

Research on the complex features about Stackelberg game model with retailers have dual identities

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(Received January 18 2018, accepted March 11 2018)

Abstract. This paper presents a 1-2 suppliers-retailers model with delayed bounded rationality. The retailers have their own products, and their products aren't manufacturer's products' substitutes, products are epiphytic relationship. The phenomenon of chaos and other complex phenomena are reported using stability region, bifurcation, attractors etc. We also introduce delayed decision into the model, study the influence of delayed decision on the stability of the model. The results show that the system's stability is mainly determined by the delay coefficient, appropriate delay coefficient can enhance the stability of the system, the inappropriate delay coefficient will reduce the stability of the system. In addition, we cannot simply think that more merchants adopt delayed decision can improve the stability of the system.

Keywords: bounded rationality, game theory, complex analysis, bifurcation.

1. Introduction

Puu[1] first discovered bifurcation and chaos exist in Duopoly Cournot model. Bischi[2] and others introduced the bounded rationality into Cournot duopoly game model with linear cost for the first time. The dynamic behavior of Bowley model under bounded rationality is studied by Agiza[3]. Since then, incomplete information has been introduced into the classic Cournot Oligopoly game model. The oligopoly enterprises are no longer the same type of decision makers, but also different type of decision makers. Literature [4-7] studied different types of heterogeneous duopoly game model, discussed the existence conditions and stability conditions of bounded equilibrium point and Nash equilibrium point. The complex dynamical behavior of the system is proved by numerical simulation of bifurcation, chaos, singular attractor and sensitivity, depending on initial conditions. The document [4] is the study of linear demand function and linear cost function, Cournot model with bounded rationality and complete rationality; literature [5] is the study of linear demand function and nonlinear cost function, double oligopoly game model of limited rationality and complete rationality; literature [6] is the study of nonlinear the demand function and linear cost function, Cournot model with bounded rationality and complete rationality; literature [7] is the study of linear demand function and asymmetric cost function, Cournot model with bounded rationality and complete rationality of the literature. Literature [8-9] studied a totally heterogeneous three oligopoly game model, analyzed the complex dynamic characteristics of the model. The difference is that the literature [8] is studied under linear cost functions, while the literature [9] is studied under nonlinear cost functions. Yao[10-11] improved the bounded rationality dynamic Cournot model, which were introduced into the advertising market and the financial field respectively, and analyzed the evolution process of the improved model.

Oligopoly competition between enterprises on the one hand is the production competition, on the other hand is the price competition. The earliest research on the price competition between the oligarch enterprises model is put forward by Bertrand in 1883[12]. In document [13], a bounded rational duopoly Bertrand model is proposed, and the dynamic characteristics of the model are analyzed. Ma[14] considered the macroeconomic model of money supply with time delays, discussed the effect of delay variation on system stability and Hopf bifurcation. Literature [15] studied the Cournot-Bertrand duopoly model, analyzed the stability of the fixed points, and recognized the chaotic behavior of the system. The [16] manufacturers to use the delayed bounded rationality hypothesis establishes dynamic game model of the market based on the theoretical analysis. The application of the complicated systematic complexity of the state system. Our Fengshan [17] improved three oligopoly price game model, restricting the production cost function using the limited resource

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condition, study the influence on the time delay changes the dynamic characteristics of the system such as. Ahmed[18] on a dynamic product differentiation Bertrand duopoly game model based on the gradient adjustment mechanism take the limited rationality of the model in the enterprise update each cycle of price.

2. The one master-two slaves price game model

2.1 Assumptions

The following assumptions are made to develop our model in this paper.

(1) There are one manufacturer and two retailers(1 and 2) . Manufacturer is a master,has negative effects on Retailers.Retailers can't affect manufacturer.

(2) Retailers can Product their products,which are substitutes,with manufacturer's products are epiphytic relationship.

(3) Both the demand functions and the cost functions are linear, and the price is used as the decision objective.

(4) Three businessmen are bounded rationality.

2.2 symbol description

$p_i(t)$, $i = 1, 2, 3$ said the business i 's product price in the t period;

$Q_i(t)$ said in the t period,the demand of the market for the business i 's products;

a_i said when the price is zero, the the biggest market demand for the product i ;

b_i is the own price sensitive coefficient of $Q_i(t)$;

d said the price sensitive factor of two retailers'influence each other;

k said the adverse impact of manufacturer cause on retailers;

c_i said the marginal cost of business i ;

$\Pi_i(t)$ said the profit of business i .

2.3 The model

According to the actual situation, and refer to scholars' previous research [19-20].Each business's demand function can be written :

$$\begin{aligned} Q_1(t) &= a_1 - b_1 p_1(t) \\ Q_2(t) &= a_2 - b_2 p_2(t) + d p_3(t) - k p_1(t) \\ Q_3(t) &= a_3 - b_3 p_3(t) + d p_2(t) - k p_1(t) \end{aligned} \quad (1)$$

where a_i, b_i, d, k are positive constant. $b_2, b_3 > d$,that is, the impact of the price of the product itself on the demand is greater than the impact of the substitute goods.

Each business's cost function can be written:

$$C_i(t) = c_i Q_i(t), i = 1, 2, 3 \quad (2)$$

The profit of business i can be written:

$$\Pi_i(t) = p_i(t) Q_i(t) - C_i(t) = Q_i(t) (p_i(t) - c_i), i = 1, 2, 3 \quad (3)$$

According to the hypothesis, the dynamic price adjustment mechanism for each merchant is as follows:

$$p_i(t+1) = p_i(t) + \alpha_i p_i(t) \frac{\partial \Pi_i(t)}{\partial p_i(t)}, i = 1, 2, 3. \quad (4)$$

where α_i is coefficient that capture the speed at which business i adjust its price according to the consequent marginal change in its profit, respectively.

Each business's marginal profit can be written: