THEORETICAL ASPECTS OF THE CONCEPT OF INTEGRATION BETWEEN FIRMS

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Annotation: Strengthening of tendencies of general economy to diversification of production, growth of concentration and centralization of capital of the largest firms, stormy development of scientific and technical revolution, the dynamic changes of the state of affairs of market were formed by pre-conditions of integration of managing subjects. The form of associations of companies was become by conglomerate of different industries.

Keywords: diversification, integration, conglomerate, confluence, absorption.

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ТЕОРЕТИЧЕСКИЕ АСПЕКТЫ МОДЕЛИРОВАНИЯ СТРУКТУРЫ РЫНКА ЭЛЕКТРИЧЕСКОЙ ЭНЕРГИИ

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Аннотация: В данной статье рассматриваются подходы к моделированию структуры рынков, применительно к разработке комплексной имитационной модели оптового рынка электроэнергии и изучение взаимодействия между экономическими субъектами. Особое внимание уделяется влиянию рынка на генерирующие компании. Рыночная власть этих компаний заключается в способности влиять на цену предложения электрической энергии без реакции со стороны конкурентов. Результаты исследования рассматриваются на основе шаблона оптового рынка электроэнергии WPMP, разработанный Федеральной комиссией по регулированию энергетики, США в 2003 году. Как показано в [1], она также применима при рассмотрении оптового рынка электрической энергии ЕС и Россией.

Ключевые слова: оптовый рынок электроэнергии; олигополия; рыночная власть; генерирующие компании; детерминанты рынка; стратегическое планирование.

INTRODUCTION

The attractiveness of complex market models with regard to energy economics motivates the use of computational approaches for modeling technological infrastructure and strategies of market participants. In this artificial environment, market agents may repeatedly interact with each other and thus to reproduce realistic feasibility dynamic system.

The simplest models are optimization models of the power system to one optimality criterion, for example, minimization of electricity production costs. The introduction of market structure of the power system management led to the creation of energy companies which make decisions on production output and input power. Optimization of the energy system requires a solution of problems with many objective functions. Examples of such models created in recent decades are the oligopolistic market models of power supply systems which were actively developed in the USA and EU within national research projects. These models are based on the mathematical tools developed in the game theory that assumes rational behavior of market participants.

At the same time, a great number of studies (D. Kahneman, A. Tversky, R. Thaler, A. Rubinstein, C. Camerer, George Lowenstein) refute one of the fundamental used approaches to modeling - the rational behavior of market agents. Daniel Kahneman and Amos Tversky are considered to be the major contributors in this area. They demonstrated that in reality, decision-makers do not cope well with the problems of logical analysis, but successful enough to quickly detect patterns of behavior. Quite often, the interpretation of the information is based on our own experience and intuitive solutions. The human factor leads to irrational features in the decision-making. That fact does not allow us to describe the behavior of market agents in the form of the optimization problem. Thus, in reality, market participants do not seek to maximize the value of the decision-making. More likely the decision-making problem is aimed at finding the most satisfactory solution that would give the average result.

This fact has led to the development of new dynamic models of the electricity market (Projects of Iowa State University, Carnegie Mellon University, Argonne National Lab, Los Alamos National Lab), which were based on agent-based modeling.

Agent-based models typically represent

computationally constructed virtual world consisting of multiple agents (encapsulated software programs) whose various interactions drive all world events over time. The agents in question are described as structural entities (e. g., transmission grids), institutional entities (e.g., markets) and cognitive entities (e. g., behavior of traders and market operators).

Agent-based modelling might be used to improve the qualitative understanding of the dynamics of active operations in the restructured wholesale electricity markets, help to familiarize the agents in question with the rules of the market, as well as to foster the development and testing of business strategies on the wholesale power market.

ANALYSIS OF OLIGOPOLISTIC MARKET MODELS

Nowadays all mathematical models of an oligopoly can be divided into two large classes. The first - a no collusive oligopoly in which each firm, focusing on the actions of competitors, independently maximizes profit by managing their own price and volume of supplies. The second class of models is represented by the collusive oligopoly in which firms are trying to increase their own profits to find a cooperative solution.

Non-collusive oligopoly models are defined by a type of parameter which is used by the company at decision-making. If the decision on output volume is made, the model represents a quantitative oligopoly, if this decision is based on price – a price oligopoly. Models of quantitative oligopoly are more adequate in a situation when after adoption of the operational plan it is difficult to companies to change capacities, and, consequently, the volume of deliveries. It is characteristic, in particular, for the energy industry.

Collusive models describe the so-called “instantaneous” competition: the companies in a single time point set prices, profit and leave the market. In practice, however, the companies interact with each other repeatedly, making it necessary to re-solve the game problem on a relatively stable set of firms. E. Chamberlin shows that in the conditions of an oligopoly making a uniform product, companies recognize their interdependence and will support monopoly price without obvious collusion [2]. If every company will make rational decisions and seek to maximize profits, their actions will have a significant influence on each other that will lead to strong counteraction in presence of a small number of competitors.

As the reduction of price undertaken by any of their competitors will lead to reduction of prices of other companies and to reduction of own profit of the enterprise, in spite of the fact that sellers are completely independent, the equilibrium result will be same as if there was a monopoly agreement between them.

The circumstances described above led to the active development and application in practice of collusive oligopoly models. In these models the company being the price leader (the potential winner in price war) is allocated. The leader regulates level of market price and assumes responsibility for the price adaptation to changing conditions of the market.

Except the leader in the market a significant number of companies offer supply, forming the competitive environment. They accept the price set by the leader, and define optimum output volume from a condition of maximizing profit.

At application of an oligopoly models for modeling of the wholesale market of the electric power it is necessary to consider available restrictions on an entrance of new sellers on this market. Entry into the market of new participants can largely affect the profitability indicators of other companies, and the equilibrium outcome. Oligopoly models with entry barriers are applied to studying this question.

Under the entry barrier means existence of an obstacle of entry into the market for the new companies that allows the sellers who have settled in the market to receive excess profits without threat of appearance of new competitors. Such barriers arise both because of government regulation of the market structures (related to the energy market), and because of the collective opposition from the vendors that are on the market.

J. Bain identified a number of restrictions on market entry of new competitors [3]. Among them will be valid for the energy market, such restrictions as absolute cost advantages (the ability to set prices at a level below the minimum average cost of companies followers, which can completely block the entry of competitors) and a positive effect of scale due to lower unit production costs (the market share of new competitors will be too small to provide the required level of profitability).

Classical model of an oligopoly is Kurno’s model. It is quantitative no collusive model. Key points:

- The fixed number of the companies (more than one) acts on the market, producing products of one type.
- Entrance on the market of new firms and an exit from it are non-existent.
- Firms possess market power.
- Firms maximize profits and operate without cooperation.
- Each firm, taking its decision, considers release of other firms by the set parameter (constant).
- Firms’ cost functions are assumed to be known to all participants.
- Function of demand represents decreasing function from the product price.
- Product price is defined as the equilibrium price of the industry market (the size of the industry offer is equal to demand size at the same price).

The disadvantage of oligopoly models is that they do not consider the possibility of the irrational behavior of market agents at decision-making.

Not search of optimal economic equilibrium becomes the main objective of modeling, but an attempt to describe and understand the nature of the underlying socio-economic phenomena. This led to the creation of a new dynamic modeling approach, called agent-based modeling.

AGENT-BASED APPROACH TO MODELING OF THE ENERGY MARKET

Agent-based modeling is a tool that allows for the development of complex adaptive systems. The model is a set of core elements, which comes from the interaction of general behavior of the system.

The meltdown in the restructured California wholesale power market in the summer of 2000 has shown what can happen when a poorly designed market mechanism is implemented without proper testing. California power market crisis was caused by unrecorded in model calculations of the strategic behavior of market participants, which led to disruption the design features of the market [4]. After the California crisis, many energy researchers have argued the need to combine structural understanding with economic analysis of incentives in order to develop wholesale power market designs.

In April 2003, the U.S. Federal Energy Regulatory Commission proposed the Wholesale Power Market Platform (WPMP) as a template for all U.S. wholesale power markets [5]. This design entails an integrated rather than unbundled market form; it recommends the operation of wholesale power markets by Independent System Operators (ISOs) or Regional Transmission Organizations (RTOs) using locational marginal pricing to price energy by the location of its injection into or withdrawal from the transmission grid. Versions of this design have been implemented in New England (ISO-NE), New York (NYISO), the mid-Atlantic states (PJM), the Midwest (MISO), the Southwest (SPP), and California (CAISO). Joskow (2006, p. 6) reports that ISO/RTO-operated energy regions now include over 50% of the generating capacity in the U.S.

The complexity of the WPMP market design has made it extremely difficult to undertake economic and physical reliability studies of the design using standard statistical and analytical tools. The demand for new approaches to modeling and analysis of electricity markets has led to the further development of agent-oriented models.

A variety of commercial agent-based frameworks are now available for the study of restructured electricity markets, for example, the EMCAS framework developed by researchers at the Argonne National Laboratory [6]. In addition, researchers such as Bower and Bunn (2001), Nicolaisen (2001), Veit (2006), and Widergren (2004) have used agent-based models to study important aspects of restructured electricity markets [7].

AGENT-BASED SOFTWARE AMES

Junjie Sun and Leigh Tesfatsion, the american scientists, have created the computational model of the wholesale power market specially for testing the dynamic efficiency and reliability of the WPMP market design. This framework – referred to as AMES (Agent-based Modeling of Electricity Systems) – models strategic traders interacting over time in a wholesale power market that is organized in accordance with core WPMP features and that operates over a realistically rendered transmission grid.

AMES is the first non-commercial open-source framework permitting the computational study of the WPMP design [8]. The core elements of the WPMP market design that have been incorporated into the AMES framework are presented in the table 1.

To help ensure empirical input validity, the AMES framework has been developed by means of an iterative participatory modeling. Learning process of the electricity market consists of the following repeated stages of analysis:

- fieldwork and data collection;
- scenario discussion and role-playing games;
- agent-based model development;
- intensive computational experiments

Currently the AMES framework is used to investigate the intermediate-term performance of wholesale power markets operating under the WPMP market design. In particular, it's used to explore the extent to which this design is capable of supporting the efficient, profitable, and sustainable operation over time of existing generation and transmission facilities, despite possible attempts by some market participants to gain individual advantage through strategic pricing, capacity withholding, and induced transmission congestion.

The computational experiments are made on the dynamic extension of a static five-node transmission grid test case used extensively for training purposes by the ISO-NE and PJM.

One of the AMES benefits is the reinforcement learning representations for the electricity traders that are based on findings from human subject multi-agent game experiments conducted by Roth and Erev [9]. Applied learning algorithms allow generations of selecting the best method of forming supply offers (marginal cost functions and production intervals) that they daily report to the AMES ISO for use in the WPMP day-ahead market. Test results of experiments show that the generation over time learn to create implicit collusion on the reporting of higher-than-true marginal costs, thus significantly

Table 1

The core elements of the WPMP market design that have been incorporated into the AMES framework

The elements of the model	Outstanding characteristics
Time	The AMES wholesale power market operates over an AC transmission grid for DMax successive days, with each day D consisting of 24 successive hours H = 00, 01, . . . , 23
Agents	The AMES wholesale power market includes an Independent System Operator (ISO) and a collection of energy traders consisting of Load-Serving Entities (LSEs) and Generators distributed across the nodes of the transmission grid
Market organization	The AMES ISO undertakes the daily operation of the transmission grid within a two settlement system consisting of a Real-Time Market and a Day-Ahead Market, each separately settled by means of locational marginal pricing
Power commitments, pricing	During the afternoon of each day D the AMES ISO determines power commitments and locational marginal prices (LMPs) for the Day-Ahead Market for day D+1 based on Generator supply offers and LSE demand bids (forward financial contracting) submitted during hours 00 − 11 of day D
Commitment schedule	At the end of each day D the AMES ISO produces and posts a day D+1 commitment schedule for Generators and LSEs and settles these financially binding contracts on the basis of day D+1 LMPs
Deviation control	Any differences that arise during day D+1 between real-time conditions and the dayahead financial contracts settled at the end of day D must be settled in the Real-Time Market for day D+1 at real-time LMPs for day D+1
Transmission grid congestion management	Transmission grid congestion in the Day-Ahead Market is managed via the inclusion of congestion components in LMPs.

affecting the cost of electricity in the model nodes.

ANALYSIS OF GENERATOR'S MARKET POWER INFLUENCE ON THE ELECTRICITY MARKET SITUATION

The generator's market power is its ability to influence the price of the offer and sale conditions in the power market without a reaction from competitors. In the electricity market generators can implement a number of strategic innovation based on the market power of the company [10]:

Financial withdrawal (price increase).

Sellers submits supply offers at a higher cost (above the marginal cost of electricity generation). Under the condition of inelastic demand, this should lead to an increase in the equilibrium market price, and the potential generator's income.

Capacity withholding (volume decrease).

Sellers submits supply offers with the reduced volume in comparison to the one that can be worked out on the generating equipment of the company. Withdrawal of a certain amount of power from the market, and thus an increase the in equilibrium market price.

Capacity withholding by free bilateral contracts.

Part of the "cheap" volume is removed from the market by free bilateral contracts. Under the condition of the growth in electricity consumption, this leads to an increase in the equilibrium market price.

The following describes one of the strategies of market power, namely "Financial withdrawal" (Fig. 1).

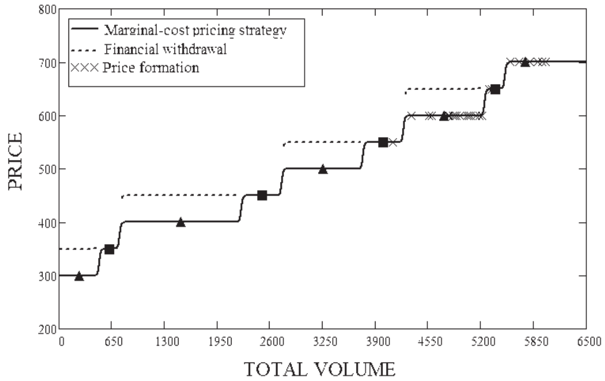

Fig. 1. The displacement of the supply curve in the transition to a strategy of financial withdrawal.

After definition of the pricing bids of one generator for each hour of the day and after increase in their cost to the next price level, we get the following graphical representation of the economic effect of the financial withdrawal strategy (Fig. 2).

Key issue: is it possible to develop the best strategy (strategic innovation) to maximize the generator's income for each hour of a day on the basis of financial withdrawal.

If the supply offer is a pricing bid according to the forecast, the increase in its cost over the next price level should lead to the fact that all or part of the volume of the application is not accepted by the market. Generator should lose profit from this bid, but more expensive bid should become a pricing one. This will increase the equilibrium price, and thus the generator's income from the other bids, accepted by the market.

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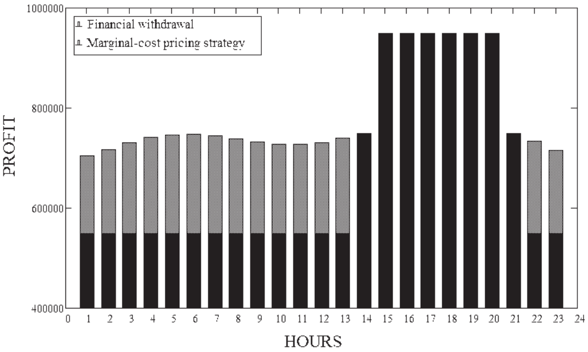

Fig. 2. Hourly income schedule of the generator using a margin strategy and a strategy of financial withdrawal.

In fact, there is an optimization problem. New price level of the bid must be find to maximize the generator's income. We propose the following step by step algorithm for the optimization problem solution:

1. The generator's bid $i = k - 1$ is considered. The cost of the bid is raised to the next price level.
2. New supply curve is constructed. The equilibrium market price at the hour of the day is determined.
3. Negative and positive components of the generator's income at this hour are calculated.
4. Hour income of the generator is determined and it's compared with the income, received through the use of margin strategy. The most revenue and the best strategy of the bids creating are fixed.
5. The cost of the bid $i = k - 2$ is raised to the next price level.
6. The condition of equality is checked: the cost of the bid must be equal with the cost of the most expensive bid in the trading system. If the condition is satisfied, the cheaper bid $i = k - 2$ is examined in the next step. Otherwise, steps 1 -5 are repeated
7. The bid $i = k - 2$ runs steps 1-6. Similarly, the following cheaper bids will be examined until all bids of the generator are examined.
8. After consideration of all generator's bids for this hour of a day, analytical analysis of the supply curves and the definition of the best strategy at this hour, which corresponds to the maximum possible revenue for hour, we go to the calculation of the maximum income and determine the best strategy for the next hour. Repeat steps 1-7.

In the end, after the execution of the algorithm we get the best strategy for the formation of applications corresponding to the maximum income of the generator that can be obtained for each hour of the day.

This strategy may significantly change the appearance of the supply curve. As an example, we present a comparison of supply curves, formed according to the margin and the best strategies for a certain hour of the day (Fig. 3).

RESUME

Recent work in the development of the wholesale electricity market models indicate that the main direction of research is to study the behavior of the wholesale electricity market's participants. In fact, market participants do not seek to maximize the utility of decision-making is likely to task of decision-making is aimed at finding the most satisfactory solution that would give the average result.

Understanding of this fact has led to the creation of new dynamic model of the electricity market, which are based on a new methodology, based on agent- modeling. The model of the electricity market is formed by the

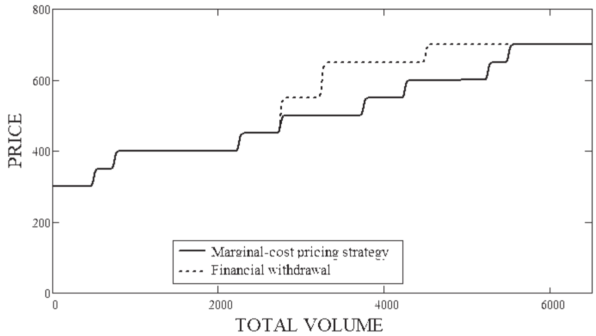

Fig. 3. A comparison of supply curves, formed according to the margin strategy and the strategic innovation.

interaction of many market agents, each of which has certain patterns of behavior.

Special attention should be attributed to the software and computational models of open source. These models include the project AMES economic division Iowa State University, designed specifically for the study of dynamic performance and reliability model of energy-market WPMP. Market power influence of the generators on the electricity market situation as well as searching the best behavioral strategy of energy companies are particularly significant problems which are discussed under the agent-based models. Considered situation was when the basis of the electricity market is trading platform hourly contracts for physical delivery of the electricity sold in the day ahead with bilateral auction. This operation mechanism of the market is fair for the majority of the world's energy markets.

In course of the work on AMES system some of the scenarios based on the description of the mechanisms of financial withdrawal applications from the trading system was compiled. Investigation of these scenarios showed that similar mechanisms of market power allowed to significant increase of the generators' income in comparison with the accepted marginal-cost pricing strategy. The result of the research was the suggestion by the authors of the step-by-step algorithm to develop the best strategies of the generation company in the spot energy market.

REFERENCES

1. Lisin E., Grigoryeva A. (2012). Generators' strategic behaviour reserch based on the agent approach to the power market modeling. – Czech Journal of Social Sciences, Business and Economics, VOL. 1, ISSUE 1, pp. 75-81.
2. Chamberlin E. (1933). The Theory of Monopolistic Competition. – Harvard University Press.
3. Bain J. (1956). Barriers to New Competition. – Harvard University Press.
4. Borenstein S. (2002). The trouble with electricity markets : Understanding California's restructuring disaster. – Journal of Economic Perspective, Vol. 16, № 1.
5. Federal energy regulatory commission White Paper (April 28, 2003), Wholesale Power Market Platform.
6. North M., Conzelmann G., Koritarov V., Macal C. (2002). E-laboratories: agent-based modeling of electricity markets. American Power Conference. April 15-17, 2002 Chicago, IL, USA.
7. Tesfatsion, Leigh (2007a). ACE Research Area: Restructured Electricity Markets, Website available at http://www.econ.iastate.edu/tesfatsi/aelect.htm
8. Tesfatsion, Leigh (2007c). The AMES Market Package (Java): A Free Open-Source Test Bed for the Agent-based Modeling of Electricity Systems, Website available at: http://www.econ.iastate.edu/tesfatsi/AMESMarketHome.htm
9. Roth A., Erev I. (1995). Learning in Extensive-Form Games: Experimental Data and Simple Dynamic Models in the Intermediate Term. – Games and Economic Behavior, №8, pp. 164-212.
10. Stoft S. (2002). Power system economics: designing markets for electricity, in Institute of Electrical and Electronics Engineers, IEEE Press

THE ORETICAL ASPECTS OF MODELING STRUCTURE OF THE MARKET ELECTRIC ENERGY

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Annotation: This article discusses the approaches to the modeling of the structure of markets, in relation to the development of an integrated simulation model of the wholesale electricity market and the study of interactions between economic agents. Particular attention is paid to influence the market for generation companies. The market power of these companies is the ability to influence the bid price of electricity with no response from competitors. Results of the study are considered on the basis of a template wholesale electricity market WPMP, developed by the Federal Energy Regulatory Commission, the United States in 2003. As shown in [1], it is also applicable when considering the wholesale electricity EU and Russia.

Keywords: wholesale electricity market; oligopoly, market power, the generating companies, the determinants of the market, strategic planning.