Essays on Competition in Health Care Markets

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Contents

Introduction

Health care is important to society because every individual may become ill or be involved in accidents and emergencies. Therefore, physicians and hospitals are needed to provide medical treatments. All over the world, the structure of health care markets varies enormously from one country to another, largely influenced by competition among suppliers, the regulation of markets and patient preferences. The purpose of competition is to improve the usage of health care services, e.g. to achieve lower prices, better treatments, shorter waiting time, etc. In all cases, according to the World Health Organization (WHO), a well-functioning health care market requires reliable information on which to base decisions and policies to deliver treatments (WHO, 2013).

We observe that in most industrial countries, e.g. Germany, Norway, Switzerland, Japan, etc., policy makers regulate the prices in health care markets. The most common argument for price regulation is that it prevents abuse of market power and/or too high consumer prices. Health care expenditures are covered either by national care or national insurance. Therefore, they do not respond to prices but to treatment quality or waiting time instead. However, there does not exist a national health care system in many less developed countries. In some developing countries and areas, not all patients have sufficient capacity (income) to acquire necessary treatments if policy makers do not regulate prices. Furthermore, treatments are normally thought to be better than non-treatment for patients. Hence, patients in these countries and areas are sensitive to prices when it comes to medical decisions. To demonstrate an entire picture of health care markets, we have to consider the different situations both in developing and developed countries.

Health care markets differ from many other industries. One of the most important features is that information about treatment quality is shared unevenly between patients and physicians or hospitals. This asymmetry leads to a partially transparent health care market. Many economists hold the opinion that consumer-sided market transparency intensifies competition and leads to better products for consumers (lower prices, higher quality, etc.) (Kuhn & Martínez, 1996). Thus, market transparency allows patients to make useful comparisons and improves social welfare (Schultz, 2009). Nevertheless, in health care markets patients often have difficulties finding the necessary information. Especially patients may lack sufficient knowledge and technical abilities to judge the quality of health care services, or they may lack confidence in the information sources that tend to generate these treatment quality indicators. We need to consider transparency when we discuss market outcomes.

Another feature of health care markets is that providers are altruistic, which is the motivation to increase their patients' welfare. Kolstad (2013) provides an empirical result that suppliers are motivated by a desire to perform well in addition to profit. Generally, it is more common to assume that self-interest as a motivating force for social benefit than with altruism in the economic literature. However, health care service is a very special product which has a direct detrimental effect on patients if decisions are made incorrectly or improperly. Economists have acknowledged that individuals do not only behave self-interested, but also care about others at least since Fehr and Schmidt (1999). Therefore, providers behave differently from what the neoclassical theory would consider rational. Providers in health care markets care about their own profits as well as their patients' welfare.

In this dissertation, different competition strategies among providers in health care markets are analyzed. Understanding the effects of provider competition not only draws a clearer picture of health care markets, but also gives policy implications. These motivations are at the heart of this dissertation.

Considering different regulatory interventions, two different markets are analyzed in this dissertation: the health care markets in developing countries without price regulation, and the market with price regulation in developed countries.

A total of four research papers are arranged according to their topic in four distinct chapters:

1. Pure Strategy Price Equilibria in a Product Differentiation Model

2. Transparency and Semi-altruism in Provider Markets (with Yiquan Gu and Burkhard Hehenkamp)

3. Market Competition Between Heterogeneously Altruistic Providers (with Yiquan Gu and Burkhard Hehenkamp)

4. The Role of Market Transparency in Hospital Mergers

In Chapter 1, a price equilibrium in a product differentiation model with unit demand is analyzed. This part of the thesis tries to answer the question whether there exists a price equilibrium in less developed countries which are characterized by no price regulation. We introduce sufficient income heterogeneity into a model with unit demand in these countries where neither national care nor a national insurance system exists. The influence of price competition is examined in a duopoly Hotelling (1929) production differentiation model. We focus on the physicians' strategy in a partially covered health care market where not every individual can acquire the necessary treatment. We shed light on the role of competition in the existence of pure strategy price equilibria. Our finding indicates that a pair of asymmetric pure strategy price equilibria exists in a model with income constraints for the specific case that two physicians locate at the maximum distance from each other and patients pay the same marginal transportation cost. In the paper by Peitz (1999) it is shown that with income heterogeneity there does not exist a price equilibrium in models of horizontal product differentiation with unit demand, because some consumers are income-constrained. We argue that the results in his Section 3 are not correct.

Chapter 2 is based on joint work with Yiquan Gu and Burkhard Hehenkamp. In this chapter, the health care markets in industrial countries which are characterized by regulated treatment prices are analyzed. It presents a theoretical two-stage model of competition. In the first stage, a large number of ex ante potential providers decide about entry. After paying a fixed entry cost, entrants are then distributed randomly at equidistant locations. In the second stage, given the number of providers entered, they compete for patients by setting their treatment quality. We investigate how patients' information about treatment qualities affects health market outcomes. We find that when the number of providers is kept constant, two cases can arise. First, when transparency is low, competition is weak and providers choose zero quality. In this case a small increase in market transparency has no effect on quality. Second, when transparency is high, competition becomes intense and providers pick positive levels of quality in equilibrium. In this case, higher transparency leads to higher quality, but also to lower profits. Equilibrium quality increases and equilibrium profits decrease in the number of firms. Eventually, quality remains constant due to the zero profit constraints. Taking the entry decision into account, the equilibrium number of providers decreases with the cost of entry. In addition, we extend the analysis to the case of (semi-)altruistic providers. We find that transparency and (semi-)altruism are policy substitutes. To complete the analysis, we continue with investigating the welfare effect of an improvement in patients' information. It is shown that social welfare remains constant when providers choose zero quality. Market transparency and (semi-)altruism show ambiguous effects on welfare when providers choose positive quality.

Chapter 3 is another result of joint research done in cooperation with Yiquan Gu and Burkhard Hehenkamp. The variation in altruism across the population of providers is likely to be large and may have an effect on market outcomes. In this chapter, we analyze the effects of different altruism for equilibrium with respect to quality and social welfare. We introduce altruism heterogeneity into a partially transparent duopoly market of quality competition with price regulation and limit physicians' location on a Salop (1979) model. We show that market transparency and altruism are policy substitutes. The main finding is that the effect of heterogeneous altruism on welfare is ambiguous. Altruism is not always beneficial to social welfare. Lower altruism does not change profits when altruism is low, but leads to lower profit offered by the more altruistic physician when altruism is medium. With increasing altruism, profits decrease due to quality competition. Eventually, both physicians are bounded by the zero profit constraints. Results show that too high altruism is harmful for social welfare if marginal cost is too high. Our findings indicate that policy makers cannot always improve quality and social welfare directly by increasing transparency or altruism.

Chapter 4 investigates the incentives of hospital merges and the effects of market transparency on the merger outcomes. We adopt the product differentiation model by Salop (1979) and adapt it to the case of regulated prices with three ex ante identical hospitals symmetrically located on a circle. Demand is explicitly derived from individual preferences and depends on quality and transportation costs (interpreted either as horizontal product differentiation or physical travelling costs). We study the effects of market transparency on a horizontal hospital merger. It is shown that, due to the symmetric locations of hospitals, treatment qualities are strategic complements and hospitals may have incentives to merge when market transparency is not extremely low. Our results show that the effect of market transparency on social welfare is ambiguous. Hospitals can provide lower quality after the merger, which in turn to a lower production cost. If the relative fixed cost is not very high, then the efficiency gains are not sufficiently larger from a merge. High market transparency does not always play a positive role on social welfare as we may expect, even though the number of hospitals is changed before and after the merger. Our findings not only provide a more profound understanding of the socioeconomic implications associated with hospital mergers, but also bear important implications from a policy perspective. The higher transparency the health care market improves, the lower the social welfare becomes after merger under certain conditions. To sum up, there is no unambiguous answer to the question if transparency is generally necessary for welfare since it strongly depends on the efficiency gains. In some cases, higher market transparency can be reasonable. In other cases, high transparency is not necessary since welfare becomes lower due to less competition.

Each project discussed in this dissertation provides a unique set of contributions to existing research. Chapter 1 presents a novel discussion of the existence of pure strategy price equilibrium in less developed countries. Moreover, Chapter 2 and Chapter 3 employ novel settings of market transparency and altruism to study physician behavior in industrial countries and to induce the social optimal levels of transparency and altruism. Finally, the study in Chapter 4 is the first to investigate the interrelationship between market transparency and hospital mergers with price regulation. In general, this dissertation provides a picture of competitions in different countries and helps us to have a better comprehension of health care markets.

Chapter 1

Pure Strategy Price Equilibria in a Product Differentiation Model

Xing Wu[*]

Abstract

Patients mind treatment prices and qualities when they visit physicians. Unlike the fully covered health care markets in many developed countries, patients are constrained by their income without national care and insurance in some less developed countries. Therefore, they are more sensitive to prices. We introduce sufficient income heterogeneity into a framework of price competition with unit demand, and address a Hotelling (1929) duopoly product differentiation model to analyze both physicians' strategies in a partially covered health care market. We prove the existence of a pair of asymmetric pure strategy price equilibria for a specific case of extreme locations and marginal transportation cost.

JEL classification: D43, I11, L11

Keywords: Duopoly, Price Competition, Product Differentiation

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1.1 Introduction

To a large extent, existing literature in health economics addresses price competition with fully covered health care markets, where all patients can receive treatments (Frank & Lamiraud, 2009; Berndt et al., 2007; Dranove et al., 1993; and Dranove et al., 1986). However, the mentioned fully covered health care markets in many industrial countries, e.g. Germany, France, Norway, etc., cannot reflect the entire world. The reality in some less developed economies is that not every individual can afford the insurance premium if there is no free national health care, e.g. in Cameroon, health care is expensive and poorly distributed, and patients have to pay “out of pocket” for treatments. Unfortunately, many developing countries do not provide free health care and aids, because of a lack of funding. In that situation, we cannot assume a fully covered health care market. Furthermore, by addressing competition among physicians in these countries, we can have an entire picture of how the health care market works in terms of price competition. Thus, we are interested in the situation where patients are not sensitive to the level of quality provided without price regulation. This may give illustration to policy makers in less developed countries to improve the use of health care resources.

The contribution in this study is that we introduce sufficient income heterogeneity into a model of physician price competition with unit demand. We prove the existence of a pair of asymmetric pure strategy price equilibria with unit demand for a specific case of extreme locations. Our result contradicts a finding in Peitz (1999), which shows the nonexistence of a price equilibrium in models of horizontal product differentiation when for some consumers the willingness to pay exceeds their capacity to pay.

The existing health economics literature mainly focuses on models where the product characteristics space is one-dimensional, e.g. Bardey et al. (2012) and Brekke et al. (2011). Bardey et al. (2012) analyze the regulation of payment schemes for health care providers competing in products. They show that in a linear city model when the regulator can only use a prospective payment, the optimal price involves a trade-off between the level of quality provision and the level of horizontal differentiation. If this pure prospective payment leads to under-provision of quality and over-differentiation, a mixed reimbursement scheme allows the regulator to improve the allocation efficiency. Brekke et al. (2011) analyze the effect of competition on quality in hospital markets with regulated prices. They state that the relationship between competition and quality is generally ambiguous. In all above mentioned articles, Hotelling's (1929) linear city model is deployed in their analysis. Hotelling (1929) proposes the principle of "Minimum Differentiation": two providers of a homogeneous product agglomerate at the center of the line market under linear transportation costs. But d'Aspremont, Gabszewicz & Thisse (1979) point out that there is no pure strategy price equilibrium under quadratic transportation costs when providers' locations are too close. However, Böckem (1994) shows that the result of maximum differentiation is not robust. She provides an example for a wide class of markets where providers will choose interior solutions if patients have an outside option for their use of money. Therefore, we use a linear city model with maximum distance of providers and look at the outcomes of price competition with unit demand in health care markets.

We follow Peitz's (1999) research and introduce income heterogeneity in the product differentiation model, to represent the income status of patients and model the partially covered health care markets without price regulation in some developing countries and areas, e.g. Cameroon and some rural areas in China. In our study, we consider both horizontal product differentiation and vertical differentiation where patients have different incomes and physicians charge possible different prices. In this two-dimensional framework, the importance of the income constraint is demonstrated by a simple example of a linear city model. Furthermore, we show that the results in Peitz's (1999) Section 3 are not correct.

This study is structured as follows: Section 1.2 presents the model. Section 1.3 considers the case of particularly extreme locations of physicians and derives the theoretical results. The last section concludes.

1.2 The Model

We use a linear city model and assume a town with just one street of length 1 (Hotelling, 1929). We analyze a model of both horizontal product differentiation and vertical differentiation. Horizontal product differentiation means that physicians and patients locate at different points, such that transportation cost is a disutility due to the distance between a patient and a physician. Vertical differentiation denotes that patients have heterogeneous income and physicians choose different prices. There exist two physicians located on the street and providing treatments. Physician i locates at $l_i \in [0,1]$, and charges price $p_i \in (0,1), i = 1,2$. We use a two-stage product differentiation model: In the first stage, physicians choose their locations simultaneously and independently. In the second stage, physicians compete on prices to maximize their profits as locations are given. In this study we focus on the second stage and investigate physicians' price strategies.

A continuum of patients distributes uniformly over the entire street. At each point there is uniformly distributed heterogeneous income. All patients decide whether to buy and from which physician to maximize their utilities. Patients' preferences on the differentiated products are different. Every patient consumes only one unit of product and pays the same price for the same product. Patients differ in their transportation costs which are quadratic in the distance needed to travel to the physician (Bardey et al., 2012).

A patient h is described by his location x_h and income y_h. Patients derive utility from one unit of the differentiated goods. According to the specification goods are perfect substitutes and patients have identical utility functions. Patients maximize their utility:

$$u_h = r - t(x_h - l_i)^2 - p_i, \tag{1.1}$$

where $r > 0$ denotes the reservation utility from consuming one unit treatment, and $t > 0$ denotes the marginal transportation cost. The transportation cost is not a monetary term but a disutility. We assume for simplicity that the reservation utility is sufficiently high to ensure that every patient would like to purchase one unit.

For simplicity, we assume both physicians produce at zero marginal costs. Patients compare their external options of no trading with trading at physician i. If any patient buys a unit of goods at physician i, these following conditions should be satisfied:

(1) Budget constraint: $p_i \leq y_h$.

(2) Participation constraint: $p_i \leq r - t(x_h - l_i)^2$. This condition is always satisfied since the reservation utility r is sufficiently high.

(3) Incentive compatibility constraint: $r - t(x_h - l_i)^2 - p_i \geq r - t(x_h - l_j)^2 - p_j$ for all $\mathrm{i} \neq j$ and $p_j \leq y_h$.

1.3 Theoretical Prediction of a Particular Case

In this section, we first derive the indifferent patient's location and then calculate physicians' demands from utility maximization. We use game theory and optimization theory to identify the price equilibrium. In this linear city model with quadratic transportation costs, we find that asymmetric price equilibria in pure strategies exist for some locations. This finding is opposite to Peitz (1999) (given the specification of extreme locations of physicians and marginal transportation cost).

Taking into consideration that $p_1 > p_2$, Figure 1.1 illustrates patients' choices in a model of product differentiation. The horizontal axis represents locations of physicians and patients. The vertical axis denotes physicians' prices and patients' income. A patient faced with a set of treatments with locations and prices is in either one of the following situations (ignoring the borderline cases).

Situation (1): A patient has a most preferred treatment and she/he can afford it.

Situation (2): No trade since the patient cannot afford any treatment.

Situation (3): A patient cannot afford her/his most preferred treatment. There is another treatment which she/he prefers over non-treatment and she/he can afford to buy one unit.

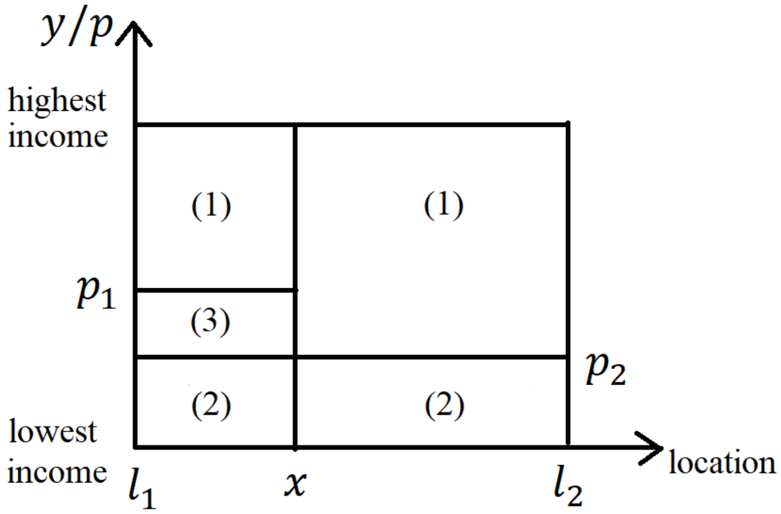

Figure 1.1: Patients' choices in a model of product differentiation.

There exists a patient located at point x (see Figure 1.1) who is indifferent between the two physicians:

$$r - t(x - l_1)^2 - p_1 = r - t(x - l_2)^2 - p_2. \tag{1.2}$$

Solving the above equation, we obtain the location of this indifferent patient x between two physicians, which is given by

$$x = \frac{p_2 - p_1}{2t(l_2 - l_1)} + \frac{l_1 + l_2}{2}. \tag{1.3}$$

Physicians maximize their profits

$$\pi_i = p_i d_i\left(p_i, p_j\right), \tag{1.4}$$

where $d_i(p_i, p_j)$ is the total demand of physician i. Following Peitz's (1999) work, the total demand of physician 1 and physician 2 depend on their own price and their competitor's price. Let $\hat{d}_i$ denote the demand of Situation (1) and $\check{d}_i$ denote the additional demand of Situation (3). We have the following:

$$\hat{d}_1 = (1 - p_1)\left(\frac{p_2 - p_1}{2t(l_2 - l_1)} + \frac{(l_1 + l_2)}{2}\right). \tag{1.5}$$

$$\hat{d}_2 = (1 - p_2)\left(1 - \frac{p_2 - p_1}{2t(l_2 - l_1)} - \frac{(l_1 + l_2)}{2}\right). \tag{1.6}$$

$$\check{d}_1 = \begin{cases} 0 & \text{if } p_1 > p_2 \\ (p_2 - p_1)\left(1 - \frac{p_2 - p_1}{2t(l_2 - l_1)} - \frac{(l_1 + l_2)}{2}\right) & \text{if } p_1 < p_2 \end{cases}. \tag{1.7}$$

$$\check{d}_2 = \begin{cases} (p_1 - p_2)\left(\frac{p_2 - p_1}{2t(l_2 - l_1)} + \frac{(l_1 + l_2)}{2}\right) & \text{if } p_1 > p_2 \\ 0 & \text{if } p_1 < p_2 \end{cases}. \tag{1.8}$$

The total demand of physician i can be composed as $d_i = \hat{d}_i + \check{d}_i$. Inserting demand functions into Equation (1.4), the profit functions of physicians are:

$$\pi_1 = \begin{cases} p_1(1-p_1)\left[\frac{p_2-p_1}{2t(l_2-l_1)}+\frac{l_1+l_2}{2}\right] & \text{if } p_1 > p_2 \\ p_1\left\{(1-p_1)\left[\frac{p_2-p_1}{2t(l_2-l_1)}+\frac{l_1+l_2}{2}\right]+(p_2-p_1)\left[1-\frac{p_2-p_1}{2t(l_2-l_1)}-\frac{l_1+l_2}{2}\right]\right\} & \text{if } p_1 < p_2 \end{cases}. \quad (1.9)$$

$$\pi_2 = \begin{cases} p_2\left\{(1-p_2)\left[1-\frac{p_2-p_1}{2t(l_2-l_1)}-\frac{l_1+l_2}{2}\right]+(p_1-p_2)\left[\frac{p_2-p_1}{2t(l_2-l_1)}+\frac{l_1+l_2}{2}\right]\right\} & \text{if } p_1 > p_2 \\ p_2(1-p_2)\left[1-\frac{p_2-p_1}{2t(l_2-l_1)}-\frac{l_1+l_2}{2}\right] & \text{if } p_1 < p_2 \end{cases}. \quad (1.10)$$

For simplicity, we only consider a particular case of symmetric locations and unit marginal transportation cost. Due to the symmetric settings of the model, asymmetric price equilibria come in pairs. If we can find equilibrium prices for both physicians if $p_1 > p_2$ for given locations and transportation cost, this is sufficient to obtain another equilibrium for the case that $p_1 < p_2$.

The first order conditions of optimal prices are given by

$$\frac{\partial \pi_1}{\partial p_1} = (1-p_1)\left(\frac{p_2-p_1}{2t(l_2-l_1)}+\frac{l_1+l_2}{2}\right)-p_1\left(\frac{p_2-2p_1+1}{2t(l_2-l_1)}+\frac{l_1+l_2}{2}\right) = 0 \text{ if } p_1 > p_2, \quad (1.11)$$

and

$$\frac{\partial \pi_2}{\partial p_2} = (1-p_2)\left(1-\frac{p_2-p_1}{2t(l_2-l_1)}-\frac{l_1+l_2}{2}\right)+(p_1-p_2)\left(\frac{p_2-p_1}{2t(l_2-l_1)}+\frac{l_1+l_2}{2}\right)+p_2\left(-1+\frac{p_2-p_1}{2t(l_2-l_1)}+\frac{l_1+l_2}{2}+\frac{-(1-p_2)}{2t(l_2-l_1)}-\left(\frac{p_2-p_1}{2t(l_2-l_1)}+\frac{l_1+l_2}{2}\right)+\frac{p_1-p_2}{2t(l_2-l_1)}\right) = 0 \text{ if } p_1 > p_2. \quad (1.12)$$

Because physicians locate symmetrically on the street, we have $l_2 = 1 - l_1$. By rewriting Equation (1.11) and (1.12), we obtain the following:

$$(1+2p_1)\big(p_2 - p_1 + t(1-2l_1)\big) = -p_1^2 + p_1, \quad (1.13)$$

$$p_2 = \frac{p_1}{2} + \frac{(p_1-1)t(1-2l_1)}{2((p_1-1)-2t(1-2l_1))}. \tag{1.14}$$

We impose particular values for the parameters and analyze whether an equilibrium exists or not. Considering the assumptions $t = 1, l_1 = 0$ and $l_2 = 1$ in Peitz (1999), we obtain a price equilibrium under $p_1 > p_2$ that $p_1 = 0.37435$ and $p_2 = 0.30632$.

Proof in Appendix.

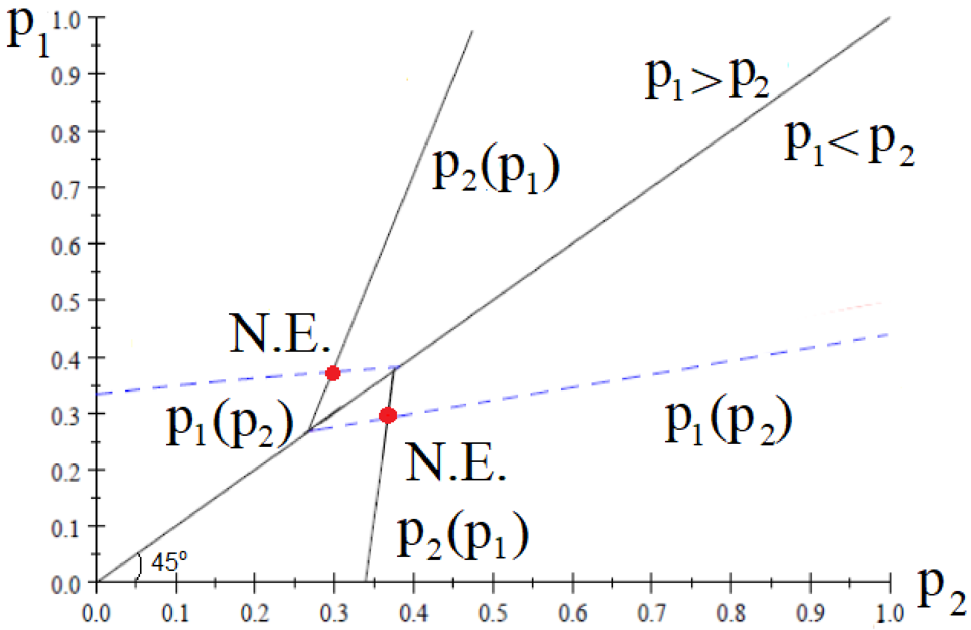

Figure 1.2: Price reaction functions of a particular case $t = 1, l_1 = 0$ and $l_2 = 1$.

In Figure 1.2, the dashed line denotes the price reaction function of physician 1 and the solid line denotes the price reaction function of physician 2. The intersections of the two reaction functions are Nash equilibria.

As there is one pair of price reaction functions from the profit maximizing physicians, we can obtain another Nash equilibrium due to the symmetry of the model if $p_1 < p_2$: $p_1 = 0.30632$ and $p_2 = 0.37435$ when $t = 1, l_1 = 0$ and $l_2 = 1$

Therefore, we find that there exists a pair of asymmetric price equilibria (Figure 1.2), which is opposite to the results in Peitz's (1999) Section 3.

1.4 Conclusion

In this study we use a Hotelling type of production differentiation model to analyze price competition between physicians. We introduce income heterogeneity to find a price equilibrium with unit demand. Transportation cost is a disutility due to the distance between a patient and a physician, but does not represent pecuniary costs. We prove the existence of an asymmetric pure strategy price equilibrium in this model for a specific case of extreme locations and unit marginal transportation cost.

1.5 Appendix

Proof of Price Equilibrium under $p_1 > p_2$.

For the case $p_1 > p_2$, the following profit functions imply:

$$\pi_1 = p_1(1-p_1)\left[\frac{p_2-p_1}{2t(l_2-l_1)} + \frac{l_1+l_2}{2}\right],$$

$$\pi_2 = p_2\left\{(1-p_2)\left[1-\frac{p_2-p_1}{2t(l_2-l_1)} - \frac{l_1+l_2}{2}\right] + (p_1-p_2)\left[\frac{p_2-p_1}{2t(l_2-l_1)} + \frac{l_1+l_2}{2}\right]\right\}.$$

Then the first order conditions are:

$$\frac{\partial\pi_1}{\partial p_1} = (1-p_1)\left(\frac{p_2-p_1}{2t(l_2-l_1)} + \frac{l_1+l_2}{2}\right) - p_1\left(\frac{p_2-2p_1+1}{2t(l_2-l_1)} + \frac{l_1+l_2}{2}\right) = 0 \text{ if } p_1 > p_2, \tag{1.11}$$

and

$$\frac{\partial\pi_2}{\partial p_2} = (1-p_2)\left(1-\frac{p_2-p_1}{2t(l_2-l_1)} - \frac{l_1+l_2}{2}\right) + (p_1-p_2)\left(\frac{p_2-p_1}{2t(l_2-l_1)} + \frac{l_1+l_2}{2}\right) +$$
$$p_2\left(-1+\frac{p_2-p_1}{2t(l_2-l_1)} + \frac{l_1+l_2}{2} + \frac{-(1-p_2)}{2t(l_2-l_1)} - \left(\frac{p_2-p_1}{2t(l_2-l_1)} + \frac{l_1+l_2}{2}\right) + \frac{p_1-p_2}{2t(l_2-l_1)}\right)$$

$$= 0 \text{ if } p_1 > p_2. \tag{1.12}$$

Physicians are bounded by zero profit constraints, which implies that $1 > p_1 > p_2$.

Inserting parameter values $t = 1, l_1 = 0$ and $l_2 = 1$ into Equation (1.11) and (1.12), we obtain a pair of price equilibrium if $p_1 > p_2$ that $p_1 = 0.37435$ and $p_2 = 0.30632$. Thus, the second order conditions are

$$\left.\frac{\partial^2\pi_1}{\partial^2 p_1}\right|_{\substack{t=1, l_1=0 \text{ and } l_2=1 \\ p_2=0.30632}} = \left.\frac{tl_1^2 - tl_2^2 + 3p_1 - p_2 - 1}{t(l_2 - l_1)}\right|_{\substack{t=1, l_1=0 \text{ and } l_2=1 \\ p_2=0.30632}} = 3p_1 - 2.30632, \qquad (1.15)$$

We can prove that $\frac{\partial\pi_1}{\partial p_1} = 1.5p_1^2 - 2.3064p_1 + 0.65316 < 0$ when $p_1 \in (0.37435,1)$. Physician 1's profit decreases monotonically until being binding by the zero profit constraint. Therefore, physician 1 earns the maximum profit when $p_1 = 0.37435$.

$$\left.\frac{\partial^2\pi_2}{\partial^2 p_2}\right|_{\substack{t=1, l_1=0 \text{ and } l_2=1 \\ p_1=0.37435}} = \left.\frac{p_1 + 2tl_1 - 2tl_2 - 1}{t(l_2 - l_1)}\right|_{\substack{t=1, l_1=0 \text{ and } l_2=1 \\ p_1=0.37435}} - 2.62565 < 0. \qquad (1.16)$$

Therefore, we obtain the profit maximizing price $p_1 = 0.37435$ and $p_2 = 0.30632$ if $p_1 > p_2$.

Q.E.D.

Chapter 2

Transparency and Semi-altruism in Provider Markets

Yiquan Gu[†] Burkhard Hehenkamp[‡] Xing Wu[§]

Abstract

Consumer-sided market transparency intensifies competition and leads to better products for consumers (lower prices, higher quality, etc.). On the other hand, providers' profits are reduced. Hence fewer firms and/or products survive in the market, which reduces consumer surplus and potentially also social welfare. In this study, we investigate this trade-off in the context of provider competition. To this end, we adopt the product differentiation model by Salop (1979) to the case of regulated prices and providers competing for patients by choosing quality and location. We investigate how the patients' information about treatment quality affects health market outcomes. We find that when transparency is low, competition is weak and providers choose zero quality. Market transparency has no effect on quality. When transparency is high, competition becomes intense and providers pick positive levels of quality in equilibrium. Higher transparency leads to higher quality, but also to lower profits. Eventually, quality does not increase with transparency due to the zero profit constraints. Equilibrium quality increases and equilibrium profits decrease in the number of firms. Taking the entry decision into account, the equilibrium number of providers decreases with the cost of entry. Social welfare remains constant when providers choose zero quality. Market transparency and the degree of semi-altruism show ambiguous effects on welfare when providers choose positive quality.

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2.1 Introduction

Over the past decades, health care systems around the world have undergone changes across a wide variety. Improving health market efficiency is the direct or indirect focus of most health policy initiatives nowadays. Many countries introduced a Diagnosis-Related Groups (DRGs)-based prospective reimbursement system intending to reduce health expenditures and increasing social welfare (Palmer & Reid, 2001). A large body of recommendations for increasing social welfare are predicated on the belief that providing information to consumers (i.e., increasing market transparency) will improve market efficiency (Schultz, 2004).

Consumer's information about price, product characteristics, etc. can affect firms' decisions about the entry and provision of quality. We define market transparency as the fraction of consumers who are informed about quality. Transparency on the consumer side may affect the competitiveness of a market. On the one hand, in equilibrium, uninformed consumers play a significant role, since providers know that these consumers rely on expectations rather than actual knowledge which, in turn, influences their demand. Transparency increases consumers' demand elasticities, and furthermore intensifies competition among providers. A common-held view is that the increased competition among providers generally has the effect of lowering prices and leads to better products for consumers (higher quality, etc.). This is beneficial for consumers and social welfare. On the other hand, due to higher transparency, competition becomes stronger, and consequently, providers' profits are reduced to zero. Hence, fewer firms and/or products survive in the market, which leads to lower consumer surplus and social welfare. The challenge for economic theory is to describe to what extent contradictory results regarding transparency can affect market outcomes.

The present paper is concerned with the effects of consumer-side transparency on product quality and general social welfare in the health care market. The existing literature primarily focuses on price competition (Salop & Stiglitz, 1977; Schultz, 2004 and Schultz, 2009). Schultz (2004) studies the effect on product differentiation in a Hotelling model with two firms competing on price. He shows that increasing transparency reduces product differentiation and improves welfare. However, price is usually regulated in the health care market, and providers compete on quality instead of price as a consequence (Arrow, 1963). The potential outcomes for health care services might differ from other price competition industries. Standard models show that in settings where consumers are poorly informed about product quality there are welfare losses due to the less-than-optimal supply of costly quality (Dranove & Satterthwaite, 1992). Nevertheless, other considerations, e.g. firms' entry decisions, may affect the provision of quality and welfare results eventually. Gu and Hehenkamp (2014) include the entry decision in a Bertrand model with imperfectly informed consumers. They illustrate that too much market transparency has a detrimental effect on consumer surplus and on social welfare. Hence, we investigate how patients' information about treatment quality affects health care market outcomes and social welfare.

We notice that in reality, health care providers care not only for their own profits but also for their patients' contentment or utilities. This phenomenon can be interpreted as characteristic for health care providers. They may obtain intrinsic utility by taking into account the consumers' welfare (Fehr & Schmidt, 2006 and McGuire, 2000). This is the main difference between general industries and health care markets. Brekke et al. (2012) show that quality may be over- or under-provided in the market equilibrium, depending on the degree of altruism when prices are regulated. However, Kolstad (2013) provides the evidence that quality increases when motivation is intrinsic. This raises the issues whether transparency and semi-altruism promote product differentiation, and whether it is beneficial or harmful for quality provision and general social welfare. Since the literature gives us different findings, it is worth looking into the consequences of market transparency under quality competition with endogenous entry.

To analyze product differentiation and providers' entry decisions, we develop a circular city model of a differentiated market with a fixed entry cost as in Salop (1979) where a fraction of patients are informed about product quality. In this context, transparency enters providers' objectives. We use the term "semi-altruism" to refer to incentives unrelated to profit and model provider behavior as maximizing their utilities instead of profits.

This paper contributes to the literature in economics on the level of transparency, semi-altruism and health care quality. There exists little evidence on quality changes with semi-altruism and transparency together in health care markets. We find that transparency and (semi-)altruism are policy substitutes. It is shown that when market transparency is too low, competition is weak and providers choose zero quality. Semi-altruism increases equilibrium utility, but has no effect on profit. Furthermore, we also illustrate that physicians provide positive qualities when transparency increases beyond a cutoff value. Due to a larger number of providers, transparency as well as semi-altruism increases quality, but decreases profit as well as provider surplus. Finally, it is worth noting that under certain conditions, transparency reduces welfare if providers are semi-altruistic.

This paper is structured as follows. Section 2.2 is devoted to the presentation of the model. Section 2.3 analyzes the equilibrium quality, utility and entry. Social welfare is analyzed in Section 2.4. The last section concludes.

2.2 The Model

We adapt a product differentiation model by Salop (1979) with a regulated price p where a continuum of patients are located on a circle. There are two stages in this model. Plenty of firms with an outside opportunity of zero can enter the market with a fixed entry cost F.

> *Stage 1: A large number of ex ante potential providers decide about entry. After paying entry cost F, entrants are then distributed randomly at equidistant locations on the circle.*
>
> *Stage 2: Given n providers have entered, they compete for patients by choosing quality q.*

Let us suppose there is a measure one of patients, each of which desires to visit one provider at one time and at most, receives one of some medical treatments. There exist two different types of patients. Patients of a proportion $\varphi \in (0,1)$ are fully aware of product qualities, while the others are not. The price is regulated. Providers are located evenly on the circle and provide possible differentiated treatments. Hence, the informed patients know qualities and seek treatments from the physician that provides the optimal combination of quality and location. All other uninformed patients $(1 - \varphi)$ seek treatment from the nearest physician.

We assume that the health care market is fully covered. Then each patient's utility from getting treatment is given as follows:

$$u = r + q_i - t|x_i - \theta|, \tag{2.1}$$

where $r > 0$ denotes the reservation utility, $q_i \geq 0$ and $x_i \in [0,1]$ provider i's quality and location, and $\theta \in [0,1]$ the patient's location. We assume that r is sufficiently large to make sure that the market is entirely covered. Then the entire market demand is always constant. With n providers in the market, the distance between any two neighboring providers is 1/n. Transportation costs are linear at a rate $t > 0$.

Suppose that providers serve both informed and uninformed patients. Treatments of different qualities are provided to all patients with the identical constant marginal cost $c, c \in (0,1)$. Quality decisions by the providers are made separately. Provider i's material profit is

$$\pi_i = (p - cq_i)d_i, \tag{2.2}$$

where p is the fixed DRG-based price which is regulated, d_i the demand for physician i, and c denotes the marginal cost of per unit per patient quality.

The provider's demand, d_i, is determined by the quality of provider i as well as the quality choices of competing providers in that market. Providers cannot discriminate patients. The only information they have is the proportion φ of informed patients. This means that when some suppliers provide the lowest zero quality, they may lose the informed patients. Nevertheless, they can still obtain positive demand from the uninformed patients and make strictly positive profits on them.

Besides of imperfect information on quality instead of price, another defining feature of health care markets is that providers are semi-altruistic. Differing from most industries, health care providers take their patients' well-being into account when medical decisions are made. To reflect this, we implement semi-altruism in addition to material profits into the provider's utility function, which is given by

$$\max_{q_i} \Psi_{i\alpha} = \pi_i + \alpha\,(r + q_i)d_i - F$$

$$= (p + \alpha r - (\mathrm{c} - \alpha)q_i)d_i - F \tag{2.3}$$

$$s.t. \pi_i \geq 0,$$

where α denotes the semi-altruism degree, $\alpha \in (0, c)$.

For the existence of altruistic providers, utilities are maximized by choosing quality levels under a necessary constraint of non-negative material profits. The parameter α plays a key role in our analysis, as it measures the semi-altruism degree. To keep our analysis tractable, we assume that all providers share an identical semi-altruism degree.

2.3 Analysis

We use backward induction to analyze this two-stage game. We first study a provider's quality decision in the second stage after it has entered the market. In the first stage, a potential provider enters if his expected profit from operating in the market at least covers the entry cost F. This condition ultimately determines the number of potential entrants who are able to survive in this market.

2.3.1 Quality Equilibrium

In this part we study the optimal quality that provider i should choose in the second stage when there are n providers existing in the market. We derive an entrant's expected utility by analyzing the providers' quality strategies after they have entered.

As uninformed patients buy from the nearest provider, each provider expects to receive a demand of $(1-\varphi)\frac{1}{n}$ from these patients when there are n active providers. Informed patients take treatment from the provider that offers them maximum utility. Thereupon, between any two adjacent providers i and $i+1$ there exists an informed patient who is indifferent between taking treatment from either of these two:

$$r + q_i - t\left(\hat{\theta}_{i,i+1} - x_i\right) = r + q_{i+1} - t\left(x_{i+1} - \hat{\theta}_{i,i+1}\right). \tag{2.4}$$

Solving this equation we get the location of the patient who is indifferent between provider i and provider $i+1$

$$\hat{\theta}_{i,i+1} = \frac{q_i - q_{i+1}}{2t} + \frac{x_i + x_{i+1}}{2}. \tag{2.5}$$

Summing up the informed and uninformed patients, the demand for provider i is given as

$$d_i = \varphi(\theta_{i,i+1} - \theta_{i-1,i}) + (1-\varphi)\frac{1}{n}$$

$$= \varphi\left(\frac{2q_i - q_{i-1} - q_{i+1}}{2t} + \frac{x_{i+1} - x_{i-1}}{2}\right) + (1-\varphi)\frac{1}{n}. \quad (2.6)$$

It can be easily seen from Equation (2.6) that the demand of provider i is increasing in his own quality and decreasing in others' qualities.

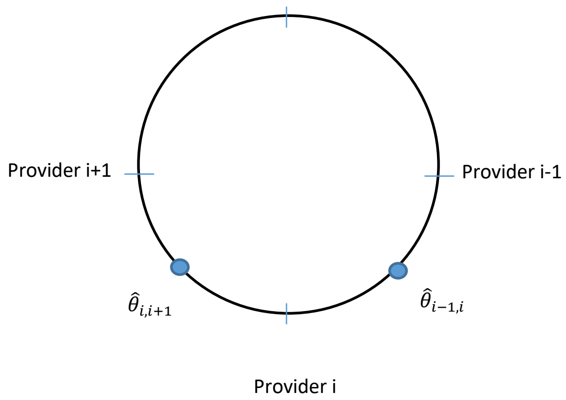

Figure 2.1: Providers' and patients' locations.

Figure 2.1 presents a graphical illustration. In Figure 2.1, several providers are located evenly on a circle. Between provider $i-1$ and provider i, the informed indifferent patient locates at $\hat{\theta}_{i-1,i}$, while the informed indifferent patient between provider i and provider $i+1$ locates at $\hat{\theta}_{i,i+1}$.

Provider i solves the following problem given other providers' qualities:

$$\max_{q_i} \Psi_{i\alpha} = \left(p + \alpha r - (\mathrm{c} - \alpha)q_i\right)d_i - F \quad (2.3)$$

$$s.t. \pi_i \geq 0.$$

We assume that marginal costs are constant and quality is simultaneously and independently chosen. Suppose n providers have entered the market, then the quality that maximizes provider i's utility is reached when

$$q_i = \frac{p + r\alpha}{2(c-\alpha)} + \frac{q_{i-1} + q_{i+1}}{4} - \frac{t}{2n\varphi}. \quad (2.7)$$

Proof. Inserting indifferent patients' locations and demand into provider i's objective function yields,

$$\max_{q_i} \Psi_{i\alpha} = (p + \alpha r - (\mathrm{c} - \alpha)q_i)d_i - F$$

$$= (p + \alpha r - (\mathrm{c} - \alpha)q_i)\left[\varphi\left(\frac{2q_i - q_{i-1} - q_{i+1}}{2t} + \frac{x_{i+1} - x_{i-1}}{2}\right) + (1 - \varphi)\frac{1}{n}\right] - F.$$

The first order condition gives us

$$\frac{\partial \Psi_{i\alpha}}{\partial q_i} = 0.$$

$$\Leftrightarrow \frac{2t(\alpha - c) + 2ct\varphi + 2np\varphi - 2t\varphi\alpha - n\varphi\alpha(q_{i-1} + q_{i+1})}{2nt}$$

$$+ \frac{2nr\varphi\alpha + n\varphi(cq_{i-1} + cq_{i+1} + 4\alpha q_i - 4cq_i)}{2nt}$$

$$+ \frac{nt\varphi(\alpha x_{i+1} - \alpha x_{i-1} + cx_{i-1} - cx_{i+1})}{2nt} = 0.$$

The second order condition gives us

$$\frac{\partial^2 \Psi_{i\alpha}}{\partial q_i^2} = -\frac{2c\varphi}{t} < 0.$$

Since providers are distributed evenly on the circle after entry, this yields

$$x_{i+1} - x_{i-1} = \frac{2}{n}.$$

By solving the above first order condition for q_i, we obtain

$$q_i = \frac{2t\alpha - 2ct + 2np\varphi - n\varphi\alpha q_{i-1} - n\varphi\alpha q_{i+1} + 2nr\varphi\alpha + cn\varphi q_{i-1} + cn\varphi q_{i+1}}{4cn\varphi - 4n\varphi\alpha}$$

$$= \frac{p + r\alpha}{2(c - \alpha)} + \frac{q_{i-1} + q_{i+1}}{4} - \frac{t}{2n\varphi}.$$

Q.E.D.

In a symmetric equilibrium $q_{i-1} = q_i = q_{i+1}$, Equation (2.7) gives us the equilibrium quality:

$$\tilde{q} = \frac{p+r\alpha}{c-\alpha} - \frac{t}{n\varphi}. \tag{2.8}$$

The equilibrium quality declines with the marginal cost of quality and transportation cost, and increases with a regulated price, market transparency and the degree of semi-altruism.

If market transparency is sufficiently low, Equation (2.8) becomes negative. There exist two independent constraints, non-negative quality and non-negative profit, which correspond to two different levels of quality. As quality is non-negative, zero quality is the minimum quality by regulation. All providers expect non-negative material profits. Thus, the maximum quality is constrained by the zero material profit condition.

Therefore, we set Equation (2.8) equal to zero and solve for the threshold of market transparency. We obtain

$$\hat{\varphi} = \frac{t(c-\alpha)}{np+nr\alpha}. \tag{2.9}$$

Equilibrium quality is then characterized by:

$$q^* = \begin{cases} \frac{p+r\alpha}{c-\alpha} - \frac{t}{n\varphi}, & \text{if } \varphi > \hat{\varphi} \\ 0, \text{otherwise.} \end{cases} \tag{2.10}$$

Proposition 2.1 *When market transparency is larger than* $\hat{\varphi} = \frac{t(c-\alpha)}{np+nr\alpha}$, *equilibrium quality increases with market transparency and the degree of semi-altruism up to the zero profit constraints become binding. When* $\varphi \leq \hat{\varphi}$, *equilibrium quality remains at zero and does not change with a marginal increase in either transparency or semi-altruism.*

Proof. If $\varphi > \hat{\varphi}$, we calculate the derivative of quality with respect to market transparency and semi-altruism separately:

$$\frac{dq^*}{d\varphi} = \frac{t}{n\varphi^2} > 0, \text{ if } \varphi > \hat{\varphi}$$

$\frac{dq^*}{d\alpha} = \frac{p+cr}{(c-\alpha)^2} > 0$, if $\varphi > \hat{\varphi}$.

If $\varphi \leq \hat{\varphi}$, because of $q^* = 0$, a small increase in transparency or semi-altruism does not lead to any change in quality.

Q.E.D.

When transparency is sufficiently large, any increase in transparency leads to more intensive competition given a fixed number of providers. As a result, equilibrium quality rises. Semi-altruism plays the same role as transparency. When transparency is low, no patient can detect quality at this sufficiently low level of transparency. Hence, no provider has an incentive to costly offer a higher quality than the bare minimum.

Alternatively, we can state that from Equation (2.9) quality is positive if and only if $n > \frac{t(c-\alpha)}{\hat{\varphi}(p+r\alpha)}$. The intuition is that given the level of market transparency, quality is positive when competition is sufficiently intense.

The equilibrium material profits and equilibrium utilities of providers are then given by

$$\pi_i = \begin{cases} \frac{ct}{\varphi n^2} - \frac{\alpha(p+cr)}{n(c-\alpha)}, & \text{if } \varphi > \hat{\varphi} \\ \frac{p}{n}, & \text{otherwise.} \end{cases} \tag{2.11}$$

$$\Psi_{i\alpha} = \begin{cases} \frac{t(c-\alpha)}{\varphi n^2} - F, & \text{if } \varphi > \hat{\varphi} \\ \frac{p+\alpha r}{n} - F, & \text{otherwise.} \end{cases} \tag{2.12}$$

Proof. For the equilibrium material profits, we insert equilibrium quality back into Equation (2.2) and obtain

$$\pi_i = (p - cq_i)d_i = \left(p - c\left(\frac{p+r\alpha}{c-\alpha} - \frac{t}{n\varphi}\right)\right)\frac{1}{n}$$

$$= \frac{-ct\alpha + c^2t - np\varphi\alpha - ncr\varphi\alpha}{\varphi n^2(c-\alpha)}$$

$$= \frac{ct}{\varphi n^2} - \frac{\alpha(p + cr)}{n(c - \alpha)} \text{ if } \varphi > \hat{\varphi},$$

$$\pi_i = (p - cq_i)d_i = \frac{p}{n} \text{ if } \varphi \leq \hat{\varphi}.$$

For equilibrium utilities, we insert equilibrium quality back into Equation (2.3) and obtain

$$\Psi_{i\alpha} = (p - cq_i)d_i + \alpha\,(r + q_i)d_i - F$$

$$= \frac{p + \alpha r - (c - \alpha)\dfrac{n\varphi p + n\varphi r\alpha + t\alpha - tc}{n\varphi c - n\varphi\alpha}}{n} - F$$

$$= \frac{t(c - \alpha)}{\varphi n^2} - F \text{ if } \varphi > \hat{\varphi},$$

$$\Psi_{i\alpha} = (p - cq_i)d_i + \alpha\,(r + q_i)d_i - F$$

$$= \frac{p+\alpha r}{n} - F \text{ if } \varphi \leq \hat{\varphi}.$$

Q.E.D.

When transparency is low $\varphi \leq \hat{\varphi}$, competition is weak and providers choose zero quality. Thus, a marginal increase in market transparency has no effect on equilibrium quality, providers' material profits and their utilities. Providers earn weakly positive profits. We notice that semi-altruism can increase equilibrium utility. However, it has no effect on equilibrium quality and material profits.

When transparency rises, providers respond by increasing quality to attract patients and hence, competition intensifies. There are two effects of increasing transparency. First, competition for informed patients strengthens and quality increases. As transparency and altruism work as policy substitutes, higher transparency leads to a higher quality provision in equilibrium if, and only if, the firms are sufficiently altruistic. Second, with increasing transparency, profits decline for all providers, and eventually reaching zero. Incentives for quality provision are dampened by zero profit constraints. Equilibrium quality and profit do not change with transparency after zero profit constraints are binding. To summarize the situation of high transparency, an increase in transparency raises equilibrium quality, but decreases material profit and utility. With increasing quality, profits become smaller. Semi-altruism plays the same role as transparency, i.e. increases quality, but decreases material profit and utility.

2.3.2 Entry Equilibrium

Let n be the number of potential entrants in the first stage. Suppose there exists an entry cost F which has to be paid before entry. In the first stage, we assume that the fixed cost F of entry is such that at least two providers enter this market. We only consider pure entry strategies, which means that the expected providers' material profit should be equal to the entry cost in a free entry equilibrium. We aim to identify the cutoff level of F such that providers enter with zero or positive quality.

When zero quality is chosen after providers enter, we have $\pi_i = \frac{p}{n} = F$. This equilibrium n should satisfy the zero quality condition $\varphi \leq \frac{t(c-\alpha)}{np+nr\alpha}$, which can be rewritten as $F \geq \frac{\varphi p(p+r\alpha)}{t(c-\alpha)}$.

The number of potential entrants is given by

$$n = \frac{p}{F} \text{ when } \frac{\varphi p(p+r\alpha)}{t(c-\alpha)} \leq F \leq \frac{p}{2}. \tag{2.13}$$

Hence, the equilibrium number of entrants does not depend on market transparency and the degree of semi-altruism. It decreases with the cost of entry and increases with the regulated price. The solution is valid only if at least two firms enter the market. If $n < 2$ it is a monopoly game. This implies $\pi_i = p \geq F$, where the only one provider enters if and only if the regulated price is larger or equal to the entry cost, irrespective of his own semi-altruism degree and market transparency.

When $F < \frac{\varphi p(p+r\alpha)}{t(c-\alpha)}$, providers enter with positive quality. The expected material profit should be equal to the entry cost in a free entry equilibrium:

$$\pi_i = \frac{ct}{\varphi n^2} - \frac{\alpha(p+cr)}{n(c-\alpha)} = F. \tag{2.14}$$

Solving Equation (2.14) for n, the only positive solution gives us the equilibrium number of entrants under a positive quality game, which is

$$n = \frac{\sqrt{(p+cr)^2\varphi^2\alpha^2 + 4Fct\varphi(c-\alpha)^2}}{2F\varphi(c-\alpha)} - \frac{\alpha(p+cr)}{2F(c-\alpha)} \text{ when } F < \frac{\varphi p(p+r\alpha)}{t(c-\alpha)}. \quad (2.15)$$

Combining Equation (2.13) and Equation (2.15), we obtain the following result.

Proposition 2.2 *The equilibrium number of providers*

(i) $n^* = \frac{p}{F}$ *if* $\frac{\varphi p(p+r\alpha)}{t(c-\alpha)} \leq F \leq \frac{p}{2}$, *and does not depend on market transparency nor semi-altruism;*

(ii) $n^* = \frac{\sqrt{(p+cr)^2\varphi^2\alpha^2 + 4Fct\varphi(c-\alpha)^2}}{2F\varphi(c-\alpha)} - \frac{\alpha(p+cr)}{2F(c-\alpha)}$ *if* $F < \frac{\varphi p(p+r\alpha)}{t(c-\alpha)}$, *and decreases with market transparency and semi-altruism.*

Proof in Appendix.

The intuition is that the entry cost is sunk at the second stage when providers decide about quality. Physicians provide zero quality to earn positive profits to cover the entry cost if F is sufficiently high. Therefore, neither market transparency nor semi-altruism play a role in the equilibrium number of entry. Providers offer positive quality if entry cost $F < \frac{\varphi p(p+cr)}{t(c-\alpha)}$. As the market transparency or semi-altruism degree increases, the equilibrium profit decreases. Hence, not all providers are capable of surviving in this market. The equilibrium number of entrants declines. This process stops until only one provider remains. Then the only remaining provider supplies as a monopolist.

For patients the effects are more complicated. On the one hand, increasing transparency and semi-altruism can directly increase their utilities as the equilibrium quality increases, which is beneficial for them. On the other hand, increasing transparency drives down the equilibrium number of providers, which leads to a longer distance to visit a physician. The reduction in equilibrium number of entrants translates into higher transportation costs. Once transparency is below a certain level, the number of providers is determined by the regulated price and the entry cost only. Alternatively, other providers serve a corresponding zero quality treatment. This is harmful both for patients and social welfare. Finally, patients may face a trade-off of a positive quality treatment with a higher transportation cost and a zero quality treatment with a lower transportation cost.

2.4 Social Welfare

In this section we combine the entry effect and quality effect together to examine the impact on social welfare.

We define the objective of the government as the one that maximizes the utilitarian welfare function, which is the sum of aggregate provider surplus and patient surplus. Since providers are uniformly distributed on a circle, total transportation costs are determined by equilibrium entry.

Social welfare is thus:

$$W = \sum_{i=1}^{n}(r + q_i - t|x_i - \theta|)d_i - \sum_{i=1}^{n}(cq_i d_i) - nF \tag{2.16}$$

Note that provider utility from altruism is not accounted for in social welfare. When the entry cost is relatively high ($\frac{\varphi p(p+r\alpha)}{t(c-\alpha)} \leq F \leq \frac{p}{2}$), providers serve zero quality at the second stage.

Substituting the equilibrium number of entrants, the social welfare function becomes

$$W = r + q - \frac{t}{4n} - cq - nF = r - p - \frac{tF}{4p}. \tag{2.17}$$

It is apparent from Equation (2.17) that social welfare does not depend on transparency and semi-altruism. It increases with the reservation utility r, but decreases with transportation cost and entry cost with price regulation. Without considering semi-altruism and transparency, a lower entry cost and marginal transportation cost implies higher social welfare. Additionally, a higher reservation utility can increase the patient surplus and social welfare.

However, we notice that entry cost works via two channels. One way is that an increasing entry cost decreases the total provider surplus directly. The other is that an increasing entry cost declines the equilibrium number of providers, which leads to larger transportation losses for patients. Both effects of increasing the entry cost are harmful for social welfare. When the entry cost is high, equilibrium quality is zero. Social welfare decreases with the entry cost, but not depends on the zero quality. Furthermore, if the cost of entry drops down to the cutoff value of a positive quality subgame, which is equivalent to $F < \frac{\varphi p(p+r\alpha)}{t(c-\alpha)}$, then social welfare depends both on the entry cost and the equilibrium quality.

Proposition 2.3 *If* $\frac{\varphi p(p+r\alpha)}{t(c-\alpha)} \leq F \leq \frac{p}{2}$, *market transparency and semi-altruism do not affect social welfare. If* $F < \frac{\varphi p(p+r\alpha)}{t(c-\alpha)}$, *market transparency and the degree of semi-altruism show ambiguous effects on welfare.*

When $\frac{\varphi p(p+r\alpha)}{t(c-\alpha)} \leq F \leq \frac{p}{2}$, equilibrium quality remains at zero and does not change with a marginal increase in either transparency or semi-altruism. Therefore, market transparency and semi-altruism do not affect social welfare.

When $F < \frac{\varphi p(p+r\alpha)}{t(c-\alpha)}$, physicians provide positive quality. We know that increasing market transparency and semi-altruism can raise equilibrium quality, which is beneficial for patients. But simultaneously, transparency decreases the equilibrium number of providers, which is harmful for patients due to less competition and higher transportation costs. Furthermore, the provider surplus diminishes with increasing transparency. When the quality gain dominates the profit loss and transportation costs, market transparency and semi-altruism have positive effects on welfare. But if the quality gain cannot compensate the providers' loss and patients' transportation loss, increasing transparency and semi-altruism decrease social welfare. Hence, the total impact on welfare depends on which effect dominates.

In the remainder of this section we specify different parameters, in order to describe different possible cases. We illustrate the two opposite effects via the following example with parameter values $c = 1, t = 1, p = 1, r = 10$. In Figure 2.2, we show the relationship between transparency and the equilibrium number of providers, equilibrium quality, and welfare when $\alpha = 0.1, F = 0.1$. We can see from Figure 2.2 that with transparency the equilibrium number of providers decreases and equilibrium quality increases. However, the number of entrants is bounded by a positive quality condition, which corresponds to the gray solid line. On the left range of the gray solid line, the equilibrium number of providers is equivalent to ten, the equilibrium quality is zero, and welfare remains constant. On the right area of the gray solid line, the equilibrium quality is positive and rises with transparency. When the market becomes more transparent, competition intensifies and the quality increases. Consequentially, fewer providers stay in the market. The effect of quality gain on welfare dominates the negative effect of less entry when transparency is not very high. Nevertheless, along with the increasing transparency, too few providers enter. Beyond a certain point, which is the welfare maximized transparency (corresponding to the black dashed line), although equilibrium quality still increases, the negative entry effect dominates the positive quality effect. Consequently, welfare declines due to under-entry.

Figure 2.3 gives another numerical example to show how the market transparency values affect market results. When $\alpha = 0.5,\ F = 0.1$, in comparison to Figure 2.2, the semi-altruism degree is higher in this example. As a result, the welfare optimal transparency is smaller. There is an immediate effect of a larger semi-altruism degree. When α is larger, the provider's utility increases which is beneficial for welfare. Since providers are more altruistic, excessive provision for quality occurs when transparency is still low. Hence, the welfare optimal transparency decreases.

In Figure 2.4, we focus on the role of semi-altruism. We show an example of the equilibrium number of providers, quality, and welfare when $\varphi = 0.1, F = 0.1$. The equilibrium number of providers decreases and equilibrium quality increases with transparency. The intuition is that providers serve higher quality when they are more altruistic, which leads to a lower profit margin. As a result, fewer providers survive in the market. However, there are two opposing effects on welfare at work, a direct effect and an indirect one. The direct effect is the immediate effect of increased semi-altruism. When providers become more altruistic, the provider surplus increases, which is beneficial for welfare. The indirect effect is that when providers become more altruistic, competition becomes more intensive and the equilibrium number of providers decreases. Hence, the transportation cost increases, which has a negative effect on welfare. Therefore, the total effect of semi-altruism on welfare increases when the semi-altruism degree is low and decreases when it is high.

In comparison to Figure 2.4, Figure 2.5 gives an additional example of semi-altruism when the market is more transparent. When $\varphi = 0.5,\ F = 0.1$, the welfare optimal semi-altruism is smaller. When market transparency is larger, competition among providers is more intensive. Providers supply positive quality even when they are not very altruistic. The negative entry effect dominates the positive quality effect when the semi-altruism degree is still low. Hence, the welfare optimal semi-altruism is lower when the market is more transparent.

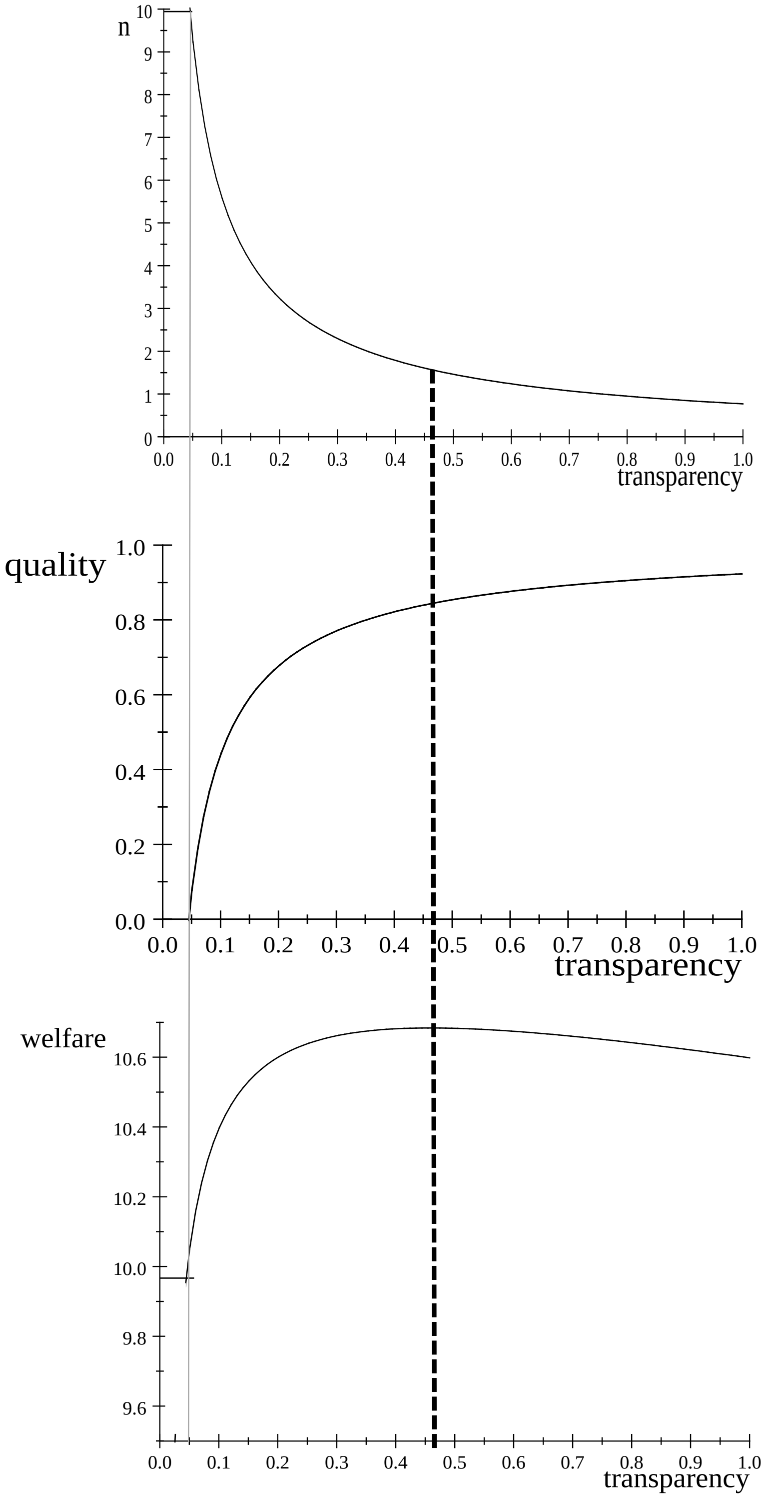

Figure 2.2: Equilibrium number of providers, quality, and welfare when $\alpha = 0.1$, $F = 0.1$.

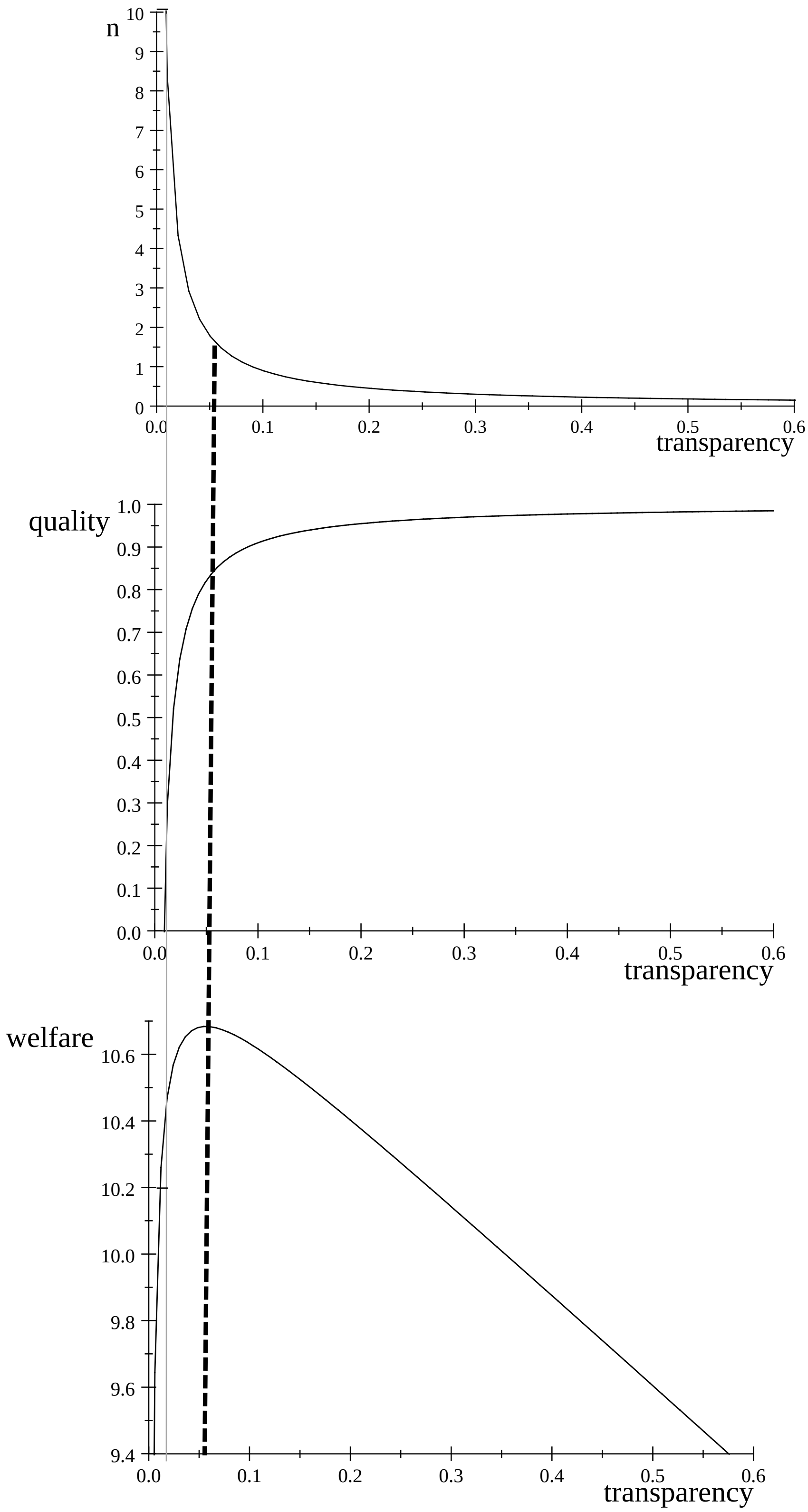

Figure 2.3: Equilibrium number of providers, quality, and welfare when $\alpha = 0.5, F = 0.1$.

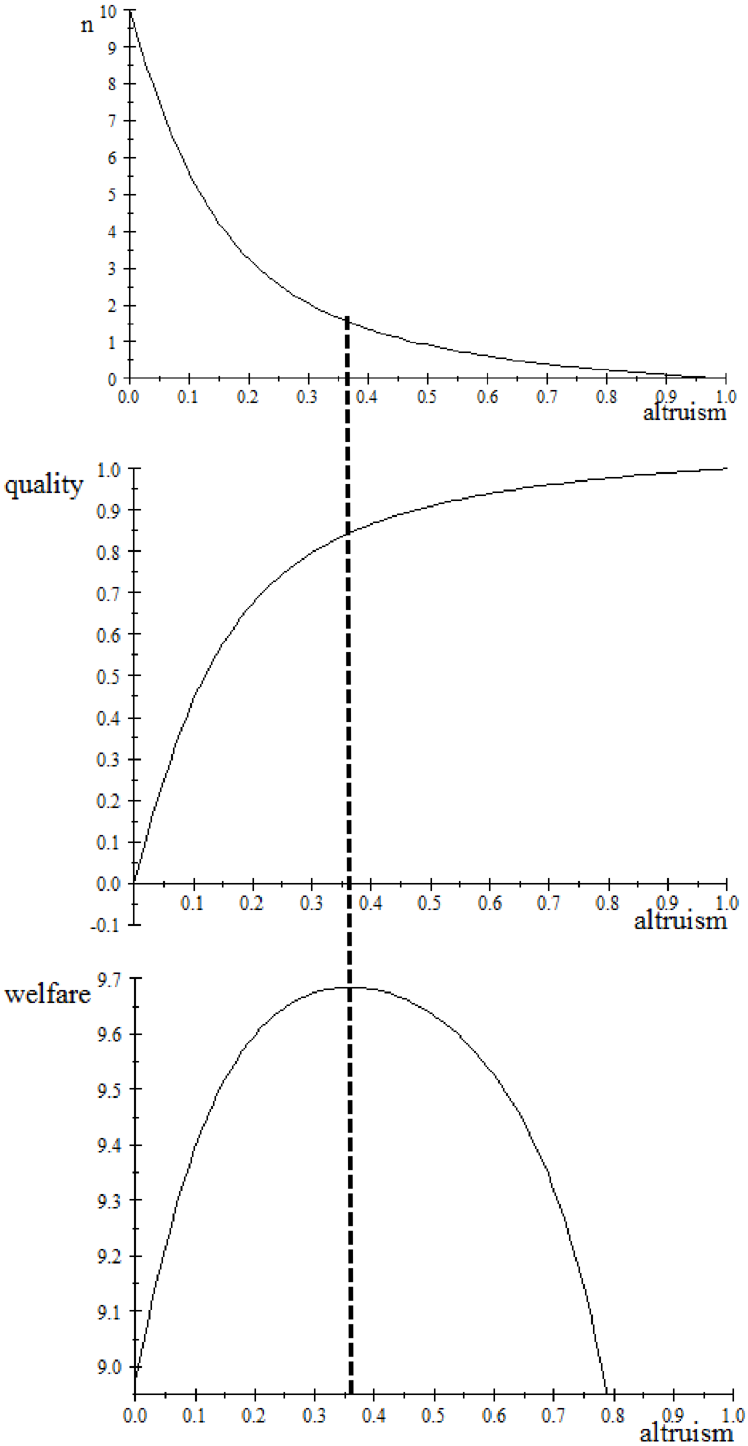

Figure 2.4: Equilibrium number of providers, quality, and welfare when $\varphi = 0.1$, $F = 0.1$.

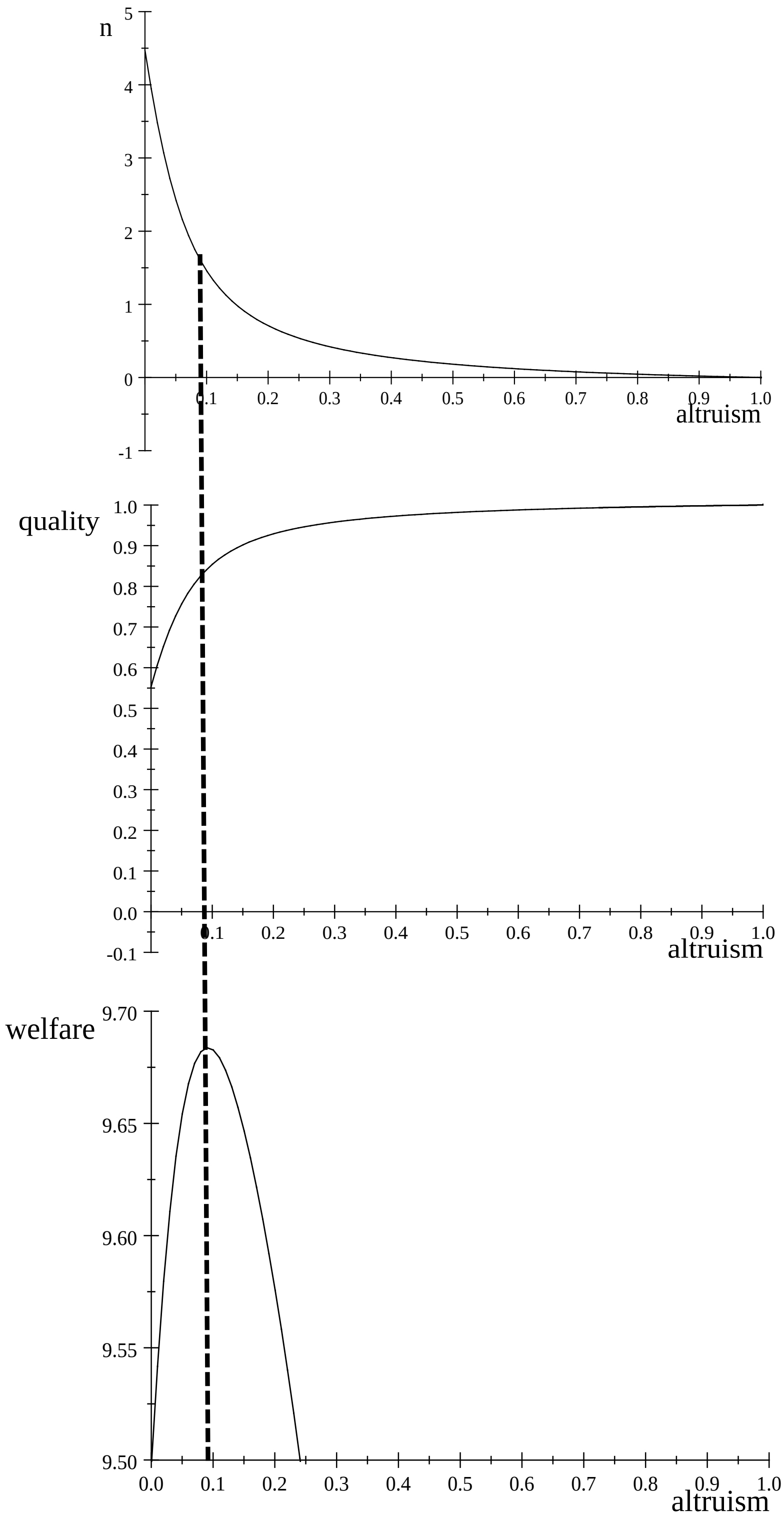

Figure 2.5: Equilibrium number of providers, quality, and welfare when $\varphi = 0.5$, $F = 0.1$.

From the four examples above, we can summarize that welfare first increases and then decreases with semi-altruism and transparency. Semi-altruism and transparency works as policy substitutes. Higher semi-altruism and market transparency is not always good for social welfare.

2.5 Conclusion

In this study we have shown that transparency on the patient side affects the competitiveness of a health care market. Our analysis has offered two sets of insights. First, when market transparency is too low, competition is weak and providers choose zero quality. Transparency plays no role for equilibrium quality, equilibrium utility, the equilibrium number of entrants, and social welfare. Semi-altruism increases equilibrium utility, but has no effect on quality and material profit under this circumstance. Because only few patients can detect quality at this low market transparency, providers have little motivation to provide positive-quality treatments. Then zero quality is chosen after providers enter the market. A small increase in transparency and semi-altruism has no effect on social welfare.

Second, when the market is sufficiently transparent, all physicians provide positive quality. More transparent markets are characterized by higher quality. This leads to more intensive competition among providers. An increase in transparency raises equilibrium quality, but decreases providers' profits as well as their utilities. Semi-altruism has the same effects on quality, providers' profits and utilities. The equilibrium number of providers decreases with market transparency and the degree of semi-altruism. However, the relationship between transparency and social welfare is theoretically ambiguous when providers are semi-altruistic. Patients prefer high transparency as it makes the market more competitive, although it reduces the equilibrium number of entrants. Less entry leads to a higher average transportation cost for patients. As long as the quality gains are larger than transportation losses, patients favor more transparency to less. Under certain conditions, quality gains cannot compensate a lower number of entrants. In this case, market transparency reduces social welfare if providers are semi-altruistic. Higher transparency is not always beneficial for welfare.

Our contribution is that positive quality effects of transparency may be dampened by less entry. One policy implication of this result is that policy makers who are worried about over-provision of quality in the health care markets should actually allow altruistic providers, usually public hospitals, to supply health care treatments, but only if the providers are not too altruistic, i.e. sufficiently profit-oriented.

2.6 Appendix

Proof of Proposition 2.2

(1) If $\frac{\varphi p(p+r\alpha)}{t(c-\alpha)} \leq F \leq \frac{p}{2}$,

$n^* = \frac{p}{F} > 0.$

(2) If $F < \frac{\varphi p(p+r\alpha)}{t(c-\alpha)}$,

$$n^* = \frac{\sqrt{(p+cr)^2\varphi^2\alpha^2 + 4Fct\varphi(c-\alpha)^2}}{2F\varphi(c-\alpha)} - \frac{\alpha(p+cr)}{2F(c-\alpha)}$$

$$= \frac{\sqrt{(p+cr)^2\varphi^2\alpha^2 + 4Fct\varphi(c-\alpha)^2}}{2F\varphi(c-\alpha)} - \frac{\sqrt{(p+cr)^2\varphi^2\alpha^2}}{2F\varphi(c-\alpha)}$$

$> 0.$

$\frac{dn^*}{d\varphi} = -\frac{ct(c-\alpha)}{\varphi A} < 0,$

$\frac{dn^*}{d\alpha} = \frac{c}{2FA}\frac{p+cr}{(c-\alpha)^2}\left(\varphi\alpha(p+cr) - \sqrt{\varphi^2\alpha^2(p+cr)^2 + 4Fct\varphi(c-\alpha)^2}\right) < 0$, where,

$A = \sqrt{4Ftc^3\varphi + c^2r^2\varphi^2\alpha^2 - 8Ftc^2\varphi\alpha + 2cpr\varphi^2\alpha^2 + 4Ftc\varphi\alpha^2 + p^2r^2\alpha^2} > 0.$

Therefore, n^* decreases with φ and α.

Next we have to prove that $n^* = \frac{\sqrt{(p+cr)^2\varphi^2\alpha^2+4Fct\varphi(c-\alpha)^2}}{2F\varphi(c-\alpha)} - \frac{\alpha(p+cr)}{2F(c-\alpha)}$ reduces to $\frac{p}{F}$ when $F = \frac{\varphi p(p+r\alpha)}{t(c-\alpha)}$.

Let $n^* = \frac{\sqrt{(p+cr)^2\varphi^2\alpha^2+4Fct\varphi(c-\alpha)^2}}{2F\varphi(c-\alpha)} - \frac{\alpha(p+cr)}{2F(c-\alpha)} = \frac{p}{F}$.

We obtain

$$\frac{\sqrt{(p+cr)^2\varphi^2\alpha^2+4Fct\varphi(c-\alpha)^2}}{2F\varphi(c-\alpha)} = \frac{\alpha(p+cr)}{2F(c-\alpha)} + \frac{p}{F}$$

$$\Leftrightarrow \frac{(p+cr)^2\varphi^2\alpha^2+4Fct\varphi(c-\alpha)^2}{4F^2\varphi^2(c-\alpha)^2} = \frac{\alpha^2(p+cr)^2}{4F^2(c-\alpha)^2} + \frac{p^2}{F^2} + \frac{p\alpha(p+cr)}{F^2(c-\alpha)}$$

$$\Leftrightarrow (p+cr)^2\varphi^2\alpha^2 + 4Fct\varphi(c-\alpha)^2$$

$$= \varphi^2\alpha^2(p+cr)^2 + 4\varphi^2p^2(c-\alpha)^2 + 4\varphi^2p\alpha(p+cr)(c-\alpha)$$

$$\Leftrightarrow Fct(c-\alpha) = \varphi p^2(c-\alpha) + \varphi p\alpha(p+cr)$$

$\Leftrightarrow \frac{\varphi p(p+r\alpha)}{t(c-\alpha)}ct(c-\alpha) = \varphi p^2(c-\alpha) + \varphi p\alpha(p+cr)$ when $F = \frac{\varphi p(p+r\alpha)}{t(c-\alpha)}$

$\Leftrightarrow c(p+r\alpha) = pc + cr\alpha$, which is always satisfied.

Therefore, $n^* = \frac{\sqrt{(p+cr)^2\varphi^2\alpha^2+4Fct\varphi(c-\alpha)^2}}{2F\varphi(c-\alpha)} - \frac{\alpha(p+cr)}{2F(c-\alpha)}$ reduces to $\frac{p}{F}$ when $F = \frac{\varphi p(p+r\alpha)}{t(c-\alpha)}$.

Q.E.D.

Chapter 3

Market Competition Between Heterogeneously Altruistic Providers

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Abstract

In health care markets, physicians are intrinsically motivated and compete on quality to maximize their utilities. We investigate to which extent physician altruism affects outcomes in a partially transparent health care market. We introduce altruism heterogeneity into a duopoly model of quality competition and fix physicians' locations to study the effects on product differentiation in a circular city framework. It is shown that transparency and semi-altruism are policy substitutes. Without competition, physicians provide treatments at the zero quality level even when they are altruistic. Market competition (transparency) can help but only when physicians are sufficiently altruistic. Our findings indicate that the effect of altruism on welfare is ambiguous. Too high altruism is not always beneficial for social welfare. Welfare decreases with altruism if the marginal cost is too high and the regulated price is low.

JEL classification: D21, D64, L11, I15

Keywords: Altruism Heterogeneity, Quality Competition, Welfare

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3.1 Introduction

In health care markets, physicians usually play an important role when medical decisions are made. A crucial feature of health care markets is that providers are altruistic, where physicians take their patients' health or well-being into account. Most economic models are based on the self-interest hypothesis which assumes that material self-interest exclusively motivates all people. Many influential economists have illustrated that physicians are motivated differently, which is called intrinsic motivation (Kolstad, 2013). Physicians take patients' well-being into account and make trade-offs when it comes to their own profits and patients' utilities. They obtain additional intrinsic utility by considering the patients' welfare in comparison to other product suppliers. A similar assumption is used by Brekke et al. (2012) in the context of non-profit firms. They study incentives for cost containment and quality provision by altruistic firms facing profit constraints. They show that depending on the degree of altruism, welfare can be improved with price regulation. A large body of evidence gathered by experimental economists and psychologists in recent years, furthermore, indicates that concerns for altruism, fairness, and reciprocity strongly motivate many people (Godager & Wiesen, 2013; Fehr & Fischbacher, 2003; Bolton & Ockenfels, 2000; Fehr & Schmidt, 1999). This study focuses on whether there exists a level of altruism that is optimal for social welfare. And subsequently, how altruism might affect the market outcomes.

Another feature of health care markets is non-transparency, where information about quality is not shared equally between physicians and patients. The literature dealing with physician behavior in health economics has been prolific (Arrow, 1963; Pauly, 1980; Fuchs, 1974; and McGuire, 2000). However, it has mainly focused on markets where both suppliers and consumers have complete information. However, not all patients could assess treatments quality levels. Patients could make better decisions and obtain better products if they were better informed. Generally, transparency on the consumer side is thought to be beneficial for the functioning of the markets. Practitioners seem to consider an increased market transparency on the customer side as an appropriate means to promote competition (Rasch & Herre, 2013). Schultz (2004) studies market transparency in a Hotelling (1929) market with unit consumer demand and quadratic transportation cost. Although firms would like to stay further away from each other to mitigate competition with increasing transparency, their incentive to move closer to increase market share dominates. He finds that increasing market transparency on the consumer side leads to less product differentiation, and lower prices and profits. This improves consumer surplus and total surplus. Schultz (2009) builds upon the Salop (1979) model of product differentiation and finds that the overall effect of transparency is unambiguously positive. Market transparency may alter physician behavior as well. If the market is totally non-transparent, physicians have little motivation to provide good service as few patients can assess their quality. Therefore, we take transparency into account and analyze the role in health care markets.

Market competition in health care sectors is an instrument for organizing decisions of improving efficiency to ensure people's usage of health care services. A more competitive market is usually considered to be beneficial for consumers, e.g. leading to lower prices, better quality, etc. For a fixed number of physicians, it is in the interest of the group to minimize competition among themselves. However, Barros et. al. (2016) prove that competition in the provision of health care is unlikely to contribute positively in all cases.

We are interested in knowing how market competition and altruism can improve quality and whether there exists a level of altruism that is optimal for social welfare. If this is the case, what factors determine this welfare optimal altruism and how might altruism affect market outcomes? To answer these questions, we apply a spatial duopoly model in which patients make their purchasing decisions based on travelling distance and quality, as in Schultz (2009) and Gu & Wenzel (2011). We assume that physicians are heterogeneously altruistic in the sense that they care about profits and (to some different extent) the benefit of patients, while Brekke et al. (2012) use an identical altruism degree in their study. Following Schultz (2009), only a fraction of the patients are informed. The rest are uninformed and randomly visit one of the physicians, with identical probability. The share of informed patients is our measure of market transparency.

Our main contribution is that we are the first, according to our knowledge, to introduce both altruism heterogeneity and transparency into a duopoly Salop (1979) circular city model of physician competition. We find that a marginal increase in market transparency increases quality only when physicians are sufficiently altruistic. Surprisingly, we also find that in some situations there is a welfare maximizing level of altruism, where a further increase in altruism would reduce social welfare.

Following the introduction in Section 3.1, Section 3.2 presents the theoretical model of patient behavior and physician behavior. We are concerned with physician motivation, and give consideration to alternatives for utilities guiding physician behavior. Altruism directly determines physicians' utilities as well as their quality level. Within a model of incomplete information, physicians can decide about quality according to altruism. Quality also indirectly affects utility via altering demand.

Section 3.3 shows how our model can be used to analyze the effect of physician altruism and market transparency on equilibrium. It shows that market transparency and semi-altruism are policy substitutes. Policy makers cannot always increase quality by raising transparency or the degree of altruism due to the zero profit constraints.

In Section 3.4 we look at the effect of altruism on welfare. The main finding is that altruism is not always beneficial to social welfare. The last section concludes.

3.2 The Model

We assume that patients locate on a Salop (1979) circle evenly and seek for treatment to maximize their own utilities. It is a fully insured market with a regulated price. There exist two heterogeneously altruistic physicians providing treatments. Physicians locate at the points leading to a maximum distance from each other (d'Aspremont et al., 1979). Physicians compete on quality to maximize utility.

We define market transparency as the share of patients $\varphi \in (0,1)$ who are informed about the treatment quality. The share $1-\varphi$ are the uninformed, who do not observe quality, but they know the providers locations.

The informed patient h maximizes his utility:

$$u_h = r + q_i - t|\theta_h - x_i|, i = 1,2, \tag{3.1}$$

where r denotes the reservation utility from consuming one unit of treatment, $t > 0$ represents the marginal transportation cost, and $\theta_h \in [0,1]$ denotes the patient h's location. We also assume without loss of generality that $t > 2|q_i - q_j|, i \neq j$. This assumption ensures that every regulatory equilibria considered in the paper exist. Physician i's quality and location are denoted by $q_i \geq 0$ and $x_i \in [0,1]$, respectively.

We assume for simplicity that the reservation value r is sufficiently high to ensure that every patient prefers treatment over non-treatment.

The informed patients maximize their objective functions by choosing which physician they visit. However, the uninformed patients have incomplete information about the quality of the physician's treatment, so they only care about transportation costs and visit the nearest physician. Prices are regulated, and all patients are fully insured. Without loss of generality, we assume that two physicians locate at 0 and ½ on the circle (see Figure 1).

The informed indifferent patient locates at the point where he obtains the same utility from the two physicians. As the two physicians locate at points leading to a maximum distance from each other, there must exists two indifferent patients with symmetric locations on the circle. Therefore, we can focus on the first half circle from 0 to ½ and have the following:

$$r + q_1 - t\theta = r + q_2 - t\left(\frac{1}{2} - \theta\right). \tag{3.2}$$

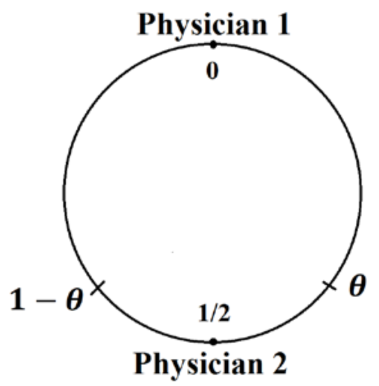

Figure 3.1: The locations of physicians and the indifferent patient.

Notes: Physician 1 locates at zero on the circle and physician 2 locates on the opposite point. Here we illustrate an example where physician 1 provides higher-quality treatment than physician 2.

Solving Equation (3.2), we obtain the location of informed patient θ who is indifferent between visiting physician 1 or 2 (see Figure 3.1, assuming $q_1 > q_2$):

$$\theta = \frac{q_1 - q_2}{2t} + \frac{1}{4}. \tag{3.3}$$

Since $t > 2\left|q_i - q_j\right|, i \neq j$, and $q_1 > q_2$, in equilibrium the location of this indifferent patient always belongs to the interval $\left(0, \frac{1}{2}\right)$. Physicians maximize their utilities via quality decisions. As $\varphi \in (0,1)$ measures the market transparency, the demand of physician 1 comes from both the informed patients and the uninformed ones:

$$d_1 = \varphi \times 2\theta + \frac{(1-\varphi)}{2} = \frac{\varphi(q_1 - q_2)}{t} + \frac{1}{2}. \tag{3.4}$$

The first term $\varphi \times 2\theta$ in Equation (3.4) denotes the demand from the informed patients. As θ only represents the indifferent patient on the circle from 0 to ½, we have to apply 2θ due to symmetry. The second term $\frac{(1-\varphi)}{2}$ denotes the demand from the uninformed patients.

The demand of physician 2 is:

$$d_2 = 1 - d_1. \tag{3.5}$$

From Equation (3.4) and (3.5), we can see that given the competitor's quality choice, the demand for a physician increases with his own quality. The location of this indifferent patient depends on the marginal transportation cost and the quality difference, not on the absolute qualities. Thus, physicians share the market equally if they provide the same quality levels.

To keep our model tractable, the material profit of physician i is given by the following:

$$\pi_i = (p - cq_i)d_i, \tag{3.6}$$

where $c \in (0,1)$ is the marginal cost of one unit of quality per patient, and $p > 0$ is the regulated price.

As discussed before, physicians take their patients' utilities into account when quality decisions are made. They maximize utilities via quality subject to the constraint of non-negative material profits. We endow physicians with a utility function of the following form:

$$\phi_i = \pi_i + \alpha_i(r + q_i)d_i = (p + \alpha_i r - (c - \alpha_i)q_i)d_i, \tag{3.7}$$

where $\alpha_i \in (0,1)$ denotes the altruism degree of physician i, which measures the relative weight of patient utility. Policy can affect altruism levels by organizing the education of physicians appropriately. The term $(r + q_i)d_i$ represents the benefit from treatments that patients receive. We can interpret this objective function of physician i as the sum of weighted own profit and patients' utilities.

We assume that: 1) $c > \alpha_i$, such that the net effect of providing higher quality involves a disutility to the physician (keeping demand fixed); 2) only two heterogeneously altruistic physicians exist in the market. For convenience, we denote the two altruistic physicians as physician 1 and physician 2. They have a different altruism degree α_i: physician 1 is α_1, and the other is α_2, respectively. Without loss of generality, we assume that $\alpha_1 > \alpha_2$.

The underlying mechanism is that physicians are usually motivated intrinsically. Therefore, this heterogeneous altruism leads to different quality options when medical decisions are made. Since the locations are fixed, both physicians get the same demand from the uninformed patients. However, from Equations (3.4) and (3.5) the demand from informed patients depends on quality differences. Physicians share the market equally if and only if they provide the same quality. However, this generally does not occur when physicians display asymmetric levels of altruism.

3.3 Equilibrium Analysis and Outcomes

We start out by deriving the Nash equilibrium quality for a given degree of altruism and market transparency, in order to analyze how the physicians' quality decisions are determined by altruism.

For the fixed locations, market transparency φ and a given pair of altruism levels α_1, α_2, we insert demand into the physician's objective function ϕ_i. The first-order condition for the optimal quality level by physician 1 is given by

$$\frac{\partial \phi_1}{\partial q_1} = \frac{1}{2t}\big(2p\varphi + t\alpha_1 - ct + 2r\varphi\alpha_1 + 2\varphi(c - \alpha_1)(q_2 - 2q_1)\big) = 0. \tag{3.8}$$

The effect of altruism on quality provision depends crucially on the nature of strategic interaction between physicians. It is therefore instructive to characterize this in detail. From Equation (3.8), if we allow each physician to optimally adjust his choices of quality in response to the other's quality change, the best-reply function of physician 1 is given by

$$q_1 = \frac{\alpha_1 r + p}{2(c - \alpha_1)} - \frac{t}{4\varphi} + \frac{q_2}{2}. \tag{3.9}$$

Similarly, the best-reply function of physician 2 is given by

$$q_2 = \frac{\alpha_2 r + p}{2(c - \alpha_2)} - \frac{t}{4\varphi} + \frac{q_1}{2}. \tag{3.10}$$

The intercepts of Equation (3.9) and Equation (3.10) represent the quality levels that physician 1(2) would provide if physician 2(1) provides a zero level of quality. Since the intercepts are both increasing in altruism, and slopes are both $\frac{1}{2}$, we have $q_1 > q_2$ because of $\alpha_1 > \alpha_2$.

Proposition 3.1 *When* $\alpha_2 > \frac{tc-2\varphi p}{2\varphi r+t}$, *both physicians provide positive quality. In particular, if* $c < \frac{2p\varphi}{t}$, $\alpha_2 > \frac{tc-2\varphi p}{2\varphi r+t}$ *is always satisfied.*

Proof. We assume that qualities are non-negative in our study. From Equation (3.9), we know that if the interception of this best-reply function is positive, physician 1 always provides positive quality, which implies the following condition $\frac{\alpha_1 r+p}{2(c-\alpha_1)} - \frac{t}{4\varphi} > 0 \Leftrightarrow \alpha_1 > \frac{tc-2\varphi p}{2\varphi r+t}$.

If $c < \frac{2p\varphi}{t}$, we have $tc - 2\varphi p < 0$. The right-hand side of the above expression is strictly negative. For any altruism $\alpha_i \in (0,1)$, the condition $\alpha_1 > 0 > \frac{tc-2\varphi p}{2\varphi r+t}$ always holds. Hence, physician 1 provides positive quality if $c < \frac{2p\varphi}{t}$.

From Equation (3.10), we can see when the intercept of physician 2's best-reply function is positive, he always provides positive quality, which implies the following condition:

$\frac{\alpha_2 r+p}{2(c-\alpha_2)} - \frac{t}{4\varphi} > 0 \Leftrightarrow \alpha_2 > \frac{tc-2\varphi p}{2\varphi r+t}$.

For any level of altruism $\alpha_2 \in (0,1)$, the condition $\alpha_2 > 0 > \frac{tc-2\varphi p}{2\varphi r+t}$ always holds if $c < \frac{2p\varphi}{t}$. Hence, physician 2 provides positive quality if $c < \frac{2p\varphi}{t}$. As $\alpha_1 > \alpha_2$, therefore, both physicians provide positive quality when $\alpha_2 > \frac{tc-2\varphi p}{2\varphi r+t}$.

Q.E.D.

The intuition is that if $c < \frac{2p\varphi}{t}$, the quality per patient is not costly. Therefore, when the cost is low, the benefit of a quality slightly higher than zero always outweighs its associated marginal cost, irrespective the other physician's quality choice.

A symmetric equilibrium occurs if and only if $\alpha_1 = \alpha_2$. This would imply that equilibria are conceivable where one physician provides positive quality while the other one provides zero quality. Comparing the two best-reply functions, and taking slopes into account, we distinguish the situations into three different cases according to their qualities.

Low-altruism Case: when $\alpha_2 < \alpha_1 \leq \frac{tc-2\varphi p}{2\varphi r+t}$, both best-reply functions have negative intercepts, and there is only one zero quality equilibrium: $q_1 = q_2 = 0$ (see Figure 3.2). Generally, both physicians can be bounded by zero profit constraints. From Equation (3.6), we set $\pi_i = (p - cq_i)d_i = 0$ and solve for q_i. We obtain that the zero profit constrained quality is $q_i = \frac{p}{c}, i = 1,2$. Therefore, there are two kinks for the best-reply functions.

Medium-altruism Case: when $\alpha_2 \leq \frac{tc-2\varphi p}{2\varphi r+t} < \alpha_1$, the two best-reply functions intersect on the x-axis, there is an equilibrium, $q_1 > 0, q_2 = 0$, and $q_1 \in \left[0, \frac{p}{c}\right]$ (see Figure 3.3).

High-altruism Case: when $\frac{tc-2\varphi p}{2\varphi r+t} < \alpha_2 < \alpha_1$, there exists a positive equilibrium, $q_1 > q_2 > 0$, and $q_i \in \left[0, \frac{p}{c}\right]$ (see Figure 3.4).

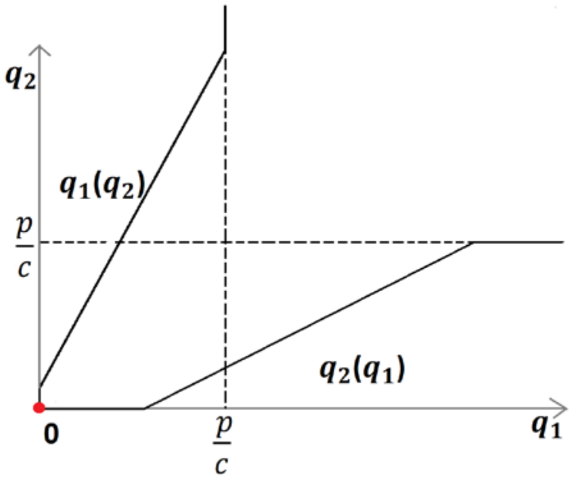

Figure 3.2: Low-altruism Case.

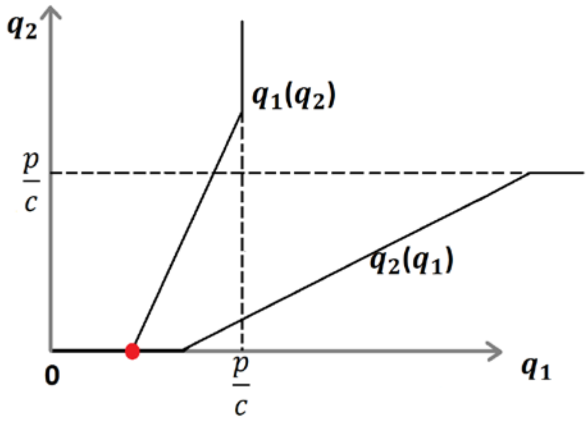

Figure 3.3: Medium-altruism Case.

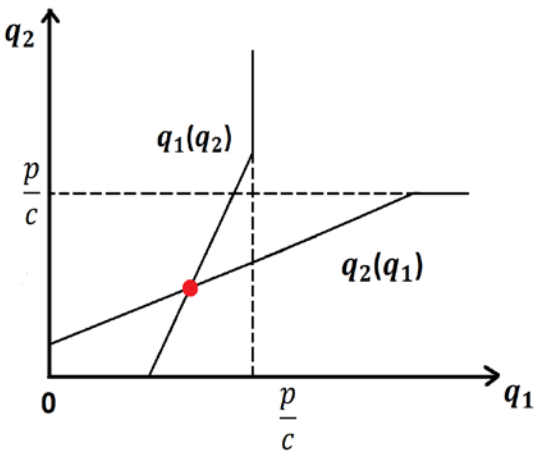

Figure 3.4: High-altruism Case.

Because $\alpha_i \in (0,1)$, we always have a Low-altruism Case when $\frac{tc-2\varphi p}{2\varphi r+t} \geq 1$ and a High-altruism Case when $\frac{tc-2\varphi p}{2\varphi r+t} \leq 0$. When $\frac{tc-2\varphi p}{2\varphi r+t} \in (0,1)$, we may have all three cases. Although we distinguish all cases according to the level of altruism α_i, the reference value of $\frac{tc-2\varphi p}{2\varphi r+t}$ monotonically decreases with market transparency. Hence, altruism and transparency are policy substitutes.

When we combine the two best-reply functions (3.9) and (3.10) in the High-altruism Case, we obtain the equilibrium quality

$$q_i^* = \frac{2(\alpha_i r + p)}{3(c-\alpha_i)} + \frac{\alpha_j r + p}{3(c-\alpha_j)} - \frac{t}{2\varphi}, i, j = 1,2, i \neq j. \quad (3.11)$$

Since by assumption $\alpha_1 > \alpha_2$, we insert α_1 and α_2 into Equation (3.11) and easily conclude:

$$q_1^* = \frac{2(\alpha_1 r+p)}{3(c-\alpha_1)} + \frac{\alpha_2 r+p}{3(c-\alpha_2)} - \frac{t}{2\varphi}. \quad (3.12)$$

$$q_2^* = \frac{2(\alpha_2 r+p)}{3(c-\alpha_2)} + \frac{\alpha_1 r+p}{3(c-\alpha_1)} - \frac{t}{2\varphi}. \quad (3.13)$$

Calculating the quality difference, we obtain that $q_1^* - q_2^* = \frac{(cr+p)(\alpha_1-\alpha_2)}{3(c-\alpha_1)(c-\alpha_2)} > 0$. Hence, $q_1 > q_2$ when $\frac{tc-2\varphi p}{2\varphi r+t} < \alpha_2 < \alpha_1$. Additionally, q_1^* and q_2^* are bounded by the zero profit constrained level $\frac{p}{c}$ when $\alpha_2 < \alpha_1 < \overline{\alpha}_{1,2} \equiv \frac{tc^2}{tc+2p\varphi+2cr\varphi}$.

The physician who has a higher altruism degree provides higher quality. This result illustrates that even though higher quality leads to a higher production cost, higher quality also leads to a higher demand. Furthermore, physician 1 still gets a higher utility from quality because of his altruistic preference.

Proposition 3.2 *Altruism affects equilibrium quality and profit as follows:*

(1) When $\alpha_2 < \alpha_1 \leq \frac{tc-2\varphi p}{2\varphi r+t}$, physicians provide zero equilibrium quality. Equilibrium quality does not change with altruism, both physicians earn constant positive material profit $\frac{p}{2}$;

(2) When $\alpha_2 \leq \frac{tc-2\varphi p}{2\varphi r+t} < \alpha_1 < \overline{\alpha_1} \equiv \frac{c(tc+2p\varphi)}{tc+2p\varphi+2\varphi(p+cr)}$*, physician 1's quality increases with his own altruism and he earns positive material profit; physician 2's quality remains at zero and does not depend on altruism. He earns positive material profit;*

(3) When $\alpha_2 \leq \frac{tc-2\varphi p}{2\varphi r+t} < \overline{\alpha_1} \leq \alpha_1$*, physician 1 provides the zero profit constrained equilibrium quality* $q_1 = \frac{p}{c}$*. Equilibrium quality does not depend on altruism and he earns zero material profit; physician 2's quality remains at zero and does not depend on altruism. He earns positive material profit;*

(4) When $\frac{tc-2\varphi p}{2\varphi r+t} < \alpha_2 < \alpha_1 < \overline{\alpha}_{1,2} \equiv \frac{tc^2}{tc+2p\varphi+2cr\varphi}$*, physicians' qualities increase with altruism and both earn positive material profits;*

(5) When $\frac{tc-2\varphi p}{2\varphi r+t} < \alpha_2 < \overline{\alpha}_{1,2} \leq \alpha_1$*, physician 1 provides the zero profit constrained equilibrium quality* $q_1 = \frac{p}{c}$*. Equilibrium quality does not depend on altruism and he earns zero material profit; physician 2's quality increases with altruism and he earns positive material profit;*

(6) When $\overline{\alpha}_{1,2} \leq \alpha_2 < \alpha_1$*, physicians provide the zero profit constrained equilibrium quality* $q_1 = q_2 = \frac{p}{c}$*. Equilibrium quality does not depend on altruism and both earn zero material profits.*

Proof in Appendix.

The underlying intuition is that when $\alpha_2 < \alpha_1 \leq \frac{tc-2\varphi p}{2\varphi r+t}$ both physicians have no intrinsic incentives to provide any treatment with positive quality. Physicians earn positive profits in the Low-altruism Case.

When $\alpha_2 \leq \frac{tc-2\varphi p}{2\varphi r+t} < \alpha_1 < \overline{\alpha_1} = \frac{c(tc+2p\varphi)}{tc+2p\varphi+2\varphi(p+cr)}$, physician 1 is more altruistic and provides positive quality. Quality increases with altruism. Market transparency plays a positive role in his quality provision. As transparency increases, more patients become informed and seek a higher quality level of medical treatment. Therefore, physician 1 increases quality as a result of growing transparency. Transparency and altruism are policy substitutes. However, physician 1's profit declines with the increasing quality, and eventually becomes zero. We have the zero profit constrained altruism, which is given by $\overline{\alpha_1} = \frac{c(tc+2p\varphi)}{tc+2p\varphi+2\varphi(p+cr)}$. As long as physician 1 has not reached this threshold, he is not bounded by the zero profit condition.

When $\alpha_2 \le \frac{tc-2\varphi p}{2\varphi r+t} < \overline{\alpha_1} \le \alpha_1$, physician 1's quality does not depend on altruism as the zero profit constraint is reached. Physician 2 is less altruistic and provides zero quality. Since there exist uninformed patients, the demand of physician 2 is always positive. Therefore, physician 2 earns a positive profit.

When $\frac{tc-2\varphi p}{2\varphi r+t} < \alpha_2 < \alpha_1 < \overline{\alpha}_{1,2} = \frac{tc^2}{tc+2p\varphi+2cr\varphi}$, physicians' qualities increase with altruism and both are not bounded by the zero profit conditions. The intuition for the rise in qualities for both best responses is fairly straightforward. In the High-altruism Case, since both physicians provide positive quality in this subgame, if one has a higher level of altruism, he intrinsically has motivation to increase quality. As long as he is not bounded by the zero profit constraint, he raises his own utility by increasing quality. Market transparency plays a positive role in quality provision. Competition between physicians becomes more intensive with transparency. The result of competition reflects a rise in quality.

When $\frac{tc-2\varphi p}{2\varphi r+t} < \alpha_2 < \overline{\alpha}_{1,2} \le \alpha_1$, because physician 1 is too altruistic, he reaches zero profit constraints first. His quality does not depend on altruism. Physician 2's quality increases with altruism as he is not constrained by zero profit.

When $\overline{\alpha}_{1,2} \le \alpha_2 < \alpha_1$, both physicians are constrained by the zero profit conditions. They cannot increase qualities any further irrespective of altruism and transparency.

We calculate physicians' demands according to their qualities and obtain:

(1) When $\alpha_2 < \alpha_1 \le \frac{tc-2\varphi p}{2\varphi r+t}$, we have $d_1^* = \frac{\varphi(q_1-q_2)}{t} + \frac{1}{2} = \frac{1}{2} = d_2^*$.

(2) When $\alpha_2 \le \frac{tc-2\varphi p}{2\varphi r+t} < \alpha_1 < \overline{\alpha_1}$, we have $d_1^* = \frac{\varphi q_1}{t} + \frac{1}{2} = \frac{2p\varphi+ct+(2r\varphi-t)\alpha_1}{4t(c-\alpha_1)} > \frac{1}{2}$, and $d_2^* = 1 - d_1^* = 1 - \frac{2p\varphi+ct+(2r\varphi-t)\alpha_1}{4t(c-\alpha_1)} < \frac{1}{2}$;

(3) When $\frac{tc-2\varphi p}{2\varphi r+t} < \alpha_2 < \alpha_1 < \overline{\alpha}_{1,2}, d_i^* = \frac{(\alpha_i r+p)\varphi}{3(c-\alpha_i)t} - \frac{(\alpha_j r+p)\varphi}{3(c-\alpha_j)t} + \frac{1}{2}, i,j = 1,2, i \ne j$, we have $d_1 > \frac{1}{2} > d_2$.

In the Low-altruism Case, demands do not change with transparency and altruism as both physicians provide zero quality.

In the Medium-altruism Case, only physician 1 provides positive quality. We can see that the demand of physician 1 increases with transparency and his own altruism. As the entire demand is fixed, the demand for physician 2 decreases with transparency and physician 1's altruism. Physician 2's altruism does not affect demands. There are two immediate effects of increasing altruism (transparency). First, physician 1 provides a positive quality in equilibrium. Therefore, given market transparency (altruism), the demand of physician 1 increases with altruism (transparency). Second, market demand shifts from the low-quality provider to the high-quality provider with an increasing altruism of physician 1 and with market transparency. It follows that physician 1 can increase his market share while physician 2 loses demand. With higher transparency, more patients become informed. Physician 1 finds it easier to attract new patients as he provides higher quality than physician 2. The competition effect and demand effect work in the same positive direction for him until the zero profit constraint becomes binding. However, contrary effects can be concluded for physician 2. With increasing transparency, physician 2 loses demand as more patients seek higher quality. Although competition becomes more intense with increasing transparency, it is still profitable for physician 2 to make a positive profit on the uninformed patients. This asymmetric effect on market shares is novel and not present in symmetric models.

In the High-altruism Case, both physicians provide positive qualities. We calculate the first derivative of demands of both physicians with respect to altruism and market transparency. We obtain that $\frac{\partial d_1}{\partial \varphi} = \frac{(p+cr)(\alpha_1-\alpha_2)}{3t(c-\alpha_1)(c-\alpha_2)} > 0$, $\frac{\partial d_1}{\partial \alpha_1} = \frac{\varphi(p+cr)}{3t(c-\alpha_1)^2} > 0$, $\frac{\partial d_1}{\partial \alpha_2} = -\frac{\varphi(p+cr)}{3t(c-\alpha_2)^2} < 0$. Since $d_2 = 1 - d_1$, we can have $\frac{\partial d_2}{\partial \varphi} < 0$, $\frac{\partial d_2}{\partial \alpha_1} = -\frac{\varphi(p+cr)}{3t(c-\alpha_1)^2} < 0$, $\frac{\partial d_2}{\partial \alpha_2} = \frac{\varphi(p+cr)}{3t(c-\alpha_2)^2} > 0$. The demand for a more (less) altruistic physician increases (decreases) with market transparency. The demands for both physicians increase with their own altruism degree but decrease with the competitor's altruism degree. Because of increasing market transparency, competition becomes more intensive. The more altruistic physician benefits from the strong competition as more patients seek higher quality until the zero profit constraint becomes binding. Altruism has the same effect on both physicians. Since their own altruism raises their own demand, physicians have a stronger motivation to provide higher-quality treatment to patients before being constrained by the zero profit conditions.

A key observation is that the effect of altruism on profits is not uniform across all cases in the market. Lower altruism does not change profits in the Low-altruism Case, but leads to lower profit offered by physician 1 in the Medium-altruism Case. With increasing altruism, profits decrease due to quality competition. Eventually, both physicians are bounded by the zero profit constraints.

3.4 Social Welfare

We define the objective of the government as the one that maximizes the utilitarian welfare function. To avoid double counting, the welfare is the sum of patients' surplus and physicians' material profits, which can be written as

$$W = CS + PS$$

$$= r + q_1 d_1 - \frac{t\theta d_1}{2} + q_2 d_2 - \frac{t\left(\frac{1}{2} - \theta\right) d_2}{2} - cq_1 d_1 - cq_2 d_2. \qquad (3.14)$$

There are three effects of altruism on social welfare. First, altruism affects quality, which enters the welfare function directly. Second, altruism has an impact on demand via quality difference. Third, altruism alters the total transportation cost due to quality difference.

Considering the different quality situations in Section 3.3, we may suspect that the impacts of altruism on social welfare will be quite different in different cases. The welfare outcomes according to all three cases are characterized in Proposition 3.3-3.5.

Proposition 3.3 *When* $\alpha_2 < \alpha_1 \leq \frac{tc - 2\varphi p}{2\varphi r + t}$, *social welfare is* $r - \frac{t}{8}$.

Proof. When $\alpha_2 < \alpha_1 \leq \frac{tc - 2\varphi p}{2\varphi r + t}$, we always have $q_1 = q_2 = 0$. Hence, we can calculate demands and profits:

$$d_1^* = \frac{\varphi(q_1 - q_2)}{t} + \frac{1}{2} = \frac{1}{2} = d_2^*,$$

$\pi_1 = \pi_2 = \frac{p}{2}$.

Inserting qualities and demands back into the welfare function, we have

$$W = r + q_1 d_1 - \frac{t\theta d_1}{2} + q_2 d_2 - \frac{t\left(\frac{1}{2} - \theta\right) d_2}{2} - cq_1 d_1 - cq_2 d_2$$

$$= r + 0 - \frac{t}{16} + 0 - \frac{t}{16} - 0 - 0 = r - \frac{t}{8}.$$

Q.E.D.

The underlying intuition is that in the Low-altruism Case both physicians have no incentive to provide any treatment with positive quality. Physicians earn the maximum profit margin by providing the minimum quality by regulation. As qualities are zero, demands and profits remain constant, and social welfare does not depend on altruism in this case.

Proposition 3.4 *When* $\alpha_2 \leq \frac{tc - 2\varphi p}{2\varphi r + t} < \alpha_1$*, altruism affects social welfare as follows:*

1) If $c \leq \frac{1}{2}$*, welfare is convex on* α_1*, it increases with altruism when* $\alpha_1 < \overline{\alpha_1}$ *and remains constant when* $\alpha_1 \geq \overline{\alpha_1}$*;*

2) If $c > \frac{1}{2}$ *and* $p \geq \frac{ct}{2\varphi(2c-1)}$*, welfare is concave on* α_1*, it decreases with* α_1 *until the zero profit constraint is reached and remains constant hereafter.*

3) If $c > \frac{1}{2}$ *and* $p \in \left(\frac{ct(1-c)}{2\varphi(2c-1)}, \frac{ct}{2\varphi(2c-1)}\right)$*, welfare is concave on* α_1*, it increases with* α_1 *until the zero profit constraint is reached and remains constant hereafter.*

4) If $c > \frac{1}{2}$ *and* $p < \frac{ct(1-c)}{2\varphi(2c-1)}$*, welfare is concave on* α_1*,and it has an optimal altruism* $\alpha_1^* = \frac{ct - 2p\varphi(2c-1)}{t + 2r\varphi(2c-1)}$.

Proof in Appendix.

The intuition is that in the Medium-altruism Case physician 2 provides zero quality. His profit depends only on the regulated price and demand. Since there always exist uninformed patients who visit the nearest physician, physician 2 always benefits from the uninformed patients. However, physician 1 provides positive quality until his altruism reaches the upper bound $\overline{\alpha_1} = \frac{c(tc+2p\varphi)}{tc+2p\varphi+2\varphi(p+cr)}$, which corresponds to the zero profit constrained altruism. If physician 1's altruism increases any further ($\alpha_1 \geq \overline{\alpha_1}$), he cannot increase quality accordingly, otherwise he will earn negative profit from excessive quality provision. Physician 1's profit decreases with his own altruism until the zero profit constraint is reached.

The effects of altruism on social welfare depend on the marginal costs when $\alpha_2 \leq \frac{tc-2\varphi p}{2\varphi r+t} < \alpha_1$. If the marginal cost is relatively low, i.e. $c \leq \frac{1}{2}$, social welfare increases with physician 1's altruism until the zero profit constraint for physician 1 is reached (see Figure 3.5). A low marginal cost is beneficial for social welfare under the Medium-altruism Case.

If the marginal cost is high, i.e. $c > \frac{1}{2}$, we calculate the unrestrained welfare maximizing altruism $\alpha_1^* = \frac{ct-2p\varphi(2c-1)}{t+2r\varphi(2c-1)}$. However, if $p \geq \frac{ct}{(2c-1)}$, α_1^* is non-positive. Hence, $\alpha_1^* < \overline{\alpha_1}$ is always satisfied. The welfare function is concave on α_1. Therefore, social welfare decreases with α_1 when $\alpha_2 \leq \frac{tc-2\varphi p}{2\varphi r+t} < \alpha_1$ until the zero profit constraint is reached (see Figure 3.6). Hence, altruism has a negative effect on welfare if the marginal cost and the regulated price is high.

If $p < \frac{ct}{2\varphi(2c-1)}$, α_1^* is positive. When $p \geq \frac{ct(1-c)}{2\varphi(2c-1)}$, we have $\alpha_1^* \geq \overline{\alpha_1}$, which means that social welfare is bounded by the zero profit condition of physician 1 before it achieves the peak (see Figure 3.7). If $c > \frac{1}{2}$ and $p \in \left(\frac{ct(1-c)}{2\varphi(2c-1)}, \frac{ct}{2\varphi(2c-1)}\right)$, social welfare increases with physician 1's altruism until the zero profit constraint. When quality is costly, physician 1 is bounded by the zero profit condition when he is not too altruistic. Altruism has a weakly positive effect on welfare.

If $c > \frac{1}{2}$ and $p < \frac{ct(c-1)}{2\varphi(1-2c)}$, we have $\alpha_1^* < \overline{\alpha_1}$, which means that social welfare attains the peak before zero profit is binding (see Figure 3.8). The social welfare optimal altruism is α_1^*. Therefore, when the regulated price is even lower, social welfare can achieve its global maximum. Too high altruism has a negative effect on welfare.

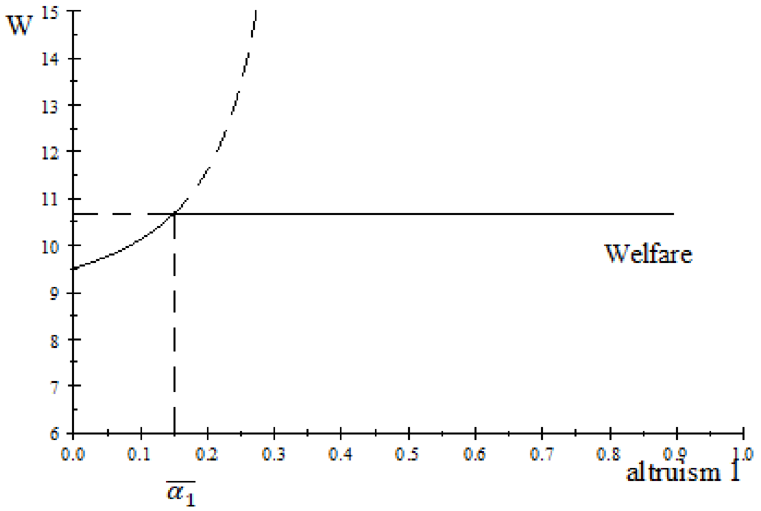

Figure 3.5: Welfare under an asymmetric quality equilibrium when $\alpha_2 \leq \frac{tc-2\varphi p}{2\varphi r+t} < \alpha_1$ if $c \leq \frac{1}{2}$. We set $t = 1, \varphi = 0.1, r = 10, p = 1, c = 0.4$.

Notes: If marginal cost is low, welfare increases with altruism until the zero profit constraint for physician 1 is reached. Welfare remains constant thereafter.

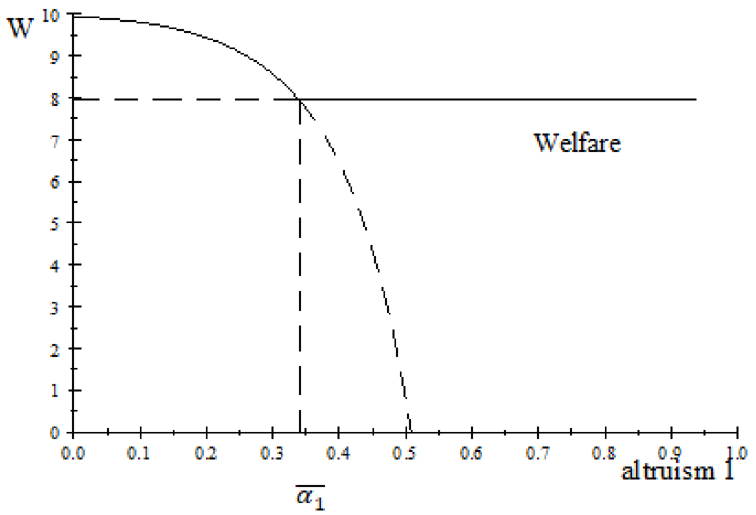

Figure 3.6: Welfare under an asymmetric quality equilibrium when $\alpha_2 \leq \frac{tc-2\varphi p}{2\varphi r+t} < \alpha_1$ if $c > \frac{1}{2}$ and $p \geq \frac{ct}{2\varphi(2c-1)}$. We set $t = 1, \varphi = 0.1, r = 10, p = 8, c = 0.8$.

Notes: If marginal cost and price is high, welfare decreases with altruism until the zero profit constraint is reached.

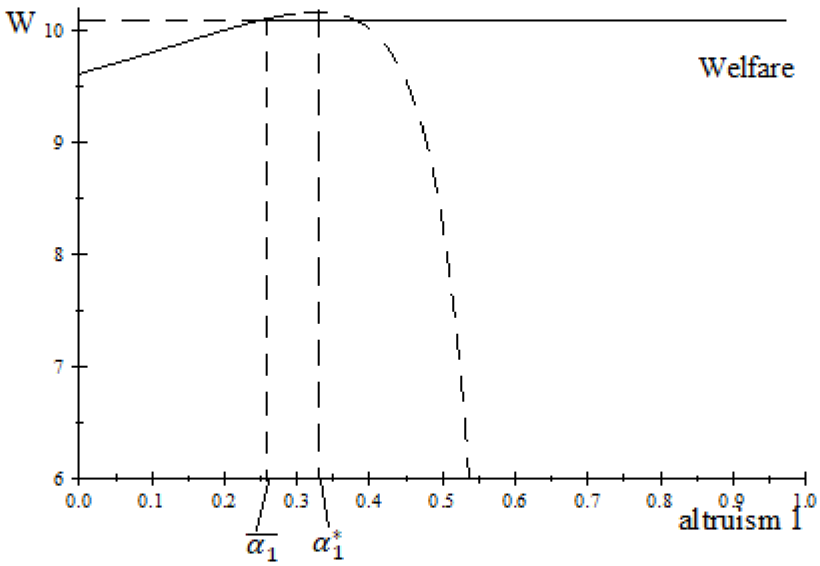

Figure 3.7: Welfare under an asymmetric quality equilibrium when $\alpha_2 \leq \frac{tc-2\varphi p}{2\varphi r+t} < \alpha_1$ if $c > \frac{1}{2}$ and $p \in \left(\frac{ct(1-c)}{2\varphi(2c-1)}, \frac{ct}{2\varphi(2c-1)}\right)$. We set $t = 1, \varphi = 0.1, r = 10, p = 7,$ $c = 0.7$.

Notes: As $\alpha_1^* \geq \overline{\alpha_1}$, welfare is bounded by the zero profit constraint before it achieves the optimal level.

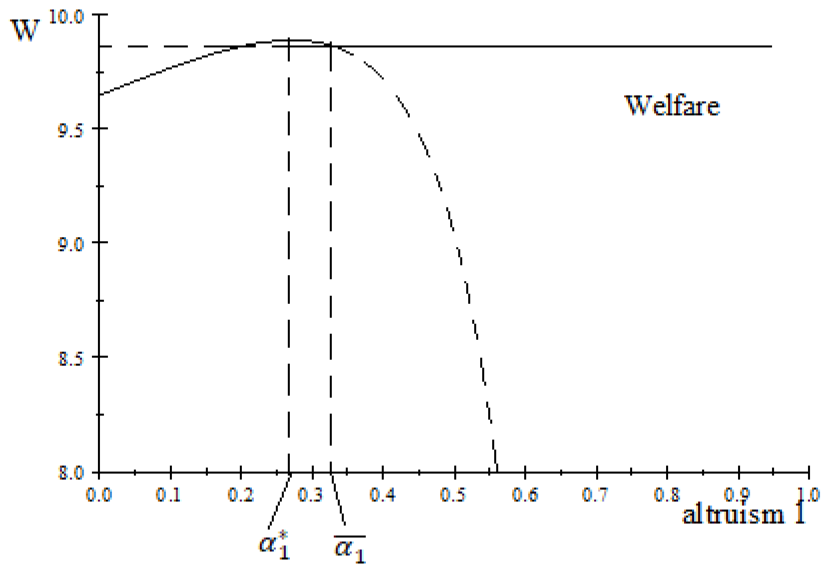

Figure 3.8: Welfare under an asymmetric quality equilibrium when $\alpha_2 \leq \frac{tc-2\varphi p}{2\varphi r+t} < \alpha_1$ if $c > \frac{1}{2}$ and $p < \frac{ct(c-1)}{2\varphi(1-2c)}$. We set $t = 1, \varphi = 0.1, r = 10, p = 1.2, c = 0.9$.

Notes: As $\alpha_1^* < \overline{\alpha_1}$, socially optimal altruism depends on the value of α_1^*.

Combining the four figures above, it appears that it is not always beneficial to society to have more altruistic physicians. In some situations, altruism plays no role after the zero profit constraint is achieved. In other situations, too high altruism even has a negative effect on social welfare.

Now we look at the case when both physicians provide positive quality.

Proposition 3.5 *When* $\frac{tc-2\varphi p}{2\varphi r+t} < \alpha_2 < \alpha_1$, *altruism affects social welfare as follows:*

(1) When $\overline{\alpha}_{1,2} = \frac{tc^2}{tc+2p\varphi+2cr\varphi} \leq \alpha_2 < \alpha_1$, *neither transparency nor altruism plays a role for welfare;*

(2) When $\frac{tc-2\varphi p}{2\varphi r+t} < \alpha_2 < \overline{\alpha}_{1,2} \leq \alpha_1$, *social welfare is lower compared to that in the first subcase;*

(3) When $\frac{tc-2\varphi p}{2\varphi r+t} < \alpha_2 < \alpha_1 < \overline{\alpha}_{1,2}$, *the effect of altruism on welfare is ambiguous.*

Proof in Appendix.

The first observation to be made is that when physicians have extremely high altruism, i.e. $\overline{\alpha}_{1,2} \leq \alpha_2 < \alpha_1$, they are both bounded by the zero profit constraints. Even if physicians became more altruistic, treatment qualities would not increase any more. Therefore, social welfare maintains the maximum level hereafter. Neither market transparency nor altruism plays a role.

However, if one of the physicians has a lower altruism degree, supposed it to be physician 2, physician 1 is still constrained by the zero profit condition but physician 2 is no longer constrained. The lower quality provided by physician 2 has a direct negative impact on social welfare. The indirect effect is through transportation costs. Since physicians provide heterogeneous qualities, the demand for them becomes asymmetric and especially the demand of physician 1 rises. As a result, the average transportation cost increases, which has a negative impact on social welfare. Altruism affects welfare indirectly via demand changes. In comparison to the first observation, the total welfare is lower.

Subsequently, when altruism is even lower, i.e. $\frac{tc-2\varphi p}{2\varphi r+t} < \alpha_2 < \alpha_1 < \overline{\alpha}_{1,2}$, none of the physicians are constrained by the zero profit conditions. Decreasing quality has a direct negative effect on patients' utilities. But as physician 1 provides lower quality than in the second subcase with $\frac{tc-2\varphi p}{2\varphi r+t} < \alpha_2 < \overline{\alpha}_{1,2} \leq \alpha_1$, the quality difference between the two physicians becomes smaller, which means the average transportation cost for patients declines. Altruism has two opposite effects on welfare. If a quality loss effect dominates transportation effect gains, social welfare decreases with altruism. If transportation effect gains dominate, then social welfare increases with altruism. The effect of altruism on welfare is ambiguous.

We also investigate the case of symmetric altruism. As we already discussed the zero profit case in Proposition 3.5, here we only look into the result for the case of positive quality and positive profit when $\frac{tc-2\varphi p}{2\varphi r+t} < \alpha_2 < \alpha_1 < \overline{\alpha}_{1,2}$.

Suppose that $\alpha_1 = \alpha_2 = \alpha \in (\frac{tc-2\varphi p}{2\varphi r+t}, \frac{tc^2}{2p\varphi+tc+2cr\varphi})$, then insert this condition into the quality reaction functions. The results are as follows:

$$q_1 = q_2 = \frac{\alpha r + p}{c - \alpha} - \frac{t}{2\varphi}. \tag{3.15}$$

We can calculate the equilibrium profits of the two physicians as follows:

$$\pi_1 = \pi_2 = \frac{p}{2} + \frac{ct}{4\varphi} - \frac{c(\alpha r + p)}{2(c - \alpha)}. \tag{3.16}$$

We insert quality into Equation (3.14) and obtain welfare:

$$W = r + (1 - c)\left(\frac{\alpha r + p}{c - \alpha} - \frac{t}{2\varphi}\right) - \frac{t}{8}. \tag{3.17}$$

Welfare increases with altruism when altruism belongs to the interval $\left(\frac{tc-2\varphi p}{2\varphi r+t}, \frac{tc^2}{2p\varphi+tc+2cr\varphi}\right)$. For higher altruism outside the interval, welfare retains the maximum $r - \frac{t}{8} + \frac{p(1-c)}{c}$ due to the zero profit constraints for both physicians; for lower altruism, welfare retains the minimum level $r - \frac{t}{8}$ due to the zero quality provision.

As physicians' utilities increase with their own altruism levels, they have the motivations to increase qualities until reaching zero profits. Afterwards, higher altruism cannot lead to higher qualities. Welfare becomes constant.

3.5 Conclusion

In this chapter we consider a partially transparent health care market with heterogeneously altruistic providers. Two physicians locate symmetrically on a Salop circle and compete on quality to maximize their utilities under price regulation. We show that market transparency and semi-altruism are policy substitutes. Without sufficient competition (transparency), physicians provide treatments at the minimum zero quality even when they are altruistic. A marginal increase in market transparency rises equilibrium quality only when physicians are sufficiently altruistic. There exists a level of altruism that is optimal for social welfare in some situations. And subsequently, the effect of altruism on welfare is ambiguous. Too high altruism is harmful for social welfare in certain situations.

In order to illustrate the equilibrium results we distinguish three different cases of the game according to the altruism degree. We show that when the degree of altruism for both physicians is low, they do not care about patients' utilities and provide zero quality. Altruism plays no role for quality and social welfare. When only one physician exhibits sufficiently high altruism, there exists an asymmetric quality equilibrium. The more altruistic physician provides positive quality and the less altruistic one provides zero quality. The social welfare optimal altruism degree alters for a different marginal cost and regulated price. A higher altruism degree does not always have a positive effect on welfare. Finally, when both physicians are sufficiently altruistic, there exists a positive quality equilibrium. Physicians' qualities increase with both market transparency and altruism until the zero profit constraint is reached. Higher altruism levels are weakly beneficial for social welfare.

Let us finally comment on our results in terms of policy recommendations. From a social welfare perspective, when current quality levels are quite low or even zero in the market, policy makers cannot always increase quality directly by hiring more altruistic physicians. Plenty of effort should be put into changing market conditions such that physicians compete more intensively. As a result, welfare improves due to a change from a zero-quality game to a positive-quality game. Market transparency and altruism are policy substitutes. However, high altruism is not always beneficial for social welfare, which contradicts to what one might expect. Raising altruism is not necessary for welfare in very competitive markets.

3.6 Appendix

Proof of Proposition 3.2

(1) When $\alpha_2 < \alpha_1 \leq \frac{tc-2\varphi p}{2\varphi r+t}$, the equilibrium quality is $q_1 = q_2 = 0$. We insert qualities into Equation (3.3) and obtain $\theta = \frac{q_1-q_2}{2t} + \frac{1}{4} = \frac{1}{4}$. Hence, the equilibrium profit is $\pi_1 = \pi_2 = \frac{p}{2}$.

Therefore, physicians' qualities and profits do not change with altruism.

(2) When $\alpha_2 \leq \frac{tc-2\varphi p}{2\varphi r+t} < \alpha_1 < \overline{\alpha_1} = \frac{c(tc+2p\varphi)}{tc+2p\varphi+2\varphi(p+cr)}$, $q_1 > 0, q_2 = 0$ implies. We insert $q_2 = 0$ into Equation (3.9) and obtain $q_1 = \frac{\alpha_1 r+p}{2(c-\alpha_1)} - \frac{t}{4\varphi}$. We calculate the first derivative of q_1 with respect to altruism and market transparency and get

$$\frac{\partial q_1}{\partial \varphi} = \frac{t}{4\varphi^2} > 0$$

$$\frac{\partial q_1}{\partial \alpha_1} = \frac{\alpha_1 r + p}{2(c-\alpha_1)^2} > 0$$

$$\frac{\partial q_1}{\partial \alpha_2} = 0$$

$$\frac{\partial q_2}{\partial \varphi} = 0$$

$$\frac{\partial q_2}{\partial \alpha_1} = 0$$

$$\frac{\partial q_2}{\partial \alpha_2} = 0.$$

Physician 1's quality increases with his own altruism and market transparency. Physician 2's quality does not depend on altruism.

We insert $q_2 = 0$ into Equation (3.6) and obtain $\pi_2 = pd_2$. There always exist uninformed patients who visit the nearest physician regardless of quality. This means that the demand of physician 2 never becomes zero. Therefore, $\pi_2 = pd_2 > 0$.

Inserting $q_1 = \frac{\alpha_1 r+p}{2(c-\alpha_1)} - \frac{t}{4\varphi}$ into physician 1's profit function, we have:

$$\pi_1 = (p - cq_1)d_1$$

$$= \left(p - c\left(\frac{\alpha_1 r + p}{2(c-\alpha_1)} - \frac{t}{4\varphi}\right)\right)\frac{2p\varphi + ct + (2r\varphi - t)\alpha_1}{4t(c-\alpha_1)}$$

$$= \frac{\left(p + \frac{c\alpha_1 r + cp}{2\alpha_1 - 2c} + \frac{ct}{4\varphi}\right)[2p\varphi - \alpha_1(t - 2r\varphi) + ct]}{4t(c-\alpha_1)}$$

From the first derivative of profit with respect to altruism $\frac{\partial \pi_1}{\partial \alpha_1} = -\frac{\alpha_1 \varphi (p+cr)^2}{2t(c-\alpha_1)^3} < 0$, we know that profit decreases with altruism until the zero profit constraint is reached.

To calculate the zero profit of physician 1, we let $\pi_1 = 0$:

$$\pi_1 = (p - cq_1)d_1 = 0$$

$$\Leftrightarrow \frac{p}{c} = q_1 = \frac{\alpha_1 r + p}{2(c-\alpha_1)} - \frac{t}{4\varphi}.$$

We can solve for the upper bound of $\overline{\alpha_1}$. $\overline{\alpha_1} = \frac{c(tc+2p\varphi)}{tc+2p\varphi+2\varphi(p+cr)}$.

Since all parameters are positive, $\overline{\alpha_1} > 0$.

Because $\overline{\alpha_1} = \frac{c(tc+2p\varphi)}{tc+2p\varphi+2\varphi(p+cr)} < \frac{(tc+2p\varphi)}{tc+2p\varphi+2\varphi(p+cr)} < \frac{(tc+2p\varphi)}{tc+2p\varphi} = 1$. We have proved that $\overline{\alpha_1} = \frac{c(tc+2p\varphi)}{tc+2p\varphi+2\varphi(p+cr)} \in (0,1)$.

We now prove that $\overline{\alpha_1} = \frac{c(tc+2p\varphi)}{tc+2p\varphi+2\varphi(p+cr)} < c$. Assume

$$\overline{\alpha_1} = \frac{c(tc + 2p\varphi)}{tc + 2p\varphi + 2\varphi(p + cr)} < c$$

$$\Leftrightarrow \frac{tc + 2p\varphi}{tc + 2p\varphi + 2\varphi(p + cr)} < 1$$

$$\Leftrightarrow tc + 2p\varphi < tc + 2p\varphi + 2\varphi(p + cr)$$

$$\Leftrightarrow 0 < 2\varphi(p + cr).$$

The above expression is always satisfied. Hence, $\overline{\alpha_1} = \frac{c(tc+2p\varphi)}{tc+2p\varphi+2\varphi(p+cr)} < c$.

If α_1 increases any further, physician 1 cannot increase quality, due to the zero profit constraint. The higher altruism, the lower his profit becomes, eventually zero.

(3) When $\alpha_2 \leq \frac{tc-2\varphi p}{2\varphi r+t} < \overline{\alpha} \leq \alpha_1$, physician 1 is bounded by the zero profit constraint. Therefore, he provides a constant quality $q_1 = \frac{p}{c}$ and earns zero profit. Physician 2 provides the zero quality and he earns a positive material profit.

(4) When $\frac{tc-2\varphi p}{2\varphi\ \alpha_2 r+t} < \alpha_2 < \alpha_1 < \overline{\alpha}_{1,2} = \frac{tc^2}{tc+2p\varphi+2cr\varphi}$, both physicians provide positive qualities. We use Equation (3.12) and (3.13) to calculate the first derivatives of quality with respect to altruism and market transparency and get

$$\frac{\partial q_1}{\partial \varphi} = \frac{t}{2\varphi^2} > 0$$

$$\frac{\partial q_1}{\partial \alpha_1} = \frac{2(p + cr)}{3(c - \alpha_1)^2} > 0$$

$$\frac{\partial q_1}{\partial \alpha_2} = \frac{p + cr}{3(c - \alpha_2)^2} > 0$$

$$\frac{\partial q_2}{\partial \varphi} = \frac{t}{2\varphi^2} > 0$$

$$\frac{\partial q_2}{\partial \alpha_1} = \frac{p + cr}{3(c - \alpha_1)^2} > 0$$

$$\frac{\partial q_2}{\partial \alpha_2} = \frac{2(p+cr)}{3(c-\alpha_2)^2} > 0.$$

Both physicians' qualities increase with altruism and transparency.

We know that both physicians can be bounded by the zero profit constraint when they provide positive qualities. We let $\pi_1 = \pi_2 = 0$, which implies that $p - cq_1 = p - cq_2 = 0$. When we solve for q_1 and q_2, we obtain $q_1^* = q_2^* = \frac{p}{c}$.

Insert q_1^* and q_2^* into Equation (3.12) and (3.13):

$$\frac{2(\alpha_1 r + p)}{3(c-\alpha_1)} + \frac{\alpha_2 r + p}{3(c-\alpha_2)} - \frac{t}{2\varphi} = \frac{p}{c}$$

$$\frac{2(\alpha_2 r + p)}{3(c-\alpha_2)} + \frac{\alpha_1 r + p}{3(c-\alpha_1)} - \frac{t}{2\varphi} = \frac{p}{c}.$$

When we solve the above two equations for the equilibrium altruism, we get the cutoff value of zero-profit altruism for both physicians $\overline{\alpha}_{1,2} = \frac{tc^2}{tc+2p\varphi+2cr\varphi}$.

Since all parameters are positive, $\overline{\alpha}_{1,2} > 0$.

Because $\overline{\alpha}_{1,2} = \frac{tc^2}{tc+2p\varphi+2cr\varphi} < \frac{tc}{tc+2p\varphi+2cr\varphi} < \frac{tc}{tc} = 1$. We prove that $\overline{\alpha}_{1,2} \in (0,1)$.

We now prove that $\overline{\alpha}_{1,2} = \frac{tc^2}{tc+2p\varphi+2cr\varphi} < c$. Assume

$$\overline{\alpha}_{1,2} = \frac{tc^2}{tc+2p\varphi+2cr\varphi} < c$$

$$\Leftrightarrow tc < tc + 2p\varphi + 2cr\varphi$$

$$\Leftrightarrow 0 < 2\varphi(p+cr)$$

The above expression is always satisfied. Hence, $\overline{\alpha}_{1,2} = \frac{tc^2}{tc+2p\varphi+2cr\varphi} < c$.

Therefore, when $\frac{tc-2\varphi p}{2\varphi\,\alpha_2 r+t} < \alpha_2 < \alpha_1 < \overline{\alpha}_{1,2} = \frac{tc^2}{tc+2p\varphi+2cr\varphi}$, both physicians provide positive qualities and they earn positive profits.

(5) When $\frac{tc-2\varphi p}{2\varphi r+t} < \alpha_2 < \overline{\alpha}_{1,2} \leq \alpha_1$, only physician 1 is bounded by the zero profit constraint and provides quality $q_1^* = \frac{p}{c}$. We insert $q_1^* = \frac{p}{c}$ into Equation (3.10):

$$q_2^* = \frac{\alpha_2 r+p}{2(c-\alpha_2)} - \frac{t}{4\varphi} + \frac{p}{2c}.$$

Insert $q_1^* = \frac{p}{c}$ and $q_2^* = \frac{\alpha_2 r+p}{2(c-\alpha_2)} - \frac{t}{4\varphi} + \frac{p}{2c}$ back into their profit functions, we have $\pi_1 = 0, \pi_2 > 0$. Therefore, physician 2's quality increases with altruism and he earns a positive material profit.

(6) When $\overline{\alpha}_{1,2} \leq \alpha_2 < \alpha_1$, both physicians are bounded by the zero profit constraints and provide quality $q_1^* = q_2^* = \frac{p}{c}$.

Q.E.D.

Proof of Proposition 3.4

1) When $\alpha_2 \leq \frac{tc-2\varphi p}{2\varphi r+t} < \alpha_1$, $q_2 = 0$. We insert $q_2 = 0$ into Equation (3.9) and obtain $q_1 = \frac{\alpha_1 r+p}{2(c-\alpha_1)} - \frac{t}{4\varphi}$. We have proved in Proposition 3 that the zero profit constrained altruism is $\overline{\alpha_1} = \frac{c(tc+2p\varphi)}{tc+2p\varphi+2\varphi(p+cr)}$.

We calculate the demands of both physicians:

$$d_1 = \frac{\varphi q_1}{t} + \frac{1}{2} = \frac{2p\varphi+ct+(2r\varphi-t)\alpha_1}{4t(c-\alpha_1)},$$

$$d_2 = 1 - d_1.$$

We insert equilibrium qualities and demand back into Equation (3.14),

$$W = r - \frac{t}{8} + \left(\frac{\alpha_1 r + p}{c-\alpha_1} - \frac{t}{2\varphi}\right)\frac{2p\varphi + ct + (2r\varphi - t)\,\alpha_1}{16t(c-\alpha_1)}(1-2c) + \frac{\alpha_1 r + p}{8(c-\alpha_1)} - \frac{t}{16\varphi}.$$

When $c \leq \frac{1}{2}$, we have $\frac{\partial W}{\partial \alpha_1} = -\frac{(p+cr)(t\alpha_1-2p\varphi-ct+4cp\varphi-2r\varphi\alpha_1+4cr\varphi\alpha_1)}{8t(c-\alpha_1)^3} > 0$. Welfare monotonically increases with α_1. However, we already know that the upper bound of altruism is $\overline{\alpha_1} = \frac{c(tc+2p\varphi)}{tc+2p\varphi+2\varphi(p+cr)}$. Hence, for any $\alpha_1 < \overline{\alpha_1}$, social welfare increases with physician 1's altruism degree; for any $\alpha_1 \geq \overline{\alpha_1}$, social welfare achieves the maximum and does not increase any more, due to the zero profit constraint.

2) and 3) When $c > \frac{1}{2}$, we let $\frac{\partial W}{\partial \alpha_1} = -\frac{(p+cr)(t\alpha_1-2p\varphi-ct+4cp\varphi-2r\varphi\alpha_1+4cr\varphi\alpha_1)}{8t(c-\alpha_1)^3} = 0$ and solve for α_1. We obtain $\alpha_1^* = \frac{ct-2p\varphi(2c-1)}{t+2r\varphi(2c-1)}$.

We now prove that $\alpha_1^* = \frac{ct-2p\varphi(2c-1)}{t+2r\varphi(2c-1)} < c$. Assume

$$\alpha_1^* = \frac{ct-2p\varphi(2c-1)}{t+2r\varphi(2c-1)} < c$$

$$\overset{c>\frac{1}{2}}{\Longleftrightarrow} ct + 2p\varphi(1-2c) < ct + 2cr\varphi(2c-1)$$

$$\Leftrightarrow 2p\varphi(1-2c) < 2cr\varphi(2c-1).$$

Because $c > \frac{1}{2}$, the left-hand side of the above expression is negative and the right-hand side is positive. The above expression is always satisfied when $c > \frac{1}{2}$. Hence, $\alpha_1^* = \frac{ct-2p\varphi(2c-1)}{t+2r\varphi(2c-1)} < c$.

The second derivative of welfare with respect to altruism is

$$\frac{\partial W^2}{\partial^2 \alpha_1} = -\frac{(p+cr)(t\alpha_1 - 3p\varphi - ct + 6cp\varphi - cr\varphi - 2r\varphi\alpha_1 + 2c^2r\varphi + 4cr\varphi\alpha_1)}{4t(c-\alpha_1)^4}$$

$$\left.\frac{\partial W^2}{\partial^2 \alpha_1}\right|_{\alpha_1^* = \frac{ct+2p\varphi(1-2c)}{t-2r\varphi(1-2c)}} = -\frac{(t-2r\varphi+4cr\varphi)^4}{64t\varphi^3(2c-1)^3(p+cr)^2} < 0.$$

This means that the welfare function is concave on altruism of physician 1.

We can calculate that if $p \geq \frac{ct}{2\varphi(2c-1)}$, $\alpha_1^* \leq 0$. Therefore, if $c > \frac{1}{2}$ and $p \geq \frac{ct}{2\varphi(2c-1)}$, social welfare deceases with physician 1's altruism when $\alpha_2 \leq \frac{tc-2\varphi p}{2\varphi r+t} < \alpha_1$.

If $p < \frac{ct}{2\varphi(2c-1)}$, $\alpha_1^* > 0$. We have to check whether α_1^* is larger or smaller than $\overline{\alpha_1}$. If $\alpha_1^* < \overline{\alpha_1}$, the social welfare optimal altruism degree is α_1^*, which is obtained from the welfare maximization; if $\alpha_1^* \geq \overline{\alpha_1}$, the social welfare optiamal altruism degree is any $\alpha_1 \geq \overline{\alpha_1} = \frac{c(tc+2p\varphi)}{tc+2p\varphi+2\varphi(p+cr)}$, which is obtained from the zero profit constraint.

We let $\alpha_1^* < \overline{\alpha_1}$ and solve for the optimal regulated price.

$$\frac{ct + 2p\varphi(1-2c)}{t - 2r\varphi(1-2c)} < \frac{c(tc + 2p\varphi)}{tc + 2p\varphi + 2\varphi(p + cr)}$$

$$\Leftrightarrow\ p < \frac{ct(1-c)}{2\varphi(2c-1)}$$

When $c > \frac{1}{2}$ and $p < \frac{ct(1-c)}{2\varphi(2c-1)}$, $\alpha_1^* < \overline{\alpha_1}$. When $c > \frac{1}{2}$ and $p \in \left(\frac{ct(1-c)}{2\varphi(2c-1)}, \frac{ct}{2\varphi(2c-1)}\right)$, $\alpha_1^* \geq \overline{\alpha_1}$.

We can wrap up the above proof to get the results:

If $c \leq \frac{1}{2}$, welfare is convex on α_1. Therefore, welfare increases with α_1 until the zero profit constraint and remains constant when $\alpha_1 \geq \overline{\alpha_1}$.

If $c > \frac{1}{2}$ and $p \geq \frac{ct}{2\varphi(2c-1)}$, welfare is concave on α_1 and $\alpha_1^* \leq 0$. Therefore, welfare decreases with α_1.

If $c > \frac{1}{2}$ and $p \in \left(\frac{ct(1-c)}{2\varphi(2c-1)}, \frac{ct}{2\varphi(2c-1)}\right)$, welfare is concave on α_1, $\alpha_1^* > 0$, and $\alpha_1^* > \overline{\alpha_1}$. Therefore, welfare increases with α_1 until the zero profit constraint and remains constant hereafter.

If $c > \frac{1}{2}$ and $p < \frac{ct(1-c)}{2\varphi(2c-1)}$, welfare is concave on α_1, $\alpha_1^* > 0$, and $\alpha_1^* < \overline{\alpha_1}$. Therefore, welfare has an optimal altruism $\alpha_1^* = \frac{ct-2p\varphi(2c-1)}{t+2r\varphi(2c-1)}$.

Q.E.D.

Proof of Proposition 3.5

1) From Proposition 3.2 we know that both physicians are bounded by the zero profit constraints when $\overline{\alpha}_{1,2} = \frac{tc^2}{tc+2p\varphi+2cr\varphi} \leq \alpha_2 < \alpha_1$.

Insert the equilibrium qualities $q_1^* = q_2^* = \frac{p}{c}$ into the welfare function,

$$W = r + q_1 d_1 - \theta \frac{t}{2} d_1 + q_2 d_2 - (1-\theta)\frac{t}{2} d_2 - c q_1 d_1 - c q_2 d_2$$

$$= r - \frac{t}{8} + \frac{p(1-c)}{c}.$$

As the reservation utility, transportation cost, price, and marginal cost are all constant numbers, welfare is constant as well. Hence, neither transparency nor altruism affects welfare.

However, higher transparency lowers the cutoff value $\overline{\alpha}_{1,2} = \frac{tc^2}{tc+2p\varphi+2cr\varphi}$. In a more transparent market, providers are more likely to supply a constrained quality level ($^p/_c$) and earn zero profits.

2) When $\frac{tc-2\varphi p}{2\varphi r+t} < \alpha_2 < \overline{\alpha}_{1,2} \leq \alpha_1$, we have proved in Proposition 3.2 (5) that $q_1^* = \frac{p}{c}$ and $q_2^* = \frac{p}{2c} + \frac{\alpha_2 r+p}{2(c-\alpha_2)} - \frac{t}{4\varphi}$. We can obtain demands as follows:

$$d_1 = \frac{p\varphi}{2tc} - \frac{(\alpha_2 r+p)\varphi}{2(c-\alpha_2)t} + \frac{3}{4}$$

$$d_2 = \frac{1}{4} - \frac{p\varphi}{2tc} + \frac{(\alpha_2 r+p)\varphi}{2(c-\alpha_2)t}.$$

The demands of both physicians are asymmetric in this subcase, which results in a higher average transportation cost. Patients pay more transportation costs and get lower quality gains. Hence, social welfare is lower compared to that in the first subcase.

3) When $\frac{tc-2\varphi p}{2\varphi r+t} < \alpha_2 < \alpha_1 < \overline{\alpha}_{1,2}$, both physicians provider positive quality and earn positive profits. The equilibrium qualities are:

$$q_1 = \frac{2(\alpha_1 r + p)}{3(c - \alpha_1)} + \frac{\alpha_2 r + p}{3(c - \alpha_2)} - \frac{t}{2\varphi}$$

$$q_2 = \frac{2(\alpha_2 r + p)}{3(c - \alpha_2)} + \frac{\alpha_1 r + p}{3(c - \alpha_1)} - \frac{t}{2\varphi}.$$

By inserting equilibrium qualities into their demand functions, we obtain the equilibrium demands:

$$d_1 = \frac{(\alpha_1 r + p)\varphi}{3(c - \alpha_1)t} - \frac{(\alpha_2 r + p)\varphi}{3(c - \alpha_2)t} + \frac{1}{2}$$

$$d_1 = \frac{(\alpha_2 r + p)\varphi}{3(c - \alpha_2)t} - \frac{(\alpha_1 r + p)\varphi}{3(c - \alpha_1)t} + \frac{1}{2}.$$

Due to even lower quality provision in comparison to the previous subcase, physicians earn higher profits. However, patients' utilities decrease directly with lower quality. Demands are asymmetric if quality differs. These asymmetric demands may lead to a higher average transportation cost compared to the first subcase. Especially when patients are very picky, even a small increase in transportation costs can dramatically decrease welfare, because the profit gains cannot compensate the transportation loss.

If patients are less picky, the profit gains may dominate the quality loss and transportation cost. Welfare rises if the physician surplus dominates the patient surplus. Overall, the effect of altruism on welfare is ambiguous.

Q.E.D.

Chapter 4

The Role of Market Transparency in Hospital Mergers

Xing Wu[§§]

Abstract

We study the effects of market transparency on a horizontal hospital merger by using a spatial competition framework. Our findings indicate that treatment qualities are strategic complements. Hospitals do not have incentives to merge when transparency is extremely low and may have incentives to merge when transparency is high. The effect of market transparency on social welfare is ambiguous. Hospitals can provide lower quality after the merger, which in turn to a lower production cost. If the relative fixed cost is not very high, then the efficiency gains are not sufficiently larger from a merge. High market transparency does not always play a positive role on social welfare, even though the number of hospitals is smaller after the merger. We also find that a hospital merger leads to a higher social welfare than before if the efficiency gains from the merger are sufficiently large and the marginal transportation cost is low.

JEL classification: D64, I11, L15, L41

Keywords: Transparency, Hospital Merger, Welfare

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4.1 Introduction

The health care market has undergone horizontal hospital mergers which are motivated by facilitating efficiency gains and enhancing the quality of medical care over the decades (Lisac et al., 2010; Brekke et al., 2016 and Choi et al., 2011). One of the reasons for the blooming hospital mergers is to avoid competition. Competition is usually considered to be beneficial for consumers, e.g. it leads to lower price, better quality, etc. For a given number of hospitals, it is in the interest of the group to minimize competition among themselves. However, Barros et al. (2016) prove that competition in the provision of health care is unlikely to contribute positively in all cases. Less competition should not necessarily be thought of as a practice detrimental to welfare. This study focuses on competition of hospital mergers and the related welfare effects.

In most countries, e.g. Germany, Norway, Sweden, Switzerland, etc., prices of health care service are regulated, such that hospitals cannot collude on price. Even though hospitals can alter prices only within this regulated interval, they still compete on other non-price characteristics such as treatment quality, waiting time, etc. Hospitals are usually assumed to compete on quality to attract patients and gain higher revenues under fixed Diagnosis-Related Groups (DRGs)-based prices. Hospital mergers may facilitate efficiency gains; however, there is a growing concern that the continuing mergers may increase market power in the health care markets and thereby lead to adverse effects for patients through lower quality of care (Gaynor et al., 2013).

Market competition in health care markets is an instrument for organizing decisions on improving quality of health care services. Several policies are aimed at increasing competition in the health sector, but Propper et al. (2004) find that the relationship between competition and quality of care appears to be negative in English National Health Service (NHS) studies. Greater competition is associated with higher death rates. While other evidence suggests that competition is good for quality. Cooper et al. (2011) find that hospital quality improved more quickly in more competitive markets after the health reforms were introduced in the NHS from 2002 to 2008. The empirical literature on US studies with fixed price markets (Medicare) shows ambiguous results on the relationship of competition and quality (Kessler & McClellan, 2000; Mukamel et al., 2001; Ho & Hamilton, 2000; Romano & Balan, 2011 and Capps, 2005). Especially Gowrisankaran and Town (2003) find converse results in their study which states that an increase in the degree of competition for health maintenance organization (HMO) patients is associated with a decrease in mortality rates. Conversely, an increase in competition for Medicare enrollees is associated with an increase in mortality rates for hospitals. Consequently, the effects of mergers on quality remain an under-researched issue, which poses a considerable challenge to competition policy practitioners who aim to deal with quality effects in a comprehensive way. It is still an open question whether competition is beneficial or harmful for the health care markets.

Market transparency is generally considered to be beneficial to social welfare (Mason & Phillips, 1997). However, one of the main characteristics of health economics is that quality information is not shared equally between hospitals and patients (Arrow, 1963). Therefore, the fully transparent model cannot be applied for health care markets. Patients have incomplete information about their conditions, and could make better decisions and obtain better products if they are better informed. Treatment quality has become an increasingly predominant part of our lives. It is even more difficult to define and measure than in other sectors, since health care service is an intangible product and cannot physically be touched, felt, viewed, counted, or measured like manufactured goods. It is often difficult to reproduce consistent health care services (Mosadeghrad, 2014). Market transparency may alter hospital behavior and further affect social welfare. The effects of hospital mergers on quality in a not fully transparent market are rarely mentioned in the existing literature. Several recent studies show the quality effects of merger without considering market transparency (Brekke et al., 2017). If the health market is totally non-transparent, hospitals have little motivation to provide good service as few patients could assess their quality. Hence, market transparency plays a significant role in our study.

Hospitals hire physicians to provide health service. Nevertheless, physicians are not only motivated by profits, but also by patients' utilities. A large body of evidence gathered by experimental economists and psychologists verify that concerns for altruism, fairness, and reciprocity strongly motivate many people (Fehr & Fischbacher, 2003; Bolton & Ockenfels, 2000; Fehr & Schmidt, 1999). Furthermore, a study by Kolstad (2013) provides an empirical result that suppliers are motivated by a desire to perform well in addition to profit. Hence, in this study, we assume that hospitals maximize a weighted sum of their own profits and patient utility.

We know that the profitability of a given firm is in many cases highly dependent on the firm's location, especially, relative to its competitors' locations. Hotelling (1929) proposes the principle of “Minimum Differentiation”: two providers of a homogeneous product agglomerate at the center of the line market under linear transportation costs. But d’Aspremont et al. (1979) state that the so-called the principle of “Minimum Differentiation”, as based on Hotelling's celebrated paper (Hotelling, 1929), is invalid. They show that there is a tendency for both sellers to maximize their differentiation. However, we are interested in mergers in a health care market with more than two hospitals. Hence, we imply Salop’s work (1979) and limit the locations of hospitals to the maximum distance from each other to obtain a symmetric circular city model.

Given the growing real-world importance of hospital mergers, we are interested in knowing the merge incentives and the effects of transparency on the outcomes. However, standard merger analyses cannot be directly applied to mergers in health care markets as the characteristics mentioned above. In order to answer how hospital mergers affect health care markets, we use a Salop (1979) circular city model with three ex ante identical hospitals symmetrically located on a circle. Demand is explicitly derived from individual preferences and depends on quality and transportation costs (interpreted either as horizontal product differentiation or physical travelling costs). Hospitals choose quality to maximize their utilities.

Our analysis offers three sets of findings. First, treatment qualities are strategic complements and hospitals may have incentives to merge under conditions of sufficiently high market transparency. When market transparency is not too low, hospitals have to provide positive quality without mergers. However, if they merge, hospitals could provide a lower quality of treatment at this transparency level to avoid too intense competition. Second, the effect of market transparency on social welfare is ambiguous. High transparency is not always related to high welfare. Finally, we show that a hospital merger leads to a higher social welfare than before at a high transparency level if the efficiency gains from the merger are sufficiently large and the marginal transportation cost is sufficiently low.

The rest of this chapter is organized as follows. In Section 4.2 we present the theoretical model of patient behavior and hospital behavior. In Sections 4.3 and 4.4 we derive the pre-merger and post-merger equilibria separately. Section 4.5 conducts the welfare results after a merger and a comparison of pre- and post- merger games. The last section concludes.

4.2 Theoretical Model

Consider a health care market where three hospitals, denoted by $i = 1, 2, 3,$ are equidistantly located on a circle. Hospitals offer treatments with quality $q_i \geq 0$. A mass one of patients are uniformly distributed on the same circle and seek treatment to maximize their own utilities. Each patient demands one unit of medical treatment from the most preferred hospital.

We adapt a two-stage product differentiation model by Salop (1979) with regulated price p.

Pre-merger Stage: Hospitals distribute evenly on the circle and set the level of quality provided. Patients choose which hospital they visit (see Figure 4.1 (a)).

Post-merger Stage: Hospitals 2 and 3 merge when it is profitable and both the insider hospital m and the outsider hospital o relocate (in product space) simultaneously (see Figure 4.1 (b)).

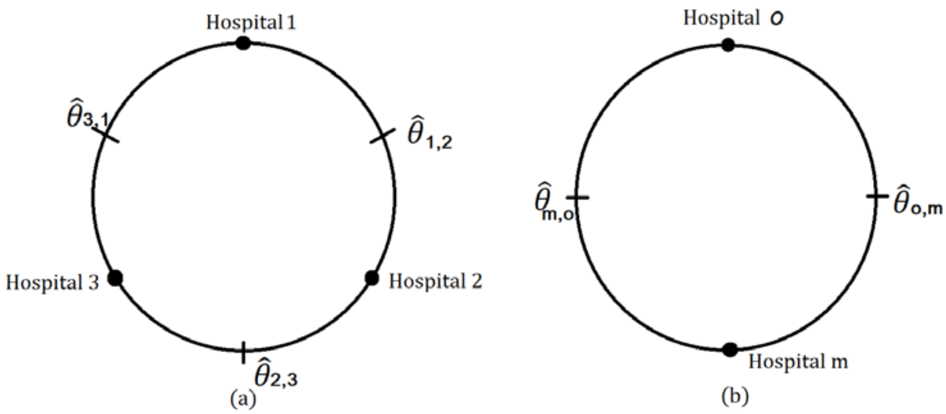

Figure 4.1: The locations of hospitals and indifferent patients.

Notes: In the pre-merger game (a), there are three hospitals. In the post-merger game (b), the number of total hospitals is two.

Without loss of generality, we assume that before merger, hospital 1 locates at 0, hospital 2 locates at 1/3 and hospital 3 locates at 2/3; after merger, the two hospitals are located at the maximum distance from each other. For simplicity, we assume that the outsider hospital o remains its location and the new merged hospital m locates at 1/2. Hospitals receive a regulated price for each patient treated and compete on quality to maximize utility. Quality is the result of the hospitals' investments in machines, diagnostic tests, and amenities that may improve the outcome of the treatment or patient comfort.

We suppose that only a share of patients $\varphi \in (0,1)$ are informed about the treatment quality, where φ is the measure of market transparency, since the health care market is usually not fully transparent. Patients of a proportion $1-\varphi$ are uninformed.

The following sections consider the behavior of the different actors. First, we focus on patients' choices in terms of hospitals. Next, we analyze the hospitals' incentives with respect to decisions on the health care quality.

4.2.1 Patient Behavior

Patients maximize their utility by purchasing one unit of the medical treatment. The informed patient with address $\theta \in [0,1]$ visiting hospital i with address x_i has a net utility:

$$u = r + q_i - t|\theta - x_i|, i = 1,2,3, \tag{4.1}$$

where $q_i \geq 0$ denotes hospital i's quality; $t > 0$ is the marginal transportation cost; $r > 0$ denotes the reservation utility from consuming one unit of treatments. We assume for simplicity that the reservation value r is sufficiently large to ensure that every patient prefers treatment over no treatment. However, the uninformed patients have incomplete information about the quality levels, and seek treatment at the closest hospital to minimize transportation cost. We also assume without loss of generality that $t > 2\left|q_i - q_j\right|, i \neq j$. This assumption ensures that every regulatory equilibria considered in the paper exist.

There exists a patient located at the point $\hat{\theta}_{i,i+1}$ (see Figure 4.1) who is indifferent between the two adjacent hospitals i and $i + 1$ ($i + 1$ denotes the next clockwise hospital on the circle, $i - 1$ denotes the next counter-clockwise hospital on the circle):

$$r + q_i - t(\hat{\theta}_{i,i+1} - x_i) = r + q_{i+1} - t(x_{i+1} - \hat{\theta}_{i,i+1}). \tag{4.2}$$

Solving the above equation for $\hat{\theta}_{i,i+1}$, we obtain the location of this informed indifferent patient $\hat{\theta}_{i,i+1}$ between hospitals i and $i+1$, which is given by

$$\hat{\theta}_{i,i+1} = \frac{q_i - q_{i+1}}{2t} + \frac{x_i + x_{i+1}}{2}. \tag{4.3}$$

As the locations of hospitals are fixed, taking the example of Figure 4.1 (a), we obtain that the indifferent patients locate at $\hat{\theta}_{1,2} = \frac{q_1 - q_2}{2t} + \frac{1}{6}$, $\hat{\theta}_{2,3} = \frac{q_2 - q_3}{2t} + \frac{1}{2}$, $\hat{\theta}_{3,1} = \frac{q_3 - q_1}{2t} + \frac{5}{6}$. We notice that the locations of these informed indifferent patients depend only on relative quality levels, not on the absolute qualities. In other words, only the marginal transportation cost and quality differences affect the indifferent patients' locations.

4.2.2 Hospital Behavior

The first step of the analysis is to derive the demand function for each hospital. Hospitals maximize their utilities via quality decisions. Since φ measures the market transparency, the demand for hospital i comes from both the informed and uninformed patients. Demand from informed patients depends on the locations of indifferent patients. Patients who are uninformed about quality go to the nearest hospital.

Hospital i's demand is given by

$$d_i = \varphi(\theta_{i,i+1} - \theta_{i-1,i}) + (1-\varphi)\frac{1}{3} = \varphi\left(\frac{2q_i - q_{i-1} - q_{i+1}}{2t}\right) + \frac{1}{3}. \tag{4.4}$$

From Equation (4.4) we can see that all hospitals share the market equally if and only if they provide identical quality.

For each unit of medical treatment supplied, each hospital receives a regulated price and has an identical marginal cost. On top of variable costs, providers also incur some fixed costs which we assume for analytical convenience to be quadratic in the level of quality (Bardey et al., 2012). The payment to hospitals for the same treatments are the same and independent of their locations or kinds of medical practice within the same Diagnosis-Related Group (DRG). To keep our model tractable, we suppose the material profit of hospital i is given by the following:

$$\pi_i = (p - cq_i)d_i - \frac{k}{2}q_i^2, \qquad (4.5)$$

where $c \in (0,1)$ is marginal cost of one unit of quality per patient, $p > 0$ is the regulated price, and $k > 0$ measures the relative importance of the fixed cost. When $c \in (0,1)$, quality is costly. This is a reasonable assumption that is consistent with constant returns to scale with respect to the number of patients treated when the cost per unit is increasing with the quality of the treatment (Brekke et al., 2016).

Hospitals take their patients' benefit from treatments into account when medical decisions are made. Hospitals are altruistic in the sense that they hire physicians that are altruistic. Therefore, hospital i's objective function is given by the sum of the hospital profit and patients' benefits from treatments without transportation costs:

$$U_i = (p - cq_i)d_i - \frac{k}{2}q_i^2 + \alpha\,(r + q_i)d_i = [p + \alpha r - (c - \alpha)q_i]d_i - \frac{k}{2}q_i^2, \qquad (4.6)$$

where $\alpha \in (0,1)$ denotes the altruism of hospitals.

Hospital i maximizes its objective function subject to the zero profit constraint.

We assume that: 1) $\alpha < c$, such that the increase in utility from altruism is less than the increase in material cost. Hence, hospital utility is decreasing in quality; 2) there is homogeneous altruism in the health care market. Hospitals set quality in order to maximize utility subject to the constraint of market demand. The term $(r + q_i)d_i$ represents the benefit from treatments that patients receive. We can interpret this utility function of hospital i as the sum of weighted own profit and patients' well-being. Given the locations, hospitals get the same demand from the uninformed patients.

4.3 Pre-merger Analysis

In order to analyze how the hospitals' decisions on quality are determined by market transparency, we start out by deriving the Nash equilibrium quality for a common given level of altruism in the pre-merger game.

To analyze the subgame perfect quality equilibrium, we have assumed that locations of the three hospitals are fixed. Inserting demand function (Equation 4.4) into the objective function (Equation 4.6), the first-order condition gives the quality reaction function of hospital i as:

$$q_i = \frac{3\varphi(p+r\alpha)-t(c-\alpha)}{6\varphi(c-\alpha)+3kt} + \frac{\varphi(c-\alpha)}{4\varphi(c-\alpha)+2kt} q_{i-1} + \frac{\varphi(c-\alpha)}{4\varphi(c-\alpha)+2kt} q_{i+1}. \quad (4.7)$$

We see that qualities are strategic complements between competing hospitals, i.e., $\frac{\partial q_i}{\partial q_{i-1}} > 0$, $\frac{\partial q_i}{\partial q_{i+1}} > 0$. The intuition is that if a hospital increases its own quality, the competing hospitals lose demand, which in turn implies a lower profit margin. Therefore, those hospitals respond by increasing their quality levels as well.

All hospitals make their quality decisions simultaneously. Assuming symmetry we can solve Equation (4.7) for equilibrium quality in the market, which gives the following:

$$q = \frac{3\varphi(p+r\alpha)-t(c-\alpha)}{3\varphi(c-\alpha)+3kt}. \quad (4.8)$$

Quality is supposed to be non-negative, and hospitals maximize their utilities subject to the zero profit constraints. We can state the following:

Proposition 4.1 *Lower market transparency affects equilibrium quality as follows:*

(1) When $\varphi \in \left(0, \frac{1}{3}\tilde{\varphi}\right]$, *where* $\tilde{\varphi} = \frac{t(c-\alpha)}{p+r\alpha}$, *hospitals provide the unique Nash equilibrium quality* $q^* = 0$. *Quality does not change when market transparency decreases. All three hospitals earn constant positive material profit* $\frac{p}{3}$*;*

(2) When $\varphi \in \left(\frac{1}{3}\tilde{\varphi}, \bar{\varphi}\right)$, *where* $\bar{\varphi} = \frac{kt\left(\sqrt{6kp+c^2}-\alpha\right)}{3k(p+r\alpha)-(c-\alpha)\left(\sqrt{6kp+c^2}-c\right)}$, *hospitals provide the unique Nash equilibrium quality* $q^* = \frac{3\varphi(p+r\alpha)-t(c-\alpha)}{3\varphi(c-\alpha)+3kt}$. *Quality falls when transparency decreases marginally. Hospitals earn positive material profits, and profits increase with lower transparency;*

(3) When $\varphi \in [\bar{\varphi}, 1)$, *hospitals provide the unique Nash equilibrium quality* $\bar{q} = \frac{\sqrt{6kp+c^2}-c}{3k}$. *Equilibrium quality does not depend on transparency and hospitals earn zero material profits.*

Proof in Appendix.

The underlying intuition is that hospitals have no incentive to provide any positive quality treatments when patients cannot assess treatment quality levels, irrespective of altruism. At a low market transparency level $\varphi \in \left(0, \frac{1}{3}\tilde{\varphi}\right]$, hospitals do not compete with each other. All hospitals provide zero quality treatments, such that a small increase in transparency does not affect equilibrium quality.

When market transparency becomes higher than the cutoff value $\frac{1}{3}\tilde{\varphi}$, hospitals compete sufficiently strongly to provide positive quality. Due to the symmetry of the game, demand levels are the same for all three hospitals. Therefore, profits are the same and affected only by the equilibrium quality level. With increasing quality, hospital profits become smaller.

Eventually market transparency rises up to a sufficiently high level $\varphi > \bar{\varphi}$. Quality competition becomes too intensive, which leads to zero profits for the hospitals. Hence, hospitals cannot increase quality any further after the zero profit is constrained.

4.4 Post-merger Analysis

In this section we focus on the post-merger game. We analyze how the equilibrium quality is determined by different market transparency levels.

The effects of market transparency on hospital mergers crucially depend on the nature of competition among hospitals. Hospital mergers occur if and only if utility rises for the merged hospital at the post-merger game compared to the sum of the individual utilities at the pre-merger game. After the merger, hospitals would cooperate to provide better service. Suppose hospital 2 and 3 merge to hospital m, they can avoid too intensive competition and provide quality q_m. The outsider is denoted by hospital o, and can adjust quality to q_o. The merged hospital relocates on the circle. We can state the following:

Proposition 4.2 *(1) When $\varphi \in \left(0, \frac{1}{3}\tilde{\varphi}\right]$, hospitals have no incentive to merge;*

(2) When $\varphi \in \left(\frac{1}{3}\tilde{\varphi}, \frac{1}{2}\tilde{\varphi}\right]$, hospitals have incentives to merge when the merged hospital's utility is larger than the total individual utilities before merger, and provide the Nash equilibrium quality $q_m^* = q_o^* = 0$;

(3) When $\varphi \in (\frac{1}{2}\tilde{\varphi}, 1)$, hospitals have incentives to merge when the merged hospital's utility is larger than the total individual utilities before merger, and provide the Nash equilibrium quality $q_m^* = q_o^* = \frac{2\varphi(p+r\alpha)-t(c-\alpha)}{2\varphi(c-\alpha)+2kt}$.

Proof in Appendix.

The underlying intuition is that competition between hospitals becomes weaker after merger because fewer hospitals provide treatments in the market. When market transparency is too low, the two merged hospitals provide zero quality treatments in both the pre-merger game and the post-merger game. Hospitals lose demand if they merge because the potential outsider can benefit from the merger. Therefore, they have no incentive to merge in this low-transparency situation.

As long as market transparency increases but not sufficiently high to let the potential merged hospitals provide positive quality, they have incentives to merge under particular parameter values. The reason is to avoid intensive competition. Hospitals provide positive quality before the merger under this level of market transparency, but they can adjust quality levels to zero if the merger occurs. Both the insider and the outsider can benefit from lower quality levels.

When transparency is sufficiently high to provide positive quality in both pre-merger and post-merger games, compared to the quality equilibrium $q^* = \frac{3\varphi(p+r\alpha)-t(c-\alpha)}{3\varphi(c-\alpha)+3kt}$ before merger, hospitals can provide lower quality via merging, which leads to higher profits for both the insider and the outsider. Therefore, hospitals may have incentives to merge in this high-transparency situation.

We give an example to illustrate that hospitals do have incentives to merge. If $t = 1$, $k = 0.01, p = 1, r = 10, c = 0.8, \alpha = 0.08$, we can calculate the utility difference after and before merger for the two merged hospitals. Figure 4.2 shows the relationship between market transparency and utility difference. If the curve stays above the horizontal axis, it means that hospital utility after merger is larger than the total utilities of the two separate hospitals. In Figure 4.2 we can see that hospitals could earn larger utility if they merge in this example because the utility difference sometimes stays above the x-axis. It means that in this example the utility in the post-merger game is partially larger than the total utilities for the two merged hospitals in the pre-merger game. Therefore, we find that hospitals have incentives to merge in this example.

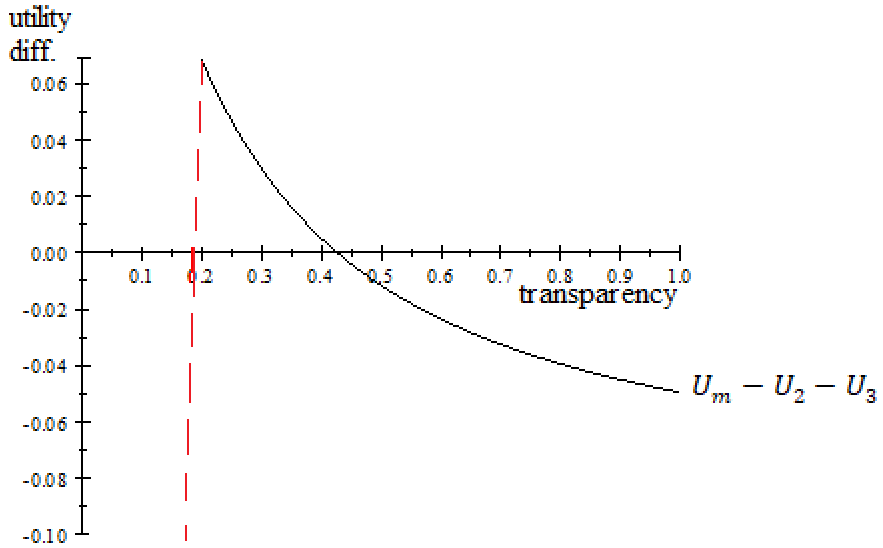

Figure 4.2: Merger incentives.

Notes: The dashed line denotes the utility difference $U_m - U_1 - U_2$ when $\varphi \in (\frac{1}{3}\tilde{\varphi}, \frac{1}{2}\tilde{\varphi}]$ and the solid line represents the case when $\varphi \in (\frac{1}{2}\tilde{\varphi}, 1)$.

4.5 Social Welfare

In this section, we analyze the welfare optimal transparency in both the pre-merger game and the post-merger game. We characterize the optimal transparency when hospitals can strategically set their qualities and compare the welfare before and after merger.

4.5.1 Pre-merger Welfare

Social welfare is defined as the sum of total consumer utility and total profits, which is given by the following:

$$W = CS + PS$$

$$= \sum_{i=1}^{3} (r + q_i - t|x_i - \theta|)d_i - \sum_{i=1}^{3} \left(cq_i d_i + \frac{k}{2} q_i^2\right). \tag{4.9}$$

When all hospitals provide positive quality treatments, the welfare optimal market transparency differs from that when all hospitals provide zero quality treatments. Hence, we can characterize the social welfare properties of the Nash equilibrium as follows:

Proposition 4.3 *Lower market transparency affects social welfare as follows:*

(1) When $\varphi \in \left(0, \frac{1}{3}\tilde{\varphi}\right]$*, welfare does not depend on transparency;*

(2) When $\varphi \in \left(\frac{1}{3}\tilde{\varphi}, \bar{\varphi}\right)$*, the effects of market transparency on welfare are ambiguous. Welfare decreases with transparency when* $k < \frac{(c-\alpha)(1-c)}{3(p+r\alpha)}$*; welfare achieves its maximum at* $\hat{\varphi} = \frac{kt(1-\alpha)}{3k(p+r\alpha)-(c-\alpha)(1-c)}$ *where* $\frac{\partial W}{\partial \hat{\varphi}} = 0$*,* $\frac{\partial^2 W}{\partial \hat{\varphi}^2} < 0$ *when* $k > \frac{(c-\alpha)(1-c)}{3(p+r\alpha)}$*;*

(3) When $\varphi \in [\bar{\varphi}, 1)$*, welfare does not depend on transparency.*

Proof in Appendix.

Briefly, competition among hospitals is too weak when market transparency stays at a low level, such that hospitals provide zero quality and earn positive profits. Hence, transparency has no effect on social welfare. Competition becomes stronger when market transparency becomes higher, therefore hospitals respond by increasing quality to attract patients. This increasing quality has two opposite effects on social welfare. The positive effect is that increasing quality can improve total consumer surplus. The negative effect is that higher quality leads to lower profit margins for hospitals. Overall, the effect of transparency on social welfare depends on which effect dominates. If the positive effect dominates, welfare is larger when transparency is large. If the negative effect dominates, welfare is lower in the second case in comparison to the first case. Depending on parameter values, social welfare increases or decreases with market transparency. It is possible to obtain maximal welfare when the fixed quality cost is sufficiently large. With increasing market transparency, profits become smaller due to higher quality, and eventually zero. Therefore, when market transparency is sufficiently high, welfare does not change with transparency due to the zero profit constraint.

4.5.2 Post-merger Welfare

There are two hospitals in the post-merger game, social welfare is given by Equation (4.9):

$$W = CS + PS = \sum_{i=o}^{m} (r + q_i - t|x_i - \theta|)d_i - \sum_{i=o}^{m} \left(cq_i d_i + \frac{k}{2} q_i^2\right). \quad (4.9)$$

We know from Proposition 4.2 that when $\varphi \in \left(0, \frac{1}{3}\tilde{\varphi}\right]$, hospitals have no incentive to merge. Therefore, welfare does not change.

When $\varphi \in \left(\frac{1}{3}\tilde{\varphi}, \frac{1}{2}\tilde{\varphi}\right]$, both hospital m and hospital o provide zero quality treatments and therefore divide the market equally. We insert qualities and demands back into the above Equation (4.9) and obtain $W = r - \frac{t}{4}$. This result shows that at the post-merger game, due to low market transparency, zero quality treatments are provided. Social welfare remains constant as qualities and demands are constant. Market transparency does not play a role for social welfare.

When $\varphi \in \left(\frac{1}{2}\tilde{\varphi}, 1\right)$, $q_o^* = q_m^* = \frac{2\varphi(p+r\alpha)-t(c-\alpha)}{2\varphi(c-\alpha)+2kt}$ applies after the merger. We obtain social welfare $W = r - \frac{t}{4} + (1-c)\frac{2\varphi(p+r\alpha)-t(c-\alpha)}{2\varphi(c-\alpha)+2kt} - k\frac{\left(2\varphi(p+r\alpha)-t(c-\alpha)\right)^2}{(2\varphi(c-\alpha)+2kt)^2}$. We can get the welfare-maximized market transparency $\hat{\varphi}_{post} = \frac{kt(1-\alpha)}{2k(p+r\alpha)-(c-\alpha)(1-c)}$, where $\frac{\partial W}{\partial \hat{\varphi}_{post}} = 0$, $\frac{\partial^2 W}{\partial \hat{\varphi}_{post}{}^2} < 0$.

However, it is not always the case that welfare-maximized transparency can be achieved within the interval $\left(\frac{1}{2}\tilde{\varphi}, 1\right)$. Under the condition $k < \frac{(c-\alpha)(1-c)}{2(p+r\alpha)}$, the global welfare-maximized transparency $\hat{\varphi}$ stays negative. Hence, when market transparency is sufficiently to ensure a hospital merger, i.e. $\varphi \in \left(\frac{1}{2}\tilde{\varphi}, 1\right)$, welfare decreases with market transparency when the efficiency gains from a merger are relatively small. The intuition is that when the relative importance of the fixed cost parameter k is small, quality is not costly. Hospitals compete more intensively with increasing market transparency and over provide quality. As a result it harms social welfare.

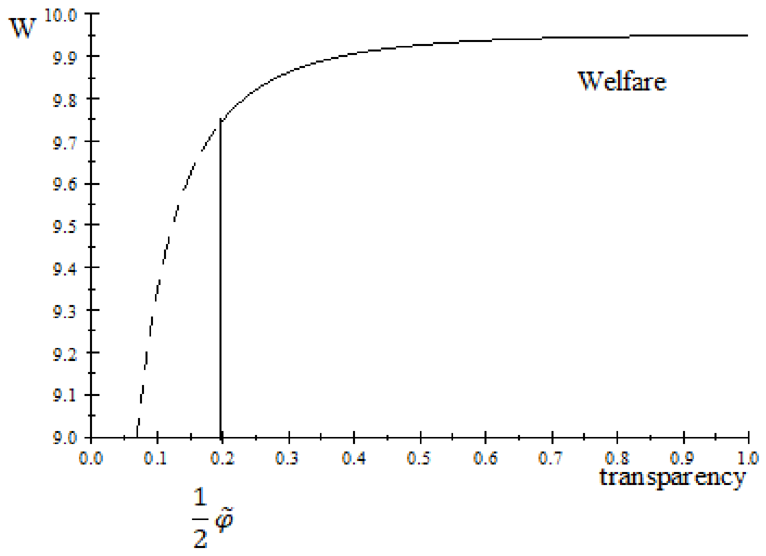

Figure 4.3: Welfare in the high transparency case if $\hat{\varphi}_{post} > 1$.

Notes: $\hat{\varphi}_{post} > 1$ when $t < \frac{2(p+r\alpha)}{1-\alpha}$ and $k \in \left(\frac{(c-\alpha)(1-c)}{2(p+r\alpha)}, \frac{(c-\alpha)(1-c)}{2(p+r\alpha)-t(1-\alpha)}\right)$.We take an example of $r = 10, t = 1,$ $p = 1, k = 0.05, c = 0.8, \alpha = 0.08$. Welfare increases with φ.

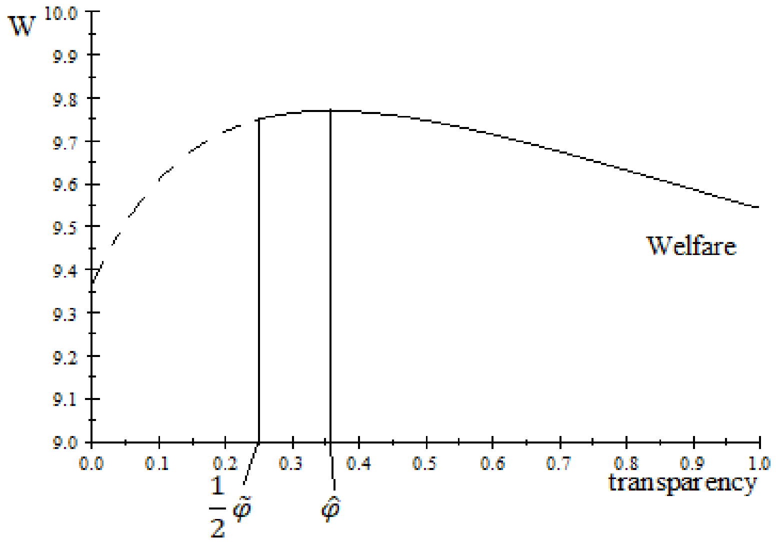

Figure 4.4: Welfare in the high transparency case if $\hat{\varphi}_{post} \in (\frac{1}{2}\tilde{\varphi}, 1)$.

Notes: $\hat{\varphi}_{post} \in (\frac{1}{2}\tilde{\varphi}, 1)$ when $t < \frac{2(p+r\alpha)}{1-\alpha}$ and $k > \frac{(c-\alpha)(1-c)}{2(p+r\alpha)-t(1-\alpha)}$. We take an example of $r = 10, t = 1, p = 0.4, k = 0.5, c = 0.8$ and $\alpha = 0.1$. Welfare reaches the maximum at $\hat{\varphi}$.

Differing from the situation when $k < \frac{(c-\alpha)(1-c)}{2(p+r\alpha)}$, welfare increases with market transparency when $t < \frac{2(p+r\alpha)}{1-\alpha}$ and $k \in (\frac{(c-\alpha)(1-c)}{2(p+r\alpha)}, \frac{(c-\alpha)(1-c)}{2(p+r\alpha)-t(1-\alpha)})$ (Figure 4.3). In this case the marginal transportation cost is at a low level and the relative importance of the fixed cost parameter k is large. Consequently, quality is costly and under-provided. Hospitals compete more intensively with increasing market transparency, and welfare increases conversely in this case.

In the last situation, social welfare achieves a maximum of $\widehat{W}_{post} = r - \frac{t}{4} + \frac{(1-c)^2}{4k}$ at $\hat{\varphi}_{post} = \frac{kt(1-\alpha)}{2k(p+r\alpha)+(c-\alpha)(c-1)}$ when $t < \frac{2(p+r\alpha)}{1-\alpha}$ and $k > \frac{(c-\alpha)(1-c)}{2(p+r\alpha)-t(1-\alpha)}$ (Figure 4.4). Figure 4.4 shows when the relative importance of the fixed cost parameter k is sufficiently large, the efficiency gains from a merger is large. Hospitals compete more intensively and provide higher quality with increasing market transparency when it stays at a low level. However, quality is too costly. Therefore, an increase in quality leads to a considerable reduction in welfare. Furthermore, as long as transparency increases until the welfare-maximized market transparency $\hat{\varphi}_{post}$, competition becomes dramatically intense, such that hospitals could not afford such a high quality anymore and would reduce their quality instead of further raising it. Hence, social welfare first increases then decreases with market transparency.

We are interested in comparing the social welfare before and after merger, such that we get the following:

Proposition 4.4 *Social welfare after the merger is larger than that before the merger if* $t < \frac{2(p+r\alpha)}{1-\alpha}$ *and* $k \in \left(\frac{(c-\alpha)(1-c)}{2(p+r\alpha)-t(1-\alpha)}, \frac{(1-c)^2}{2t}\right)$.

Proof in Appendix.

As k measures the relative importance of the fixed cost, when quality becomes lower after merger, hospitals have lower production costs. Hence, the efficiency gains from the merger are sufficiently large if $k \in \left(\frac{(c-\alpha)(1-c)}{2(p+r\alpha)-t(1-\alpha)}, \frac{(1-c)^2}{2t}\right)$. Furthermore, the marginal transportation cost is small. Even though the number of hospitals decreases after a merger, which harms the patient surplus, the transportation effect gains and the production cost-savings (efficiency gains) are sufficiently large to compensate the negative effects of a lower quality on patient surplus if hospitals merge.

From the social welfare perspective, high market transparency does not always play a positive role as we may expect. The reasons could be that hospitals reduce quality after a merger to release competition. The average disutility due to transportation decreases with the number of hospitals. As there exist fewer hospitals after a merger, transportation costs increase, which is harmful for welfare. Hence, welfare decreases with transparency when the efficiency gains from a merger is small. However, if the marginal transportation cost is low, the total transportation costs do not increase so much in comparison to the cost reduction on the supply side. Hospitals have lower production costs, which is beneficial for welfare. Therefore, when the efficiency gains are large and the marginal transportation cost is relatively low, social welfare after merger can be larger than that before merger, even though the number of hospitals is reduced.

4.6 Conclusion

Mergers between hospitals is a pervasive phenomenon. In this paper, we analyze the impact of a merger between two hospitals in a Salop (1979) model, taking into account the different levels of market transparency. In a model with homogeneous altruism, we show that hospitals may have incentives to merge and provide treatment of a lower quality when market transparency is not extremely low. More importantly, we find that the effect of market transparency on social welfare is ambiguous.

Our analysis has been based on some specific assumptions. Welfare decreases with market transparency if the efficiency gains from a merger are too small. If the marginal transportation cost is low and quality is costly, social welfare increases with transparency. The reason is that quality is under-provided. Therefore, hospitals compete more intensively with increasing market transparency, which is beneficial for welfare. Social welfare achieves a maximum when the marginal transportation cost is low and the efficiency gains from a merger are sufficiently large. Mergers imply a decrease in quality, lower variety and fixed production costs. Part of these cost reductions is passed on to hospitals in the form of higher profits. On the patient side, fewer hospitals serving in the market means a larger average transportation cost. However, if the marginal transportation cost is low, the benefit that hospitals receive from cost reductions can compensate the negative impact on patient surplus, social welfare may become larger after the merger than before.

Evidence on the impacts of mergers on quality and welfare in health care markets is vital to policy decisions regarding competition. Our analysis offers a theoretical investigation of hospital mergers under price regulation. As a result, the welfare effects of a merger will be conditional on the specific parameter values, such as production costs and transportation costs. Social welfare cannot always be improved by increasing market transparency.

4.7 Appendix

Proof of Proposition 4.1

(1) As discussed in Section 4.3, quality is supposed to be non-negative. We set Equation (4.8) equal to zero and calculate the corresponding market transparency level.

$$q = \frac{3\varphi(p+r\alpha)-t(c-\alpha)}{3\varphi(c-\alpha)+3kt} > 0$$

$$\xRightarrow{3\varphi(c-\alpha)+3kt>0} 3\varphi(p+r\alpha)-t(c-\alpha) > 0$$

$$\Rightarrow \varphi > \frac{t(c-\alpha)}{3(p+r\alpha)}.$$

Let $\tilde{\varphi} = \frac{t(c-\alpha)}{p+r\alpha}$, we could easily obtain that when $\varphi \leq \frac{1}{3}\tilde{\varphi}$, Equation (4.8) $q = \frac{3\varphi(p+r\alpha)-t(c-\alpha)}{3\varphi(c-\alpha)+3kt} \leq 0$. Hence, the unique Nash equilibrium quality under this case is $q^* = 0$.

Quality remains zero when $\varphi \in \left(0, \frac{1}{3}\tilde{\varphi}\right]$, such that any marginal increase in market transparency has no effect on quality.

Hence, the equilibrium profit is $\pi_1 = \pi_2 = \pi_3 = \frac{p}{3}$. All three hospitals earn constant positive material profit.

(2) When $\varphi > \frac{1}{3}\tilde{\varphi}$, the numerator of Equation (4.8) $q = \frac{3\varphi(p+r\alpha)-t(c-\alpha)}{3\varphi(c-\alpha)+3kt}$ is strictly positive. In addition, its denominator is positive. Hence, the equilibrium quality is $q^* = \frac{3\varphi(p+r\alpha)-t(c-\alpha)}{3\varphi(c-\alpha)+3kt} > 0$ under this case.

By total differentiation it is possible to calculate the impact of a transparency change on the marginal quality, which is

$$\frac{dq^*}{d\varphi} = \frac{t\left((c-\alpha)^2+3k(p+r\alpha)\right)}{3(\varphi(c-\alpha)+kt)^2} > 0.$$

Consequently, market transparency has a positive effect on equilibrium quality when $\varphi > \frac{1}{3}\tilde{\varphi}$.

Hospitals are not bounded by the zero profit constraints and earn positive material profits. However, profits decrease with higher transparency.

(3) Hospital profits cannot become negative, which puts an upper bound on quality. We set

$$\pi_i = (p - cq_i)d_i - \frac{k}{2}q_i^2 = 0.$$

Solving for q, we obtain the upper bound quality $\bar{q} = \frac{\sqrt{6kp+c^2}-c}{3k}$.

Let $q = \frac{3\varphi(p+r\alpha)-t(c-\alpha)}{3\varphi(c-\alpha)+3kt} = \bar{q}$, we get the upper bound transparency:

$$\bar{\varphi} = \frac{kt\left(\sqrt{6kp+c^2}-\alpha\right)}{3k(p+r\alpha)-(c-\alpha)\left(\sqrt{6kp+c^2}-c\right)}.$$

Now we have to prove that $\bar{\varphi} > \frac{1}{3}\tilde{\varphi}$.

$$\bar{\varphi} - \frac{1}{3}\tilde{\varphi}$$

$$= \frac{kt\left(\sqrt{6kp+c^2}-\alpha\right)}{3k(p+r\alpha)-(c-\alpha)\left(\sqrt{6kp+c^2}-c\right)} - \frac{t(c-\alpha)}{3(p+r\alpha)}$$

$$> \frac{kt\left(\sqrt{6kp+c^2}-\alpha\right)}{3k(p+r\alpha)} - \frac{t(c-\alpha)}{3(p+r\alpha)}$$

$$= \frac{t\left(\sqrt{6kp+c^2}-\alpha\right)}{3(p+r\alpha)} - \frac{t(c-\alpha)}{3(p+r\alpha)}$$

$$> \frac{t(c-\alpha)}{3(p+r\alpha)} - \frac{t(c-\alpha)}{3(p+r\alpha)}$$

$$= 0$$

We prove that $\bar{\varphi} - \frac{1}{3}\tilde{\varphi} > 0$.

When $\varphi \in [\bar{\varphi}, 1)$, hospitals are bounded by zero profit constraints and provide the unique Nash equilibrium quality $\bar{q} = \frac{\sqrt{6kp+c^2}-c}{3k}$. Quality remains constant when transparency changes marginally.

Q.E.D.

Proof of Proposition 4.2

(1) When $\varphi \in (0, \frac{1}{3}\tilde{\varphi}]$, hospitals provide zero quality before and after merger. The sum of the individual utilities before merger is denoted by $U_2 + U_3 = \frac{2(p+\alpha r)}{3}$. However, if the two hospitals merge, the utility becomes $U_m = \frac{p+\alpha r}{2}$ which is smaller than the previous total utilities. Therefore hospitals have no incentive to merge.

(2) and (3) When $\varphi \in (\frac{1}{3}\tilde{\varphi}, 1)$ hospitals provide positive quality $q^* = \frac{3\varphi(p+r\alpha)-t(c-\alpha)}{3\varphi(c-\alpha)+3kt}$ before merger. The sum of the individual utilities before merger can be calculated by inserting q^* into Equation (4.6), which is given by

$$U_2 + U_3 = \frac{2(p+r\alpha)}{3} - \frac{(3\varphi(p+r\alpha)-t(c-\alpha))\left(2\varphi(c-\alpha)^2+3kt(c-\alpha)-3\varphi k(p+r\alpha)\right)}{9(\varphi(c-\alpha)+kt)^2}.$$

Next, we have to calculate hospital m's utility U_m and compare it with $U_2 + U_3$.

If the two hospitals merge, the informed indifferent patient between hospital m and hospital o locates at $\hat{\theta}_{o,m}$, where $r + q_o - t(\hat{\theta}_{o,m} - 0) = r + q_m - t\left(\frac{1}{2} - \hat{\theta}_{o,m}\right)$.

Solving for the indifferent patient's location after merger, we obtain

$$\hat{\theta}_{o,m} = \frac{q_o - q_m}{2t} + \frac{1}{4}.$$

We can solve for the demand of hospital m and hospital o by inserting $\hat{\theta}_{o,m}$ back into demand functions, which implies the following:

$$d_m = \frac{1}{2} + \frac{\varphi(q_m - q_o)}{t}, \tag{4.10}$$

$$d_o = \frac{1}{2} + \frac{\varphi(q_o - q_m)}{t}. \tag{4.11}$$

The merged hospital provides quality q_m and the outsider adjusts to q_o to maximize their utilities U_m and U_o. Inserting demand into the objective function (Equation 4.6), the first-order conditions give the quality reaction functions as:

$$q_m = \frac{2\varphi(p+r\alpha)-t(c-\alpha)}{4\varphi(c-\alpha)+2kt} + \frac{\varphi(c-\alpha)q_o}{2\varphi(c-\alpha)+kt}, \tag{4.12}$$

$$q_o = \frac{2\varphi(p+r\alpha)-t(c-\alpha)}{4\varphi(c-\alpha)+2kt} + \frac{\varphi(c-\alpha)q_m}{2\varphi(c-\alpha)+kt}. \tag{4.13}$$

Since quality levels never become negative, we set Equation (4.12) and (4.13) equal to zero and calculate the corresponding market transparency level. We can easily obtain that $q_m^* = q_o^* = 0$ when $\varphi \in (\frac{1}{3}\tilde{\varphi}, \frac{1}{2}\tilde{\varphi}]$ and $q_m^* = q_o^* = \frac{2\varphi(p+r\alpha)-t(c-\alpha)}{2\varphi(c-\alpha)+2kt}$ when $\varphi \in \left(\frac{1}{2}\tilde{\varphi}, 1\right)$.

Sequentially, hospital m's utility after merger becomes:

i) $U_m = \frac{p+\alpha r}{2}$ when $\varphi \in (\frac{1}{3}\tilde{\varphi}, \frac{1}{2}\tilde{\varphi}]$;

ii) $U_m = \frac{p+r\alpha}{2} - \frac{2\varphi(p+r\alpha)(c-\alpha)-t(c-\alpha)^2}{4\varphi(c-\alpha)+4kt} + \frac{4k\varphi t(p+r\alpha)(c-\alpha)-4k\varphi^2(p+r\alpha)^2-kt^2(c-\alpha)^2}{8(\varphi(c-\alpha)+kt)^2}$ when $\varphi \in (\frac{1}{2}\tilde{\varphi}, 1)$.

We can compare utilities directly by setting parameter values, e.g. $t = 1$, $k = 0.01$, $p = 1$, $r = 10$, $c = 0.8$, $\alpha = 0.08$ (Figure 4.2). In Figure 4.2, we can see that the utility difference after and before merger sometimes stays above the x-axis. It means that in this example the utility in the post-merger game is partially larger than the total utilities for the two merged hospitals in the pre-merger game. This can support the statement that hospitals may have incentives to merge under certain conditions.

Q.E.D.

Proof of Proposition 4.3

(1) Given by Equation (4.9) $W = \sum_{i=1}^{3}(r + q_i - t|x_i - \theta|)d_i - \sum_{i=1}^{3}\left(cq_i d_i + \frac{k}{2}q_i^2\right)$, quality has direct and indirect effects (via demand) on welfare. As discussed in Section 4.3.1, the unique Nash equilibrium quality is $q^* = 0$ when $\varphi \in (0, \frac{1}{3}\tilde{\varphi}]$. Hence, any marginal increase in market transparency has no effect on welfare due to zero quality.

(2) When $\varphi \in \left(\frac{1}{3}\tilde{\varphi}, \bar{\varphi}\right)$, positive equilibrium quality $q^* = \frac{3\varphi(p+r\alpha)-t(c-\alpha)}{3\varphi(c-\alpha)+3kt}$ applies.

By inserting quality into the welfare function, we get the following welfare level:

$$W = \sum_{i=1}^{3}(r + q_i - t|x_i - \theta|)d_i - \sum_{i=1}^{3}\left(cq_i d_i + \frac{k}{2}q_i^2\right)$$

$$= r - \frac{t}{12} + \frac{\varphi(p + r\alpha)(1 - c)}{\varphi(c - \alpha) + kt} - \frac{t(c - \alpha)(1 - c)}{3(\varphi(c - \alpha) + kt)} - \frac{k\big(3\varphi(p + r\alpha) - t(c - \alpha)\big)^2}{6(\varphi(c - \alpha) + kt)^2}.$$

Performing first- and second-order differentiation to the above equation with respect to market transparency, we obtain

$$\frac{dW}{d\varphi} = \frac{t\big((c - \alpha)^2 + 3k(p + r\alpha)\big)}{-3(\varphi(c - \alpha) + kt)^3}[3k\varphi(p + r\alpha) - \varphi(c - \alpha)(1 - c) - kt(1 - \alpha)].$$

Let $\frac{dW}{d\varphi} = 0$, we solve for transparency and obtain

$$\hat{\varphi} = \frac{kt(1 - \alpha)}{3k(p + r\alpha) - (c - \alpha)(1 - c)}.$$

The second order condition is given by

$$\frac{d^2W}{d\hat{\varphi}^2} = -\frac{t\big((c - \alpha)^2 + 3k(p + r\alpha)\big)}{3(\varphi(c - \alpha) + kt)^4}[2\varphi(c - \alpha)^2(1 - c) + kt(c - \alpha)^2$$

$$+2kt(c - \alpha)(1 - \alpha) + 3k^2t(p + r\alpha) - 6\varphi k(p + r\alpha)(c - \alpha)].$$

When $k < \frac{(c-\alpha)(1-c)}{3(p+r\alpha)}$, we can obtain that $\hat{\varphi} < 0$ and $\frac{d^2W}{d\hat{\varphi}^2} < 0$. Social welfare achieves its maximum at $\hat{\varphi}$ globally. Considering that market transparency should be positive, therefore, social welfare decreases with transparency When $k < \frac{(c-\alpha)(1-c)}{3(p+r\alpha)}$.

When $k > \frac{(c-\alpha)(1-c)}{3(p+r\alpha)}$, we can obtain that $\hat{\varphi} > 0$ and $\frac{d^2W}{d\hat{\varphi}^2} < 0$. Social welfare achieves its maximum at $\hat{\varphi} = \frac{kt(1-\alpha)}{3k(p+r\alpha)-(c-\alpha)(1-c)}$.

To summarize, when $\varphi \in \left(\frac{1}{3}\tilde{\varphi}, \bar{\varphi}\right)$, social welfare decreases with market transparency when $k < \frac{(c-\alpha)(1-c)}{3(p+r\alpha)}$; social welfare achieves its maximum at $\hat{\varphi} = \frac{kt(1-\alpha)}{3k(p+r\alpha)-(c-\alpha)(1-c)}$ when $k > \frac{(c-\alpha)(1-c)}{3(p+r\alpha)}$. The effects of market transparency on social welfare are ambiguous.

(3) When $\varphi \in [\bar{\varphi}, 1)$, qualities are bounded by zero profits. Therefore, transparency has no effect on welfare in this situation.

Q.E.D.

Proof of Proposition 4.4

First, we have to prove that $\hat{\varphi}_{post} = \frac{kt(1-\alpha)}{2k(p+r\alpha)+(c-\alpha)(c-1)} > \frac{1}{2}\tilde{\varphi}$.

We set $\hat{\varphi}_{post} = \frac{kt(1-\alpha)}{2k(p+r\alpha)+(c-\alpha)(c-1)} > \frac{1}{2}\tilde{\varphi}$

$$\overset{t>0}{\Longleftrightarrow} \frac{k(1-\alpha)}{2k(p+r\alpha)+(c-\alpha)(c-1)} > \frac{c-\alpha}{2(p+r\alpha)}$$

$$\xLeftrightarrow{k>\frac{(c-\alpha)(1-c)}{2(p+r\alpha)}} 2k(p+r\alpha)(1-c) > -(c-\alpha)^2(1-c)$$, which is always satisfied.

Next, we let $\hat{\varphi}_{post} = \frac{kt(1-\alpha)}{2k(p+r\alpha)+(c-\alpha)(c-1)} < 1$

$$\Leftrightarrow kt(1-\alpha) < 2k(p+r\alpha) + (c-\alpha)(c-1)$$

$\Leftrightarrow k > \frac{(c-\alpha)(1-c)}{2(p+r\alpha)-t(1-\alpha)}$ when $t < \frac{2(p+r\alpha)}{1-\alpha}$.

Therefore, we always have $\hat{\varphi}_{post} \in (\frac{1}{2}\tilde{\varphi}, 1)$ when $t < \frac{2(p+r\alpha)}{1-\alpha}$ and $k > \frac{(c-\alpha)(1-c)}{2(p+r\alpha)-t(1-\alpha)}$.

Welfare reaches its maximum $\widehat{W}_{post} = r - \frac{t}{4} + \frac{(1-c)^2}{4k}$ at $\hat{\varphi}_{post}$ when $\varphi \in (\frac{1}{2}\tilde{\varphi}, 1)$.

When $\varphi = \hat{\varphi}_{post}$, we always have $\widehat{W}_{pre}\big|_{\hat{\varphi}_{post}} < \widehat{W}_{pre}\big|_{\hat{\varphi}} = r - \frac{t}{12} + \frac{(1-c)^2}{6k}$.

Comparing $\widehat{W}_{pre}\big|_{\hat{\varphi}}$ to $\widehat{W}_{post}$, we find if $k < \frac{(1-c)^2}{2t}$, we have $\widehat{W}_{pre}\big|_{\hat{\varphi}} < \widehat{W}_{post}\big|_{\hat{\varphi}_{post}}$.

Therefore, if $t < \frac{2(p+r\alpha)}{1-\alpha}$ and $k \in \left(\frac{(c-\alpha)(1-c)}{2(p+r\alpha)-t(1-\alpha)}, \frac{(1-c)^2}{2t}\right)$, $\widehat{W}_{pre}\big|_{\hat{\varphi}_{post}} < \widehat{W}_{post}\big|_{\hat{\varphi}_{post}}$. Social welfare becomes larger after the merger.

Q.E.D.

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