How to design reserve markets? The case of the demand function in capacity markets

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**Initial motivations**

For some essential goods such as electricity, [5], or medical supplies [3], having sufficient investment is crucial to avoid significant system and rationing costs.

Markets’ incentives are sometimes not adequate to ensure that producers make enough investments.

Reserve markets, such as capacity markets, where producers sell their investment availability, can be a solution against underinvestment.

While the supply function emerges naturally on those markets, the demand function is not always spontaneous. Therefore, the regulator must administratively create the demand so the market can clear.

In this paper, we discuss the economic implications of different options of implementing the demand function in capacity markets.

**Who should buy the capacities?**

Two options:

- **A centralized design** with a regulated entity who forecasts the aggregated consumers’ demand and buys the capacities.
- **A decentralized design** with retailers who have to cover their future consumers’ demand by buying enough capacities.

**Benchmark model**

We use the traditional approach [1] [8] [7] to model (i) investment decisions in one technology for (ii) a non-storable homogeneous good with (iii) an uncertain stochastic demand. The timing is as follow with four stages and two distinct periods:

<table>
<thead>
<tr>
<th>Uncertain demand</th>
<th>Certain demand</th>
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<tbody>
<tr>
<td>Capacity market</td>
<td>Investment decision</td>
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<tr>
<td>Wholesale market</td>
<td>Retail market</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
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<td>3</td>
<td>4</td>
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We introduce two imperfections to create the underinvestment in the model:

1. A binding price cap on the wholesale market which generates too low market investment.
2. An inefficient rationing (due to the price cap with an elastic demand) which generates the need for financing a public good.

**A tale of two designs**

In the model, the indirect effect depends on how it affects the retailer profit functions at the margin. When demand is known, the maximization of the following retailers’ profit function gives the stage 4 equilibrium:

**Centralized demand**:

\[
\text{Retailer profit} = \text{Retailer revenue} - p(q_i, \theta) \times \beta_i \times \text{Allocation cost}
\]

**Decentralized demand**:

\[
\text{Retailer profit} = \text{Retailer revenue} - p(q_i, \theta) - S(q_i, \theta) \times \theta \times \text{Individual capacity cost} - \text{Penalty system}
\]

**The devil is in the details**

The magnitude of the indirect effect will depend on:

- **DCA vs DCP**: How capacity price is charged to final consumers (lump sum vs marginal cost).
- **DD**: Two crucial elements:
  1. How retailers control the demand of their final consumers?
  2. What is the value of an additional capacity for retailers?

We provide some comparative statistics on the following parameters:

- Demand
- Price cap
- System cost with rationing
- Mkt structure (# retailers)
- Penalty value

As well as a numerical illustration based on an exponential distribution on the intercept of the final consumers’ demand function. We also look at each design’s Pareto effect: who bear the burden of capacity markets?

**What are capacity markets for?**

Our approach highlights two different but related issues:

1. How much to invest to maximize social welfare?
2. How to increase the social welfare by resolving the negative effect of lacking investments?

If we seek to ensure sufficient investment (1): centralized design.

If we seek to ensure sufficient investment and better manage the demand via price signals (1 & 2): decentralized design.

**The next steps**

We plan to develop this work in progress with two extensions:

- **Information**: Quantity of information (aggregated vs individual) and quantity of information (private vs common value).
- **Consumers**: Pricing (flat rate vs dynamic) and heterogeneity (regulated price vs price reactive).