Stackelberg vs Cournot: A Differential Game Approach

Luca Colombo
Deakin University

Abstract: In this paper, we compare and contrast feedback Nash and Stackelberg equilibria in a differential oligopoly game in which production requires exploitation of a common-pool renewable resource. In the absence of any exploitation, the resource stock grows according to a linearized logistic function. Firms' control variables are exploitation rates and the state variable is the resource stock. We are interested in comparing per firm, total output and welfare in the Stackelberg differential game with per firm, total output and welfare in the Cournot differential game analyzed in Benchekroun (2003; 2008) and in Colombo and Labrecciosa (2015). We aim to shed some light on whether the traditional Stackelberg-Cournot welfare ranking (Stackelberg is more efficient than Cournot) is robust to a continuous-time formulation. The main findings of our analysis can be summarized as follows. There exists an interval of initial resource stocks where, in the short-run, the Stackelberg follower produces more and earns higher profits than a Cournot firm, and the Cournot equilibrium turns out to be more efficient than the Stackelberg equilibrium. Irrespective of initial conditions, equilibrium strategies induce a trajectory of the resource stock that converges to a lower stock in Stackelberg than in Cournot, implying that the presence of a Stackelberg leadership exagerbates the "tragedy of the commons", a result that is new in the literature. At the stationary equilibrium, total welfare turns out to be higher in Cournot than in Stackelberg, thus reversing the traditional welfare ranking. Furthermore, not only consumers' surplus, but also industry profits turn out to be higher in Cournot than in Stackelberg, implying that Cournot turns out to be not only welfare- but also Pareto-superior. The traditional Stackelberg-Cournot welfare ranking is also reversed when taking the discounted sum of welfare as a criterion for relative efficiency. In terms of policy implications, if the initial asset stock belongs to the region where firms play non degenerate feedback strategies in both the Stackelberg and the Cournot games, then a hypothetical social planner seeking to maximize the discounted sum of total surplus should regulate the industry in such a way to eliminate or at least reduce firms' asymmetry in the timing of moves.