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Complexity in a monopoly market with a general demand and quadratic cost function

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Abstract

In this paper we extend the work done by Askar, 2013. (Askar, S.S., 2013. On complex dynamics of monopoly market, Economic Modelling, 31, 586-589). The equilibrium state of a bounded rational monopolist model is studied. It is assumed that the entire demand has a general non-linear form and the cost function is quadratic. The equilibrium of the model is equal to the level of price that maximizes profits, as can be seen in the classical microeconomic theory. However, complex dynamics can arise and the stability of equilibrium state is discussed. The complex dynamics, bifurcations and chaos are displayed by computing numerically Lyapunov numbers and sensitive dependence on initial conditions.

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Keywords: Monopoly, Difference Equation; Equilibrium, Stability, Sensitive dependence on initial conditions, Chaotic Behavior.

1. Introduction

In recent years, many researchers have demonstrated that economic agents may not be fully rational. Even if one tries to do more efforts to perform things correctly, it is important to utilize simple rules previously tested in the past (Kahneman *et al*,1986; Naimzada and Ricchiuti, 2008). Efforts have been made to model bounded rationality to

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different economic areas: oligopoly games (Agiza, Elsadany, 2003, Bischi *et al*, 2007); financial markets (Hommes, 2006); macroeconomic models such as multiplier-accelerator framework (Westerhoff,2006). In particular, difference equations have been employed extensively to represent these economic phenomenons (Elaydi, 2005; Sedaghat, 2003).

Oligopolistic market structures have a distinguishing feature that is the output, pricing and other decisions of one firm affect, and are affected by, the similar decision made by other firms in the market. Indeed, game theory is one of the important tools in the economists' analytical kit for analyzing the strategic behavior of this market (Gibbons, 1992, Webb, 2007). Various empirical works have shown that difference equations have been extensively used to simulate the behaviour of monopolistic markets (Abraham et al., 1997; Elaydi, 2005; Sedaghat, 2003).

The canonical approach of the monopoly theory is essentially static and the monopolist has full rationality: both perfect computational ability and large informational set in such a way that she can determine both quantity and price to maximize profits. However, in the real market producers do not know the entire demand function, though it is possible that they have a perfect knowledge of technology, represented by the cost function. Hence, it is more likely that firms employ some local estimate of the demand. This issue has been previously analyzed by Baumol and Quandt, 1964, Puu 1995, Naimzada and Ricchiuti, 2008, Askar, 2013. Naimzada and Ricchiuti evaluate a discrete time dynamic model with a cubic demand function without an inflexion point and linear cost function. Askar extends the work done by Naimzada and Ricchiuti with a general demand function.

In this paper, the equilibrium state of a bounded rational monopolist model is studied. It is assumed a general demand and quadratic cost functions and in this way we extend the work done by Askar, 2013. We show that complex dynamics can arise and the stability of equilibrium state is discussed. The complex dynamics, bifurcations and chaos are displayed by computing numerically Lyapunov numbers and sensitive dependence on initial conditions.

2. The model

The inverse demand function has a general form, it is downward sloping and concave:

$$p = a - bq^n, \ \mathrm{n} \in \mathbb{Z}, \ \mathrm{n} > 1 \tag{1}$$

where p indicates commodity price, q indicates the quantity demanded, and a and b are positive constants. The downward sloping is guaranteed if:

$$\frac{dp}{dq} = -nbq^{n-1} < 0 \tag{2}$$

that is if b>0.

The quantity produced, q, is positive and non-negative prices are achieved if

$$0 < q < \sqrt[n]{\frac{a}{b}} \tag{3}$$

We suppose that the cost function is quadratic

$$\mathrm{C(q)=cq^2} \tag{4}$$

Moreover, we assume the general principle of setting price above marginal cost, p - c > 0, for each non negative q; that is, a > c. The main aim of the firm is to maximize the following profit function:

$$\Pi(q) = (a - bq^n)q - cq^2 \tag{5}$$