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# SUPPLY FUNCTION EQUILIBRIA – IS IT WORTH THE EFFORT?

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## Overview

Modeling oligopolistic behavior in liberalized electricity markets is a critical cornerstone of modern competition policy and merger control. As the standard tools of competition policy, such as the Herfindahl-Hirschman Index (HHI), are not suitable for electricity markets, because they neglect the institutions and the technical constraints of the electricity market, we have to rely on computational models. In order for computational models to be used in competition policy, they need to be able to make robust predictions. The two main types of models applied to electricity markets are the Cournot model and the Supply Function Equilibrium model (SFE), both having drawbacks and advantages. While standard Cournot models are easy to calculate, the results often do not represent realistic market outcomes. Supply Function Equilibria (Klemperer and Meyer, 1989) on the other hand are considered to represent electricity markets in a more realistic way than Cournot models. The main drawbacks of supply function models are that they are difficult to calculate, have often multiple equilibria, might have unstable solutions, and require strong simplifications with respect to the market and cost structures.
The aim of this paper is to compare two modeling approaches, the Cournot model with fixed percentage of forward contracting and the Supply Function Equilibrium (SFE) model. It shall be tested whether they give similar predictions, and whether the range of uncertainty is similar. We check in how far the added complexity of SFE models is offset by more robust and more realistic predictions.

## Methods

In order compare the outcomes of the Cournot and the SFE approach we develop two GAMS-based simulation models for the German electricity market. We calculate market equilibria assuming identical demand, horizontal demand shocks, market structure and production cost. Transmission constraints are not considered. The SFE model is based on the technique presented in Anderson and Hu (2005), which allows to reformulate the SFE as an MPEC problem (mathematical problem with equilibrium constraints). Their method discretizes the demand distribution and approximates the supply function with piecewise linear functions. The most important advantage of this method is that it allows for asymmetric cost functions of the strategic players. The Cournot model is calculated by rewriting the production as a Mixed Complementarity Problem. Both models result in a bundle of equilibrium supply functions, which are compared on the basis of statistical and economic criteria. A sensitivity analysis is carried out to estimate the impact of generation costs and the number of market participants on the outcome.

## Results

We expect differences between both models to be relatively small on average. However, in extreme demand realizations, the shape of the supply function equilibria might differ significantly from the Cournot supply functions. We expect that it will be justified to use Cournot models with a fixed percentage of forward contracting, for most load situations, having a similar explanatory power as the SFE models.

**Conclusions**

For the first time, the Cournot and the SFE approach, both said to be good simulation approaches for electricity markets, are compared on the basis of an identical data set for Germany. The purpose of this paper is to test whether the added complexity of SFE models in comparison with Cournot models is offset by more robust and more realistic predictions. We try to show that SFE and Cournot models can obtain similar models on average, but give different predictions for extreme demand regimes (low and high demand levels). Therefore, it might be justified to use Cournot models – properly calibrated with the amount of forward contracts – to predict average market outcomes, e.g. to evaluate merger effects.

**Selected References**

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