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Duopoly quality commitment☆

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ABSTRACT

Firms' quality commitment can efficiently improve the demand. This paper addresses the quality commitment under the duopoly. By establishing a Cournot model, the effects of quality commitment are discussed. Firstly, under one-sided quality commitment, the higher efficiency firm committing in quality brings about larger price difference, larger price dispersion and higher social welfare than the lower efficiency firm launching quality commitment. Secondly, bilateral quality commitment reduces price difference and price dispersion. Thirdly, the social welfare reaches maximization under bilateral quality commitment. Finally, two firms' optimal strategies are no-commitment or simultaneously commitment and the threshold value to commitment in quality is outlined.

1. Introduction

In the game theory, because commitment has important effects on rival's strategies, commitment is an extremely popular strategy of decision-makers (Schelling, 1960) and there exists much literature about the commitment theory in economic field. Krueger and Uhlig (2006) developed one-sided commitment theory. Bade et al. (2009) explored bilateral commitment theory and argued that commitment has social values. Based on the dynamic game theory, Caruana and Einav (2008) explored the theory of the commitment recently, in which the commitment is endogenous.

In application aspect, the commitment of firms has crucial effects on the prices of the corresponding goods. Based on the data of U.S.A. storable goods, Krueger et al. (2008) confirmed that the household consumption with the commitment yields low prices. Dudine et al. (2006) compared commitment with non-commitment under the monopoly for the storable goods. The prices with the commitment are lower than those without the commitment under the monopoly. Recently, Nie (2009) extended the commitment with storable goods to the vertical integration case. Nie (2012a) recently explored the guarantee commitment theory and showed that exaggerated quality reduces demands and the social welfare. By a two-stage model, Goering (2008) discussed the level of the commitment for the socially concerned firms about the storable goods. Based on the Stackelberg game, Kopel and Loffler (2008) analyzed the effects of the commitment.

The quality commitment, in which the producer launches a commitment in the quality, is exceedingly important in the market (Gupta et al., 2008). Shepard (1987) developed the theory of the quality commitment in semiconductor industry and argued that the quality commitment is not credible for a single firm. Reitzes (1992) discussed the effects of quality commitment under international trade with duopoly market structure and showed that the set-up cost has crucial effects on the quality choice. Especially, in some industries, the producers have private information of the products while the consumers lack academic knowledge about the products. Nie (2012a,b) recently explored the theory of quality commitment under monopoly and argued that high prices of old products and high expenditures of new products are two major factors to deter the producer from releasing the new product under monopoly.

It is therefore important to further acknowledge the quality commitment. This motivates the intensive research on the quality commitment under duopoly. When there exist multiple firms, some firms may launch quality commitment while others do not. This paper compares the case of higher efficiency firms making quality commitment with that of lower efficiency firms launching quality commitment. Bilateral quality commitment is also addressed. The social welfare, price dispersion and the price difference under three cases are compared.

When the quality commitment is introduced, the model of Reitzes (1992) is employed. Compared with the interesting paper of Reitzes (1992), this paper addresses the effects of various quality commitments on the price dispersion and social welfare. Compared with recent paper of Nie (2012a,b), this paper addresses the value of

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quality commitment under duopoly while Nie (2012a,b) focused on whether to release the new product or not under monopoly. The technology in this work parallels Bester and Petrakis (1993) and the subsequent research (Belleflamme and Vergari, 2011).

Almost all the existing literature about quality commitment focus on whether to employ quality commitment and this paper investigates the quantitative level of the quality commitment. Therefore, this paper develops the theory about quality commitment and extends the research about quality commitment from qualitative studies to quantitative ones.

This paper is organized as follows: The model is given in Section 2. Some analysis and the main results about one-sided quality commitment are presented in Section 3. The price difference and price dispersion under the one-sided quality commitment is discussed. Bilateral commitment is addressed in Section 4. The effects of bilateral quality commitment are addressed and are compared with one-sided quality commitment. Some remarks are given in the final section.

2. The model

The model about the quality commitment is formally introduced and two producers are introduced. We consider two firms to simplify the problem and it can be extended to general cases. Denote two firms to be $i \in \{1,2\}$. Two firms produce the substitutability products and simultaneously launch quality commitment. Two producers compete both in quantity and in quality commitment.

2.1. Consumers

Given the price vector of two producers $p = (p_1, p_2)$, the quantity $q = (q_1, q_2)$ and the value of the quality commitment $qc = (qc_1, qc_2)$, the utility function of the representative consumer is given as follows

$$U(p_1, p_2, q_1, q_2, qc_1, qc_2) = A(1+qc_1)q_1 + A(1+qc_2)q_2 - \frac{1}{2}q_1^2 - \frac{1}{2}q_2^2 - p_1q_1 - p_2q_2 - \lambda q_1q_2, \quad (1)$$

where $\lambda \in [0,1]$ presents the product substitutability and the constant $A > 0$ means market capacity without quality commitment. $\lambda = 0$ means that goods are independent and $\lambda = 1$manifests perfect substitutes (Liu et al., 2012; Nie and Chen, 2012). According to Eq. (1), the quality commitment improves the corresponding market size efficiently, which affects the firm's other strategies.

For $i, j \in \{1, 2\}$ and $i \neq j$, the corresponding inverse demand function is induced by Eq. (1), which is presented as

$$p_i = A(1+qc_i) - q_i - \lambda q_j. \quad (2)$$

From Eq. (2), q_i increases with qc_i while it decreases with qc_j. This means that the quality commitment can improve the corresponding demand and reduce the rival's demand. The quality commitment has expansion effects on the demand and crowding-out effects on the rivals. Similarly, the quality commitment promotes the price of the corresponding products while reduces the rival's price.

2.2. Producers

The profits of firms are presented as follows. For $i \in \{1, 2\}$,

$$\pi_i = p_iq_i - (c_i + \alpha qc_i)q_i - \frac{1}{2}(qc_i)^2, \quad (3)$$

where $\frac{1}{2}(qc_i)^2$ is the cost incurred by the quality commitment independent of the quantity of products. $\alpha > 0$ is a constant. In general, $\alpha < A$. αqc_i represents the additional marginal costs to launch the quality commitment. c_i is the marginal costs without the quality commitment. This paper addresses asymmetrical situation or two firms have the different marginal costs. Without loss of generality, we stipulate $c_1 < c_2$ throughout. Or, the first firm owns the cost advantage compared to the second firm.

Firm $i \in \{1, 2\}$ maximizes its profits by qc_i and q_i. According to Eqs. (2) and (3), the profit function is concave both qc_i and q_i. There exists the unique solution for the above system. Moreover, the above functions are all consistent with the hypothesis in Reitzes (1992). To guarantee the existence of a unique solution, the following assumptions are launched

Assumption.

$$2 - (A-\alpha)^2 - \lambda > 0.$$

The above assumption and $\lambda \in [0, 1]$ jointly indicates the relationship $2 - (A - \alpha)^2 - \lambda^2 > 0$. The above model is analyzed in two cases. One is the one-sided quality commitment, in which one firm launches the quality commitment while the other does not commit in the quality. The other is the bilateral quality commitment, in which two firms simultaneously launch the quality commitment.

We point out that this paper employs a static model to address the quality commitment. On one hand, the static model is easy to handle and this simplifies the model. On the other hand, when the time is short, the static model has no effects on the relationship between variables. Moreover, the static model is most relevant for our purposes because it focuses on attributes and behaviors of firms and members of their value chain that relate to quality commitment as well as to properties of the commitments themselves. We assume that the properties that concern us will be stable for a reasonable time period. Therefore, it is rational to use the static model in this work.

3. One-sided quality commitment

The herein model is analyzed under one-sided quality commitment. We discuss it in two cases. One is that the first firm launches quality commitment and the other is that the second firm makes quality commitment. We discuss them respectively and compare them.

3.1. The first firm having quality commitment

The first firm launches quality commitment while the second firm does not make quality commitment. In this case, $qc_2 = 0$and $qc_1 \geq 0$. The profit functions of two producers are restated as follows.

$$\pi_1 = [A(1+qc_1) - q_1 - \lambda q_2]q_1 - (c_1 + \alpha qc_1)q_1 - \frac{1}{2}(qc_1)^2, \quad (4)$$

$$\pi_2 = (A - q_2 - \lambda q_1)q_2 - c_2q_2. \quad (5)$$

The first optimal conditions imply

$$\frac{\partial \pi_1}{\partial q_1} = A(1+qc_1) - 2q_1 - \lambda q_2 - (c_1 + \alpha qc_1) = 0, \quad (6)$$

$$\frac{\partial \pi_1}{\partial qc_1} = Aq_1 - \alpha q_1 - qc_1 = 0, \quad (7)$$

$$\frac{\partial \pi_2}{\partial q_2} = A - 2q_2 - \lambda q_1 - c_2 = 0. \quad (8)$$