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Increase-Decrease Game under Imperfect Competition in Two-stage Zonal Power Markets - Part I: Concept Analysis

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Electricity markets around the world use different methods to manage transmission congestion. The US uses nodal pricing while Europe has favoured zonal pricing. Nodal pricing explicitly considers the transmission constraints and all accepted bids are paid with the local price in the node where the participant is located. In Europe, the zonal market is settled in two stages. The first stage is the day-ahead market. This stage considers transmission constraints between zones, but neglects transmission constraints within zones. The second stage is the real-time market, where all transmission constraints are considered.

A problem with zonal pricing is that different representations of the transmission constraints in the two stages yield different prices. This gives producers an arbitrage opportunity. A producer located in an export-constrained node can increase its profit by overselling in the day-ahead market and then repurchasing the electricity at a lower price in the real-time market. This type of arbitrage strategy is referred to as the increase-decrease (inc-dec) game. The game increases the turn-over in the real-time market. Hence, more production decisions have to be taken in the last minute. This increases production costs and it also makes it more difficult to keep the system in balance. In the long-run, the arbitrage profits lead to inefficient investments.

In practice, the inc-dec game is said to result in large payments to Scottish producers in the UK. The game was a major concern during the California electricity crisis and in the original design of the PJM (Pennsylvania - New Jersey – Maryland)

market. Partly due to these problems, more or less all markets in the US have now adopted nodal pricing.

In this paper, we develop a new method that can be used to simulate the inc-dec game in a zonal market. We apply the new method to the 30-bus test system of the Institute of Electrical and Electronics Engineers (IEEE). We consider a zonal market design that is inspired by the Nordic market. We solve for an equilibrium where each producer chooses a bid strategy that will maximize its expected profit, given strategies of the competitors. We transform this optimization problem, into a Mixed Integer Linear Program (MILP), which can be straightforwardly solved by means of standard mathematical programming algorithms.
Zonal pricing is often favoured by market participants and politicians, and it also simplifies hedging and intra-day trading. But our numerical results illustrate that the inc-dec game in such markets can lead to substantial production inefficiencies and excessive profits for producers in export-constrained nodes. The latter can increase their profits by several hundred percent and the dispatch cost could go up by 10-30%, in comparison to markets with nodal pricing.

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