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Decision making in dynamic stochastic Cournot games

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Abstract

In this paper, the Cournot competition is modeled as a stochastic dynamic game. In the proposed model, a stochastic market price function and stochastic dynamic decision functions of the rivals are considered. Since the optimal decision of a player needs the estimation of the unknown parameters of the market and rivals' decisions, a combined estimation–optimization algorithm for decision making is proposed. The history of the rivals' output quantities (supplies) and the market clearing price (MCP) are the only available information to the players. The convergence of the algorithm (for both estimation and decision making processes) is discussed. In addition, the stability conditions of the equilibrium points are analyzed using the converse Lyapunov theorem. Through the case studies, which are performed based on the California Independent System Operator (CA-ISO) historical public data, the theoretical results and the applicability of the proposed method are verified. Moreover, a comparative study among the agents using the proposed method, naïve expectation and adaptive expectation in the market is performed to show the effectiveness and applicability of the proposed method.

Keywords: Cournot game; Stochastic game; Oligopoly market; Estimation; Nash equilibrium

1. Introduction

The first dynamic model in the field of oligopoly games was introduced by Cournot [13]. In this game model, the players make their decisions according to the strategies of their rivals using the naïve expectations model (that assumes the rivals would repeat their last strategies in the next step of the game).

In Refs. [1,2,7], the oligopoly dynamic models were considered assuming the naïve expectation of the rivals' strategies. In Ref. [1], the dynamics of three and four player Cournot game model were studied with linear cost functions of the players. In Ref. [7], the results of Ref. [1] were extended to an n-player game with linear cost functions. The basins of attraction for multiple Nash equilibrium points were discussed in Ref. [2], where the players used naïve expectations and did not estimate the rivals' behaviors. In Ref. [10], a duopoly game with adaptive adjustment of the rival's behavior was taken into account. A review of the studies on complicated dynamics of oligopoly games can be found in Ref. [22]. Many research works have considered homogeneous expectations of the rivals, where the players use the same rule for rivals' behavior adjustment [3–5,17,22]. This approach may not be useful for the cases that players have different decision making strategies.

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