

Chapter 10

Multi-Agent Economically Motivated Decision-Making

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ABSTRACT

The key motivation for this chapter is the perception that within the near future, markets will be composed of individuals that may simultaneously undertake the roles of consumers, producers and traders. Those individuals are economically motivated “prosumer” (producer-consumer) agents that not only consume, but can also produce, store and trade assets. This chapter describes the most relevant aspects of a simulation tool that provides (human and virtual) prosumer agents an interactive and real-time game-like environment where they can explore (long-term and short-term) strategic behaviour and experience the effects of social influence in their decision-making processes. The game-like environment is focused on the simulation of electricity markets, it is named ITEM-game (“Investment and Trading in Electricity Markets”), and it is publically available (ITEM-Game, 2013) for any player to explore the role of a prosumer agent.

1. INTRODUCTION

This chapter describes the perspective of agents with the ability to take the roles of consumers, producers and traders under the same market-context. This “multi-role” ability is named as the “prosumer” perspective of an agent (or simply prosumer agent). In this chapter the prosumer agent is characterized from a problem-oriented (specific domain) approach with emphasis to the liberalized electricity market environment and its relation with the emergence of prosumer agents.

There is a world-wide shift towards a low carbon economy where electric motors (free from internal fuel combustion) pervade the transportation industry (e.g., personal vehicles, high speed trains) and the increasing demand for renewable power generation calls for a huge amount of such generators, distributed across both the transmission and distribution networks. The current scenario of a grid where electricity flows one-way from producers to consumers is making the first moves towards a distributed network of prosumer agents that both produce and consume electricity according to their individual profiles, thus giving

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rise to flows of electricity that continuously vary in magnitude and direction (Ramchurn et al., 2012). Each prosumer agent continuously makes decisions and evaluates its own position in respect to all other prosumers. The combination of both the prosumer and the market perspectives opens a space for those companies and individuals that intend to make long-term investment decisions (e.g., acquire generation or storage capacity) and to explore short-term strategies on trading (e.g., selling or buying) the electricity asset. Hence, prosumers will be able to act (sell and buy) in the market not simply either as producer or a (close to price agnostic) consumer, but also aiming for the profit.

A major economic rationale for the liberalization of the electricity industry was the vision of lower prices and more efficient power generation (and consumption) through market competition. A key assumption behind such rationale was that the power generation (after being separated from the power distribution) would endow competitive markets, rather than markets in which a small numbers of firms exercise market power. The foundational directives for an energy market where competition is to be achieved within a fair and transparent environment were settled by current European Directive (EC, 2009).

Usually the behaviour of markets depends on the participants' economical motivation, but often the market environment is too complex for the analytical game-theoretic analysis. Therefore it is of utmost importance to develop simulation and prediction tools where the observations of all the agents' plays are used to compute estimates for the utility of their strategies. This follows the "empirical game simulation" approach where, despite the lack of an analytic game formulation, agents evolve within a strategic scenario, at a practical level of abstraction, such that the analysis is computationally feasible and the game-theoretic concepts can still be explored.

A special concern with the market power concept guides this research. Although a company's market share is often correlated with market power, this is not always the case. Additional factors, apart from the number and size of companies in a market, impact the degree of competition within an industry. These factors include the price-responsiveness (elasticity) of both the demand and the production. In markets where customers can easily choose not to consume a product, or to consume a substitute instead, producers cannot raise prices far above costs without significantly reducing sales. Also, just as a producer with very price responsive customers cannot exercise much market power, neither can a producer faced with many price-responsive competitors. The market competition is driven by each stakeholder's search for means of influencing others' decisions in order to achieve (or increase) its own exercise of market power. The basic measure of the exercise of market power is the price-cost margin, which measures the degree to which prices exceed marginal costs. Both the price-cost margin and the elasticity of demand and production will be used to describe and to (graphically) represent, at each decision epoch, the power and influence relations among agents.

This chapter describes a game-like market simulator, named ITEM-game ("Investment and Trading in Electricity Markets"), where human and virtual agents can explore the investment and trading strategies for the electricity market. The ITEM-game was implemented as a derivation from the previous TEMMAS ("The Electricity Market Multi-agent Simulator") simulator (Trigo et al., 2010). The main difference between both simulators (TEMMAS and ITEM-game) is that, the TEMMAS follows a machine (reinforcement learning method to autonomously search for a (near optimal) competitive trading (pool bidding) strategy, while the ITEM-game is designed for humans to explore investment and trading strategies. Thus, the ITEM-game is an interactive tool and

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