Hindawi Publishing Corporation
Journal of Applied Mathematics
Volume 2014, Article ID 152060, 12 pages
http://dx.doi.org/10.1155/2014/152060

Research Article

CSR Impact on Hospital Duopoly with Price and Quality Competition

Youguang Xu

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

Correspondence should be addressed to Youguang Xu; neoeconomist@163.com

Received 21 December 2013; Accepted 11 February 2014; Published 2 April 2014

Academic Editor: X. Henry Wang

This paper investigates the impact of corporate social responsibility (CSR) on hospital duopoly with price and quality competition. A CSR hospital is defined in this paper that cares about not only the profit but also the patient benefit. We start our analysis by establishing a two-stage Hotelling model with and without CSR. Results indicate that privatization mechanism may not be the best way of improving medical quality. Competition between hospitals with zero-CSR would lower the equilibrium qualities compared to the first-best level. So the coexistence of a public (more accurately, partial public) and a private hospital might be more efficient than a private-private hospital duopoly. During the competition with CSR in price and quality, social welfare level acts in accordance with an inverted U-shaped trajectory as CSR degree increases. The main reason lies in tha fact that optimal degree of CSR is determined by the trade-off between the benefit of quality improvement and the cost of quality investment. Numerical simulation shows that the optimal degree of CSR is less than a third.

1. Introduction

Hospital markets are of different ownership types all over the world. Privatization reform is recently a major concern in medical treatment market. Many countries including China are deepening medical system reform. The focus of the problem is that ownership type of hospital has influence on medical treatment quality. The existence of public hospitals tends to undermine the quality of medical treatment quality in order to reduce the cost, so it is difficult to monitor quality of medical service precisely. Social public calls for reforms in medical treatment system, one of which is to privatize the state-owned hospital so as to improve the medical service quality. But whether the introduction of quality competition can achieve the regulation objective remains a question to explore.

Another problem is that physician-patient relationships are worsening in many countries. Medical tangles and doctor-patient disputes are emerging every day in many aspects, such as drug utilization practice, medical diagnosis and intrusion detection, surgical therapy and operative treatment, and aesthetic and reconstructive surgery. People claim for humanistic care from hospitals; so hospitals should take corporate social responsibility (CSR) into their running operations or even enhance the degree of CSR during their businesses. However, high degree of CSR will result in heavy burden on investment and incubus expense of quality improvement. Social welfare is not always increasing with CSR degree. There exists welfare trap during the increase of CSR. It is meaningful, therefore, to find the optimal degree of CSR.

This paper is related to three different branches of economic literature, respectively, on hospital behavior, mixed oligopoly, and corporate social responsibility.

Since medical disputes and hospital reform are becoming social concerning problems in many countries, a lot of literature focusing on hospital behaviors and patient treatment appears in recent years. Herr [1] analyses the effect of heterogeneous objectives of the hospitals on quality differentiation in a price regulated Hotelling duopoly. Privatization of the public hospital may increase overall welfare if the public hospital is similar to the private hospital or less efficient. Brekke et al. [2] analyze the effect of competition on quality in hospital markets with regulated prices by establishing a Salop model.

They find that the relationship between competition and quality is generally ambiguous. Sanjo [3] investigates a health care market with uncertainty in a mixed duopoly, showing that the quality of the partially privatized hospital becomes higher than that of the private hospital when the patient's preference for quality is relatively high. Eggleston and Yip [4] develop a framework of public-private hospital competition under regulated prices and use data from China to calibrate the impact of China's payment and organizational reforms. Simulations reveal the benefits of mixed payment and expanded insurance cover for mitigating price distortion and over/under use of services. Kessler and McClellan [5] exhibit an empirical study on the consequences of hospital competition for Medicare beneficiaries' heart attack care from 1985 to 1994. In the 1980s, the welfare effects of competition were ambiguous; but in the 1990s, competition unambiguously improves social welfare. Bundorf et al. [6] and Montefiori [7] also discuss the hospital competition and social welfare.

In short, the existing body of literature is mainly focused on the quality competition with regulated price. However the price of hospital service is closely related to quality. Therefore, in our paper, we will demonstrate the competition in price and quality to find the impact on the social welfare.

Another strand of related literature is mixed oligopoly theory. Matsumura [8] investigates a quantity setting duopoly involving a private firm and a privatized firm; results show that neither full privatization nor full nationalization is optimal under moderate conditions. Ishibashi and Kaneko [9] analyze price and quality competition in a mixed duopoly, finding that the welfare-maximizing public firm provides a lower quality product than the private firm when they are equally efficient. Results support a partial privatization of the public firm under the presence of quality competition. Sanjo [10] investigates a mixed duopoly market by introducing quality choice into the Hotelling-type spatial competition model, showing that there does not exist an SPNE in the three-stage game (location-quality-price game). George and La Manna [11] introduce a cost asymmetry between public and private firms and argue that partial public ownership may be welfare improving, if the public firm is Stackelberg leader. Matsumura and Kanda [12] find that mixed markets are better than pure markets involving no public firm if and only if the public firm earns nonnegative profits.

Generally, existing works support a partial privatization; mixed oligopoly is optimal under moderate conditions. These statements give relatively advantageous support to our viewpoint of introducing CSR into a firm's objective.

Finally, a lot of literature studies corporate social responsibility (CSR). Friedman [13] points out that a firm with CSR should consider the stockholders, the customers, and the employees or even has the responsibility to restrain inflation, improve the environment, fight poverty, and so forth. The social responsibility of business is to increase its profits. Baron [14] studies the desirability of CSR. CSR not only has a direct effect on the costs of the firm, but also has a strategic effect by altering the competitive positions of firms in an industry. Lambertini and Tampieri [15] examine the stability of mixed oligopoly equilibria with CSR firms. Equilibrium in mixed duopoly is stable for low impact of productivity on pollution and high CSR sensitivity to consumer surplus if the number of CSR is sufficiently low. Kopel and Brand [16] find that if the unit production costs of the firms are similar, then the socially concerned firm has a higher market share and even higher profit, but the profit is nonmonotonic in the share of consumer surplus. It pays off to take stakeholders' interests into account, but not too much.

In brief, the existing literature indicates that a firm with CSR mostly considers one group of stakeholders in its objective function and maximizes its profit plus a share of consumer surplus. However, we will present our paper on assumption that a hospital with CSR takes two groups of stakeholders into the objective function—its patients and its rival hospital's patients—and maximizes its profit plus a share of both hospitals' patient benefits. It is a perspective of generalized social responsibility with the empirical fact that a hospital may give medical assistance to another one when its patients need help for blood, bone marrow, or technical support.

In this paper, we construct a duopoly model based on Hotelling model to discuss hospital price and quality competition problems. The main contributions of this paper lie in two aspects. The first one is that privatization mechanism may not be the best way of improving medical service quality. Competition between two hospitals with zero-CSR would lower the equilibrium qualities than the first-best level. So the coexistence of a (partial) public and a private hospital might be more efficient than a private-private hospital duopoly. But this is not always the case. The second contribution is to explore the optimal degree of CSR. During the analysis, we should concern the trade-off between the benefit of quality improvement and the cost of quality investment.

The rest of this paper proceeds as follows. In Section 2, we give the primary assumptions and establish the model. In Section 3, we discuss the game structure with the absence of CSR. In Section 4, we present the game structure with CSR and analyze the optimal degree of CSR. In Section 5, we conclude the paper.

2. The Model

For some characteristics of hospital service, the optimal choice depends on the particular patient. Patients' tastes vary in the population, and location is one of the obvious examples. According to Hotelling [17], we consider a linear city with length equal to 1. Assume that two hospitals 1 and 2 are located at the extremes of the city. The location of hospital 1 is marked as $A_1 = 0$, and that of hospital 2 is $A_2 = 1$. Both hospitals supply a kind of medical treatment program to the market. The price and quality of medical treatment in one hospital differ from those of the other one, correspondingly equal to p_i and s_i, $i = 1, 2$. Both hospitals face a continuum of patients, and the mass of patients is normalized to one with a uniform distribution on $[0, 1]$ interval. The character of patient is described by a random variable x. Here, x is the location of patient, which stands for the horizontal preference in Hotelling Model.

2.1. Patients' Utility Function. According to assumptions by Herr [1] and Brekke et al. [2], we define patients' utility function as follows:

$$U(x, s_i, p_i, A_i) = v + s_i - p_i - t|x - A_i|. \quad (1)$$

Function (1) implies that a patient at the location x gets a medical treatment program of quality s_i at the price of p_i from the hospital located at A_i. Here, $v > 0$ is the evaluation of the medical treatment service, which stands for the willingness to pay for the treatment. Each rational patient buys from the hospital that offers a higher net utility. We assume that v is sufficiently large so as to ensure the full coverage of the whole market at any time. Any patient prefers buying medical service to buying nothing. The parameter $t > 0$ captures the unit cost of transportation, which measures the preference heterogeneity degree of patient at x to hospital i. Transportation cost can be comprehended as an exogenous transaction cost, including patient's evaluation of time cost and accessibility to a well-known hospital or doctor, especially for the emergency patients and those who lack professional information about the therapeutic effect. Here t is assumed to be large enough to ensure significant differences of patients preference to hospital characteristics.

2.2. Demand Function. We first find the medical treatment demand of each hospital. The demand of hospital 1 is given by $q_1 = \overline{x}$, and that of hospital 2 is correspondingly $q_2 = 1 - \overline{x}$ where $\overline{x}$ is the location of indifferent patient. The indifferent location $\overline{x}$ satisfies equation $U(x, s_1, p_1, A_1) = U(x, s_2, p_2, A_2)$, where $A_1 = 0$ and $A_2 = 1$. We get the indifference patient's location by solving $v + s_1 - tx - p_1 = v + s_2 - t(1 - x) - p_2$. Consider

$$\overline{x} = \frac{1}{2} + \frac{(s_1 - s_2) - (p_1 - p_2)}{2t}. \quad (2)$$

We denote hospital 1's and hospital 2's demand functions as follows:

$$\begin{aligned} q_1(p_1, p_2, s_1, s_2) &= \overline{x} = \frac{1}{2} + \frac{(s_1 - s_2) - (p_1 - p_2)}{2t}, \\ q_2(p_1, p_2, s_1, s_2) &= 1 - \overline{x} = \frac{1}{2} + \frac{(s_2 - s_1) - (p_2 - p_1)}{2t}. \end{aligned} \quad (3)$$

The integrated demand function can be written as

$$q_i(p_i, p_j, s_i, s_j) = \frac{1}{2} + \frac{(s_i - s_j) - (p_i - p_j)}{2t}, \quad (i, j = 1, 2;\ i \neq j). \quad (4)$$

2.3. Consumer Surplus . We can meanwhile calculate the consumer surplus of each hospital. The benefit of patients treated at hospital 1 is

$$\begin{aligned} B_1 &= \int_0^{\overline{x}} U(x, s_1, p_1, A_1)\, dx \\ &= \int_0^{q_1} (v + s_1 - tx - p_1)\, dx. \end{aligned} \quad (5)$$

The surplus to patients treated at hospital 2 is given by

$$\begin{aligned} B_2 &= \int_{\overline{x}}^{1} U(x, s_2, p_2, A_2)\, dx \\ &= \int_0^{q_2} (v + s_2 - tx - p_2)\, dx. \end{aligned} \quad (6)$$

The summarized form for the benefits of patients treated at hospital i is

$$B_i = \int_0^{q_i} (v + s_i - tx - p_i)\, dx \quad (i = 1, 2). \quad (7)$$

2.4. Hospitals' Objective Functions. Here we model the duopoly hospitals in the medical treatment market. We derive the objective function of public hospital different from that of a private one. The private hospital is just a profit-seeking one, while the public hospital may integrate corporate social responsibility (CSR) into its business operation. Here, corporate social responsibility means that the treatment provider is semialtruistic and may care about the patients' benefits.

According to Brekke et al. [2], Ishibashi and Kaneko [9], and Herr [1], we firstly assume that quality and quantity are separable in costs. The marginal production cost of one quantity can be linearly separated from that of producing a certain quality. Suppose each hospital has an identical quantity production technology, and the costs invested into higher quality are not related to the marginal cost of production. The cost function of hospital i is accordingly given as

$$C(q_i, s_i) = cq_i + \frac{1}{2}s_i^2, \quad (i = 1, 2). \quad (8)$$

The marginal cost $c > 0$ is constant, indicating the identical production technology in quantity q_i. The cost of providing a quality level is $(1/2)s_i^2$, which is assumed to be quadratic during the analysis to ensure a concave profit function and a unique maximum. The profit function of each hospital is

$$\pi_i = p_i q_i - C(s_i, q_i) = (p_i - c)\, q_i - \frac{1}{2}s_i^2, \quad (9)$$

where $i = 1, 2$. A private hospital without CSR maximizes its profit (9), while a public hospital with altruistic behavior would care about the patients' benefits and take CSR into its account. The objective function of a public hospital is thereby defined as follows:

$$H_i = \pi_i + \gamma \sum_{i=1,2} B_i. \quad (10)$$

Here π_i is the profit of hospital i, and $\sum_{i=1,2} B_i$ is the sum of patients' benefits in hospitals 1 and 2. This function is expressed as a mixed objective of profit and consumer surplus. The parameter $\gamma \in [0, 1]$ captures the degree of CSR. The existence of CSR makes it possible for hospital 1 to care for the patients' benefits $\sum_{i=1,2} B_i$, not only in hospital 1 but also in hospital 2. For example, one hospital may transfer its patients to another one if it is unable to cure the patients

suffering from acute emergency. The hospital may even give medical assistance when another one needs help in medicine, blood supply, medical technology, and medical assistance in bone marrow transplantation (BMT), and so forth.

2.5. Social Welfare Function. Meanwhile we calculate the social welfare function. It is the sum of patients' benefits and hospitals' profits, $\mathrm{SW} = \sum_{i=1,2}(\pi_i + B_i)$. From (7) and (9), we have

$$\mathrm{SW} = v - c + \sum_{i=1,2}\left[s_i q_i - \frac{1}{2}t q_i^2 - \frac{1}{2}s_i^2\right]. \tag{11}$$

We put (4) into (11) and characterize the socially efficient prices and qualities as a benchmark. The first-best condition can be solved by maximizing (12) as follows:

$$\begin{aligned}\mathrm{SW} = {} & v - c \\ & + \sum_{\substack{i,j=1,2\\ i\neq j}}\left\{s_i\left[\frac{1}{2} + \frac{(s_i - s_j) - (p_i - p_j)}{2t}\right]\right. \\ & \left. -\frac{1}{2}t\left[\frac{1}{2} + \frac{(s_i - s_j) - (p_i - p_j)}{2t}\right]^2 - \frac{1}{2}s_i^2\right\}.\end{aligned} \tag{12}$$

The first-order conditions are, respectively,

$$\frac{\partial \mathrm{SW}}{\partial s_1} = \frac{1}{2t}\left[t + (1-2t)s_1 - s_2\right] = 0 \tag{13}$$

$$\frac{\partial \mathrm{SW}}{\partial s_2} = \frac{1}{2t}\left[t + (1-2t)s_2 - s_1\right] = 0 \tag{14}$$

$$\frac{\partial \mathrm{SW}}{\partial p_1} = -\frac{1}{2t}(p_1 - p_2) = 0 \tag{15}$$

$$\frac{\partial \mathrm{SW}}{\partial p_2} = -\frac{1}{2t}(p_2 - p_1) = 0. \tag{16}$$

Denote the first-best solution as $(s_1^*, s_2^*; p_1^*, p_2^*)$. We have $s_1^* = s_2^* = 1/2$ from (13) and (14) and get $p_1^* = p_2^*$ from (15) and (16). The market shares are correspondingly $q_1^* = q_2^* = 1/2$. We therefore have social welfare $\mathrm{SW}^* = v - c - (1/4)t + 1/4$.

2.6. Game Structure. In the coming analysis, we consider a two-stage game structure. The timing of the game proceeds as follows: in the first stage, each hospital chooses qualities s_i to maximize objective function H_i. In the second stage, both hospitals simultaneously choose prices p_i. The game will be solved by employing backward induction method to identify the equilibrium.

3. Game Structure with the Absence of CSR

In the scenario without corporate social responsibility, two private hospitals compete to maximize their own profits. The corresponding objective functions are thereby $H_i = \pi_i$, $i = 1, 2$. By substituting demand function (4) into (9), we have

$$H_i = (p_i - c)\left[\frac{1}{2} + \frac{(s_i - s_j) - (p_i - p_j)}{2t}\right] - \frac{1}{2}s_i^2, \tag{17}$$

where $i, j = 1, 2,\ i \neq j$.

3.1. Price Competition. At the beginning we consider the subgame of price competition in stage 2. The CSR parameter γ is acquiescently equal to 0 and the quality s_i is predetermined in stage 1. Each hospital chooses price p_i to maximize (17). The first-order condition is

$$\frac{\partial H_i}{\partial p_i} = \left[\frac{1}{2} + \frac{(s_i - s_j) - (p_i - p_j)}{2t}\right] - \frac{p_i - c}{2t} = 0, \tag{18}$$

where $i, j = 1, 2;\ i \neq j$. Symmetric structure yields the following unique equilibrium prices:

$$p_i(s_i, s_j) = c + t + \frac{1}{3}(s_i - s_j), \tag{19}$$

where $i, j = 1, 2;\ i \neq j$. The equilibrium price p_i describes the strategic effects of hospital i and its rival's quality. By differentiating $p_i(s_i, s_j)$ in (19) with respect to s_j, we get

$$\frac{\partial p_i}{\partial s_j} = -\frac{1}{3}, \tag{20}$$

where $i, j = 1, 2;\ i \neq j$. This expression of $\partial p_i/\partial s_j < 0$ indicates that private hospital i reacts with a lower price to compensate for its demanding disadvantage resulting from a unit increase of its rival's quality s_j. We name this reaction as price undercutting effect, which is denoted as $\mathrm{PE}^{\mathrm{NR}}$.

By substituting (19) into (4), we have the equilibrium market share as follows:

$$q_i(s_i, s_j) = \frac{1}{2} + \frac{1}{6t}(s_i - s_j), \tag{21}$$

where $i, j = 1, 2;\ i \neq j$. By differentiating $q_i(s_i, s_j)$ in (21) with respect to s_i and s_j, we obtain each hospital's quality effect on its market share. Consider

$$\frac{\partial q_i}{\partial s_i} = \frac{1}{6t}, \qquad \frac{\partial q_i}{\partial s_j} = -\frac{1}{6t}. \tag{22}$$

This expression of $\partial q_i/\partial s_j < 0$ agrees with the statement of price undercutting effect above. It says that private hospital i confronts a lower market share as a result of an increase in its rival's quality s_j. We name it as quantity undercutting effect, which is denoted as $\mathrm{QE}^{\mathrm{NR}}$.The results can be summarized as Proposition 1.

Proposition 1 (Rule 1. Rule of PE and QE). *In the scenario of no CSR, private hospital reacts according to the rules of quantity undercutting effect (QE) and price undercutting effect (PE). Both hospitals reduce $1/6t$ units quantity and $1/3$ units prices as one unit increase of their rival's quality. $QE^{NR} = -1/6t$, $PE^{NR} = -1/3$.*

3.2. Quality Competition. Next we consider the subgame of quality competition in stage 1. Now each hospital chooses quality s_i to maximize the objective function H_i for a given CSR degree. Substituting price function (19) and quantity function (21) into the objective function (17), we obtain

$$H_i\left(s_i, s_j\right) = \frac{1}{18t}\left(3t + s_i - s_j\right)^2 - \frac{1}{2}s_i^2, \tag{23}$$

where $i, j = 1, 2$; $i \neq j$. Hospital i chooses quality s_i to maximize objective function H_i. The first-order condition is

$$\frac{\partial H_i\left(s_i, s_j\right)}{\partial s_i} = \frac{1}{9t}\left(3t + s_i - s_j\right) - s_i = 0, \tag{24}$$

where $i, j = 1, 2$; $i \neq j$. Symmetric structure yields the following unique equilibrium qualities:

$$s_1^{*\mathrm{NR}} = s_2^{*\mathrm{NR}} = \frac{1}{3}. \tag{25}$$

Therefore the equilibrium quantities are obtained from (21), $q_1^{*\mathrm{NR}} = q_2^{*\mathrm{NR}} = 1/2$, and the corresponding prices are from (19), $p_1^{*\mathrm{NR}} = p_2^{*\mathrm{NR}} = c + t$. The results can be concluded as Proposition 2.

Proposition 2. *In the scenario of no CSR, two hospitals possess the same equilibrium prices, quantities, and qualities,* $p_1^{*NR} = p_2^{*NR} = c + t$, $q_1^{*NR} = q_2^{*NR} = 1/2$, $s_1^{*NR} = s_2^{*NR} = 1/3$. *Prices satisfy and quantities equal the first-best level, while qualities become lower than the first-best level* ($s_1^* = s_2^* = 1/2$).

Remark 3. Proposition 2 demonstrates that in the competition scenario of no CSR, the hospitals have the same market position and no one has competitive advantage. From Proposition 1, we find that hospitals tend to undercut their medical prices (PE) in order to seize more market share. At last, both hospitals suffer from the same equilibrium price, equal to marginal cost plus the transportation cost, $p_1^{*\mathrm{NR}} = p_2^{*\mathrm{NR}} = c + t$.

In this case, hospitals have no incentive to lower down the prices. When all is said, the fact remains that equilibrium prices satisfy the first-best solution, $p_1^* = p_2^*$.

Meanwhile the profit-driven competition induces hospitals to decrease medical quality so as to reduce the medical cost and earn more profit. The equilibrium qualities are $s_1^{*\mathrm{NR}} = s_2^{*\mathrm{NR}} = 1/3$, which are smaller than the first-best level $s_1^* = s_2^* = 1/2$. The result indicates that hospital without CSR tends to ignore the interests of the patients and reduce the quality of medical service, which leads to the deviation from the first-best level. We also give analysis on social welfare as follows and, furthermore, make a comparison with the first-best solution.

Social Welfare. We now discuss the social welfare in the private-private scenario. Social welfare is the sum of the profit of hospitals and consumer surplus of patients $\mathrm{SW} = \pi + \mathrm{CS}$, where profit is $\pi = \sum_{i=1,2} \pi_i$, and consumer surplus is $\mathrm{CS} = \sum_{i=1,2} B_i$. Here, the patients' benefit of each hospital is

$$B_i = \frac{1}{2}\left[v + \frac{1}{3} - \left(c + \frac{5}{4}t\right)\right], \quad i = 1, 2. \tag{26}$$

And the profit of each hospital is

$$\pi_i = \frac{1}{2}\left(t - \frac{1}{9}\right), \quad i = 1, 2. \tag{27}$$

In (27), if $0 < t < 1/9$, the profit of the hospital will be negative; in this case, this hospital will exit from the hospital market, and we have given an assumption in Section 2 that t is large enough to ensure that patients can easily distinguish from two hospitals during their decision; therefore this case could be ignored.

Denote the equilibrium social welfare as $\mathrm{SW}^{*\mathrm{NR}}$. By calculation, we have

$$\mathrm{SW}^{*\mathrm{NR}} = v - c - \frac{1}{4}t + \frac{2}{9}. \tag{28}$$

Compared with the first-best welfare solution in Section 2, $\mathrm{SW}^* = v - c - (1/4)t + 1/4$, we can see that $\mathrm{SW}^{*\mathrm{NR}} < \mathrm{SW}^*$. This expression shows that competition without CSR lowers quality $s_i^{*\mathrm{NR}} = 1/3$, which leads to the loss of social welfare $\mathrm{SW}^{*\mathrm{NR}}$. We then have Proposition 4.

Proposition 4. *In the scenario of no CSR, profit-maximizing competition lowers social welfare,* $SW^{*NR} < SW^*$. *The maximum social welfare is* $SW^{*NR} = v - c - (1/4)t + 2/9$.

4. Game Structure with CSR

In this section, we involve CSR degree into analysis so as to see the effect of CSR on the game equilibrium. Suppose hospital 1 is a public hospital with CSR, the degree of CSR denoted as γ, while hospital 2 is a private hospital without CSR. This assumption is conducive to distinguish whether or not the CSR has effect on equilibrium prices, quantities, and qualities between hospitals with different ownerships. This scenario is a mixed duopoly game structure. The objective functions of hospitals 1 and 2 are, respectively, $H_1 = \pi_1 + \gamma \sum_{i=1,2} B_i$ and $H_2 = \pi_2$. They can be expressed as (29) and (30), respectively,

$$\begin{aligned} H_1 = {} & \left[\left(p_1 - c\right) q_1 - \frac{1}{2}s_1^2\right] \\ & + \gamma\left[v + \left(s_1 q_1 - p_1 q_1 - \frac{1}{2}t q_1^2\right)\right. \\ & \left. + \left(s_2 q_2 - p_2 q_2 - \frac{1}{2}t q_2^2\right)\right] \end{aligned} \tag{29}$$

$$H_2 = \left(p_2 - c\right) q_2 - \frac{1}{2}s_2^2. \tag{30}$$

As denoted in (3), quantities q_1, q_2 in (29) and (30) are the functions of prices p_1, p_2 and qualities s_1, s_2.

4.1. Price Competition. We firstly consider the subgame of price competition in stage 2. The qualities s_1 and s_2 are predetermined in stage 1. Hospital 1 chooses price p_1 to

maximize (29), and hospital 2 chooses price p_2 to maximize (30). The first-order conditions for (29) and (30) are

$$\frac{\partial H_1}{\partial p_1} = (1-\gamma) q_1 - \frac{1}{2t}(p_1 - c) = 0$$
$$\frac{\partial H_2}{\partial p_2} = q_2 - \frac{1}{2t}(p_2 - c) = 0. \tag{31}$$

By substituting (3) into (31), the first-order conditions yield the following reaction functions in prices

$$p_1 = \frac{1-\gamma}{2-\gamma}(c + t + s_1 - s_2) + \frac{1}{2-\gamma} p_2$$
$$p_2 = \frac{1}{2}(c + t + s_2 - s_1) + \frac{1}{2} p_1; \tag{32}$$

equilibrium prices can be calculated by combining (32):

$$p_1 = c + \frac{1-\gamma}{3-\gamma}[3t + (s_1 - s_2)]$$
$$p_2 = c + \frac{1}{3-\gamma}[(3 - 2\gamma_1) t - (s_1 - s_2)]. \tag{33}$$

4.1.1. Price Undercutting Effect (PE). The expressions of p_1 and p_2 say that a hospital's CSR degree and the treatment qualities of both hospitals are the influencing factors to prices. The strategic effects on prices can be deduced by differentiating $p_1(s_1, s_2)$ with respect to s_2 and $p_2(s_1, s_2)$ with respect to s_1. Consider

$$\frac{\partial p_1}{\partial s_2} = -\frac{1-\gamma}{3-\gamma} < 0, \qquad \frac{\partial p_2}{\partial s_1} = -\frac{1}{3-\gamma} < 0. \tag{34}$$

We denote the price undercutting effect (PE) for hospitals 1 and 2, respectively, $\mathrm{PE}_1^{\mathrm{WR}} = \partial p_1/\partial s_2 = -(1-\gamma)/(3-\gamma)$ and $\mathrm{PE}_2^{\mathrm{WR}} = \partial p_2/\partial s_1 = -1/(3-\gamma)$. Price undercutting effect is interpreted as two effects, that is, looting effect and CSR effect. On one hand, looting effect is reflected in the expressions of $\partial p_1/\partial s_2 < 0$ and $\partial p_2/\partial s_1 < 0$, indicating that hospital 1 (or 2) reacts with a lower price to compensate for its demanding disadvantage resulting from a unit increase of its rival's quality s_2 (or s_1). This is in line with the scenario without CSR. On another hand, we find that CSR effect is reflected as $|\mathrm{PE}_1^{\mathrm{WR}}| \le |\mathrm{PE}_2^{\mathrm{WR}}|$ (equality is satisfied at $\gamma = 0$). This inequation demonstrates that although the CSR-hospital would decrease its medical price as stated above, a hospital with CSR does not undercut the price as fiercely as a hospital without CSR reacting to its rival's quality improvement. This is the CSR effect on price undercutting. Moreover, the PE of hospital 1 in the scenario of competing with CSR is weaker than that of competing with the absence of CSR, $|\mathrm{PE}_1^{\mathrm{WR}}| \le |\mathrm{PE}_1^{\mathrm{NR}}|$, and the PE of hospital 2 is stronger than the scenario of No-CSR, $|\mathrm{PE}_2^{\mathrm{WR}}| \ge |\mathrm{PE}_2^{\mathrm{NR}}|$. We have Proposition 5 as follows.

Proposition 5 (Rule 2a. Rule of PE). *In the scenario of competing with CSR, both hospitals have negative PE, but PE of public hospital 1 with CSR is weaker than that of the private hospital 2, $|PE_1^{WR}| \le |PE_2^{WR}|$. Compared with the scenario of competing without CSR, the PE of hospital 1 is weaker, $|PE_1^{WR}| \le |PE_1^{NR}|$, and the PE of hospital 2 is stronger, $|PE_2^{WR}| \ge |PE_2^{NR}|$.*

Remark 6. When the CSR-hospital improves medical quality, its quality advantage may enlarge its market share and need not undercut the medical price, but, as a rival, the private hospital would undercut its medical price in order to compensate for the lost market share resulting from quality disadvantage. When the private hospital improves medical quality, the CSR-hospital has the same reaction. But the expression $|\mathrm{PE}_1^{\mathrm{WR}}| \le |\mathrm{PE}_2^{\mathrm{WR}}|$ indicates that the CSR-hospital may not undercut the medical price so much as the private hospital. Recall that when the two hospitals compete in the scenario of no CSR, they have the same market position. But in the CSR-scenario, a hospital with CSR will maintain and ultimately win over more patients. However, it might be awkward for the patients to acknowledge and trust a hospital without CSR when they enjoy the medical service. Therefore the private hospital should lower down its medical price more significantly than before and the CSR-hospital need not decrease its price so much as before (no-CSR scenario). This result will be supported in the following analysis again.

4.1.2. Quantity Undercutting Effect (QE). The equilibrium quantities are accordingly obtained by substituting (33) and (37) into (3). Consider

$$q_1 = \frac{1}{2} + \frac{1}{2t(3-\gamma)}[\gamma t + (s_1 - s_2)]$$
$$q_2 = \frac{1}{2} - \frac{1}{2t(3-\gamma)}[\gamma t + (s_1 - s_2)]. \tag{35}$$

The strategic effects on prices can be deduced by differentiating $q_1(s_1, s_2)$ with respect to s_2 and $q_2(s_1, s_2)$ with respect to s_1. Consider

$$\frac{\partial q_1}{\partial s_2} = -\frac{1}{2t(3-\gamma)} < 0, \qquad \frac{\partial q_2}{\partial s_1} = -\frac{1}{2t(3-\gamma)} < 0. \tag{36}$$

The quantity undercutting effects for hospitals 1 and 2 are, respectively, denoted as $\mathrm{QE}_1^{\mathrm{WR}} = \partial q_1/\partial s_2 = -1/2t(3-\gamma)$ and $\mathrm{QE}_2^{\mathrm{WR}} = \partial q_2/\partial s_1 = -1/2t(3-\gamma)$. Similarly as the PE, the expressions of $\partial q_1/\partial s_2 < 0$ and $\partial q_2/\partial s_1 < 0$ indicate that each hospital confronts a lower market share as a result of an increase in its rival's quality. In addition, both hospitals have the same reaction to rival's quality changing, $|\mathrm{QE}_1^{\mathrm{WR}}| = |\mathrm{QE}_2^{\mathrm{WR}}|$. When compared with the scenario of no CSR, the expression $|\mathrm{QE}_i^{\mathrm{WR}}| > |\mathrm{QE}_i^{\mathrm{NR}}|$ $(i = 1, 2)$ shows that the quantity undercutting effect becomes stronger. As stated in the remarks paragraph for Proposition 5, CSR has particularly become a kind of competition advantage. Patients are sensitive to hospital's CSR. They prefer a CSR-hospital rather than a private one. In the CSR-scenario, patients get aware of the existence of CSR and identify the favorite

hospital. CSR has great impact on market share allocation during the competition. Thus the market share of both hospitals may change even more significantly than before (no-CSR scenario). The statements above are summarized as Proposition 7.

Proposition 7 (Rule 2b. Rule of QE). *In the scenario of competing with CSR, both hospitals have the same negative QE,* $|QE_1^{WR}| = |QE_2^{WR}|$. *Compared with the scenario of competing without CSR, QE of both hospitals become stronger,* $|QE_i^{WR}| > |QE_i^{NR}| (i = 1, 2)$.

4.1.3. Demand Compensating Effect (DE). The strategic impact of CSR on quantity is obtained from comparison of q_1 and q_2 for a given CSR degree. Consider

$$q_1 - q_2 = \frac{\gamma t + (s_1 - s_2)}{(3-\gamma)t}. \tag{37}$$

When the quality of hospital 1 is no less than that of hospital 2, $s_1 \geq s_2$, we find in (37) that quality advantage ensures a larger market share, $q_1 > q_2$. That is to say, CSR fails to have DE impact on quantity if $s_1 \geq s_2$. When the quality of hospital 1 is less than that of hospital 2, $s_1 < s_2$, CSR degree has different effect on the quantity markup. In this case, if $\gamma > (1/t)|s_1 - s_2|$, we have $q_1 > q_2$, and hospital 1 occupies a larger market share. If $\gamma < (1/t)|s_1 - s_2|$, we have $q_1 \leq q_2$, and hospital 1 occupies a relatively smaller (or equal) market share. The results indicate that high degree of CSR has DE impact on quality while low degree CSR does not. The reason lies in that high degree of CSR is conducive to compensating for the loss of market share as a result of quality disadvantage if the CSR degree is greater than a threshold $\gamma > (1/t)|s_1 - s_2|$. The statement above is summarized as Proposition 8.

Proposition 8 (Rule 2c. Rule of DE). *In the scenario of competing with CSR, when* $s_1 \geq s_2$, *CSR has no impact on quantity; when* $s_1 < s_2$, *high CSR has demand compensating effect on quantity on condition that* $\gamma > (1/t)|s_1 - s_2|$, *and low CSR does not have demand compensating effect on quantity if* $\gamma < (1/t)|s_1 - s_2|$.

4.2. Quality Competition. In this section, we consider the quality competition in stage 1. Each hospital chooses quality to maximize objective function. Substituting price function (37) and quantity function (40) into the objective function (30), we obtain hospital 2's objective as function of s_1 and s_2:

$$H_2(s_1, s_2) = \frac{1}{2t(3-\gamma)^2}\left[(3-2\gamma)t - (s_1 - s_2)\right]^2 - \frac{1}{2}s_2^2. \tag{38}$$

The first-order condition for (38) is

$$\frac{1}{t(3-\gamma)^2}\left[(3-2\gamma)t - (s_1 - s_2)\right] - s_2 = 0. \tag{39}$$

Substituting price function (33) and quantity function (35) into the objective function (29) and (30), respectively, we obtain hospital 1's objective as a function of s_1 and s_2:

$$H_1(s_1, s_2) = \pi_2(s_1, s_2) + \gamma \sum_{i=1,2} B_i(s_1, s_2). \tag{40}$$

In order to get the first-order condition $\partial H_1(s_1, s_2)/\partial s_1 = \partial \pi_1/\partial s_1 + \gamma(\partial/\partial s_1)(\sum_{i=1,2} B_i) = 0$ for (40), we give $\partial \pi_1/\partial s_1$ and $(\partial/\partial s_1)(\sum_{i=1,2} B_i)$ as the forms of

$$\begin{aligned} \frac{\partial \pi_1}{\partial s_1} &= \frac{1-\gamma}{t(3-\gamma)^2}\left[3t + (s_1 - s_2)\right] - s_1 \\ \frac{\partial}{\partial s_1}\left(\sum_{i=1,2} B_i\right) &= \frac{1}{2t(3-\gamma)^2}\left[3t + (s_1 - s_2)\right] + \frac{1}{3-\gamma}. \end{aligned} \tag{41}$$

By (41), the first-order condition for (40) is therefore reduced as

$$\frac{2-\gamma}{2t(3-\gamma)^2}\left[3t + (s_1 - s_2)\right] + \frac{\gamma}{3-\gamma} - s_1 = 0. \tag{42}$$

The equilibrium qualities are obtained from (39) and (42):

$$\begin{aligned} s_1^{*\mathrm{WR}} &= \frac{\left(6 + 3\gamma - 2\gamma^2\right)(3-\gamma)t - 4}{(3-\gamma)\left[2(3-\gamma)^2 t - (4-\gamma)\right]} \\ s_2^{*\mathrm{WR}} &= \frac{2(3-\gamma)(3-2\gamma)t - 4}{(3-\gamma)\left[2(3-\gamma)^2 t - (4-\gamma)\right]}. \end{aligned} \tag{43}$$

Substituting (43) into (33) and (37) yields the corresponding prices:

$$\begin{aligned} p_1^{*\mathrm{WR}} &= c + \frac{3(1-\gamma)}{3-\gamma}t + \frac{(1-\gamma)(7-2\gamma)\gamma t}{(3-\gamma)\left[2(3-\gamma)^2 t - (4-\gamma)\right]} \\ p_2^{*\mathrm{WR}} &= c + \frac{3-2\gamma}{3-\gamma}t - \frac{(7-2\gamma)\gamma t}{(3-\gamma)\left[2(3-\gamma)^2 t - (4-\gamma)\right]}. \end{aligned} \tag{44}$$

Substituting (43) into (35) and (40) yields the corresponding quantities:

$$\begin{aligned} q_1^{*\mathrm{WR}} &= \frac{1}{2} + \frac{1}{2t(3-\gamma)}\left[\gamma t + \frac{(7-2\gamma)\gamma t}{2(3-\gamma)^2 t - (4-\gamma)}\right] \\ q_2^{*\mathrm{WR}} &= \frac{1}{2} - \frac{1}{2t(3-\gamma)}\left[\gamma t + \frac{(7-2\gamma)\gamma t}{2(3-\gamma)^2 t - (4-\gamma)}\right]. \end{aligned} \tag{45}$$

Proposition 9. *In the scenario of competing with CSR, both the qualities and quantities of hospital with CSR are greater than those of hospital without CSR,* $s_1^{*WR} > s_2^{*WR}$, $q_1^{*WR} > q_2^{*WR}$, *while the price of hospital with CSR is less than that of hospital without CSR,* $p_1^{*WR} < p_2^{*WR}$.

Remark 10. Proposition 9 shows that when hospital duopolies compete in the scenario with CSR, there is a driving force for hospital 1 to upgrade the treatment quality. Hospital 1 has motivation to reduce the treatment price as a result of CSR. High quality and low price attract comparatively larger market share as well. As a supplement, we compare the differences of equilibrium qualities, prices, and quantities between hospital 1 and hospital 2. The difference between $s_1^{*\mathrm{WR}}$ and $s_2^{*\mathrm{WR}}$ is given as $s_1^{*\mathrm{WR}} - s_2^{*\mathrm{WR}} = (7 - 2\gamma)\gamma t/[2(3-\gamma)^2 t - (4-\gamma)]$. By recalling that t is assumed to be large enough for patients to distinguish from both hospitals in Section 2, we then have $s_1^{*\mathrm{WR}} - s_2^{*\mathrm{WR}} = (7-2\gamma)\gamma t/[2(3-\gamma)^2 - (4-\gamma)/t] > (7-2\gamma)\gamma/2(3-\gamma)^2 > 0$ and get $s_1^{*\mathrm{WR}} > s_2^{*\mathrm{WR}}$. To compare $p_1^{*\mathrm{WR}}$ and $p_2^{*\mathrm{WR}}$, we have $p_1^{*\mathrm{WR}} - p_2^{*\mathrm{WR}} = 2\gamma(3-\gamma)(1-t)/[2(3-\gamma)^2 - (4-\gamma)/t] < 0$ for a sufficiently large parameter t. We then get $p_1^{*\mathrm{WR}} < p_2^{*\mathrm{WR}}$. Meanwhile we compare $q_1^{*\mathrm{WR}}$ and $q_2^{*\mathrm{WR}}$ and give $q_1^{*\mathrm{WR}} - q_2^{*\mathrm{WR}} = \{\gamma t + (7-2\gamma)\gamma t/[2(3-\gamma)^2 t - (4-\gamma)]\}/[2t(3-\gamma)] = [\gamma t + (s_1^{*WR} - s_2^{*\mathrm{WR}})]/[2t(3-\gamma)] > 0$, so we get $q_1^{*\mathrm{WR}} > q_2^{*\mathrm{WR}}$.

4.3. Social Welfare and Optimal Degree of CSR. In this section, we discuss the social welfare and the optimal CSR degree. We denote the equilibrium in stage1 by $s_1(\gamma)$ and $s_2(\gamma)$ and the equilibrium quantity in stage 2 by $q_1(\gamma)$ and $q_2(\gamma)$. Social welfare function (11) can be written as follows:

$$\begin{aligned}\mathrm{SW} = v - c &+ \left[s_1(\gamma) q_1(\gamma) - \frac{1}{2}t[q_1(\gamma)]^2 - \frac{1}{2}[s_1(\gamma)]^2\right] \\ &+ \left[s_2(\gamma) q_2(\gamma) - \frac{1}{2}t[q_2(\gamma)]^2 - \frac{1}{2}[s_2(\gamma)]^2\right].\end{aligned} \tag{46}$$

The first-order condition for social welfare function (46) is

$$\begin{aligned}\frac{d\mathrm{SW}}{d\gamma} &= \left[(q_1 - s_1)\frac{ds_1}{d\gamma} + (q_2 - s_2)\frac{ds_2}{d\gamma}\right] \\ &\quad + \left[(s_1 - tq_1)\frac{dq_1}{d\gamma} + (s_2 - tq_2)\frac{dq_2}{d\gamma}\right] = 0.\end{aligned} \tag{47}$$

The former bracket in (47) indicates the impact of CSR on social welfare as quality changes, and the latter captures the impact as quantity changes. Unfortunately, we cannot guarantee that social welfare function (46) is globally concave in CSR degree γ, and explicit solution could not be found thereby. So we firstly demonstrate the optimal CSR degree in the scenario with the absence of quality competition and then give a numerical analysis in the scenario with the presence of both price and quality competition.

When two hospitals compete under the absence of quality competition, s_1 and s_2 are fixed, so $ds_1/d\gamma = 0$, and $ds_2/d\gamma = 0$. From (35) and (40), we easily get $dq_1/d\gamma = 1/2t(3-\gamma)$, $dq_2/d\gamma = -1/2t(3-\gamma)$. We get the reduced form of (47) as follows:

$$\frac{d\mathrm{SW}}{d\gamma} = \frac{(s_1 - s_2)[(2-\gamma)(s_1 - s_2) - \gamma t]}{2t(3-\gamma)^2}. \tag{48}$$

Proposition 11. *Under the absence of quality competition: (i) when $s_1 = s_2$, social welfare is independent of γ. Social welfare is optimal for any degree of CSR, $\gamma \in [0,1]$. (ii) When $s_1 > s_2$, social welfare is increasing in γ, if $s_1 - s_2 > \gamma t/(2-\gamma)$, and is decreasing in γ, if $s_1 - s_2 < \gamma t/(2-\gamma)$. (iii) When $s_1 < s_2$, social welfare is increasing in γ.*

Remark 12. (i) We can see from (48) that in the case where both hospitals have the same qualities, $d\mathrm{SW}/d\gamma = 0$ in (48) is invariably satisfied for any degree of CSR, $\gamma \in [0,1]$. That is to say, social welfare is constant with CSR degree. (ii) When hospital 1 has quality advantage, $s_1 > s_2$, social welfare is not always increasing in γ. $d\mathrm{SW}/d\gamma > 0$ is satisfied only if $s_1 - s_2 > \gamma t/(2-\gamma)$. It means that slight difference between qualities is inoperative to social welfare. A hospital should have such comparatively significant advantage in quality greater than $\gamma t/(2-\gamma)$ that CSR would be a beneficial instrument to better social welfare. (iii) When hospital 1 has quality disadvantage, $s_1 < s_2$, $d\mathrm{SW}/d\gamma > 0$, social welfare is increasing in CSR degree. As discussed in Section 4, CSR degree has impact (DE) on demand for a hospital with quality disadvantage. Low degree of CSR attracts few patients, while high degree could induce emerging demand to hospital. In other words, DE ensures more patients to experience hospital treatment and enlarges the market coverage.

Next, turn to the case of competition with price and quality competition. Substituting equilibrium qualities (43), equilibrium prices (44), and equilibrium quantities (45) into social welfare function (11), we construct the function of social welfare in CSR degree. We find that there are some other parameters, v, c, and t in the welfare function. Given that we cannot get the fully definite properties of the social welfare function, we just give Proposition 13 without proof.

Proposition 13 (welfare trap). *In the scenario of competition with CSR in price and quality, social welfare level changing basically shows an inverted U-shaped trajectory as CSR degree changes, if v and t are sufficiently large.*

Remark 14. In the scenario of competition with CSR in price and quality, we have equilibrium qualities, $s_1^{*WR} > s_2^{*WR}$. We denote $\Delta s = s_1 - s_2$, in this case and find from Proposition 11 (ii) that social welfare is increasing in CSR degree γ, if $\Delta s > \gamma t/(2-\gamma)$, that is $\gamma < 2\Delta s/(t + \Delta s)$ and is decreasing in γ if $\Delta s > \gamma t/(2-\gamma)$, that is $\gamma > 2\Delta s/(t + \Delta s)$. The analyses above give us inspiration and reference to the inverted U-shaped welfare curve in CSR degree. From the objective function of hospital 1, $H_1 = p_1 q_1 - C(s_1, q_1) + \gamma \sum_{i=1,2} B_i$, we give further explanation to the first-order condition in quality s_1:

$$p_1 \frac{\partial q_1}{\partial s_1} + \gamma \frac{\partial}{\partial s_1}\left(\sum_{i=1,2} B_i\right) = \frac{\partial C}{\partial s_1} + \frac{\partial C}{\partial q_1}\frac{\partial q_1}{\partial s_1}. \tag{49}$$

the left hand side of (49) is the marginal benefit from quality. $p_1(\partial q_1/\partial s_1)$ is the direct marginal revenue (monetary benefit), and $\gamma(\partial/\partial s_1)(\sum_{i=1,2} B_i)$ is the indirect revenue (nonmonetary benefit) arising from CSR. The right hand side of (49) is the marginal cost of quality. $\partial C/\partial s_1$

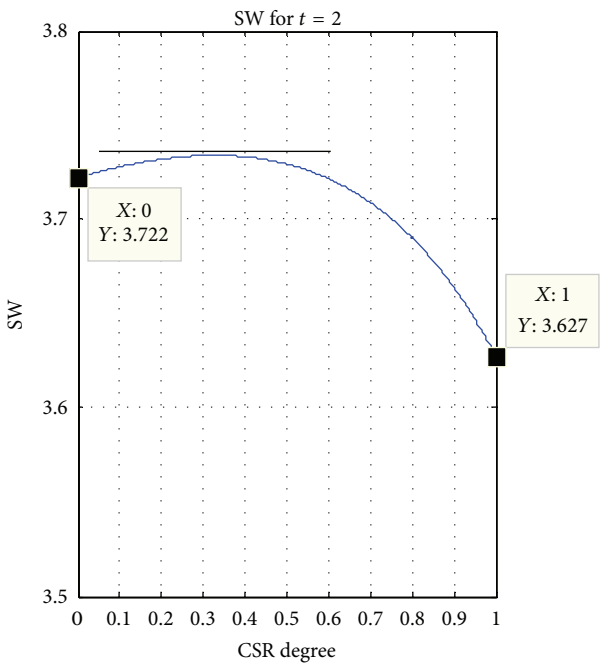

Figure 1: Social welfare for $t = 2$.

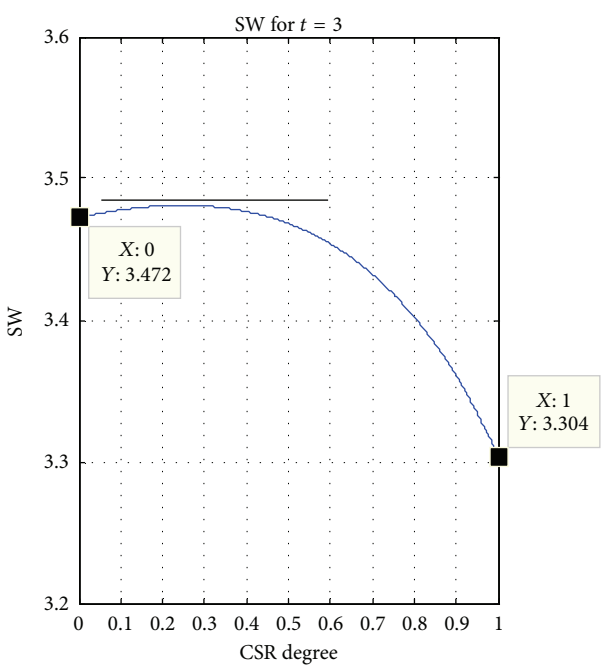

Figure 2: Social welfare for $t = 3$.

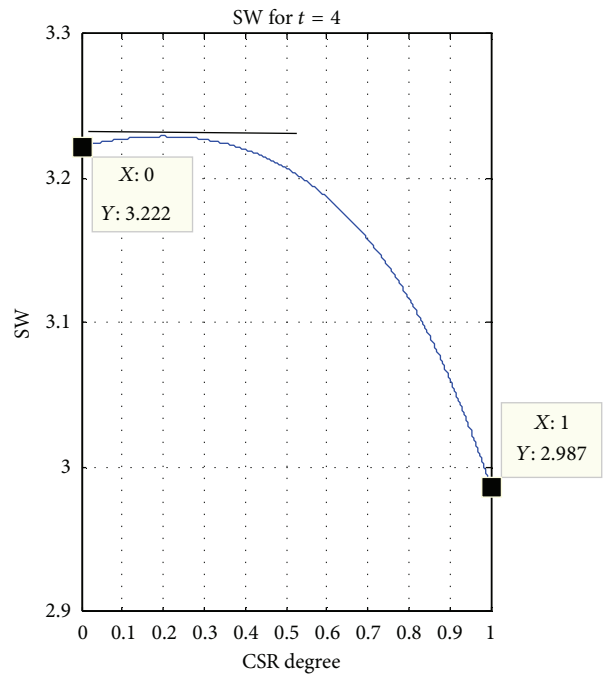

Figure 3: Social welfare for $t = 4$.

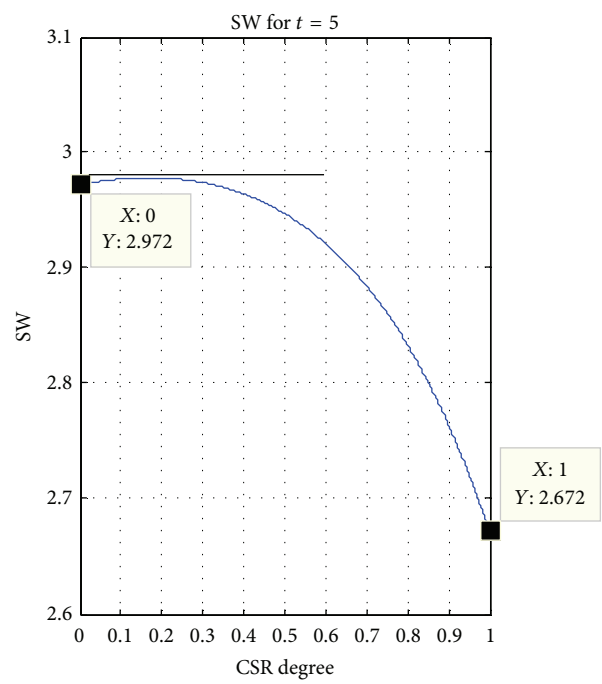

Figure 4: Social welfare for $t = 5$.

is the direct marginal cost for quality improvement and $(\partial C/\partial q_1)(\partial q_1/\partial s_1)$ is the indirect marginal cost (derived marginal cost) arising from demand increase. We can see from Proposition 9 that hospital 1 suffers from heavy cost when $s_1^{*\mathrm{WR}} > s_2^{*\mathrm{WR}}$ and $q_1^{*\mathrm{WR}} > q_2^{*\mathrm{WR}}$ but gains less benefit when $p_1^{*\mathrm{WR}} < p_2^{*\mathrm{WR}}$. This is a disaster for hospital 1 when it is a hospital of high-type CSR. This should not come as a surprise since it in itself is a negative for social welfare improvement inevitably.

To better illustrate our viewpoint, we give numerical analysis as an example. Let $v = 5$ and $c = 1$ in social welfare function (46). Figures 1, 2, 3, 4, 5, and 6 illustrate social welfare curves in CSR degree when $t = 2$ to $t = 6$ and $t = 10$. The numerical evaluation of social welfare illustrates that SW

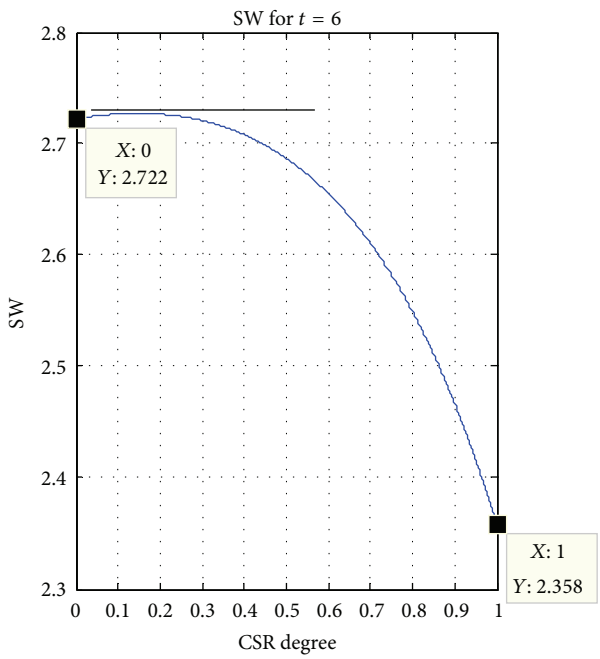

Figure 5: Social welfare for $t = 6$.

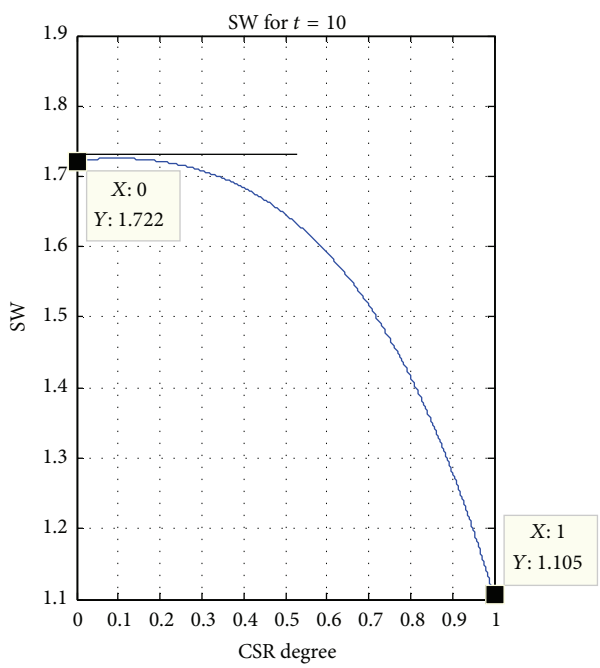

Figure 6: Social welfare for $t = 10$.

is concave in γ. The inverted U-shaped curves indicate the optimal CSR degree is less than 1. Full degree of CSR cannot lead to maximum welfare.

We also give in Table 1 the welfare level when $\gamma = 0$ and $\gamma = 1$, the maximum and minimum of welfare, and the optimal CSR degree when $t = 2$ to $t = 6$ and $t = 10$. From Table 1 we can see that the minimum of welfare is obtained at CSR degree equal to 1 for any parameter values of t. It means that $\gamma = 1$ is not the optimal degree of CSR. The

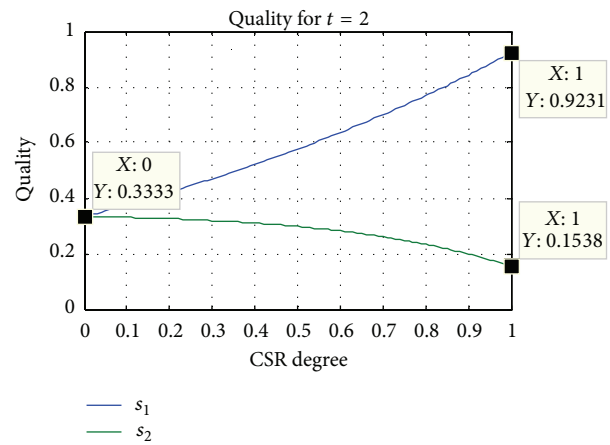

Figure 7: Quality for $t = 2$.

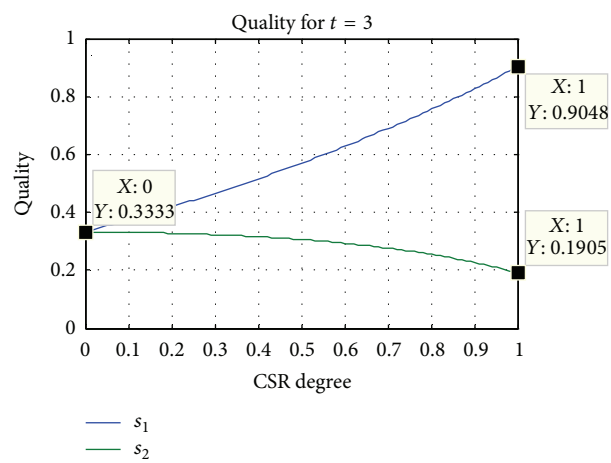

Figure 8: Quality for $t = 3$.

optimal CSR degree is not equal to 0, either. It should be some level between 0 and 1. As we have seen in Table 1, the optimal degree of CSR is approximately less than 1/3. The result indicates that low CSR degree less than a third would improve welfare, and an excessively high degree of CSR which is greater than a third would reduce social welfare.

In order to better explain the statement above, we meanwhile give the qualities of two hospitals in Figures 7, 8, 9, 10, 11, and 12. As the figures illustrated, the quality of hospital 1 is upward sloping and that of hospital 2 is downward sloping as CSR degree changes. The quality investment of hospital 1 correspondingly increases and that of hospital 2 reduces. Furthermore, it can be shown in the figures that the absolute value of slope rate in s_1 is greater than s_2 for any degree of CSR. It might have no remarkable impact on quadratic cost function when hospital has low degree of CSR. However, when CSR degree surpasses a definite level, the cost increase of hospital 1 may overtake the cost reduction of hospital 2, which leads to undesired welfare inefficiency.

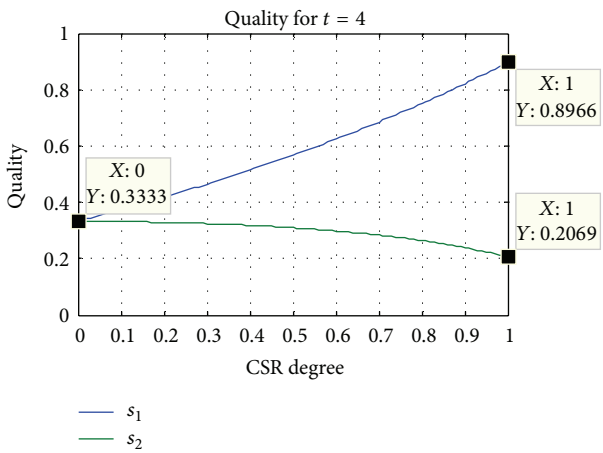

Figure 9: Quality for $t = 4$.

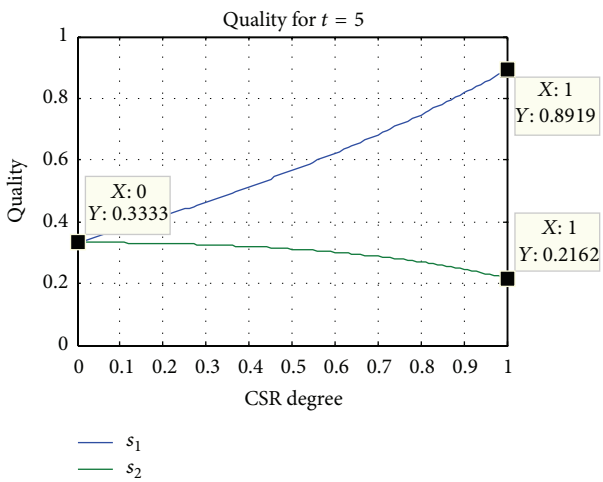

Figure 10: Quality for $t = 5$.

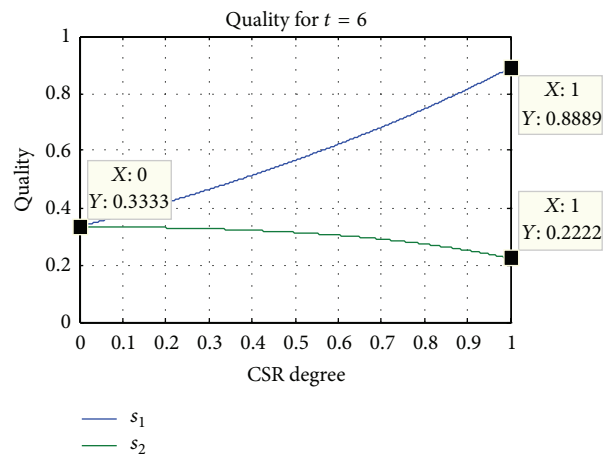

Figure 11: Quality for $t = 6$.

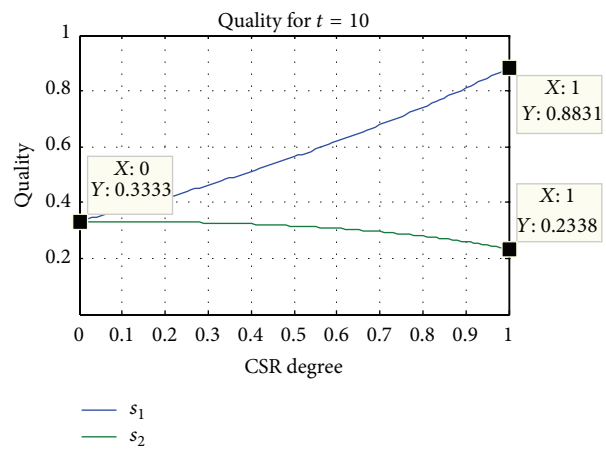

Figure 12: Quality for $t = 10$.

Table 1: Social welfare and optimal CSR degree.

t	2	3	4	5	6	10
SW (CSR = 0)	3.7222	3.4722	3.2222	2.9722	2.7222	1.7222
SW (CSR = 1)	3.6272	3.3039	2.9869	2.6720	2.3580	1.1052
SW (Max)	3.7341	3.4810	3.2293	2.9781	2.7273	1.7255
SW (Min)	3.6272	3.3039	2.9869	2.6720	2.3580	1.1052
Optimal CSR	0.3295	0.2495	0.2040	0.1730	0.1505	0.0995

5. Concluding Remarks

This paper develops the theory of corporate social responsibility (CSR) on hospital industry. The main work of exploring the CSR impact on social welfare goes on in a mixed hospital duopoly with price and quality competition. We start our analysis by involving quality variable into the Hotelling model and present a two-stage game to compare the effects during competition with the absence and presence of CSR.

There are at least three strategic effects in the game structure with CSR, that is, price undercutting effect (PE), quantity undercutting effect (QE), and demand compensating effect (DE). In the scenario of competing with CSR, both hospitals have negative PE. But the PE of a CSR-hospital is weaker than that of a private hospital, because the CSR-hospital is not as sensitive to price as the private hospital. We also find that both hospitals have the same negative QE, but stronger than the scenario of competing without CSR. Results also show that CSR has no DE impact on quantity if the CSR-hospital has advantage in quality, and the conclusion is not clear when the CSR-hospital is of quality disadvantage. We find that high CSR has DE impact on quantity on condition that the degree of CSR is greater than a threshold, while low degree of CSR still has no DE impact on quantity.

Moreover, the results indicate that fully privatized mechanism fails to be the best way of improving quality of medical service, and overcompetition would lower down the equilibrium qualities. We find that the equilibrium qualities of both hospitals are less than the first-best level in the scenario of competing without CSR. Therefore, we derive a competition mechanism by introducing CSR into our analysis. Unfortunately, full degree of CSR would not be the best choice for the improvement of social welfare, either. It is, therefore, meaningful to explore the optimal degree of CSR. Results indicate that the optimal degree of CSR lies in (0,1)

interval, with a numerically simulated value of less than a third. It means that when hospital has low degree of CSR, CSR has no remarkable impact on quadratic cost function. However, when the degree of CSR surpasses a threshold, the cost increase of a CSR-hospital would overtake the cost reduction of the private hospital. Social welfare level acts as an inverted U-shaped trajectory in CSR degree. We will fall into the social welfare trap if the hospital cares about excess degree of CSR.

In summary, the main contribution of this paper is the introduction of CSR into hospital competition. The altruistic behavior which cares about the patients' benefits from not only the CSR-hospital but also the private hospital demonstrates three meaningful strategic effects, PE, QE, and DE. Social welfare analysis and numerical simulation of optimal CSR degree are of practical significance for social welfare improvement. The remaining problem is that patients always vary in their tastes on medical treatment program, and high-income patients are different from low-income ones, so the heterogeneity of patients' preference should be considered during the research. Another problem is whether CSR has impact on equilibrium solutions and social welfare when both hospitals take CSR into their running operation. These will be our further research topic.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

References

[1] A. Herr, "Quality and welfare in a mixed duopoly with regulated prices: the case of a public and a private hospital," Discussing Paper, Düsseldorf institute for competition economics, 2010.

[2] K. R. Brekke, L. Siciliani, and O. R. Straume, "Hospital competition and quality with regulated prices," *Scandinavian Journal of Economics*, vol. 113, no. 2, pp. 444–469, 2011.

[3] Y. Sanjo, "Quality choice in a health care market: a mixed duopoly approach," *European Journal of Health Economics*, vol. 10, no. 2, pp. 207–215, 2009.

[4] K. Eggleston and W. Yip, "Hospital competition under regulated prices: application to urban health sector reforms in China," *International Journal of Health Care Finance and Economics*, vol. 4, no. 4, pp. 343–368, 2004.

[5] D. P. Kessler and M. B. McClellan, "Is hospital competition socially wasteful?" NBER Working Paper 7266, 1999.

[6] M. K. Bundorf, J. Levin, and N. Mahoney, "Pricing and welfare in health plan choice," *The American Economic Review*, vol. 102, no. 7, pp. 3214–3248, 2012.

[7] M. Montefiori, "Spatial competition for quality in the market for hospital care," *European Journal of Health Economics*, vol. 6, no. 2, pp. 131–135, 2005.

[8] T. Matsumura, "Partial privatization in mixed duopoly," *Journal of Public Economics*, vol. 70, no. 3, pp. 473–483, 1998.

[9] K. Ishibashi and T. Kaneko, "Partial privatization in mixed duopoly with price and quality competition," *Journal of Economics*, vol. 95, no. 3, pp. 213–231, 2008.

[10] Y. Sanjo, "Hotelling's location model with quality choice in mixed duopoly," *Economics Bulletin*, vol. 18, no. 2, pp. 1–11, 2007.

[11] K. George and M. M. A. la Manna, "Mixed duopoly, inefficiency, and public ownership," *Review of Industrial Organization*, vol. 11, no. 6, pp. 853–860, 1996.

[12] T. Matsumura and O. Kanda, "Mixed oligopoly at free entry markets," *Journal of Economics*, vol. 84, no. 1, pp. 27–48, 2005.

[13] M. Friedman, "The social responsibility of business is to increase its profits," *The New York Times Magazine*, 1970.

[14] D. P. Baron, "Private politics, corporate social responsibility, and integrated strategy," *Journal of Economics & Management Strategy*, vol. 10, no. 1, pp. 7–45, 2001.

[15] L. Lambertini and A. Tampieri, "On the stability of mixed oligopoly equilibria with CSR firms," Working Paper 723, University of Bologna, 2011.

[16] M. Kopel and B. Brand, "Socially responsible firms and endogenous choice of strategic incentives," *Economic Modelling*, vol. 29, no. 3, pp. 982–989, 2012.

[17] H. Hotelling, "Stability in competition," *Economic Journal*, vol. 39, pp. 41–57, 1929.