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

Leopold Monjoie[1]

[1]University of Paris Dauphine, PSL Research University

Dauphine | PSL
CHAIRE EUROPEAN ELECTRICITY MARKETS

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.

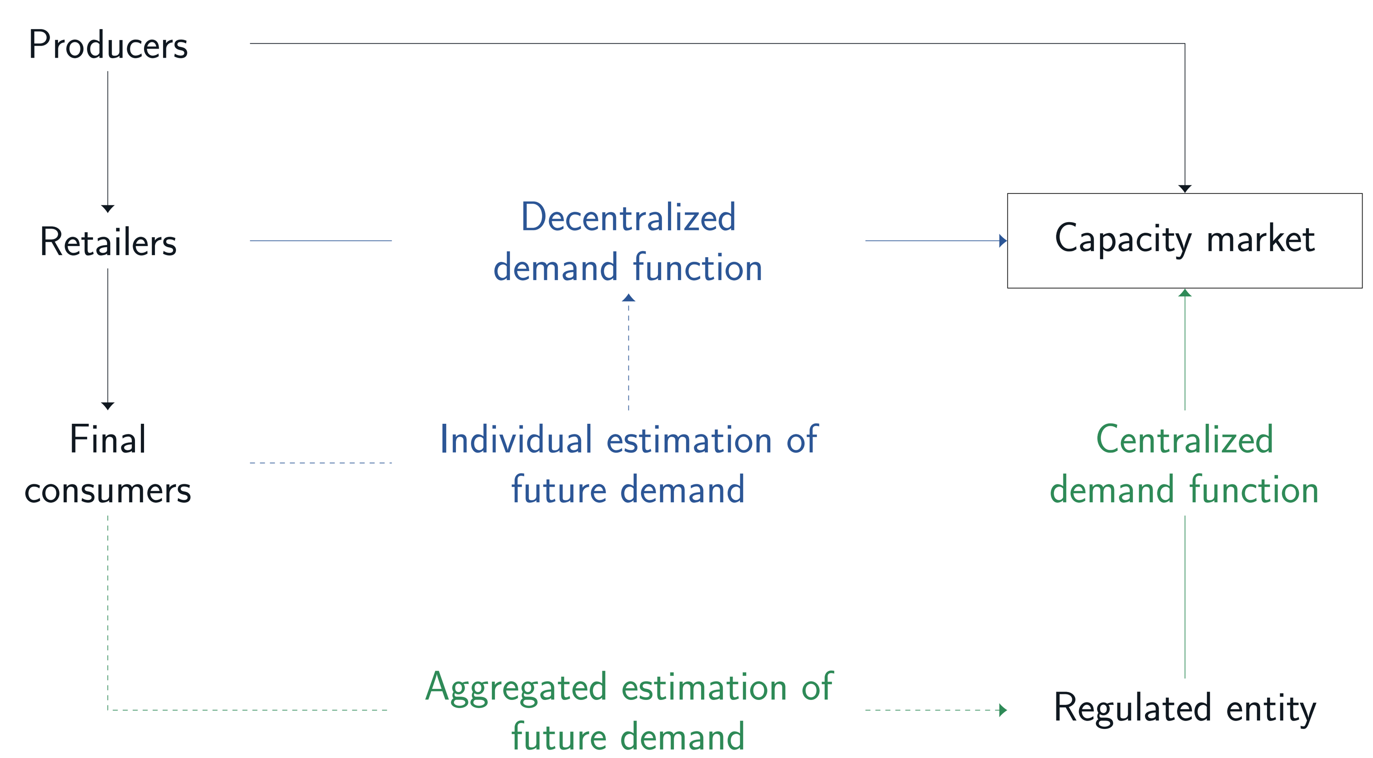
While the supply function emerges naturally on those markets, the demand function is not always spontaneous. Therefore, the regulator must administratively create the demand so the market can clear.

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.



The direct effect of having different demand functions is well known in the capacity markets' literature [2] [6] [4]. We focus on the indirect effect :

- **How capacity markets can impact the demand side in power systems and what are the implications?**

The comparison between the two options boils down to a well-known issue :

Centralization	versus	Decentralization
Better aggregation & information		More flexibility & incentives

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 :

Uncertain demand		Certain demand	
Capacity market	Investment decision	Wholesale market	Retail market
1	2	3	4

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 :

$$\text{Retailer profit} = \text{Retailer revenue} - \overbrace{p^c(\theta)\theta}^{\text{Allocation cost}} \times \underbrace{\beta_i}_{\text{Allocation ratio}}$$

Ex post ratio $\beta_i = \frac{q_i}{q_i + q_{-i}}$ (Realized market share)

Ex ante ratio $\overline{\beta_i}$ (Regulated entity forecast or past market share)

Decentralized demand :

$$\text{Retailer profit} = \text{Retailer revenue} - \underbrace{p^c(\theta)\theta_i}_{\text{Individual capacity cost}} - \underbrace{[S(q_i,\theta) \times (q_i - \theta_i)]^+}_{\text{Penalty system}}$$

Given the retail market equilibrium found in **stage 4**, we solve the model by backward induction :

1. Wholesale market	2. Investment decision	3. Capacity market
Retailer's demand fct.	Inframarginal rent	**Supply** Capacity marginal opp. cost
Wholesale equilibrium	Market investment level	**Demand** DCA & DCP : Maximization of welfare fct. DD : Capacity marginal value for the retailer

Centralized demand ex ante : DCA - Centralized demand ex post : DCP - Decentralized demand : DD

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 :

Demande ε_D	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** - Quality 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).

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