Strategic bidding of electricity market participants and the occurrence of scarcity prices and sufficient investment incentives in energy-only markets – an agent-based modeling experiment

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(1) Overview

The question whether the current electricity-only market can provide for efficient investment in power plants and other flexibility options is currently heavily discussed. In the German context, investments in power plants have been realized since liberalization. It is however unclear whether these investments were actually driven by electricity market price signals or by other factors such as the free allocation of CO_2 allowances.

The main doubts regarding the functioning of energy-only markets regarding investments is based on the missing-money problem: Necessary peak prices in situations of scarcity cannot occur due to politically set or technical price caps and thus financing of fixed costs is not possible especially for peak load plants. The increasing share of renewables in the electricity sector aggravate the missing money problem as technologies with close to zero marginal costs decrease both peak prices and average electricity market prices ('merit order effect').

Current spot market electricity prices in Germany are too low to incentivize investments in new conventional power plants, especially those with comparatively high fuel costs such as gas turbines or combined cycle gas power plants. A number of studies take this as a proof for the non-functioning of energy-only markets in setting investment incentives (see among others BET 2011, WWF 2012, ewi 2012). The current low price levels can however be explained by existing overcapacities due to progressing European market integration and increasing renewable shares.

The ability of plants to recover their fixed costs in periods of scarcity depends on their ability to realize sufficiently high peak load prices. These prices can occur either based on a more flexible demand side setting the price in scarcity periods or due to strategic bidding of marginal plants bidding in above marginal costs.

The paper at hand focuses on the supply side. It aims at contributing to the debate about investment incentives by analyzing in how far strategic behavior based on game theoretic assumptions can be realized in an oligopolistic electricity market and in how far such behavior will contribute to achieving efficient peak load prices and investment incentives.

(2) Methods

An agent-based electricity market model will be used to model the behavior of power plant operators in the electricity market. Agent-based models are well suited to model and analyze strategic behaviour of electricity market participants (compare among others Sensfuß 2007). The modeling will use the existing electricity market model PowerAce (compare among others Sensfuß 2007).

In the model, power plants currently offer their electricity based on marginal costs of electricity production and costs of starting and stopping the plant. In addition a mark-up is applied to bids in times of scarcity. The markup was however developed with the objective of improving the model fit to actual electricity prices but without any theoretical basis. In order to analyse the effects of rational strategic behavior this markup will be changed to one which is based on game theory for oligopolistic markets.

The basis for the modeling is that electricity markets are oligopolistic markets and therefore market participants are not simply price takers but can influence market prices by using strategic bids above marginal prices especially in scarcity situations. The aim of the modeling is to use a more realistic approach for the bidding behavior of power plants and thus find out in how far this leads to higher scarcity prices, income and investment incentives.

The modeling of oligopolistic behavior will be based on the conjectured supply function approach. This concept is easier to model and needs less computational capacity than a full equilibrium supply function model. Still, it allows for reactions based on competitors' expected prices and quantities and can include Cournot and Bertrand kinds of oligopolistic competition. Therefore this approach seems best suited for covering all options while reducing complexity in a complex and realistic agent-based model (compare among others Díaz et al. 2010; Holberg & Newbery 2010; Willems et al 2009; Rebennack et al. 2010).

A number of authors have already combined agent-based electricity market models with conjectured supply functions (see among others Day & Bunn 2001; Kimborough & Murphy 2008; Chen et al. 2006). These authors have however focused on either the modeling technique per se or on analyzing market power in current electricity markets.

The paper at hand will implement this still novel modeling technique to find out about the possibilities for rational peak prices introduced from the supply side. Results from market simulations with and without the possibility for rational strategic behavior will be detected and explained. The methodology will also include sensitivity analysis to test for the robustness of achieved results.

(3) Results

The results will show if and under which circumstances strategic bidding can contribute to sufficient and efficient peak prices and thus incentivize investment incentives in energy-only markets even when the demand side is considered as inflexible.

It is expected that market players that are able to use strategic behavior in capacity restricted market will be able to achieve higher prices in scarcity situations and thus be able to cover fixed costs. It will also be shown in how far rational strategic bidding leads to higher average electricity costs.

(4) Conclusions

The modeling results will contribute to solving the question whether energy-only markets can provide for investment incentives even under the assumption of a low price elasticity of demand. The modeling might show that financing of power plants in the energy-only market is possible when rational behavior is allowed (i.e. there is no strict restriction of bids above marginal costs) and no price caps are installed.

The conclusion might be that energy-only markets are able to provide for sufficient investment incentives under certain circumstances. However, this could lead to higher electricity prices (at least at peak times) and might need a number of adaptations to the current market rules and regulations. As high scarcity prices are necessary for the efficient functioning of the market and setting investment incentives, they do not need to be considered as an unnecessary and market-distorting usage of market power. Nevertheless a tight control of market power abuse would be necessary to distinguish between efficient peak pricing and inefficient abuse prices.

The results of the analysis can serve as a valuable input for the current discussion about the necessity of capacity mechanisms by adding more information about the functioning of energy-only markets.

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