An Evolutionary Model of the Relationship between Forward and Spot Electricity Markets

Abstract: An important research topic in electricity markets is the relationship between forward and spot markets. Allaz and Vila (1993) defended that the introduction of futures markets improves competition, not only in electricity markets, but in markets with tradable commodities, in general.

Evidence supporting this hypothesis has been presented by, for example, Herguera (2000), Le Coq and Orzen (2006). However this issue is still controversial. Mahenc and Salanie (2004) showed that, in a Bertrand duopoly, firms buy their own production in the forward markets, increasing equilibrium prices, when compared with the scenario without forward trading.

In this context, an important question regards the type of competition in the electricity market (which type of model can better represent the way firms behave, Cournot, Bertrand, Supply curves?) and the interaction between forward and spot markets.

We analyze the process of inter-temporal decision making in electricity markets, looking at the relationship between futures and spot markets. We present an evolutionary model that we use to test the evolutionary stability of the different strategies available for the players regarding generation quantity and forward trading, taking into account uncertainty as in Allaz (1992).

We test under which conditions the models developed by Allaz and Vila (1993) and Allaz (1992) are robust under learning and under which conditions the game fails to converge to equilibrium. In the evolutionary model proposed in this paper, we represent the strategies implemented by the firms as automata that evolve over time, as the players interact to each other. The questions we want to answer relate to the conditions under which this evolutionary algorithm converges to the same strategies proposed by Allaz and Vila (1993) and Allaz (1992).

These experiments are important as, in general, the assumptions in the Cournot model are very demanding regarding the knowledge of the players involved in the game: games based on the concept of Nash-Cournot equilibrium rely on the basic assumption of common knowledge of the structure of the game (payoffs, number of players, rules of the game). Moreover, the players are assumed to act rationally, i.e., all the players take the optimal decisions assuming the others also behave in a rational manner

Our evolutionary model, on the other hand, does not constrain the players to any type of behavior, and we assume that they learn by exploring the environment, by trial and error, in order to improve their profit. Therefore, if these models do converge to the Dynamic Cournot equilibria presented in Allaz and Vila (1993) and Allaz (1992) it will prove that these are very robust.

We present an application of our model to the analysis of typical trading days in the Iberian electricity market.

Keywords: electricity, evolutionary models, forward markets.

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