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Altruism heterogeneity, quality competition and horizontal differentiation among healthcare providers

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Abstract

Recent empirical evidence shows substantial altruism heterogeneity among healthcare providers. Spurred by this evidence, we build a quality competition model with altruism heterogeneity among healthcare providers that also endogenously determine the degree of horizontal differentiation within the healthcare provision market. We find that relatively more altruistic healthcare providers treat more patients and provide higher quality per patient. In addition, we show that when healthcare providers endogenously choose their location, the more altruistic provider locates more centrally. In terms of specialization this indicates that more altruistic providers can afford to engage in less horizontal differentiation.

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1 Introduction

Recent and ongoing healthcare reforms in several countries aim to stimulate quality competition and to promote patient choice among healthcare providers such as practicing physicians and hospitals. Policy means to achieve this goal include the implementation of payment schemes with regulated prices like capitation or diagnosis related groups. These payment schemes incentivize healthcare providers to attract patients by vertically competing on quality and horizontally in terms of location choice or "product" differentiation, e.g. by specializing on certain treatment approaches.

The way healthcare providers compete on these two dimensions crucially depends on their and competitors' objective functions and in particular on the assumption of altruistic preferences. The importance of altruism in the profession of healthcare providers has already been highlighted by Arrow (1963) and has ever since been a pivotal element in healthcare providers' objective functions. Following Ellis and McGuire (1986), contributions typically assume a healthcare provider's objective function as combination of the own profit π and patients' health benefit B. For example, if a healthcare provider i chooses the quantity of medical services q in order to maximize utility $U_i(q) = \pi(q) + \alpha_i B(q)$, the parameter $\alpha_i \geq 0$ is a measure for healthcare provider i's level of altruism.[1]

While there is a large body of theoretical literature on quality competition with regulated prices, most notably Brekke et al. (2006) who study a healthcare provider's endogenous choice of medical treatment quality and location choice, Brekke et al. (2011) were the first to study the effect of altruism within a spatial quality competition framework. In their model, the authors assume symmetric healthcare providers and focus on demand side asymmetry in terms of different patient types in order to explain empirical evidence both on quality and horizontal differentiation.[2]

However, recent empirical evidence highlights the importance of acknowledging asymmetry in terms of altruism heterogeneity on the supply side. Using laboratory experiments Godager and Wiesen (2013), Brosig-Koch et al. (2017), Li (2018), and Attema et al. (2023) report substantial heterogeneity in the degree of altruism across healthcare providers. In case of practicing physicians the latter resemble heterogeneous individual degrees of semi-altruism, and in case of hospitals different profit structures (for profit vs. not-for-profit). Concerning the relationship between altruism heterogeneity and quality of care there is also numerous evidence for for-profit hospitals and not-for-profit hospitals showing that the latter provide better quality, cf. Schlesinger et al. (1997), Sloan (2000) and Eggleston et al. (2008). Various theoretical papers acknowledge altruism heterogeneity and investigate its effect on quality of care, cf. Ma and Riordan (2002), Jack (2005), Siciliani (2009), Chone and Ma (2011), Lui and Ma (2013). However, the effect of altruism heterogeneity on vertical quality and the implications for horizontal differentiation is not well explored yet.[3]

[1] Cf. Chalkley and Malcomson (1998), Eggleston (2005), Heyes (2005), Jack (2005), Chone and Ma (2011), and Kaarboe and Siciliani (2011) for similar approaches.

[2] Cf. Grytten and Sørensen (2003), Epstein and Nicolson (2009), Gravelle and Sivey (2010), Bardey et al. (2012), and Gravelle et al. (2014) for related empirical evidence.

[3] Cf. Newhouse (1970), Woodward and Warren-Boultan (1984), Farley (1986) for early contributions.

In the field this heterogeneity in semi-altruism among healthcare providers has recently been spurred by policy measures that allow for a mixture of public and private providers. The UK and several Scandinavian countries have, for example, been opened up to private for-profit healthcare providers which directly compete with non-profit providers on quality and location choice, see e.g. Hehenkamp and Kaarbøe (2020). For healthcare markets that already have a mixture of heterogeneously semi-altruistic providers the vertical aspect of competition can be interpreted in terms of product differentiation.

One important and recent exception is the contribution by Hehenkamp and Kaarbøe (2020). They study a mixed duopoly of a semi-altruistic public hospital and a for-profit private hospital that enter the healthcare market sequentially and engage in vertical quality competition. With market-entry, the private hospital endogenously chooses its location while the public hospital as a former monopolist is fixed to the mid-point of a unit interval. This assumption is, however, restrictive to the interpretation of horizontal differentiation in terms of location. Hospitals and healthcare providers in general may also engage in horizontal differentiation, e.g. in terms of specializing in certain treatment approaches. In contrast to the model framework of Hehenkamp and Kaarbøe (2020), we therefore study the endogenous location choice of *both* healthcare providers, quality provisions and the interaction with altruism heterogeneity. In order to simplify the analysis, we abstract from the reimbursement regime of the regulator and the sequential market entry.

We explore how heterogeneously semi-altruistic healthcare providers' compete in terms of the medical treatment quality they provide and the location choice or product differentiation. Intuitively, our model shows that one channel to explain heterogeneous quality choice and location or product differentiation choice can be altruism heterogeneity. Understanding the role of heterogeneity in altruism for quality and product differentiation can be relevant for policy makers to design policy measures such as reimbursement schemes.

Our main results can be summarized as follows. We find that relatively more altruistic healthcare providers treat more patients, endogenously position themselves closer to the centre (decrease the degree of horizontal differentiation), and provide higher quality per patient. This can be understood quite intuitively. A healthcare provider benefits from increasing the quality per patient as well as from increasing the share of patients treated. Thus, the more altruistic healthcare provider with quasi lower marginal costs per patient can "afford" to locate more centrally, i.e. engage in less horizontal differentiation. This in turn then induces pressure on the rival, both in terms of horizontal differentiation (a more centrally located healthcare provider decreases horizontal differentiation) as well as in terms of quality competition (since a more centrally located healthcare provider also increases quality provision). The rival will dampen these two competition effects by evading to the corner of the unit interval in order to increase horizontal differentiation. In an extreme scenario, the less altruistic rival will exit the market. Furthermore, the rival will keep up with the vertical dimension of competition by increasing quality per patient but not as high as the high altruism type.

2 Model

2.1 Setup

We consider a two-stage game with two active players: two semi-altruistic healthcare providers that heterogeneously care about their patients' wellbeing. Healthcare providers may either be hospitals or practicing physicians that differ in their objective function due to different profit structures or individual degrees of altruism. At stage 1, healthcare providers decide whether to enter and where to locate or how to engage in product differentiation, where the regulated price is given and medical treatment quality per patient independent of this. Finally, at stage 2, the healthcare providers choose their quality levels, and patients decide where to receive one unit of medical care. Such a model framework is more suitable to countries with quality competition and location choice in which outpatient sectors are characterized by a large heterogeneity in physician altruism or have opened their inpatient markets to private for-profit providers, such as the UK and Scandinavian countries.

2.2 Demand Side

We utilize a textbook model of horizontal differentiation along the lines of Hotelling (1929) with a unit mass of consumers, hereafter referred to as patients, uniformly distributed on a unit interval. Patients are treated by healthcare providers. Patients face quadratic transportation costs $\tau > 0$ that can either be interpreted in geographic terms (e.g. time to travel to a particular healthcare provider) or more suitable in a taste dimension (e.g. a particular healthcare provider is preferred due to certain non-quality related criteria such as medical treatment approach). We assume that a patient located at $x \in [\ell_1, 1-\ell_2]$ with $\ell_1 < 1-\ell_2$, and $\ell_i \in [0,1]$, $i = 1,2$, bears quadratic transportation costs of $\tau(x-\ell_1)^2$ to visit a healthcare provider located at ℓ_1 and $\tau\left(1-\ell_2-x\right)^2$ for a healthcare provider located at $1-\ell_2$.[4] We combine horizontal differentiation with vertical differentiation induced by different quality levels. For a given patient, a healthcare provider i can offer the observable quality $q_i > 0$. The patient benefit function is $B\left(q_i\right) = b\, q_i$ with $b > 0$. A patient located at x is indifferent between a healthcare provider located at ℓ_1 and $1-\ell_2$ if

$$B\left(q_1\right) - \tau\left(x-\ell_1\right)^2 = B\left(q_2\right) - \tau\left(1-\ell_2-x\right)^2 \tag{1}$$

holds. The share x_i of patients that visit a healthcare provider i can be written as

$$x_1\left(q_1, q_2, \ell_1, \ell_2\right) = \ell_1 + \frac{1-\ell_1-\ell_2}{2} + \frac{b\ \left(q_1-q_2\right)}{2\tau\left(1-\ell_1-\ell_2\right)} \tag{2}$$

with $x_2 = 1 - x_1$. It follows that a higher quality increases (decreases) own (competitor's) patient demand. Furthermore, locating closer to the rival increases (decreases) own (rival's) demand.

[4]Cf. Kessler and McClellan (2000) and Tay (2003) for empirical evidence that distance is a major predictor of patients' choice of hospital.

2.3 Supply Side

Healthcare provider i earns a regulated payment $p > 0$ per patient which is independent of the provided medical treatment quality, i.e. healthcare providers are financed by a public payer offering a lump-sum transfer.[5] Healthcare providers heterogeneously care about their patients' wellbeing. This benevolent element is captured in healthcare provider i's utility function by the altruism term $\theta_i B(q_i)$ where $\theta_i > 0$ is a healthcare provider specific and exogeneous altruism shifter. The provision of quality q_i involves costs $c\, q_i$ per patient with $c > 0$.[6] The utility function of a healthcare provider i can be written as

$$\Pi_i(q_i, \ell_i) = x_i(q_i, \ell_i)\ \pi_i(q_i) = x_i(q_i, \ell_i)\ (\, p + \theta_i\, b\, q_i - c\, q_i\,) \tag{3}$$

where π_i denotes the per patient utility and x_i the patients share.

2.4 Timing of Events

We consider the following two-stage game: In the first stage, both healthcare providers endogenously choose locations on the unit interval, i.e. the degree of horizontal differentiation. Healthcare provider 1 (2) chooses ℓ_1 (ℓ_2) in order to maximize utility as given in Eq. (3), anticipating optimal quality choices in the second stage. The first stage optimal location choices are denoted by ℓ_1^* and ℓ_2^*. In the second stage, healthcare provider 1 (2) chooses quality levels $q_1^*(\ell_1^*, \ell_2^*)$ ($q_2^*(\ell_1^*, \ell_2^*)$ respectively), which maximize Eq. (3) given first stage location choices. We solve via backward induction.

2.5 Market Outcome

2nd Stage: The second stage utility of healthcare provider i, given location choices ℓ_1 and ℓ_2, is given by Eq. (3). Deriving the first-order-conditions ("FOCs") with respect to quality levels and solving for the Nash equilibrium quality levels yields:

$$q_i^*(\ell_i, \ell_j) = \frac{2\,p}{3\,(c - b\theta_i)} + \frac{p}{3\,(c - b\,\theta_j)} - \frac{\tau\,\Delta\,\delta_i}{3\,b} \tag{4}$$

where $\Delta = 1 - \ell_1 - \ell_2 \geq 0$, $\delta_i = 3 + \ell_i - \ell_j$ and $j = 1, 2$ with $i \neq j$. In order to secure positive quality levels and second-order conditions, we have to assume sufficiently high marginal costs of quality provision (i.e. $c > b\,\theta_i$ and $c > b\,\theta_j$) and sufficiently low transportation costs (i.e. $\tau < \bar{\tau}_i$ and $\tau < \bar{\tau}_j$), cf. Appendix A.1 for the explicit parameter restrictions $\bar{\tau}_i$ and $\bar{\tau}_j$ as well as second-order conditions.

[5] Cf. Economides (1989), Economides (1993), Calem and Rizzo (1995), Lyon (1999), Gravelle and Masiero (2000) and Barros and Martinez-Giralt (2002) for similar approaches.

[6] This cost specification implies that costs are not separable between quality and quantity, which is reasonable if quality provision involves costs on a per-patient basis, cf. Siciliani (2009). Total costs are $C = c\, q_i\ x_i(q_i, \ell_i)$ and convex with $\partial^2 C/\partial q_i^2 > 0$.

In case of altruism homogeneity and for given locations, we mirror the "standard" results that higher altruism levels increase quality provision of healthcare providers. Intuitively, higher altruism increases the marginal benefit (or decreases marginal costs) of quality provision. This result holds independent of healthcare providers' locations, i.e. for $\theta = \theta_i = \theta_j$ it follows $\partial q_i^*/\partial\theta = \partial q_j^*/\partial\theta > 0$.

The novelty is to study the effects emerging due to altruism heterogeneity. It follows from Eq. (4) that a more altruistic healthcare provider offers higher quality levels, i.e., $\partial q_i^*/\partial\theta_i > 0$. As in the case of homogeneous degrees of altruism, higher altruism levels can be interpreted as serving a patient at lower marginal costs per unit of provided treatment quality. However, this feeds back to the rival, which in turn also increases its quality level, i.e., $\partial q_j^*/\partial\theta_i > 0$. Similarly, the location choice of one healthcare provider also spills over to the rival's location choice. If one of the healthcare provider locates closer to each other, both increase quality levels irrespective of their current location, i.e., $\partial q_i^*/\partial\ell_i > 0$ and $\partial q_j^*/\partial\ell_i > 0$. In both cases, the rival aims not to loose too many patients, either by locating closer to the centre or by providing better quality. In the following section we derive the healthcare providers' endogenous location choices (i.e. the endogenously determined degree of horizontal differentiation), and determine whether the high or low altruism healthcare provider type actually provides higher quality per patient.

1st Stage: In the first stage healthcare provider i chooses its location ℓ_i in order to maximize utility given by Eq. (3), anticipating quality choices in the second stage. Using Eq. (4), the first stage utility of healthcare provider i can be written as:

$$\pi_i(\ell_i) = \frac{\left(c\,\tau\,\Delta\,\delta_i\,(c - b\,(\theta_i+\theta_j)) + b^2\,(p\,(\theta_i-\theta_j) + \tau\,\Delta\,\delta_i\,\theta_i\,\theta_j)\right)^2}{18\,b\,\tau\,\Delta\;(c-b\,\theta_i)\,(c-b\,\theta_j)^2} \tag{5}$$

Deriving the FOCs and solving for the Nash equilibrium location of healthcare provider i yields:

$$\ell_i^* = \max\left\{0, -\frac{1}{4} + \frac{p\,b}{3\,\tau}\left(\frac{1}{c-b\,\theta_i} - \frac{1}{c-b\,\theta_j}\right)\right\} \tag{6}$$

In order to secure second-order conditions, we have to assume a medium level of transportation costs, i.e $\underline{\tau}_i < \tau < \bar{\tau}_i$ for $i = 1, 2$, cf. Appendix A.2 for the second-order conditions and corresponding explicit parameter restrictions $\underline{\tau}_i$ and $\bar{\tau}_i$. In the altruism homogeneity case (i.e. $\theta_i = \theta$ for $i = 1, 2$) we denote the lower and upper threshold by $\underline{\tau} = 0$ and $\bar{\tau} = \frac{p\,b}{c-b\,\theta}$ respectively. In the following we differentiate between three cases which mirror different degrees of altruism heterogeneity.

1. Altruism homogeneity: Using $\theta_1 = \theta_2 = \theta$ in Eq. (6) imlies that healthcare providers locate at the corners of the unit interval with the highest degree of horizontal differentiation, i.e. $\ell_1^* = \ell_2^* = \ell^* = 0$.[7] It follows from Eq. (4) that quality levels are given by

[7]This mirrors the standard price competition result where the "strategic" effect (lower horizontal differentiation decreases prices) dominates the direct "stealing" effect (locating closer steals market shares).

$q_1^* = q_2^* = -\frac{\tau}{b} + \frac{p}{c-b\,\theta}$ and positive if $\tau < \bar{\tau}$. More altruistic healthcare providers, while still assuming the same exogeneously given altruism levels, increase quality provisions but do not change locations. Using Eq. (2), both healthcare providers serve the same share of patients, i.e. $x_1^* = x_2^* = 1/2$.

2. Weak altruism heterogeneity: If healthcare provider i is more altruistic than healthcare provider j but the difference is not too strong, i.e. $\theta_j < \theta_i \leq \underline{\theta}_i$ with

$$\underline{\theta}_i = \frac{4\,p\,b^2\,\theta_j + 3\,c\,\tau\,(c - b\,\theta_j)}{b\,(4\,p\,b + 3\,\tau\,(c - b\,\theta_j))} \tag{7}$$

it follows from Eq. (6) that both healthcare providers still locate at the corners of the interval with $\ell_1^* = \ell_2^* = 0$. However, quality offers now differ across healthcare providers. Using $\ell_1^* = \ell_2^* = 0$ and $\theta_i = \underline{\theta}_i$ in Eq. (4) shows that the more altruistic healthcare provider i increases quality levels up to $q_i^* = -\frac{1}{2}\frac{\tau}{b} + \frac{p}{c-b\,\theta_j}$ while the less altruistic healthcare provider j also increases quality levels but relatively less up to $q_j^* = -\frac{3}{4}\frac{\tau}{b} + \frac{p}{c-b\,\theta_j}$. Both qualities are positive if we assume $\tau < \bar{\tau}_i$ and $\tau < \bar{\tau}_j$.[8] Using these qualities and locations in Eq. (2) reveals that the more altruistic healthcare provider i attracts a larger share of patients, i.e. $x_i^* = 5/8 > x_j^* = 3/8$.

3. Strong altruism heterogeneity: If healthcare provider i is more altruistic than healthcare provider j but the difference is strong, i.e. $\underline{\theta}_i < \theta_i \leq \bar{\theta}_i$ with

$$\bar{\theta}_i = \frac{4\,p\,b^2\,\theta_j + 5\,c\,\tau\,(c - b\,\theta_j)}{b\,(4\,p\,b + 5\,\tau\,(c - b\,\theta_j))} \tag{8}$$

the more altruistic healthcare provider locates closer to the mid point (interior solution with $\ell_i^* > 0$) while the less altruistic healthcare provider still remains at the corner of the unit interval (corner solution with $\ell_j^* = 0$). Using Eq. (4) and $\theta_i = \bar{\theta}_i$, the quality levels further increase up to $q_i^* = \frac{\tau}{4\,b} + \frac{p}{c-b\,\theta_j}$ and $q_j^* = \frac{p}{c-b\,\theta_j}$ with the more altruistic healthcare provider still providing higher quality levels. Again, if we assume $\tau < \bar{\tau}_i$ and $\tau < \bar{\tau}_j$ quality levels are positive. In case $\theta_i = \bar{\theta}_i$, the more altruistic healthcare provider i serves all patients leaving the less altruistic healthcare provider with no patients, i.e. $x_i^* = 1 > x_j^* = 0$. Table I summarizes all three cases assuming healthcare provider 1 is the more altruistic healthcare provider, i.e. $\theta_1 \geq \theta_2$.

Taken together we find that the more altruistic healthcare provider offers relatively higher quality levels per patient, serves more patients, and is more centrally located if altruism heterogeneity is sufficiently strong. These results can be understood quite intuitively. The benevolent motive as modeled in Eq. (3) has two channels. First, a healthcare provider benefits from increasing the quality per patient but second also with the share of patients treated. The more altruistic healthcare provider has implicit lower marginal

[8] Using $\ell_1^* = \ell_2^* = 0$ the thresholds reduce to $\bar{\tau}_i = \frac{p\,b^2(\theta_i - \theta_j)}{\sqrt{5}(c-b\,\theta_i)(c-b\,\theta_j)}$ and $\underline{\tau}_i = \frac{p\,b}{3}\left(\frac{2}{c-b\,\theta_i} + \frac{1}{c-b\,\theta_j}\right)$ with $\underline{\tau}_i < \bar{\tau}_i$.

Table I. Altruism heterogeneity and equilibrium outcome

	1. Altruism Homogeneity $\theta = \theta_1 = \theta_2$		*2. Weak Heterogeneity* $\theta_2 < \theta_1 = \underline{\theta_1}$		*3. Strong Heterogeneity* $\underline{\theta_1} < \theta_1 = \bar{\theta}_1$	
i	1	2	1	2	1	2
ℓ_i^*	0	0	0	0	1/2	0
q_i^*	$-\frac{\tau}{b} + \frac{p}{c-b\,\theta}$	$-\frac{\tau}{b} + \frac{p}{c-b\,\theta}$	$-\frac{1}{2}\frac{\tau}{b} + \frac{p}{c-b\,\theta_2}$	$-\frac{3}{4}\frac{\tau}{b} + \frac{p}{c-b\,\theta_2}$	$\frac{\tau}{4\,b} + \frac{p}{c-b\,\theta_2}$	$\frac{p}{c-b\,\theta_2}$
x_i^*	1/2	1/2	5/8	3/8	1	0

costs per patient and can thus “afford” to locate more centrally, i.e. engage in less horizontal differentiation. Locating more centrally increases ceteris paribus the share of patients treated.

This in turn induces pressure on its rival, both in terms of horizontal differentiation (a more centrally located healthcare provider decreases horizontal differentiation) as well as in terms of quality competition (since a more centrally located healthcare provider also increases quality provision). The rival will thus dampen these two competition effects by evading to the corner in order to increase horizontal differentiation. Furthermore, the rival will keep up with the vertical dimension of competition by also increasing quality. In equilibrium, the low altruism type’s quality is lower, and the healthcare provider serves less patients.

However, higher degrees of altruism heterogeneity may also result in a market situation with a very strong quasi monopolistic market position of the more altruistic healthcare provider and a complete loss of its market share for the less altruistic healthcare provider. Thus, for degrees of altruism heterogeneity up to the threshold threshold $\bar{\theta}_i$, quality per patient as well as weighted average of qualities increases while for high degrees of altruism heterogeneity above this threshold the less altruistic healthcare provider completely looses its market share and the more altruistic healthcare provider can act as a quasi monopolist that serves patients with the lowest feasible level of quality.

3 Conclusion

Motivated by the empirical evidence of altruism heterogeneity among healthcare providers, we have presented a competition framework of horizontal and vertical differentiation with heterogeneously altruistic healthcare providers. We show that altruism heterogeneity can explain different quality and location or product differentiation choices of healthcare providers. Our results complement the insights by Hehenkamp and Kaarbøe (2020). First, we also find that the more altruistic healthcare provider offers a higher quality of care per patient. Second, in contrast to their model framework we assume endogenous location of both healthcare providers. Similar to Hehenkamp and Kaarbøe (2020) we find that the (private) healthcare provider with the lower degree of altruism avoids quality competition by locating closer to the boundary of the unit interval. However, our more general model framework shows that the more altruistic healthcare provider endogenously chooses a location closer to the mid point of the unit interval such that vertical quality competition is intensified and horizontal differentiation is dampened. In an extreme scenario, the more altruistic healthcare provider locates at the mid point and forces the less altruistic healthcare provider to not enter or exit the market.

For health policy makers that observe, e.g. after opening the healthcare market, a heterogeneous market outcome with one almost "central" high quality healthcare provider, this can be a sign that the other healthcare provider is substantially less altruistic. In an extreme scenario the more altruistic healthcare provider can act as a quasi-monopolist such that patients served from the outlier are inferior compared to the situation with two healthcare more equal altruistic providers. Hence, understanding the role of heterogeneity in altruism for quality and location choice or product differentiation can be a relevant means for policy makers to design for instance reimbursement schemes.

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Appendix

Appendix A.1: 2nd Stage Maximization - Quality Choice

i.) FOC: The first-order conditions (FOCs) in the second stage are given by

$$\frac{\partial \Pi_i}{\partial q_i} = \frac{p\,b + (c - b\,\theta_i)\,(b\,(q_j - 2\,q_i) - \tau\,(1 + \ell_i - \ell_j)\,(1 - \ell_i - \ell_j))}{2\,\tau\,(1 - \ell_i - \ell_j)} = 0 \tag{A1}$$

for $i = 1, 2$ and $i \neq j$. If for $i = 1, 2$ marginal costs of quality provision are sufficiently high, i.e. $c > b\,\theta_i$, as well as transportation costs are sufficiently low, i.e. $\tau < \bar{\tau}_i$ where

$$\bar{\tau}_i = \frac{p\,b\,(3\,c - b\,(\theta_i + 2\,\theta_j))}{(3 + \ell_i - \ell_j)\,(1 - \ell_i - \ell_j)\,(c - b\,\theta_i)\,(c - b\,\theta_j)} > 0, \tag{A2}$$

and $i \neq j$, positive quality levels are secured.

ii.) SOC: The second-order conditions (SOCs) in the second stage are given by

$$\frac{\partial^2 \Pi_i}{\partial q_i^2} = -\frac{b\,(c - b\,\theta_i)}{\tau\,(1 - \ell_1 - \ell_2)} < 0, \quad i = 1, 2. \tag{A3}$$

for $i = 1, 2$ and $i \neq j$. Thus, with our assumption $c > b\,\theta_i$ the SOCs are satisfied.

Appendix A.2: 1st Stage Maximization - Location Choice

i.) FOC: The FOCs in the first stage are given by

$$\frac{\partial \Pi_i}{\partial \ell_i} = \Pi_i\,\frac{c\,\tau\,\Delta\,(2\,\Delta - \delta_i)\,(c - b\,(\theta_1 + \theta_2)) + b^2\,(p\,\theta_i - (p + \tau\,\Delta\,(\delta_i - 2\,\Delta)\,\theta_i)\,\theta_j)}{\Delta\,(c^2\,\tau\,\Delta\,\delta_i - b\,c\,\tau\,\Delta\,\delta_i\,(\theta_1 + \theta_2) + b^2\,(p\,(\theta_i - \theta_j) + \tau\,\Delta\,\delta_i\,\theta_1\,\theta_2))} = 0 \tag{A4}$$

for $i = 1, 2$ and $i \neq j$.

ii.) SOC: The SOCs in the first stage are given by

$$\begin{aligned}\frac{\partial^2 \Pi_i}{\partial \ell_i^2} = {} & \frac{(p\,b^2\,(\theta_i - \theta_j))^2 - \Delta^3\,\eta_i\,(\tau\,b^2\,\theta_1\,\theta_2)^2 + c\,\tau^2\,\Delta^3\,\eta_i\,(\theta_1 + \theta_2)\,(2\,b\,c^2 + 2\,b^3\,\theta_1\,\theta_2)}{9\,b\,\Delta^3\,\tau\,(c - b\,\theta_i)\,(c - b\,\theta_j)^2} \\ & - \frac{c\,\tau^2\,\Delta^3\,\eta_i\,(b^2\,c\,(\theta_1^2 + 4\,\theta_1\,\theta_2 + \theta_2^2) + c^3)}{9\,b\,\Delta^3\,\tau\,(c - b\,\theta_i)\,(c - b\,\theta_j)^2}\end{aligned} \tag{A5}$$

for $i = 1, 2$ and $i \neq j$ with $\eta_i = 5 + 3\ell_i - \ell_j$. If for $i = 1, 2$ marginal costs of quality provision are sufficiently high, i.e. $c > b\,\theta_i$, as well as transportation costs are sufficiently high, i.e. $\tau > \underline{\tau_i}$ where

$$\underline{\tau}_i = \frac{p\,b^2\,(\theta_i - \theta_j)}{\sqrt{(5 + 3\,\ell_i - \ell_j)\,(1 - \ell_1 - \ell_2)^3\,(c - b\,\theta_1)^2\,(c - b\,\theta_2)^2}} \tag{A6}$$

the SOCs are negative and satisfied. In case of altruism homogeneity, it follows $\underline{\tau} = 0$ and $\bar{\tau} = (2\,b\,p)\,/\,(3\,(c - b\,\theta))$ such that $\underline{\tau} < \tau < \bar{\tau}$ can be secured.