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MINIMUM QUALITY STANDARDS AND WELFARE IN A MIXED DUOPOLY: THE CASE OF A PUBLIC AND A PRIVATE HOSPITALS

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Abstract

We analyze the effects of implementing minimum quality standards (MQS) on the quality choices of both private and public hospitals in a vertically differentiated market. It is found that the standards can enhance the health care quality provided by both hospitals and can reduce the quality differentiation. It is also found that MQS can increase the utilization rate of the public hospital since demand for its health care services increases. The effects of MQS on prices, consumer surplus and social welfare depend on the quality costs, and the degree of competition which is influenced by the degree of quality differentiation and consumer heterogeneity. There is a non-linear relationship between consumer heterogeneity and the resulting consumer surplus and social welfare.

Keywords: minimum quality standards, public hospital, private hospital, health care, competition.

INTRODUCTION

Public hospitals and private hospitals are established for different purposes: private hospitals take operating profit as the ultimate goal, are less willing to reduce prices, and tend to increase investment in quality improvement to attract consumers; while public hospitals are established to ensure the health and well-being of the commonwealth and to allow the equal flow of medical resources in the market, rather than to provide services to consumers in the order of willingness to pay. Therefore, in addition to profit, the consideration of overall well-beings is also important. Moreover, due to the inefficiency of public hospitals, the quality of health care provided by public hospitals is generally lower than that of private hospitals.

In the process of receiving health care services, the utility of consumers should be in direct proportion to the health care quality they receive. If all consumers have such a perception of quality, there should be only medical institutions providing the top health care quality in the society. However, the health care quality provided by the hospitals often varies, which is obviously inconsistent with the above statement. There are other factors affecting the qualities offered by hospitals such as the accessibility of hospitals and the quality improvement cost such that hospitals may provide different levels of quality in health care market. In addition, there is a tradeoff between qualities and prices. How to make people consume a certain level of health care quality without excessive medical expenditure should be an important issue for the government.

The government may impose taxes, subsidies, price control or quality control on health care providers as a means of medical policy. However, if the aim is to improve consumers' acceptance of the quality level of public hospitals, the most immediate method is to directly regulate the lower bound of care quality provided by public hospitals. i.e. to employ a minimum quality standard(MQS) in the health care market. The regulated lower bound can serve as a guarantee of health care quality received by consumers. This study examines how such policy can affect consumer surplus and social welfare.

If the minimum quality standard control is implemented, it may increase the production cost of controlled hospitals and reduce profits, but it may also improve the health care quality and utility obtained by consumers. The changes in hospital profits and consumer surplus could be the main reason for the improvement or decline of overall social welfare.

The minimum quality standard is a very common policy in other industries, but there is little relevant literature to discuss its application in the health care industry. In addition, it is rare to analyze the impact of the minimum quality standard when there are both public hospitals and private hospitals. Therefore, this paper hopes to fill this gap to discuss the effects of a minimum quality standard on the quality of health care and social welfare when a private hospital competes with a public one simultaneously.

Many studies have focused on vertical differential products in duopoly markets. For example, Choi and Shin (1992) pointed out that in the case of an uncovered market, the low-quality firm would provide a quality $\frac{4}{7}$ of that produced by the high-quality firm and charged a price only $\frac{2}{7}$ of the price of high-quality products. Wauthy(1996) investigated the conditions for covered and uncovered markets. The results show that whether the market is covered or not depends on the consumer preference. In equilibrium, firms must choose to produce differentiated qualities in order to relax price competition. The resulting degree of product differentiation is negatively related to the degree of consumer heterogeneity. The high-quality firm earns higher profits than the of low-quality one.

As for the MQS policy, a lot of literature focuses on this subject. Wherein, Ronnen (1991) pointed out that under MQS policy, the product quality of both firms would rise, but the high-quality firm raises the quality more than the low-quality firm does, which leads to a decrease in quality differentiation and thus an increase in degree of competition. Crampes and Hollander (1995) showed that a moderate MQS increased the profit of the low-quality firm and reduced that of the high-quality one. The effects on consumer surplus depended on the response of the high-quality firm to the low-quality firm. With a weak response, consumer surplus and social welfare both increase. Scarpa (1998) further discussed that when there were more than two firms in the market, the implementation of MQS would lead to excessive competition, which, on the contrary, would reduce the quality provided by the highest-quality firm and decrease social welfare. Moreover, low-quality firms cannot exist in the market for a long time. Ecchia and Lambertini (1997) considered how MQS could affect collusion among firms. With the policy, the higher the willingness to pay for quality, the more difficult for the conclusion to sustain. In addition, the implementation of this policy would raise the profits of low-quality firm while lowers profits of high-quality firm. The resulting social welfare would increase. Herr (2010) found that the first best allocation is achieved when a public hospital with cost advantage competes with a private one.

Most of the above literature are based on the competition between private firms so this study switches to the case of mixed duopoly to analyze the impacts of the MQS policy on qualities and welfare. This study found that MQS can improve the health care quality provided by both public and private hospitals and narrows the quality gap between them. In addition, the demand for health care services from the public hospital increases while decreases for the private hospital. As for medical prices, social welfare, hospital profit and consumer surplus, they all depend on the degree of consumer heterogeneity.

In the case of high (low) consumer heterogeneity, the degree of competition between hospitals is low (high), the medical prices increase (decrease), profit increase (decrease), consumer surplus decreases (increases), and the decrease of consumer surplus (hospital profit) is greater than the increase of hospital profit (consumer surplus), then, social welfare is worse;

only when the degree of consumer heterogeneity is moderate, the increase of consumer surplus can be greater than the decrease of hospital profit, so as to improve social welfare.

Compared with the literature, Ronnen (1991) showed that under such a policy, social welfare would inevitably improve; Crampes and Hollander (1995) indicated that the change in social welfare hinges on how strong the high-quality firm respond to the policy, which is different from the conclusion here that the impacts on welfare depend on the heterogeneity of consumers. However, the results on qualities are consistent with the literature, which is that MQS can induce both hospitals(firms) raising the health care qualities.

This paper is organized as follows: Section 1 is the introduction, Section 2 presents the models under no policy and with policy, Section 3 provides comparative static analysis on MQS equilibrium. Concluding remarks are in Section 4.

THE MODEL

Basic Descriptions

Suppose that in the health care market, there are two health care service providers, namely a public hospital and a private one, (with subscript 1 and 2, respectively). Each of the two providers provides health care service with quality $q_i > 0$ and charges price p_i, with $q_i > 0, i = [1,2]$, and $q_1 < q_2$. In other words, the public hospital (hospital 1) provides lower health care quality than the private one. This setting is in line with the situation that public institutions are generally inefficient and produce a good with low quality in practice. In addition, suppose that two medical service providers need to bear the cost of $c_i = \frac{1}{2}{q_i}^2, i = [1,2]$ for providing each unit of medical quality.

Consumers are evenly distributed along the range $[\,\bar{\theta} - 1, \bar{\theta}\,]$, $\bar{\theta} > 1$, according to their willingness to pay for quality, θ. Assume that the market is covered by the two providers, i.e., each consumer will consume one unit of health care service from either hospital 1 or 2. When consumer θ pays the price p_i and enjoys the health care services of quality q_i, the utility function is $\theta q_i - p_i, i = 1,2$.

We can find marginal consumer who is indifferent in receiving medical treatment from public hospital (1) and from private hospital (2) as $\theta^* = \frac{q_2 - q_1}{p_2 - p_1}$. The demand functions of public and private hospitals can be derived as follows:

$$D_1 = \theta^* - (\bar{\theta} - 1) = \frac{q_2 - q_1}{p_2 - p_1} - (\bar{\theta} - 1) \quad \text{(1a)}$$

$$D_2 = \bar{\theta} - \theta^* = \bar{\theta} - \frac{q_2 - q_1}{p_2 - p_1} \quad \text{(1b)}$$

The profit functions of the two hospitals are:

$\pi_1 = (p_1 - c_1)D_1$ (2a)

$\pi_2 = (p_2 - c_2)D_2$ (2b)

Social welfare (*W*) is the sum of consumer surplus and the profits of the two hospitals. Consumer surplus from obtaining treatment in hospital 1 is $CS_1 = \int_{\bar{\theta}-1}^{\theta^*} \theta\, q_1 - p_1\, d\theta$ while $CS_2 = \int_{\theta^*}^{\bar{\theta}} \theta\, q_2 - p_2\, d\theta$ is the consumer surplus obtained by receiving medical services in hospital 2. Thus,

$W = CS_1 + CS_2 + \pi_1 + \pi_2$ (3)

The game proceeds as follows: Stage1: both hospitals determine levels of health care quality simultaneously. Stage 2: both hospitals choose their prices simultaneously.

Equilibrium without Policy

The objective function of the public hospital is to maximize social welfare W, while the private hospital is to maximize of its own profits π_2. The free market equilibrium is derived and discussed first, which can serve as the benchmark for comparison.

$$W = \int_{\bar{\theta}-1}^{\theta^*} \theta\, q_1 - p_1\, d\theta + \int_{\theta^*}^{\bar{\theta}} \theta\, q_2 - p_2\, d\theta + \left(p_1 - \frac{{q_1}^2}{2}\right)\left[\frac{q_2-q_1}{p_2-p_1} - (\bar{\theta} - 1)\right] + \left(p_2 - \frac{{q_2}^2}{2}\right)\left(\bar{\theta} - \frac{q_2-q_1}{p_2-p_1}\right) \quad (4)$$

$$\pi_2 = \left(p_2 - \frac{{q_2}^2}{2}\right)\left(\bar{\theta} - \frac{q_2-q_1}{p_2-p_1}\right) \quad (5)$$

Price Competition

The prices charged by the public hospital and the private hospital in the second stage are solved first through the backward induction.

The first order conditions for maximizing the objective functions of the two hospitals are as follows:

$$\frac{\partial W}{\partial p_1} = \frac{2(p_2-p_1)+{q_1}^2-{q_2}^2}{2(q2-q1)} = 0 \quad (6)$$

$$\frac{\partial \pi_2}{\partial p_2} = \frac{2\bar{\theta}(q_2-q_1)+2p_1-4p_2+{q_2}^2}{2(q2-q1)} = 0 \quad (7)$$

By solving Eqs. (6) and (7) simultaneously, the equilibrium prices of the public and private hospitals can be obtained as follows:

$$p_1 = {q_1}^2 - \frac{1}{2}{q_2}^2 + (q_2 - q_1)\bar{\theta} \quad (8a)$$

$$p_2 = \frac{1}{2}{q_1}^2 + (q_2 - q_1)\bar{\theta} \quad (8b)$$

Quality Competition

In the first stage, the public hospital and the private hospital determine their respective quality levels.

By substituting equilibrium solutions of Eqs. (8a) and (8b) back to Eqs. (4) and (5), the following equations can be obtained:

$$W = \frac{1}{2}\left\{q_1\left[\frac{1}{2}(-q_1+q_2)+\bar{\theta}-1\right]\left[\frac{1}{2}(q_1+q_2)-\bar{\theta}+1\right] + q_2\left[\bar{\theta}+\frac{1}{2}(q_1-q_2)\right]\left[-\frac{1}{2}(q_1+q_2)+\bar{\theta}\right]\right\} \quad (9)$$

$$\pi_2 = -\frac{1}{4}(q_1+q_2-2\bar{\theta})[{q_1}^2-{q_2}^2-2\bar{\theta}(q_1-q_2)] \quad (10)$$

Then the first order conditions are:

$$\frac{\partial W}{\partial q_1} = -\frac{1}{8}(3q_1-q_2-2\bar{\theta}+2)(q_1+q_2-2\bar{\theta}+2)=0 \quad (11)$$

$$\frac{\partial \pi_2}{\partial q_2} = -\frac{1}{4}(q_1-3q_2+2\bar{\theta})(q_1+q_2-2\bar{\theta})=0 \quad (12)$$

By solving the equations (11) and (12) simultaneously, the quality levels of the public and private hospitals can be obtained as follows[1]:

$$q_1 = \bar{\theta}-\frac{3}{4} \quad (13a)$$

$$q_2 = \bar{\theta}-\frac{1}{4} \quad (13b)$$

We can thus derive equilibrium prices:

$$p_1 = \frac{1}{2}\bar{\theta}^2-\frac{3}{4}\bar{\theta}+\frac{17}{32} \quad (14a)$$

$$p_2 = \frac{1}{2}\bar{\theta}^2-\frac{1}{4}\bar{\theta}+\frac{9}{32} \quad (14b)$$

Based the equilibrium quality and price, the profits of the public and private hospitals are:

$$\pi_1 = \pi_2 = \frac{1}{8} \quad (15)$$

The consumer surpluses are:

$$CS_1 = \frac{1}{4}\bar{\theta}^2-\frac{3}{8}\bar{\theta}+\frac{1}{64} \quad (16a)$$

$$CS_2 = \frac{1}{4}\bar{\theta}^2-\frac{1}{8}\bar{\theta}-\frac{7}{64} \quad (16b)$$

The level of social welfare is:

$$W = \frac{1}{2}\bar{\theta}^2-\frac{1}{2}\bar{\theta}+\frac{5}{32} \quad (17)$$

where,

$\bar{\theta} > \frac{3}{4}+\frac{1}{2}\sqrt{2}$, so that the model is viable.

[1] Three sets of solutions can be obtained from the first-order conditions, but two of them do not generate reasonable results. Please refer to Appendix A.1 for details.

Equilibrium under Minimum Quality Standards (MQS)

This section includes the MQS policy into the basic structure. Assuming that the government establishes a minimum quality standard $\hat{q}$, $\hat{q} > q_1$. The equilibrium under such policy is solved below.

Price Competition

Following the same procedure as before, we can solve the equilibrium medical prices for the public and private hospitals as:

$$p_1^* = \hat{q}^2 - \frac{1}{2}{q_2^*}^2 + (q_2^* - \hat{q})\bar{\theta} \quad (18a)$$

$$p_2^* = \frac{1}{2}\hat{q}^2 + (q_2^* - \hat{q})\bar{\theta} \quad (18b)$$

Quality Competition

By substituting Eqs. (18a) and (18b) back to the objective function of the private hospital, the following equations can be obtained:

$$\pi_2^* = \frac{1}{4}(q_2^* + \hat{q} - 2\bar{\theta})^2(q_2^* - \hat{q}) \quad (19)$$

$$\frac{\partial \pi_2^*}{\partial q_2^*} = \frac{3}{4}{q_2^*}^2 + \left(\frac{1}{2}\hat{q} - 2\bar{\theta}\right)q_2^* + \bar{\theta}^2 - \frac{1}{4}\hat{q}^2 = 0 \quad (20)$$

Thus, the levels of medical quality provided by the public and private hospitals are as follows[2]:

$$q_1^* = \hat{q} \quad (21a)$$

$$q_2^* = \frac{1}{3}\hat{q} + \frac{2}{3}\bar{\theta} \quad (21b)$$

The equilibrium prices are:

$$p_1^* = \frac{4}{9}\bar{\theta}^2 - \frac{8}{9}\hat{q}\bar{\theta} + \frac{17}{18}\hat{q}^2 \quad (22a)$$

$$p_2^* = \frac{2}{3}\bar{\theta}^2 - \frac{2}{3}\hat{q}\bar{\theta} + \frac{1}{2}\hat{q}^2 \quad (22b)$$

Based on the equilibrium quality and price, the profits of the public and private hospitals are:

$$\pi_1^* = \frac{4}{27}(2\hat{q} - 2\bar{\theta} + 3)(\hat{q} - \bar{\theta})^2 \quad (23a)$$

$$\pi_2^* = -\frac{8}{27}(\hat{q} - \bar{\theta})^3 \quad (23b)$$

The consumer surpluses are:

$$CS_1^* = -\frac{1}{54}(2\hat{q} - 2\bar{\theta} + 3)(8\bar{\theta}^2 - 28\hat{q}\bar{\theta} + 11\hat{q}^2 + 9\hat{q}) \quad (24a)$$

[2] Two sets of solutions can be obtained from the first-order condition, but one of them does not generate reasonable results. See Appendix A.2 for details.

$CS_2^* = \frac{1}{27}(\hat{q} - \bar{\theta})(4\bar{\theta}^2 - 20\hat{q}\bar{\theta} + 7\hat{q}^2)$ (24b)

The social welfare is:

$W^* = \frac{4}{27}\bar{\theta}^3 - \frac{4}{9}\hat{q}\bar{\theta}^2 + \frac{4}{9}\hat{q}^2\bar{\theta} + \hat{q}\bar{\theta} - \frac{4}{27}\hat{q}^3 - \frac{1}{2}\hat{q}^2 - \frac{1}{2}\hat{q}$ (25)

where, $\begin{cases} \hat{q} < \bar{\theta} < \frac{1}{2}(5 + 3\sqrt{2})\hat{q}, & \text{if } \hat{q} + \frac{3}{2} > \frac{1}{2}(5 + 3\sqrt{2}) \\ \hat{q} < \bar{\theta} < \hat{q} + \frac{3}{2}, & \text{if } \frac{1}{2}(5 + 3\sqrt{2}) > \hat{q} + \frac{3}{2} \end{cases}$, so that the model is viable.

COMPARATIVE STATICS

The section discusses how quality standard $\hat{q}$ affects health care qualities, prices, profits, and social welfare.

Proposition 1: As the minimum quality standard $\hat{q}$ increases, both public and private hospitals raise the health care qualities.

Proof: It is straightforward that $\frac{\partial q_2^*}{\partial \hat{q}} = \frac{1}{3} > 0$.[3]

When the quality standard set by the government is improved, the public hospital is forced to raise medical quality, which reduces the high-quality advantage originally enjoyed by the private hospital. If the private hospital does not improve the quality, the quality difference between them is smaller, which causes a more intense competition. Therefore, the private hospital has an incentive to improve the medical quality in order to mitigate the competition.

This is in line with the conclusions from Ronnen (1991) and Crampes and Hollander (1995), indicating that no matter whether the market is covered or not, the improvement of control standard will enable the high-quality manufacturer to improve product quality along with the low-quality firm under the quality control. In other words, MQS contributes to the improvement of product quality in the market.

Lemma 1: With the improvement of the minimum quality standard, the quality differentiation between the two hospitals decreases.

Due to the convexity of the cost function, i.e. $C'(q_i) > 0$ and $C''(q_i) > 0$, the cost of the private hospital (the high-quality firm) increases faster than that of the public hospital as both raise quality by the same degree. When the minimum quality standard is improved, the extent of

[3] The public hospital (low-quality firm) is constrained to produce $\hat{q}$ which is higher than the free market quality level.

quality improvement of high-quality hospital is less than that of low-quality one, and the quality gap between two hospitals decreases.

Proposition 2: The smaller $\bar{\theta}$ is, the more likely the medical price increases in $\hat{q}$ for both hospitals.

Proof: $\frac{\partial p_1}{\partial \hat{q}} = \frac{17}{9}\hat{q} - \frac{8}{9}\bar{\theta} \begin{cases} > 0, if\ \bar{\theta} < \frac{17}{8}\hat{q} \\ < 0, if\ \bar{\theta} > \frac{17}{8}\hat{q} \end{cases}$

$\frac{\partial p_2}{\partial \hat{q}} = \hat{q} - \frac{2}{3}\bar{\theta} \begin{cases} > 0, if\ \bar{\theta} < \frac{3}{2}\hat{q} \\ < 0, if\ \bar{\theta} > \frac{3}{2}\hat{q} \end{cases}.$

The lower the value of $\bar{\theta}$, the more differentiated consumers are so the less competitive the market is. Therefore, as $\hat{q}$ rises, both hospitals are more inclined to raise prices. Similarly, the higher the value of $\bar{\theta}$, the more competitive the market is. The two hospitals tend to lower prices even both incur higher costs because qualities produced are improved as $\hat{q}$ increases. The impacts of MQS on medical prices depend on $\bar{\theta}$ (consumer heterogeneity).

Compared with the previous studies, Ronnen (1991) pointed out that MQS would inevitably lower the prices of firms. While Crampes and Hollander (1995) held the opposite opinion and thought that the prices would rise instead. The difference between our results and the existing conclusions may arise from two effects. (1) Cost effects: the "production cost" increases with the improvement of quality, which makes the firms increase the price; (2) Competitive effects: when the quality gap decreases or the consumers are less differentiated, the more competitive the market is. As a result, firms are more likely to reduce their prices. If the former effect outweighs the latter, then the price goes up as the quality standard $\hat{q}$ increases.

Ronnen (1991) employed fixed cost structure while Crampes and Hollander (1995) adopted the form of variable cost. Variable cost seems to be more influential in product prices since the increase in quality not only raises the total cost but the cost also increases with the output. In our study, variable cost structure together with lower degree consumer differentiation (smaller $\bar{\theta}$) can bring about an increase in price as $\hat{q}$ increases. Therefore, the medical price increases with smaller $\bar{\theta}$ as quality standard goes up.

Lemma 2: With the improvement of the minimum quality standard, the demand for health care services from public hospital increases, while decreases for the private hospital.

Proof:

$$\frac{\partial D_1}{\partial \hat{q}} = \frac{2}{3} > 0$$

$$\frac{\partial D_2}{\partial \hat{q}} = -\frac{2}{3} < 0$$

When the quality standard increases, the quality provided by the public hospital increases, so some consumers switch from private to public hospital. Such conclusion is in line with Crampes and Hollander (1995), namely, the market share of high-quality firm is reduced due to MQS.

Lemma 3: As $\hat{q}$ increases, the effects on consumer surplus depend on $\bar{\theta}$. Specifically,

$$\frac{dCS_1}{\partial \hat{q}} \begin{cases} > 0, if\ \bar{\theta} < j\ or\ \bar{\theta} > k \\ < 0, if\ j > \bar{\theta} > k \end{cases};$$

$$\frac{dCS_2}{\partial \hat{q}} \begin{cases} > 0, if\ \bar{\theta} < \left(\frac{9}{8}\hat{q} - \frac{5}{8}\right)\ or\ \bar{\theta} > \left(\frac{9}{8}\hat{q} + \frac{5}{8}\right) \\ < 0, if\ \left(\frac{9}{8}\hat{q} + \frac{5}{8}\right) > \bar{\theta} > \left(\frac{9}{8}\hat{q} - \frac{5}{8}\right) \end{cases}.$$

where, $j = \left(\frac{13}{12}\hat{q} + \frac{17}{24} - \frac{1}{24}\sqrt{148\hat{q}^2 + 68\hat{q} + 73}\right)$,

$k = \left(\frac{13}{12}\hat{q} + \frac{17}{24} + \frac{1}{24}\sqrt{148\hat{q}^2 + 68\hat{q} + 73}\right)$.

Proof: Direct differentiation can give the results.

$$\frac{\partial CS_1}{\partial \hat{q}} = \left(-\frac{4}{3}\right)\bar{\theta}^2 + \left(\frac{26}{9}\hat{q} + \frac{17}{9}\right)\bar{\theta} - \left(\frac{11}{9}\hat{q}^2 + \frac{17}{9}\hat{q} + \frac{1}{2}\right) \gtrless 0$$

$$\frac{\partial CS_2}{\partial \hat{q}} = \frac{8}{9}\bar{\theta}^2 - 2\hat{q}\bar{\theta} + \frac{7}{9}\hat{q}^2 \gtrless 0$$

As the quality standard increases, there are three effects on consumer surplus: (1) quality effect : higher medical quality leads to higher consumer surplus. (2) cost effect: higher quality is associated with higher costs which in turn results in a higher price. Consumer surplus decreases when price goes up. (3) competition effect: as product differentiation decreases (which may be caused by the increase in $\hat{q}$) or as consumers are more homogeneous (larger $\bar{\theta}$), the degree of competition is intensified which can benefit consumers.

When $\bar{\theta}$ is small, with the improvement of $\hat{q}$, the quality gap between public and private hospitals decreases, and the degree of competition degree increases, which is beneficial to consumers. When $\bar{\theta}$ is larger, consumers are more homogeneous and competition among hospitals is fiercer, which can also improve consumer surplus. Therefore, competition effect together with quality effect tend to outweigh the cost effect with a relatively small a relative large

$\bar{\theta}$. However, when $\bar{\theta}$ is an intermediate value, the cost effect entailed by the improvement of $\hat{q}$ dominates the quality and competition effect. The consumer surplus thus decreases.

Different from our conclusion, Ronnen (1991) indicated that the demand expands because of the implementation of MQS so the consumer surplus rises. Crampes and Hollander (1995) pointed out that the effect of MQS on consumer surplus depends on how strong the high quality firm responds to the low quality one. A weak response leads to a more intensive competition so consumer surplus increases; otherwise, the consumer surplus decreases.

Lemma 4: The profits of private hospital decrease in quality standards .

Proof: $\frac{\partial \pi_2}{\partial \hat{q}} = -\frac{8}{9}(\hat{q} - \bar{\theta})^2 < 0.$

An $\hat{q}$ increases, the quality differentiation between public and private hospitals decreases and thus the competition between the two hospitals is intensified. Fiercer competition, higher cost and smaller market share lead to a lower level profit for the private hospital. Ronnen (1991) also pointed out that the improvement of quality by high-quality firm raised the cost (and the cost increased in quadratic form), while the reduction of product differentiation made the price competition more intense, so high-quality firm was hurt by MQS policy. Crampes and Hollander (1995) also indicated that high-quality firm suffered from higher costs and lower demand under MQS which resulted in a decrease in profits.

Proposition 3: Depending on $\bar{\theta}$, the social welfare may rise or fall as quality standard $\hat{q}$ increases.

$$\frac{dW}{\partial \hat{q}} \begin{cases} > 0, if \left(\hat{q} + \frac{3}{4}\right) < \bar{\theta} < \left(\hat{q} + \frac{3}{2}\right) \\ < 0, if\ \bar{\theta} < \left(\hat{q} + \frac{3}{4}\right)\ or\ \ \bar{\theta} > \left(\hat{q} + \frac{3}{2}\right) \end{cases}.$$

Proof: $\frac{dw}{d\hat{q}} = -\frac{1}{18}(2\hat{q} - 2\bar{\theta} + 3)(4\hat{q} - 4\bar{\theta} + 3) \gtrless 0.$

Following the above analysis, as the quality standards increase, there are cost effects and competition effects. The former causes higher prices and the latter leads to lower ones. In the case of relatively high (low) $\bar{\theta}$, the degree of competition is high (low),[4] the decrease in profits (consumer surplus) exceeds the increase (decrease) in consumer surplus (profits) from lower (higher) prices. Therefore, with relatively large or small values of $\bar{\theta}$, an increase in quality standards reduces social welfare. With a medium level of $\bar{\theta}$, an increase in the quality standards can improve social welfare.

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[4] The higher (lower) $\bar{\theta}$ is, the more homogeneous (heterogeneous) consumers are more, the lower (higher) the price.

Compared with the argument in this study that the consumer heterogeneity determines the changes in social welfare with MQS, Ronnen (1991) pointed out that under the MQS policy, the more competitive market and larger number of consumers served inevitably lead to the improvement of social welfare. While Crampes and Hollander (1995) believed that the strength of high-quality firm's response to the rival determines the changes in social welfare.

The implementation of MQS can induce both public and private hospitals to raise the medical qualities they offer. The private hospital suffers from the MQS. The effects of MQS on prices, consumer surplus and social welfare depend on the quality costs, and the degree of competition which is influenced by the degree of quality differentiation and consumer heterogeneity. It is worth noting that there is a non-linear relationship between consumer heterogeneity and the resulting consumer surplus and social welfare.

CONCLUDING REMARKS

This study discussed the mixed duopoly case in the health care market, among which the public hospital is a low-quality hospital while the private hospital is a high-quality hospital. The effects of the MQS policy on various economic variables are examined.

The results are in line with the literature in that the high-quality (private) hospital suffers from such policy. The effects on prices, consumer surplus and social welfare depend on the cost effects which raise prices if hospitals provide higher quality, and the competition effect as well which reduce price if quality differentiation gets smaller or consumers are less heterogeneous. There is a non-linear relationship between consumer heterogeneity and the resulting consumer surplus and social welfare.

In other words, MQS is beneficial for the society when the degree of consumer differentiation is moderate. An extreme level of consumer heterogeneity (relatively low or relative high) results in excessive competition or too mild competition in the market, which will make one side of market (firms and consumers) benefits and the other side suffers from it. The disadvantages outweigh the benefits such that the social welfare is lower than the free market level. In addition, it is also found that MQS can increase the utilization rate of the public hospital since demand for its health care services increases.

The above results may depend on the cost structure of the model which assumes that quality-dependent costs are variable costs, i.e. the costs are incurred when the actual production takes place in the second stage of the game. However, in practice, hospitals can also bear costs of medical equipment and appliances upfront in the first stage of the game. These fixed costs do not directly affect the pricing strategies of two hospitals. Therefore, the degree of price competition with variable costs should be considered as an upper bound as compared to a more practical situation. In addition, the benefits of a quality standard discussed in this study hinges on the capability of the policy maker as well. If the quality standard is extremely restrictive, the resulting negative effects could outweigh the positive effects. Thus, the policy implications shall be applied with caution.

One important policy instrument in health care market is price control which is not included here. The price competition is mitigated or can be completely deleted by price control policy such that hospitals could compete on qualities only. Hospitals may be less willing to raise quality given the prices are fixed by the government. However, higher qualities can attract more patients for hospital. Given the above two opposite forces, it is interesting to investigate how price control affects health care qualities offered by hospitals.

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APPENDICES

A.1

There are three sets of quality solutions under free market quality competition:

(i) $q_1 = \bar{\theta} - \frac{3}{4},\ \ q_2 = \bar{\theta} - \frac{1}{4}$

(ii) $q_1 = \bar{\theta} - \frac{3}{2},\ \ q_2 = \bar{\theta} - \frac{1}{2}$

(iii) $q_1 = \bar{\theta} - \frac{1}{2},\ \ q_2 = \bar{\theta} + \frac{1}{2}$

The first set of solution generates reasonable results; the other two sets lead a zero-demand situation.

A.2

There are two sets of quality solutions at the stage of quality competition when MQS is implemented:

(i) $q_1^* = \hat{q},\ \ q_2^* = \frac{1}{3}\hat{q} + \frac{2}{3}\bar{\theta}$

(ii) $q_1^* = \hat{q},\ \ q_2^* = 2\bar{\theta} - \hat{q}$

The first set produces reasonable results.