Economic Modelling 26 (2009) 414–417

Contents lists available at ScienceDirect

Economic Modelling

journal homepage: www.elsevier.com/locate/econbase

Commitment for storable goods under vertical integration ☆

Pu-yan Nie

Institute of Industrial Economics, Jinan University, Guangzhou, 510632, PR China

ARTICLE INFO

Article history:
Accepted 29 August 2008

JEL classification:
C02
C73
D40
L1

Keywords:
Market structure
Industrial organization
Storable goods
Commitment
Game theory
Vertical integration

ABSTRACT

The role of commitment under monopoly for storable goods has been fully considered in many papers. In general, if the monopolist with storable goods cannot commit, the prices are higher than in the case in which the monopolist launches commitment. According to the discrete-time dynamic model, commitment for storable goods under vertically integrated structures is considered in this paper. The similar results to the monopoly are correspondingly obtained. Namely, the prices without commitment are also higher than that with commitment under vertical integration.

1. Introduction

In the industrial organization theory, the firm behavior close relates to market structures. Furthermore, the properties of the products in a firm also play the crucial role to determine firm behavior (Tirole, 1988; Church and Ware, 2000; Gaffard and Quere, 2006; Tesfatsion, 2001;Caves, 2007; Lambson and Phillips, 2007; Akkoyunlu-Wigley and Mihci, 2006; Kultti, 2003; Nie, 2007; Goerke and Runkel, 2006; Joshi, 2007; Luis, 2000). For the durable and storable goods, for example, there exist great effects on the behaviors both of the consumers and of the firms. There is a large literature about the storable goods under monopoly (Dudine et al., 2006; Coase, 1972).

A firm is a monopolist if it believes that it is not in competition with other firms. A monopolist therefore does not worry about how and whether other firms will respond to its prices. Its profits depend only on the behavior of consumers, its costs and its price or outputs. A firm will be a monopolist if there are no close substitutes for its product. There are many examples about monopoly all over the world. In the early 1980s, for example, the only artificial sweetener that does not appear to cause cancer in rats was aspartame. Other firms were excluded from producing aspartame by the patents of the sole producer, the NutraSweet Company (Friedman, 1983; Church and Ware, 2000; Dudine et al., 2006).

In the industrial economics, the term vertical integration describes a style of ownership and control. Vertically integrated companies are united through a hierarchy and share a common owner. Usually each member of the hierarchy produces a different product or service, and the products combine to satisfy a common need. It is contrasted with horizontal integration. The vertical integration is one method of avoiding the hold-up problem.

One of the earliest, largest and most famous examples of vertical integration was the Carnegie Steel company. The company controlled not only the mills where the steel was manufactured, but also the mines where the iron ore was extracted, the coal mines that supplied the coal, the ships that transported the iron ore and the railroads that transported the coal to the factory, the coke ovens where the coal was coked, etc.

A monopoly produced through the vertical integration is called a vertical monopoly, although it might be more appropriate to speak of this as some form of cartel. Vertical integration is the degree to which a firm owns its upstream suppliers and its downstream buyers.

The storable goods are exceedingly important in the whole society and there exists extensive research on the storable goods. The commitment is compared with non-commitment under the monopoly for the storable goods, see the interesting paper (Dudine et al., 2006). The purchasing patterns responding to price change are recently investigated for storable goods (Pesendorfer, 2002; Hendel and Nevo, 2006). In the recent paper, (Board, 2008), storable goods with varying demands are considered and analyzed.

☆ This work is partially supported by New Century Excellent Talents in University (NCET-07-0375),State Education Ministry, and National Natural Science Foundation of China (No. 10501019).

E-mail address: pynie2005@yahoo.com.cn.

0264-9993/$ – see front matter © 2008 Elsevier B.V. All rights reserved.
doi:10.1016/j.econmod.2008.08.008

We aim to consider the dynamic market behavior under vertical integration, which is different from that in (Dudine et al., 2006) under monopoly. We consider the vertical integration structure, with a unique producer and a unique seller, while the monopoly producer is considered in (Dudine et al., 2006). The situation in this paper seems more popular and more difficult in economics than that in (Dudine et al., 2006). The main difference between this paper and that (Dudine et al., 2006) lies in the different market structures, which issues in the different model. Furthermore, the model in this paper seems more difficult than that in (Dudine et al., 2006).

This paper is organized as follows: The model is given in Section 2. Some analysis and main results are presented in Section 3. Some remarks are given in the final section.

2. The model

For the vertical integration, we assume that there are two parts in some industry: The monopoly producer and the monopoly seller for some product. Similar to that in (Dudine et al., 2006), some assumptions are given as follows. For simplicity, we assume that costs of production are zero and there is no discounting. The vertical integration faces demand for a storable good in each of T periods. The following notations are always employed in this paper for $t=1,2,\cdots,T$.

p_t^{nc} denotes the price of the storable goods without commitment at the stage t.

p_t^{c} denotes the price of the storable goods with commitment at the stage t.

S_t^{c} indicate the quantity of the storages of the consumers at the stage t for commitment and for non-commitment, respectively.

$S_t^{\mathrm{c},s}, S_t^{\mathrm{nc},s}$ indicate the quantity of the storages for the unique seller at the stage t for commitment and for non-commitment, respectively.

$S_t^{\mathrm{c},f}, S_t^{\mathrm{nc},f}$ indicate the quantity of the storages for the unique firm for the corresponding product at the stage t for commitment and for non-commitment, respectively.

$p_t^{\mathrm{nc},f}$ means the price of the storable goods from the unique producer to the unique seller without commitment at the stage t.

$p_t^{\mathrm{c},f}$ denotes the price of the storable goods from the unique producer to the unique seller with commitment at the stage t.

c denotes the costs of storages for per unit goods (or the marginal costs) for both the consumers and the others.

We assume that the costs to store the goods to be $c(s)=cs$. The utility of the consumers is quasi-linear in the consumption of the goods x_t, and money m_t. Namely, $U_t(x_t,m_t)=u_t(x_t)+m_t$. We further assume that u_t is continuously differentiable. The model for the consumers is given as follows: At each stage t, given any sequence of prices $p_t, p_{t+1},\cdots, p_T$ and current inventory S_{t-1}, consumers choose q_t,x_t,S_t to maximize the utility. Namely

$$\max_{x_t,q_t,S_t} \sum_{i=t}^{T} [U_i(x_i,m_i)-q_ip_i-cS_i] \tag{1}$$

where $q_i=x_i+S_i-S_{i-1}$. The term $q_i=x_i+S_i-S_{i-1}$ means that the demand of the consumers in each stage meets both the consumption and the storages.

Let $D_t(p_t)$ be the static demand function associating with U_t. Denote revenue and marginal revenue of the unique seller at stage t by $R_t(p_t)=D_t(p_t)(p_t-p_t^f)$ and $\mathrm{MR}_t(p_t)$, respectively. Denote revenue and marginal revenue of the unique producer at stage t by $R_t^f(p_t)=D_t^f(p_t)p_t^f$ *and* $MR_t^f(p_t)$*, respectively.*

For the unique producer, the monopoly firm aims to maximize its objective function

$$\max_{p_t^f,q_t^f,S_t^f} \pi^f\left(p^f,q^f,S^f\right)=\sum_{t=1}^{T}\left(p_t^fq_t^f-cS_t^f\right) \tag{2}$$

where $q_t^f=q_t^s+S_t^f-S_{t-1}^f$. cS_t^f is the costs to storage for the unique producer at the stage t. $q_t^f=q_t^s+S_t^f-S_{t-1}^f$ manifests that the quantity of the producer meets both the demand of the unique seller and the storages of the unique producer.

The monopoly seller tries to maximize the following objective function

$$\max_{p_t,q_t^s,S_t^s} \pi^S(p^s,q^s,S^s)=\sum_{t=1}^{T}\left[\left(p_t-p_t^f\right)q_t^s-cS_t^s\right] \tag{3}$$

where $q_t^s=q_t+S_t^s-S_{t-1}^s$. $q_t^s=q_t+S_t^s-S_{t-1}^s$ means that the quantity of the seller meets not only the demand of the consumers but also the storages of the unique seller. cS_t^s is the costs to storage for the unique seller at the stage t.

Remarks. In the above model, the monopoly producer, the unique seller and the consumers all consider both the consuming products and the storages at each stage. It is thus reasonable to employ the three special terms, $q_i=x_i+S_i-S_{i-1}$, $q_i^f=q_t^s+S_t^f-S_{t-1}^f$ and $q_t^s=q_t+S_t^s-S_{t-1}^s$.

Similar to that (Dudine et al., 2006), the following assumptions are presented.

Assumption 1. $R_t(p_t)=D_t(p_t)(p_t-p_t^f)$ and $R_t^f(p_t)=D_t^f(p_t)p_t^f$ are all concave and t-time differentiable.

Assumption 2. $D_t\left(\max_{\tau}\{p_\tau^s\}\right)>0$ for all $t=1,2\cdots T$.

Assumption 3. $c\leq\max_{1\leq t\leq T-1}\{p_{t+1}^s-p_t^s\}$ and $c\leq\max_{1\leq t\leq T-1}\{p_{t+1}-p_t\}$.

Assumption 2 guarantees that in equilibrium the consumers consume a positive quantity at each stage. Assumption 3 ensures that storage matters.

3. Main results

In this section, we aim to consider the roles of commitment. For convenience, we compare the situation, in which the unique seller and the monopoly producer simultaneously launch a commitment, and that, in which no commitment is given.

3.1. The equilibrium under commitment

We first consider the equilibrium for storable goods under commitment with vertical integration structure. Under commitment, the following result holds

Proposition 1. *For an equilibrium under commitment with vertical integration structure, for all t, we have the following results*

$$p_{t+1}^{\mathrm{c}}\leq p_t^{\mathrm{c}}+c,\ p_{t+1}^{\mathrm{c},s}\leq p_t^{\mathrm{c},s}+c,\ S_t^{\mathrm{c},s}=S_t^{\mathrm{c},f}=0 \tag{4}$$

$$\text{and}\quad \sum_{t=1}^{T}\mathrm{MR}_t(p_t^{\mathrm{c}})=0,\quad \sum_{t=1}^{T}\mathrm{MR}_t^f\left(p_t^{\mathrm{c},f}\right)=0.$$

Proof. It is obvious that $p_{t+1}^{\mathrm{c}}\leq p_t^{\mathrm{c}}+c, p_{t+1}^{\mathrm{c},s}\leq p_t^{\mathrm{c},s}+c$ according to Assumption 3.

Similar to the measure of Lemma 1 of the paper (Dudine et al., 2006), we show that $S_t^{\mathrm{c},s}=S_t^{\mathrm{c},f}=0$ by contradiction. We firstly show that $S_t^{\mathrm{c},s}=0$. Let $\tilde{t}$ be the last stage such that the storage is positive. Namely, $S_t^{\mathrm{c},s}=0$ for $t=\tilde{t}+1,\ldots T$. We note that $p_{t+1}^{\mathrm{c}}=p_t^{\mathrm{c}}+c$ if $S_t^{\mathrm{c},s}>0$. Define $\sigma^{\mathrm{c}}=\{p_t^{\mathrm{c}}\}_{t=1}^{T}$ and $\sigma=\{p_t\}_{t=1}^{T}$. Namely, given p_t^f for all t, σ^{c} is the equilibrium trajectory of the monopoly seller. Let

$$p_t=p_t^{\mathrm{c}}, t=1,2,\cdots,\tilde{t};$$

$$p_t=p_t^{\mathrm{c}}-(t-\tilde{t})\varepsilon, t=\tilde{t}+1,\cdots,T.$$

We then have

$$\pi^s(\sigma)-\pi^s(\sigma^{\mathrm{c}})=\sum_{\tau=\tilde{t}}^{T}\left[\left(p_\tau-p_\tau^f\right)q_\tau^s\right]-\sum_{\tau=\tilde{t}}^{T}\left[\left(p_\tau^{\mathrm{c}}-p_\tau^f\right)q_\tau^s-cS_\tau^{\mathrm{c}}\right]$$