

$$\underbrace{V(q) - E(J_i(c_i))}_{\text{Consumer Surplus}} + \underbrace{E(J_i(c_i)) - E(c_i)}_{\text{Producer Surplus}}$$

$$V(q) - E(c).$$

Welfare: MCPF

- Define λ as the MCPF

$$\underbrace{V(q) - E(J_i(c_i)) - \lambda \mathrm{E}(J_i(c_i))}_{\text{Consumer Surplus}} \quad \underbrace{E(J_i(c_i)) - E(c_i)}_{\text{Producer Surplus}}$$

- The new Welfare Function:

$$V(q) - (1+\lambda)\mathrm{E}(c_i) - \lambda \mathrm{E}\left(\frac{G_i(c_i)}{g_i(c_i)}\right)$$

- The new cost and discrimination functions:

$$J_i(c_i) = c_i + \left(1 - \frac{1}{1+\lambda}\right)\frac{G_i(c_i)}{g_i(c_i)}.$$

$$z(c_1) = c_1 + \left(1 - \frac{1}{1+\lambda}\right)\left(\frac{G_1(c_1)}{g_1(c_1)} - \frac{G_2(z(c_1))}{g_2(z(c_1))}\right).$$

Offshore Wind Procurement in Practice

Offshore Wind Policy Examples

Netherlands

- A certain amount of capacity is put up for auction
- Developers select the ideal site and technology
- Developers compete on price

Denmark

- The government dictates the location, capacity and technical specifications of projects
- Firms bid on specific locations

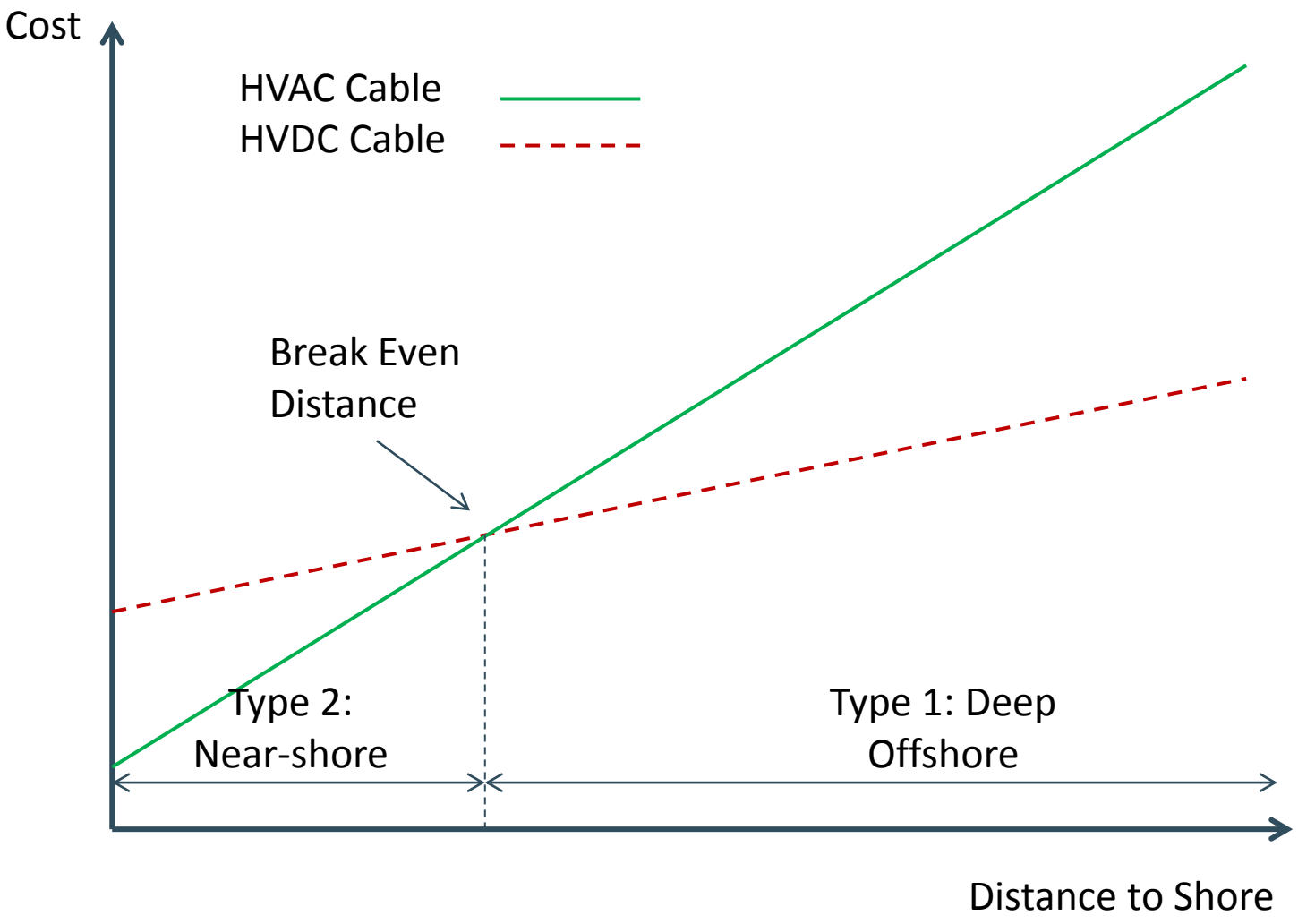
France

- Switched from tendering to feed-in tariffs in 2005
- Projects are selected based on a variety of criteria, including long term benefits, diversity of location, economic benefits, reliability and environmental impact.

The U.K.

- The tender specifies the capacity on the project
- The government evaluates the projects and defines a reservation price. All bids below the reservation price are accepted

Transmission Cost as a Competitive Vehicle



Bidding in Practice

In practice, bidding is based on a multiple of a cost rather than cost itself. The bidders determine their bids based on the following formula:

$$Revenue\ Requirement = O + T + d + r(I - D)$$

O — Operating Expenses (O&M)

T — Taxes (Corporate taxes and other)

d — Annual Depreciation Expense

I — Gross Investment

D — Accumulated Depreciation

R — Rate of Return

There may not exist an equlibrium when there is “mark-up” present. To design the discrimination policy we must use “multiplicative strategies” (Rothkope, Harstad and Fu 2003).

Other Practical Extensions

Multiple Competing Firms

- There may be more than one firm of each type competing
- I rewrite probabilities of winning, the bid and the policy to adjust for multiple firms

Proportional Subsidies

- Some governments ventured into proportional subsidies to compensate the deep offshore wind for additional transmission costs.
- I show that proportional subsidies are only optimal in a very special case.

Technology Preference

- To promote diversity in energy technologies, governments may discriminate in favor of a particular technology.
- E.g. to incentivize offshore wind developers to venture deeper offshore, the government may design a price preference policy that incorporates the preference for deep offshore wind.

Multiple Accepted Projects

- The government may wish to accept more than one project based on a specific call for proposals.

Numerical Illustration

Conclusions