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Competition, equity and quality in public services[☆]

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ABSTRACT

This paper examines the implications of consumer heterogeneity for the choice of competition and monopoly in public services delivery. In a setting with motivated providers who favour one type of service user over another, we show that competition can raise average quality. However, this may be at the expense of the minority type of user if the providers favour the majority type. Then an inequity averse regulator may protect the minority by not introducing competition. Alternatively, if the providers favour the minority type, the regulator may introduce competition to incentivize the providers to pay attention to the less rewarding majority type.

1. Introduction

The introduction of competition in the delivery of public services such as healthcare or education is a popular reform model. One long recognized feature of public services is that the providers of these services are motivated and derive private benefits from service provision as well as caring about financial rewards. Agent motivation in this context may be beneficial — for example it may reduce the cost of service provision. But it may also skew provision towards what providers value and away from what service users value (Newhouse, 1970; Besley and Malcomson, 2018). This may be particularly an issue where the service is universal but the benefits motivated agents get vary across users *within* a service. This heterogeneity gives rise to match-specific effects: certain users will benefit more from the service than others.

Provider preferences may depend on verifiable user heterogeneity — for example, teachers may favour pupils who score highly in national tests or social workers may prefer working with refugees rather than native born individuals. But the preferences of providers may depend on nonverifiable user type. Doctors may prefer patients who comply with their treatment. Teachers may prefer students with a good attitude to learning. Such provider preferences may affect whether it is optimal or not to have competition in the delivery of public services.

This paper addresses this issue. We examine the simplest case of a universal service with decentralized service provision funded by taxation in which the service is free to all users. In common with much of the literature on public services, we assume that the quality of the service is not verifiable and is thus noncontractible. Unverifiable quality is at the heart of concerns that the use of

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competition in public services may have detrimental effects (for example, Hart et al., 1997; Federal Trade Commission, and U.S. Department of Justice, 2004). We also assume that user types are not verifiable and providers get higher private benefits from one type of user. For simplicity we assume two user types. In this setting we assume that the decision as to whether the user has choice of provider is made by a regulator who maximizes consumer welfare. The regulator raises funds for the universal service from taxation and the service is provided free of charge to users. Given the existence of heterogeneous users and the publicly funded nature of the service, it is natural that a regulator will care about the distribution of the service as well as its average quality and cost. We therefore explicitly incorporate inequity aversion (e.g. Fehr and Schmidt, 1999) of the regulator.[1]

Our analysis shows the following. Under no competition, as quality is non-contractible, the regulator cannot induce the providers to provide any quality other than that which is motivated by the providers' private benefits. As the quality of the service and its distribution across user types depend only on the providers' private benefits, the service favours those users who are more rewarding for the providers. No competition is therefore low cost, but quality is (potentially) low and the distribution of quality across consumer types is inequitable, in that the less rewarding type will be underserved.

Competition can provide incentives to raise quality if it is *observable* to users, for example, due to word of mouth or use of provider league tables. We examine two possibilities. The users can either observe type-specific quality or only average quality of the provider. In both cases competition will induce higher average quality from providers — competition in essence makes quality quasi-contractible. However, importantly, it will not necessarily increase the level of quality for *both* types of user. Competition will induce more effort at the margin on the majority type. When type-specific quality is observable, higher quality for the majority type increases the provider's share of the larger (majority type) market. While when users observe only average quality, higher quality for the majority type is an effective way to increase average quality, which attracts users of both types. However, in both cases quality for the minority type may actually fall if this type is in a sufficiently small minority.

In making the choice between monopoly and managed competition the regulator has to balance the increase in average quality and the change in the distribution of quality across types brought about by competition against the increased costs of competition. Under no competition, as transfers cannot be contingent on nonverifiable quality, the regulator will pay only the minimum required to get the providers to participate. To induce competition, the regulator has to pay more for each user. A regulator who is not concerned about equity would introduce competition to increase average quality if the marginal tax cost is not too high. But when a regulator is concerned about inequity, our model yields the key insight that the choice between monopoly and competition is not simple. An inequity averse regulator will not necessarily be less likely to introduce competition than one who has no distributional concerns or vice versa. If the providers find the minority type rewarding (putting the majority at a disadvantage under monopoly), competition forces the providers to pay more attention to the majority type thus improving equity *within* the institution. Then the more concerned the regulator is about equity, the more likely she is to introduce competition. However, when the majority group is more rewarding for the service providers, an inequity averse regulator can choose to protect the minority by not introducing competition, as the majority (more rewarding) type will be favoured even more under competition than under monopoly.

Our paper contributes to the literature that examines whether competition is beneficial in the provision of tax funded public services.[2] Close to our focus, a number of papers have examined quality effects of competition in healthcare markets with semi-altruistic providers. Brekke et al. (2011) find that when the marginal profits are negative (and subsidized by altruism), providers may reduce quality when competition is introduced in order to discourage demand by the unprofitable patient type (see also Brekke et al. (2008) and Brekke et al. (2012)). An important difference from our model is that their quality costs are ex post treatment costs, while our focus is on ex ante investments in the quality of the service, for example, designing a curriculum or a healthcare programme.[3] Siciliani and Straume (2019) examine the effect of tougher competition on equity when one of the for-profit hospitals has a cost advantage. Their potential adverse effect on equity is *between* the high-cost and the low-cost hospital, while we focus on within provider equity.[4]

There is also an extensive literature on competition in schooling, beginning with Hoxby (2000).[5] A growing body of research emphasizes that the match between a student's instructional needs and the school's instructional level is an important determinant of learning (e.g. Arcidiacono et al., 2016). A recent paper by Bau (2022) focuses on the implications of such matches for the effect of increased competition between schools in Pakistan. Her focus, which is perhaps closest to ours in the competition in schooling literature, is on whether inequality in learning *within* schools is affected by competition. In her model, rich and poor students have different optimal instructional levels and rich students are more sensitive to match-specific quality, making them "more marginal". A private school thus chooses an instructional level that favours the richer students. She shows that increased competition (in the form of private school entry) increases inequality in pupils' outcomes, driven by an increased inequality *within* rather than *between* schools, and confirms this empirically. In contrast with our model, Bau (2022) examines private profit maximizing schools rather

[1] Horizontal equity goals are common in the case of universal services. See e.g. Wagstaff et al. (1999).

[2] Gravelle (1999) analyses the role of prospective payments for quality provision under different market structures and focuses on how market structure evolves. Halonen-Akatwijuka and Propper (2008) analyse the choice of a self-interested politician between competition and monopoly and show that the politician is more likely to introduce competition for services that have considerable political support.

[3] Hart et al. (1997) and Besley and Ghatak (2001) provide the key insight that appropriate choice of institution can incentivize ex ante investments in noncontractible quality (although they examine private versus public provision).

[4] The large empirical literature on competition in healthcare is reviewed in Gaynor et al. (2015).

[5] Positive findings from voucher programmes include Figlio and Hart (2014) on public schools exposed to competition by Florida's private school voucher program and Neilson et al. (2013) for Chile. Whether charter schools in the US induce competitive test score responses from public schools remains an unsettled question (Epple et al., 2016).

than public suppliers run by motivated agents, but in both cases the suppliers respond to competition by increasing quality for the more marginal customer type, affecting equity within the institution.

Finally, we contribute to the literature on motivated agents in public service delivery. Newhouse (1970) drew attention to this in the context of healthcare. Francois (2000) argues that agent motivation justifies the choice of a public supplier over private supplier. Besley and Ghatak (2005) show that matching between mission orientated firms and motivated agents reduces the need for high powered contracts. Delfgaauw and Dur (2007, 2008) show that both non-profit providers and for-profit providers can exist in equilibrium but they will differ in altruism and productivity. A recent paper by Besley and Malcomson (2018) links the literature on motivated agents and competition in public services. They explore whether consumers benefit from entry when some aspects of quality are unobservable and the incumbent not-for-profit provider has (partial) concerns for customer welfare. In their setup competition raises observable quality. However, there may be an adverse effect on unobservable quality chosen ex post. In our setup the potential adverse effect is on the ex ante chosen service quality for the minority type, even if it is fully observable to the users.

None of this research addresses how type-dependent private benefits or the regulator's inequity aversion affect the optimal choice of competition or monopoly provision of a universal tax-funded public service. Given the importance of motivated providers and user heterogeneity in public services, it seems important to understand how providers' motivation may affect equity in service delivery and whether this is altered by competition. Indeed, this very concern lies at the heart of the argument that monopoly public service providers favour certain individuals at the expense of others Le Grand (2003) and therefore competition may improve welfare by making providers more responsive to the users whom they favour less.

The rest of the paper is organized as follows. Section 2 presents our model. Sections 3 and 4 analyse no competition and competition respectively, while Section 5 derives the optimal institution. Extensions including the addition of monetary costs of provision, provider private benefits that are dependent on market shares, and heterogeneous private provider benefits are discussed in Section 6. Section 7 concludes.

2. The model

Our set up is one of a (potentially) inequity averse regulator, R, choosing whether to introduce competition between two public providers, 1 and 2, of a tax-funded service. Providers are intrinsically motivated by quality of the service, but they may have a bias for one of the two types of users, A or B.

The following timeline summarizes our setup.

Stage 0. R chooses competition or no competition. R designs transfers, T_1 and T_2, to the providers.

Stage 1. Providers choose qualities for type A and type B, v_i^A and v_i^B, at effort cost $c\left(v_i^A, v_i^B\right)$, $i = 1, 2$.

Stage 2. R allocates users to providers (under no competition) or users choose their provider (under competition). R pays T_1 and T_2 to the providers.

2.1. Providers and users

At stage 1, providers invest in the quality of the service for two types of users, A and B. They, for example, design a curriculum or a healthcare programme that will be delivered at stage 2.[6] The users differ, for example, in their attitude to learning or compliance to treatments, and their type is not verifiable. Proportion γ_A of the population is of type A and proportion $\gamma_B = \left(1 - \gamma_A\right)$ is of type B. The provider chooses a quality level for each type, v_i^A and v_i^B, at an effort cost $c\left(v_i^A, v_i^B\right)$.[7] It is more costly to provide quality for type A. We assume that quality efforts are substitutes at the margin.[8] Quality is nonverifiable and thus noncontractible.

Assumption 1. $c\left(v_i^A, v_i^B\right)$ is strictly increasing with $c(0,0) = \frac{\partial c(0,0)}{\partial v_i} = 0$, $\frac{\partial c(v_i^A, v_i^B)}{\partial v_i^A} > \frac{\partial c(v_i^A, v_i^B)}{\partial v_i^B}$ if $v_i^A = v_i^B > 0$. $c\left(v_i^A, v_i^B\right)$ is sufficiently convex so that $\frac{\partial^2 c(v_i^A, v_i^B)}{\partial (v_i^k)^2} > \frac{\partial^2 c(v_i^A, v_i^B)}{\partial v_i^A \partial v_i^B} > 0$ and $\frac{\partial c(v_i^A, v_i^B)}{\partial v_i^k}$ is convex, where $i = 1, 2$, $k = A, B$.

The provider is intrinsically motivated by the quality of the service and receives a private benefit measured in monetary terms, $b\left(v_i^A, v_i^B\right) = \mu_A v_i^A + \mu_B v_i^B$.[9] The provider is run by motivated professionals who care about the quality of the service they provide but may have a bias for one type of user, e.g. students with a good attitude to learning or patients who comply with treatments. We assume that the low-cost type B is (weakly) more rewarding.[10]

Assumption 2. $\mu_B \geq \mu_A > 0$.

6 This is similar to ex ante effort in quality innovation in Hart et al. (1997) or ex ante investment in quality in Besley and Ghatak (2001), following Grossman and Hart (1986) and Hart and Moore (1990).

7 We introduce monetary cost of quality provision in Section 6.2.

8 Section 6.3 discusses complementary or independent efforts.

9 In Section 6.5 we take into account that private benefits may depend also on the number of users served.

10 In Section 6.4 we show that our main results are robust to the high-cost type being more rewarding.

In addition to the private benefits and effort costs, the provider's objective function includes the transfer they receive from the regulator for providing the service, T_i.[11]

$$V_i = T_i + \mu_A v_i^A + \mu_B v_i^B - c\left(v_i^A, v_i^B\right) \tag{1}$$

The provider's outside option is zero.

2.2. Competition or no competition

At stage 2, the users are either allocated to a provider (*no competition*) or choose their provider (*competition*). In both cases users pay zero at point of service as it is funded by taxation. We assume a Hotelling model where the two providers are located at the extremes of the unit interval $[0,1]$. Provider 1 is located at 0 and provider 2 at 1. The users of each type are uniformly distributed with density one on the unit interval. A user of type k located at $x \in [0,1]$ receives utility $v_1^k - tx$ if he is supplied by 1 and utility $v_2^k - t(1-x)$ if he is supplied by 2, where t is the transportation cost. We assume that the transportation cost is sufficiently low so that no user opts out of the service.

Under *no competition*, R allocates users to the providers and pays them a direct transfer T_i for the service. T_i cannot be contingent on quality since quality is nonverifiable. Under *competition*, the users can choose their provider. Type k user's choice is based on *observable* quality $\sigma v_i + (1-\sigma)v_i^k$, where $\sigma \in [0,1]$ and $v_i = \gamma_A v_i^A + \gamma_B v_i^B$. This formulation encompasses the case where the user can observe type-specific quality, $\sigma = 0$, and the alternative where the user can observe only average quality of the provider, $\sigma = 1$. In the Hotelling model the provider's market share depends on the relative value of the service and the transportation costs. We assume that providers cannot select users.

$$q_i^k = \frac{\sigma(v_i - v_j) + (1-\sigma)(v_i^k - v_j^k) + t}{2t}, \tag{2}$$

where $i,j = 1,2, i \neq j, k = A,B$. Note that although quality is nonverifiable and thus noncontractible, some aspects of quality are observable to the users, e.g. due to word of mouth or use of provider league tables, so that competition can provide incentives. In effect, competition makes quality quasi-contractible.[12]

Under competition, the provider is paid price p per user, set by R. p cannot depend on user type as types are not verifiable. It can be thought of as a voucher that the user can take to a provider of their choosing. Thus, $T_i = pq_i$, where $q_i = (\gamma_A q_i^A + \gamma_B q_i^B)$ is the aggregate demand for provider i.

2.3. The regulator

At stage 0, R chooses whether to introduce competition between the providers.

If R introduces competition, he also sets the per-user price p. If he chooses no competition, he sets the direct transfers T_1 and T_2 to the providers. R cares about the total value of the service to the users as well as its distribution and the transfer costs.[13] The total value of the service is

$$\gamma_A \int_0^{q_1^A} (v_1^A - tx)dx + \gamma_B \int_0^{q_1^B} (v_1^B - tx)dx + \gamma_A \int_{q_1^A}^1 (v_2^A - t(1-x))dx + \gamma_B \int_{q_1^B}^1 (v_2^B - t(1-x))dx. \tag{3}$$

We show in Sections 3 and 4 that the equilibrium is symmetric under both no competition and competition. Therefore $q_1^k = 1/2$ and $v_1^k = v_2^k \equiv v^k$ for $k = A,B$. R's objective function simplifies to

$$U = \gamma_A v^A + \gamma_B v^B - \frac{1}{4}t - \lambda(v^B - v^A)^2 - D(T), \tag{4}$$

where $\lambda \geq 0$ measures R's concern for equity and, for simplicity, equity implies equal service quality for both types.[14] $D(T)$ is the cost of transfers, where $T = T_1 + T_2$. Transfers are paid for by taxation and, thus, $D(T)$ reflects the cost of increasing taxes for the public service. Therefore $D'(T) > 0$ even for $T = 0$. Transfer costs are convex as increasing T reduces funding for other public services or increases public debt, which is increasingly costly in terms of welfare and politically. Finally, there is a budget constraint of $\overline{T}$.

Assumption 3. $D'(T) > 0$, $D''(T) > 0$ for $T \in \left[0, \overline{T}\right)$. $\lim_{T \to \overline{T}} D'(T) = \infty$.

3. No competition

Under no competition, R allocates users to the two providers located at the extremes of Hotelling line and pays them a direct transfer T_i for the service. As quality is noncontractible, T_i cannot depend on quality. The provider can earn decision rents due to

[11] For simplicity, the running costs are equal to zero. In Section 6.2 we include fixed running costs in the analysis.

[12] An enforceable contract cannot be contingent on a quality measure that is only observable.

[13] In political economy models it is common to ignore the welfare of providers.

[14] In Section 6.1 we examine alternative formulation of inequity aversion based on extended Gini coefficient.

their ability to determine the mix of qualities they prefer. The provider maximizes

$$Max \quad T_i + \mu_A v_i^A + \mu_B v_i^B - c\left(v_i^A, v_i^B\right). \tag{5}$$

The first-order conditions for the quality choices are

$$\mu_A - \frac{\partial c\left(v_i^{A,N}, v_i^{B,N}\right)}{\partial v_i^A} = 0, \tag{6}$$

$$\mu_B - \frac{\partial c\left(v_i^{A,N}, v_i^{B,N}\right)}{\partial v_i^B} = 0, \tag{7}$$

where superscript N refers to no competition. Since the marginal cost of increasing quality for type B is lower and the marginal private benefit from type B is weakly higher, the provider chooses a higher quality service for type B, $v_i^{B,N} > v_i^{A,N}$, $i = 1, 2$.

Proposition 1. *Under no competition the rewarding type B receives a higher quality service than type A.*

The proofs are in Appendix.

R allocates the closest half of users to each provider to minimize transportation costs.[15] As R can only pay a fixed transfer to the provider and a fixed transfer has no incentive effects, R chooses T_i to minimize the transfer costs subject to satisfying the provider's participation constraint.[16] As the provider obtains positive decision rents by choosing the quality mix optimally and their outside option is zero, R can set $T_i = 0$ without violating the participation constraint.[17] R's utility under no competition is therefore given by

$$U^N = \gamma_A v^{A,N} + \gamma_B v^{B,N} - \frac{1}{4}t - \lambda(v^{B,N} - v^{A,N})^2 - D(0). \tag{8}$$

4. Competition

Under competition the provider is paid p per user, where p is equal across providers. At stage 1 the provider chooses the quality for each type anticipating that its market share at stage 2 will depend on the relative value of the service. The provider maximizes

$$Max \quad p(\gamma_A q_i^A + \gamma_B q_i^B) + \mu_A v_i^A + \mu_B v_i^B - c\left(v_i^A, v_i^B\right). \tag{9}$$

The horizontal differentiation model gives the following demand function for type k.

$$q_i^k = \frac{\sigma(v_i - v_j) + (1-\sigma)(v_i^k - v_j^k) + t}{2t} \tag{10}$$

Accordingly, provider i's aggregate demand is

$$q_i = \gamma_A \frac{\sigma(v_i - v_j) + (1-\sigma)(v_i^A - v_j^A) + t}{2t} + \gamma_B \frac{\sigma(v_i - v_j) + (1-\sigma)(v_i^B - v_j^B) + t}{2t} \tag{11}$$

$$= \frac{v_i - v_j + t}{2t}. \tag{12}$$

According to (12), the aggregate demand does not depend on σ. It depends only on the difference in the providers' *average* qualities irrespective of whether the users can observe type-specific quality or only average quality. If the users can observe type-specific quality, $\sigma = 0$, provider i's market share of type A is $\frac{v_i^A - v_j^A + t}{2t}$ and of type B it is $\frac{v_i^B - v_j^B + t}{2t}$. Multiplying these market shares with the proportions of each type in the population gives us the average qualities in (12).

While the aggregate demand function is identical in the two cases, the intuition for the competition effect is different. For $\sigma = 0$ higher quality for type A increases provider i's market share of type A by $\frac{\partial q_i^A}{\partial v_i^A} = \frac{1}{2t}$ and thus its revenues by $\gamma_A p \frac{\partial q_i^A}{\partial v_i^A} = \frac{\gamma_A p}{2t}$. While for $\sigma = 1$ higher quality for type A increases provider i's average quality by $\frac{\partial v_i}{\partial v_i^A} = \gamma_A$, its market share (of both type A and B) by $\frac{\partial q_i}{\partial v_i}\frac{\partial v_i}{\partial v_i^A} = \frac{\gamma_A}{2t}$ and its revenues by $p\frac{\partial q_i}{\partial v_i}\frac{\partial v_i}{\partial v_i^A} = \frac{\gamma_A p}{2t}$.

The first-order conditions for quality choices are given by

$$\gamma_A \frac{p}{2t} + \mu_A - \frac{\partial c\left(v_i^{A,C}, v_i^{B,C}\right)}{\partial v_i^A} = 0, \tag{13}$$

$$\gamma_B \frac{p}{2t} + \mu_B - \frac{\partial c\left(v_i^{A,C}, v_i^{B,C}\right)}{\partial v_i^B} = 0, \tag{14}$$

[15] Note that we have assumed that t is sufficiently low so that even the user with the maximal transportation costs of $\frac{1}{2}t$ does not opt out of the service.

[16] T_i could include a payment per user but since R both allocates users and determines the payment, it is equivalent to a fixed transfer.

[17] Note that if the provider had fixed running costs $T_i > 0$ as fixed costs have to be covered. See Section 6.2.

where superscript C denotes competition. Comparing these first-order conditions with the no competition case, ((6)) and (7), competition introduces the first term. Under competition, a higher value service increases market share and so revenues. Competition thus introduces a monetary reward for increasing quality. While an enforceable contract cannot be contingent on unverifiable quality, competition can provide incentives under a weaker assumption of observable quality, irrespective of whether the users can observe type-specific or average quality. The monetary reward is higher the tougher the competition (the lower t), as market share is more responsive to quality.

The monetary reward depends also on the per-user price, p, that R pays to the provider. In particular, if $p = 0$ the first-order conditions (13) and (14) are equivalent to those under no competition, (6) and (7). This implies that we can obtain the quality effect of competition by differentiating (13) and (14) with respect to p. Applying the implicit function theorem, we obtain

$$\frac{\partial v_i^{A,C}}{\partial p} = \frac{\gamma_A c_{BB} - \gamma_B c_{AB}}{2t\left[c_{AA}c_{BB} - (c_{AB})^2\right]}, \tag{15}$$

$$\frac{\partial v_i^{B,C}}{\partial p} = \frac{\gamma_B c_{AA} - \gamma_A c_{AB}}{2t\left[c_{AA}c_{BB} - (c_{AB})^2\right]}, \tag{16}$$

where $c_{kk} = \frac{\partial^2 c(v^{A,C}, v^{B,C})}{\partial (v_i^k)^2}$ for $k = A, B$ and $c_{AB} = \frac{\partial^2 c(v^{A,C}, v^{B,C})}{\partial v_i^A \partial v_i^B}$. The denominator of (15) and (16) is positive by Assumption 1. Therefore, $\frac{\partial v_i^{k,C}}{\partial p} > 0$ if and only if

$$\gamma_k c_{ll} - \gamma_l c_{AB} > 0, \tag{17}$$

where $k, l = A, B$ and $k \neq l$. (17) holds if $\gamma_k \to 1$ or if $\gamma_k = \frac{1}{2}$, but is not satisfied if $\gamma_k \to 0$. Thus, there exists $\hat{\gamma}_k \in (0, \frac{1}{2})$ such that

$$\hat{\gamma}_k c_{ll} - (1 - \hat{\gamma}_k) c_{AB} = 0. \tag{18}$$

Accordingly, $\frac{\partial v_i^{k,C}}{\partial p} > 0$ if and only if $\gamma_k \in (\hat{\gamma}_k, 1)$. Thus, competition increases quality for the majority type, but decreases quality for a sufficiently small minority.

Since the aggregate demand and, thus, the monetary reward depends on average quality, the providers respond to competition by increasing average quality. This creates strong incentives to increase quality for the majority type. If the users can observe type-specific quality, the providers have stronger incentives to increase quality for the majority type because of their larger market size. If the users can observe only the average quality, increasing quality for majority is an effective way to increase average quality and higher average quality attracts users of *both* types.

But while the majority type benefits from competition, the service level for the minority type may decline. Suppose the minority is very small, $\gamma_k \to 0$. Then the first-order condition for improving quality for the minority type, (13) or (14), is equivalent to the no competition case. However, higher quality for the majority type increases the marginal cost of the minority type and thus the service level for the minority is reduced. We summarize these results in Proposition 2.

Proposition 2. *Introduction of competition*

(*i*) *increases the average quality,*

(*ii*) *increases quality for both types if and only if* $\gamma_A \in (\hat{\gamma}_A, 1 - \hat{\gamma}_B)$*,*

(*iii*) *decreases quality for type k and increases quality for type l if and only if* $\gamma_k \in (0, \hat{\gamma}_k)$*, where* $k, l = A, B$*,* $k \neq l$ *and* $\hat{\gamma}_k \in (0, \frac{1}{2})$.

Proposition 2 shows that the benefit of competition is the increased average quality of the service. Service quality increases for *both* types if the population proportions are fairly equal. However, if there is a large majority, competition favours the majority at the expense of the minority type. Good quality service for the majority is an effective way to increase average quality. If the users can observe only average quality, higher average quality attracts also the minority type, although the provider may provide a reduced quality service for them. If the users can observe type-specific quality, higher quality for the majority type increases provider's share of the larger market.

Combining this result with Proposition 1 – according to which the unrewarding type A gets a lower quality service under no competition – implies that competition exacerbates inequity when A is a small minority, $\gamma_A \in (0, \hat{\gamma}_A)$. Inequity increases even when the service level for both types increases as long as the quality increase is greater for type B. It follows from (15) and (16) that $\frac{\partial v_i^{A,C}}{\partial p} < \frac{\partial v_i^{B,C}}{\partial p}$ if and only if

$$\gamma_A (c_{BB} + c_{AB}) - \gamma_B (c_{AA} + c_{AB}) < 0. \tag{19}$$

(19) holds if $\gamma_A \to 0$, but is not satisfied if $\gamma_A \to 1$. Thus, there exists $\tilde{\gamma}_A$ such that

$$\tilde{\gamma}_A (c_{BB} + c_{AB}) - (1 - \tilde{\gamma}_A)(c_{AA} + c_{AB}) = 0. \tag{20}$$

Accordingly, $\frac{\partial v_i^{A,C}}{\partial p} < \frac{\partial v_i^{B,C}}{\partial p}$ if and only if $\gamma_A \in (0, \tilde{\gamma}_A)$. Note that $\tilde{\gamma}_A > \hat{\gamma}_A$ since by Assumption 1 $c_{AB} < c_{AA}$.

Proposition 3 summarizes this result.

Proposition 3. *Introduction of competition increases (resp. reduces) inequity if and only if* $\gamma_A \in (0, \tilde{\gamma}_A)$ *(resp.* $\gamma_A \in (\tilde{\gamma}_A, 1)$*), where* $\tilde{\gamma}_A \in (\hat{\gamma}_A, 1)$.

Proposition 3 also shows that competition may make the service more equitable. This is the case when type A is in a sufficient majority. Then competition forces the provider to turn her attention to the majority type. The provider either increases quality for type A at the expense of type B (if $\gamma_A \in (1-\hat{\gamma}_B, 1)$) or increases quality for both types though favouring type A (if $\gamma_A \in (\tilde{\gamma}_A, 1-\hat{\gamma}_B)$).

Therefore, a public service where professionals find the minority type more rewarding may become more equitable under competition as professionals are incentivized to design the service to work well for the majority. Alternatively, if the minority type is more costly and possibly less rewarding, competition may exacerbate inequity by emphasizing the average quality of the service and, therefore, the majority type.

Finally, since the equilibrium under competition is symmetric, we can simplify notation by $v_1^{k,C} = v_2^{k,C} \equiv v^k(p)$ for $k = A, B$ and by Proposition 2 write quality as a function of p. Note that $v^k(0) = v^{k,N}$. This property will be useful in designing the optimal institution.

5. Optimal institution

Under competition, R chooses p to maximize the benefit from the total value of the service adjusted by his concern for equity minus the cost of transfers to the providers[18]

$$Max \quad \gamma_A v^A(p) + \gamma_B v^B(p) - \frac{1}{4}t - \lambda \left[v^B(p) - v^A(p)\right]^2 - D(p), \tag{21}$$

where transfers to the providers are equal to the providers' revenues

$$T = \sum_{i=1}^{2} p q_i = p \sum_{i=1}^{2} q_i = p. \tag{22}$$

Suppose $p = 0$. Then the incentives under competition and no competition are equivalent, $v^k(0) = v^{k,N}$ for $k = A, B$. Furthermore, the transfers to the providers are equal to zero in both institutions as R chooses $T_i = 0$ under no competition. Therefore, the optimal institution boils down to the question whether $p^* > 0$ or $p^* = 0$ solves (21). If $p^* > 0$, it must be that competition dominates no competition. On the other hand, if $p^* = 0$, that is in effect choosing no competition.

Accordingly, it is optimal for R to introduce competition if and only if the inequity adjusted marginal benefit of competition is greater than the marginal cost of raising taxes evaluated at $p = 0$,

$$\gamma_A \frac{\partial v^A(0)}{\partial p} + \gamma_B \frac{\partial v^B(0)}{\partial p} - 2\lambda \left(v^B(0) - v^A(0)\right) \left(\frac{\partial v^B(0)}{\partial p} - \frac{\partial v^A(0)}{\partial p}\right) > D'(0). \tag{23}$$

If (23) is satisfied, $p^* > 0$ and it is given by[19]

$$\gamma_A \frac{\partial v^A(p^*)}{\partial p} + \gamma_B \frac{\partial v^B(p^*)}{\partial p} - 2\lambda \left(v^B(p^*) - v^A(p^*)\right) \left(\frac{\partial v^B(p^*)}{\partial p} - \frac{\partial v^A(p^*)}{\partial p}\right) = D'(p^*). \tag{24}$$

If (23) is not satisfied, $p^* = 0$ and it is not optimal for R to introduce competition. Note that $\frac{\partial v^k(0)}{\partial p}$ can be small since this maximization problem is about increasing quality from the level under no competition, not from zero. Furthermore, according to Assumption 3 the marginal cost of increasing taxes is positive, $D'(0) > 0$. Therefore, an interior solution to (21) is not guaranteed.

We are particularly interested in how the decision to introduce competition is affected by R's inequity aversion. Differentiating the left-hand-side of (23) with respect to λ, we obtain $2\left(v^B(0) - v^A(0)\right)\left(\frac{\partial v^A(0)}{\partial p} - \frac{\partial v^B(0)}{\partial p}\right)$. By Proposition 3 this is negative if and only if $\gamma_A \in (0, \tilde{\gamma}_A)$. Therefore, a more inequity averse R is weakly less likely to introduce competition if type A is in minority because that is when competition increases inequity. Conversely, R with a larger λ is weakly *more* likely to introduce competition when type A is in majority because that is when competition improves equity.

Proposition 4 summarizes how inequity aversion affects R's decision to introduce competition and, if competition is chosen, the price R pays to the providers.

Proposition 4 (*i*). *It is optimal for R to introduce competition if and only if* $\gamma_A \frac{\partial v^A(0)}{\partial p} + \gamma_B \frac{\partial v^B(0)}{\partial p} - 2\lambda \left(v^B(0) - v^A(0)\right)\left(\frac{\partial v^B(0)}{\partial p} - \frac{\partial v^A(0)}{\partial p}\right) > D'(0)$.

R with a higher λ is weakly less (resp. more) likely to introduce competition if and only if $\gamma_A < \tilde{\gamma}_A$ *(resp.* $\gamma_A > \tilde{\gamma}_A$*).*

(ii) Under competition, R with a higher λ sets a lower (resp. higher) p if and only if $\gamma_A < \tilde{\gamma}_A$ *(resp.* $\gamma_A > \tilde{\gamma}_A$*).*

Suppose first that $\gamma_A < \tilde{\gamma}_A$ so that competition increases inequity, see the left-hand-sides of Figs. 1 and 2.[20] In Fig. 1 the marginal cost of increasing taxes is relatively low, as illustrated by the horizontal (blue) line. The figure also includes the inequity adjusted marginal benefit of competition for three types of R. R with no concern for inequity, $\lambda = 0$, is illustrated by the solid (red) U-shaped curve, moderately inequity averse R, $\lambda = 0.5$, by the dotted (green) line, and R with a high concern for equity, $\lambda = 0.95$, by the broken (blue) line.

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18 Note that the transportation costs do not depend on p in a symmetric equilibrium.

19 It follows from Assumption 1 that $\frac{\partial^2 v^k}{\partial p^2} < 0$, guaranteeing concavity of R's objective function.

20 Figs. 1 and 2 are drawn for $c(v_i^A, v_i^B) = \frac{1}{2}\alpha_A (v_i^A)^2 + \frac{1}{2}\alpha_B (v_i^B)^2 + \delta v_i^A v_i^B$, where $\alpha_A > \alpha_B > \delta > 0$.

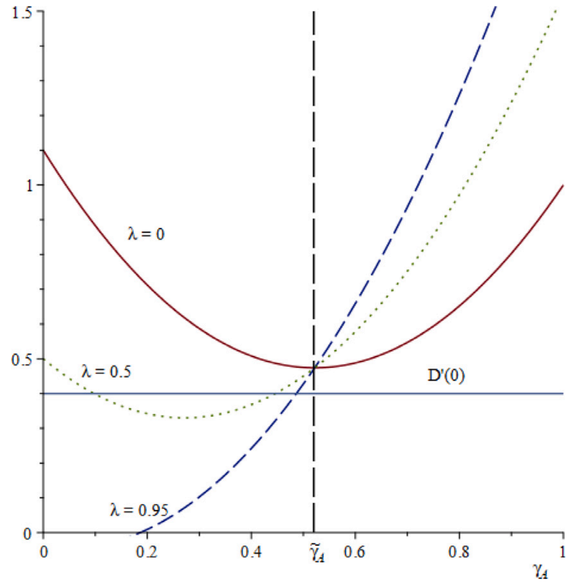

Fig. 1. *R*'s choice of competition (Low tax cost). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

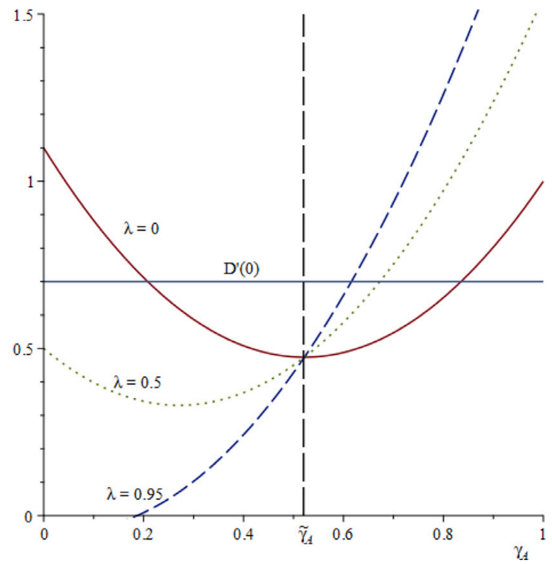

Fig. 2. *R*'s choice of competition (High tax cost). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Since competition increases inequity for $\gamma_A < \tilde{\gamma}_A$, the marginal benefit of competition is decreasing in λ and a more inequity averse R is less likely to introduce competition. R with no concern for inequity will introduce competition for all $\gamma_A < \tilde{\gamma}_A$ in Fig. 1 because the marginal benefit of increasing average quality from no competition level exceeds the marginal cost of increasing taxes. R with $\lambda = 0.95$ has much lower marginal benefit and, thus, will not introduce competition for most of the range where $\gamma_A < \tilde{\gamma}_A$ in order to protect the minority type A from increased inequity.[21] Only when γ_A is very close to $\tilde{\gamma}_A$ and the inequity effect is minimal, will he introduce competition in order to increase average quality. Finally, R with $\lambda = 0.5$ can accept more than minimal inequity effect and introduces competition for values of γ_A further away from $\tilde{\gamma}_A$. Furthermore, while a moderate R will not introduce competition for a wide range of γ_A, he will not protect a tiny minority at the cost of lower quality for the large majority. Although the inequity

[21] Note that the marginal benefit of competition can be negative for a very inequity averse R. In Figs. 1 and 2 this is the case if $\lambda > \frac{\alpha_A}{2(\alpha_A+\delta)(v_B(0)-v_A(0))}$. Then R does not introduce competition for small values of γ_A even if increasing taxes is costless.

effect is the greatest when γ_A is the smallest, the proportion of population suffering from it is very small. Therefore, a moderate R will introduce competition when γ_A is very small. However, R takes the equity concern into account by reducing p so that the inequity effect is mitigated (Proposition 4(ii)).

In Fig. 2 the tax cost is higher and R of any type is less likely to introduce competition as compared to Fig. 1. In fact, R with $\lambda = 0.5$ or $\lambda = 0.95$ will not introduce competition for any $\gamma_A < \widetilde{\gamma}_A$, while R with $\lambda = 0$ introduces competition only when it is most effective in increasing average quality.[22]

Suppose then that $\gamma_A > \widetilde{\gamma}_A$ so that competition improves equity, see the right-hand-sides of Figs. 1 and 2. Now the marginal benefit of competition is increasing in λ and more inequity concerned R is *more* likely to introduce competition. In Fig. 2 there are values of $\gamma_A > \widetilde{\gamma}_A$ for which only an inequity averse R is willing to pay the high tax cost of competition because it shifts the quality balance towards underserved majority. An inequity averse R even pays a premium p to strengthen the equalizing effect (Proposition 4(ii)). While in Fig. 1 R with any λ introduces competition for all $\gamma_A > \widetilde{\gamma}_A$ because tax cost is low and there is the added benefit of reduced inequity.

6. Extensions

6.1. Alternative inequity aversion

In our main model we have examined the common quadratic formulation of inequity aversion. One property of this formulation is that the disutility from inequity to R does not depend on the proportion of population receiving the lower quality service. We now consider an alternative formulation introduced by Wagstaff (2002), based on the extended Gini coefficient of Yitzhaki (1983), where the proportion of population is taken into account. R's objective function is now

$$v^A(p)\int_0^{\gamma_A}(1+\lambda)(1-x)^{\lambda}\,dx + v^B(p)\int_{\gamma_A}^{1}(1+\lambda)(1-x)^{\lambda}\,dx - \frac{1}{4}t - D(p), \tag{25}$$

where

$$\int_0^{\gamma_A}(1+\lambda)(1-x)^{\lambda}\,dx = 1-(1-\gamma_A)^{1+\lambda}, \tag{26}$$

$$\int_{\gamma_A}^{1}(1+\lambda)(1-x)^{\lambda}\,dx = (1-\gamma_A)^{1+\lambda}. \tag{27}$$

R's utility depends on the weighted average of the qualities. For R with no concern for inequity, $\lambda = 0$, this is a simple average quality of the service, identical to the formulation in Section 5. Inequity averse R, however, increases the weight given to the users receiving the lower quality service, that is, type A.

Now R introduces competition if and only if

$$\left[1-(1-\gamma_A)^{1+\lambda}\right]\frac{\partial v^A(0)}{\partial p} + (1-\gamma_A)^{1+\lambda}\frac{\partial v^B(0)}{\partial p} > D'(0). \tag{28}$$

Differentiating the left-hand-side of (28) with respect to λ, we obtain

$$-(1-\gamma_A)^{1+\lambda}\ln(1-\gamma_A)\left(\frac{\partial v^A(0)}{\partial p} - \frac{\partial v^B(0)}{\partial p}\right). \tag{29}$$

Therefore – as in Proposition 4 – R with a higher λ is weakly less likely to introduce competition if and only if $\gamma_A < \widetilde{\gamma}_A$. If competition increases the difference in the qualities provided for the rewarding and the unrewarding types, it is costly for inequity averse R also in this formulation.

What is different in this formulation is that, irrespective of the degree of inequity aversion, R puts a negligible weight on a tiny minority, $\lim_{\gamma_A\to 0}\left(1-(1-\gamma_A)^{1+\lambda}\right) = 0$. Therefore, the marginal benefit of competition for any λ converges in the vertical axis in Fig. 3 – unlike in Figs. 1 and 2. Accordingly, even an extremely inequity averse R will not protect a tiny minority from increased inequity by not introducing competition. However, with respect to our main results, Fig. 3 gives a similar picture to Figs. 1 and 2: whether a greater concern for inequity leads R to be less or more likely to introduce competition depends on whether γ_A is smaller or greater than $\widetilde{\gamma}_A$.

6.2. Monetary costs

We have assumed that the costs of quality, $c\left(v_i^A, v_i^B\right)$, are effort costs. We now allow for some monetary costs.

[22] It is clear from (13) and (14) that increasing p from zero has the strongest effect on $v^{B,C}$ – and the weakest effect on $v^{A,C}$ – when $\gamma_A \to 0$. Increasing γ_A gives less weight for the strong effect and more weight for the weak effect and thus average quality is reduced. (A.9) in the Appendix shows that the marginal benefit of competition for R with $\lambda = 0$ is quadratic in γ_A and has a U-shape as illustrated in Figs. 1 and 2.

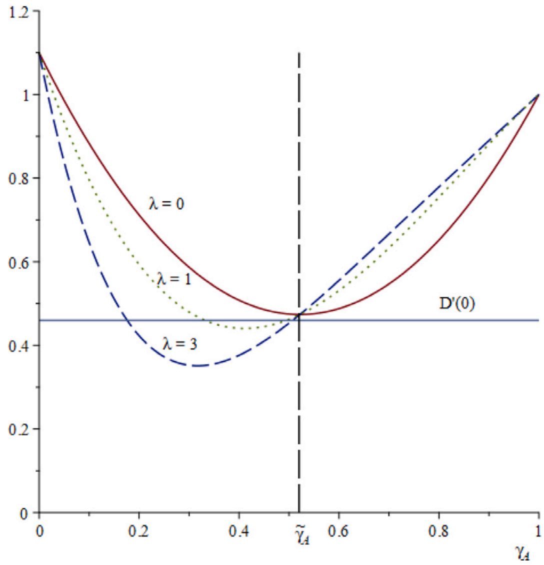

Fig. 3. *R*'s choice of competition with Gini coefficient.

If we introduce a fixed monetary cost of running the service, f, in the analysis, then competition becomes less costly for R to introduce. Under no competition R covers f by a direct transfer to the provider resulting in transfer costs of $D(2f)$. Under competition the provider has to cover f by winning enough users. Therefore, competition increases transfers only by $D(p^*) - D(2f)$. R is then more likely to introduce competition, the higher the fixed cost. Note that this does not imply that competition will always dominate for large f. When R is very inequity averse, the marginal benefit of competition can be negative and R would not introduce competition however low the cost is (see the broken line in Fig. 1).

Note that this result differs from the opposite argument that high fixed costs favour no competition because only one fixed cost is paid under monopoly (see e.g. Beitia, 2003). We take the existing provider network, e.g. schools or hospitals, as given and compare competition between the providers to no competition where each provider has a monopoly in their local market. In both structures the fixed costs equal $2f$.

Second, we allow for a monetary cost of quality provision. In particular, suppose that in addition to effort costs, $c\left(v_i^A, v_i^B\right)$ includes a monetary setup cost that depends on the average quality of the service, $F(v_i)$. Given the higher average quality under competition, the setup cost is higher under competition, $F(v_i^C) > F(v_i^N)$. Then – similar to the fixed cost f of running the service – R has to pay $T_i = F(v_i^N)$ under no competition to satisfy provider's participation constraint, while under competition the providers have to win enough users to pay for the (higher) setup cost. Including such monetary costs of quality makes competition less costly to introduce than in our main model as competition increases transfers only by $D(p^*) - D(2F(v_i^N))$.

6.3. Complementary quality efforts

In Assumption 1 quality efforts are substitutes at the margin. This plays an important role in Proposition 2(iii). If quality efforts are complementary or independent, competition increases quality for both types as higher quality for the majority does not increase the marginal cost for the minority. However, the quality increase is still greater for type B if $\gamma_A < \tilde{\gamma}_A$. Therefore our main results (Propositions 3 and 4) are robust to this assumption.

6.4. Rewarding high-cost users

We have analysed the case where professionals find the low-cost users more rewarding. Alternatively, the high-cost users could be more rewarding, for example, if designing a successful service for the difficult cases reaps significant professional kudos. This case is broadly a mirror image of the main model. Now the high-cost type A gets a better service under no competition, assuming the cost difference is not too large. An inequity averse R may then need to protect minority type B by not introducing competition or incentivize the provider to pay attention to the majority type B by introducing competition.

6.5. Private benefits depending on market share

We have assumed that the providers are intrinsically motivated by the quality of the service. Suppose now that private benefits depend also on the number of users served, so that there is an additional element of $\gamma_A q_i^A \mu'_A + \gamma_B q_i^B \mu'_B$. Then the first order conditions (13) and (14) under competition change to

$$\gamma_A \frac{p+\mu'_A}{2t} + \mu_A - \frac{\partial c\left(v_i^{A,C}, v_i^{B,C}\right)}{\partial v_i^A} = 0, \tag{30}$$

$$\gamma_B \frac{p+\mu'_B}{2t} + \mu_B - \frac{\partial c\left(v_i^{A,C}, v_i^{B,C}\right)}{\partial v_i^B} = 0. \tag{31}$$

As in the main model, if $\gamma_k \to 0$, the first order condition for the minority type is equivalent to the no competition case. Therefore, as per Propositions 2 and 3, competition increases inequity if type A is a small minority. What is different, however, is that while the comparative statics with respect to p remains unchanged, competition provides additional effort incentives even if $p = 0$ as private benefits can be increased by winning more users. Therefore, R can strictly prefer competition to no competition at $p = 0$, in particular when competition reduces inequity. Therefore, R can be more likely to introduce competition than Proposition 4 implies if private benefits depend also on the number of users served.

6.6. Heterogeneous private benefits

We will conclude with some remarks about heterogeneous private benefits. Our interest has been in examining the effect of competition on within institution inequity. (15) and (16) show that the competition effect does not interact with private benefits. $\frac{\partial v_i^{A,C}}{\partial p} < \frac{\partial v_i^{B,C}}{\partial p}$ if and only if $\gamma_A < \widetilde{\gamma}_A$ irrespective of the level of private benefits. Thus, if both providers prefer type B but to a different extent, e.g. $\mu_1^A < \mu_2^A < \mu_2^B < \mu_1^B$ and $\mu_1^A + \mu_1^B = \mu_2^A + \mu_2^B$, competition still increases (resp. decreases) within institution inequity if γ_A <(resp. >)$\widetilde{\gamma}_A$.

If the providers have the opposite preferences, e.g. $\mu_1^B = \mu_2^A > \mu_1^A = \mu_2^B$, the effects are more subtle and the results less clear-cut. Note that under no competition inequity within provider 1 (favouring type B) is greater than inequity within provider 2 (favouring type A) because 1 prefers the low-cost type. Furthermore, the magnitude of the competition effect, i.e. $\frac{\partial v_i^{A,C}}{\partial p}$ and $\frac{\partial v_i^{B,C}}{\partial p}$, is equal for both providers (see (A.5)). Then, if $\gamma_A < \widetilde{\gamma}_A$, $\frac{\partial v_i^{A,C}}{\partial p} < \frac{\partial v_i^{B,C}}{\partial p}$ for both providers. In other words, competition increases the greater inequity within provider 1 (in favour of type B) and decreases the smaller inequity within provider 2 (in favour of type A) by the same amount. Given the convexity of R's disutility from inequity, this can have a negative overall effect, as in the main model. While if $\gamma_A > \widetilde{\gamma}_A$, competition reduces the greater inequity and increases the smaller inequity and the overall effect can be positive, similar to the main model.

Provider heterogeneity also introduces *between* institution inequity. Under no competition type A (resp. B) users located just below (resp. above) $x = \frac{1}{2}$ would have received a better quality service from provider 2 (resp. 1). Under competition these users are able to switch provider, but the effect depends on what aspects of quality are observable. If the users can observe type-specific quality, competition reduces between institution inequity as users can choose a provider that delivers better quality for their type (taking into account transportation costs). However, if users can only observe average quality, competition can increase between institution inequity for the minority type. The minority type may switch to the provider that has higher average quality but can end up receiving a lower quality service for their type than they would have received from their allocated provider under no competition.

7. Conclusions

There is considerable debate as to whether competition increases the quality of public services. We consider a setting in which service providers are motivated, but the benefits motivated agents get from different type of users vary. We analyse the choice of a (potentially) inequity averse regulator over whether or not to introduce competition in the provision of a universal service. We show that in a world where providers favour a minority group, competition forces the providers to shift the balance of their efforts towards the underserved majority, in addition to providing a higher average quality. Then competition is a good reform model as long as the marginal tax cost of competition is not too high. Alternatively, in a world where providers find the minority group unrewarding, competition further exacerbates the inequity in service levels and can even reduce quality for the minority group. Then an inequity averse regulator chooses to protect the minority group by not introducing competition. Finally, a regulator who is not concerned about equity will introduce competition as long as the benefit of higher average quality outweighs the marginal tax cost of competition.

Our analysis identifies the effect of competition on within institution inequity. An interesting direction for future research is to examine interactions of within and between institution inequity.

Appendix

Proof of Proposition 1.

(6) and (7) imply that $v_1^{k,N} = v_2^{k,N} \equiv v^{k,N}$ for $k = A, B$ and

$$\frac{\mu_B}{\mu_A} = \frac{\frac{\partial c(v^{A,N}, v^{B,N})}{\partial v^B}}{\frac{\partial c(v^{A,N}, v^{B,N})}{\partial v^A}}. \tag{A.1}$$

Since by Assumption 2 $\mu_B \geq \mu_A$,

$$\frac{\partial c(v^{A,N}, v^{B,N})}{\partial v^B} \geq \frac{\partial c(v^{A,N}, v^{B,N})}{\partial v^A} \tag{A.2}$$

has to hold in equilibrium. By Assumption 1, (A.2) cannot be satisfied for $v^{A,N} = v^{B,N}$. Given the convexity of costs, $v^{A,N} < v^{B,N}$ in equilibrium. □

Proof of Proposition 2.

We can rewrite the first-order conditions (13) and (14) as

$$p\frac{\partial q_i}{\partial v_i^A} + \mu_A - \frac{\partial c\left(v_i^{A,C}, v_i^{B,C}\right)}{\partial v_i^A} = 0, \tag{A.3}$$

$$p\frac{\partial q_i}{\partial v_i^B} + \mu_B - \frac{\partial c\left(v_i^{A,C}, v_i^{B,C}\right)}{\partial v_i^B} = 0. \tag{A.4}$$

The monetary reward competition introduces is for increasing average quality, v_i (see (12)). (A.3) and (A.4) solve for the most effective way to increase average quality, proving Proposition 2(i). The proofs of 2(ii) and (iii) are in the main text. □

Proof of Proposition 4.

The proof of (i) is in the main text.

(ii) If (23) is satisfied, p^* is given by (24). Differentiating the left-hand-side of (24) with respect to λ, we obtain 2 $\left(v^B(p^*) - v^A(p^*)\right)\left(\frac{\partial v^A(p^*)}{\partial p} - \frac{\partial v^B(p^*)}{\partial p}\right)$, which is negative if and only if $\gamma_A < \widetilde{\gamma}_A$. Therefore, R with a higher λ sets a lower p if and only if $\gamma_A < \widetilde{\gamma}_A$.

Finally, let us verify that $v^B(p^*) > v^A(p^*)$. If $\gamma_A < \widetilde{\gamma}_A$, $\frac{\partial v^{A,C}}{\partial p} < \frac{\partial v^{B,C}}{\partial p}$, and since $v^A(0) < v^B(0)$, it follows that $v^A(p) < v^B(p)$ for any p. If $\gamma_A > \widetilde{\gamma}_A$, $\frac{\partial v^{A,C}}{\partial p} > \frac{\partial v^{B,C}}{\partial p}$ and there exists $\overline{p}$ such that $v^A(\overline{p}) = v^B(\overline{p})$. By Assumption 3 $\lim_{T\to\overline{T}} D'(T) = \infty$, and thus $p^* < \overline{T}$. Assuming $\overline{T} \leq \overline{p}$, $v^A(p^*) < v^B(p^*)$ for any γ_A. □

Figs. 1 and 2. Given $c(v_i^A, v_i^B) = \frac{1}{2}\alpha_A(v_i^A)^2 + \frac{1}{2}\alpha_B(v_i^B)^2 + \delta v_i^A v_i^B$, where $\alpha_A > \alpha_B > \delta > 0$, we can solve from (13) and (14)

$$v^{k,C} = \frac{\left(\alpha_l\gamma_k - \delta\gamma_l\right)\frac{p}{2t} + \alpha_l\mu_k - \delta\mu_l}{\alpha_A\alpha_B - \delta^2}, k, l = A, B, k \neq l. \tag{A.5}$$

Therefore,

$$\frac{\partial v^{k,C}}{\partial p} = \frac{\alpha_l\gamma_k - \delta\gamma_l}{(\alpha_A\alpha_B - \delta^2)2t} \tag{A.6}$$

and $\frac{\partial v^{A,C}}{\partial p} > \frac{\partial v^{B,C}}{\partial p}$ if and only if

$$\gamma_A > \frac{\alpha_A + \delta}{\alpha_A + \alpha_B + 2\delta} \equiv \widetilde{\gamma}_A > \frac{1}{2}. \tag{A.7}$$

By standard calculations we can obtain the inequity adjusted marginal benefit of competition evaluated at $p = 0$, denoted by $\Lambda(\gamma_A, \lambda)$.

$$\Lambda(\gamma_A, \lambda) = \gamma_A\frac{\partial v^{A,C}}{\partial p} + \gamma_B\frac{\partial v^{B,C}}{\partial p} - 2\lambda\left(v_B(0) - v_A(0)\right)\left(\frac{\partial v^{B,C}}{\partial p} - \frac{\partial v^{A,C}}{\partial p}\right) \tag{A.8}$$

$$= \frac{(\alpha_A + \alpha_B + 2\delta)(\gamma_A)^2 - 2(\alpha_A + \delta)\gamma_A + \alpha_A}{(\alpha_A\alpha_B - \delta^2)2t} - 2\lambda\left(v_B(0) - v_A(0)\right)\frac{(\alpha_A + \delta) - (\alpha_A + \alpha_B + 2\delta)\gamma_A}{(\alpha_A\alpha_B - \delta^2)2t}, \tag{A.9}$$

where $\left(v_B(0) - v_A(0)\right) = \frac{(\alpha_A+\delta)\mu_B - (\alpha_B+\delta)\mu_A}{\alpha_A\alpha_B - \delta^2} > 0$.

The following properties help us draw Figs. 1 and 2. (i) $\frac{\partial\Lambda(\gamma_A,\lambda)}{\partial\gamma_A} > 0$ if and only if $\gamma_A > \widetilde{\gamma}_A - \lambda\left(v_B(0) - v_A(0)\right)$, ($ii$) $\frac{\partial\Lambda(\gamma_A,\lambda)}{\partial\lambda} > 0$ if and only if $\gamma_A > \widetilde{\gamma}_A$ and (iii) $\Lambda(0, \lambda) \leq 0$ if and only if $\lambda \geq \frac{\alpha_A}{2(\alpha_A+\delta)(v_B(0) - v_A(0))}$.

Fig. 3When R's inequity aversion is based on the extended Gini coefficient, the inequity adjusted marginal benefit of competition is given by

$$\widetilde{\Lambda}(\gamma_A, \lambda) = \frac{\partial v^A(0)}{\partial p} + (1 - \gamma_A)^{1+\lambda}\left(\frac{\partial v^B(0)}{\partial p} - \frac{\partial v^A(0)}{\partial p}\right) \tag{A.10}$$

$$= \frac{\alpha_B\gamma_A - \delta\gamma_B}{(\alpha_A\alpha_B - \delta^2)2t} + (1 - \gamma_A)^{1+\lambda}\frac{\gamma_B(\alpha_A + \delta) - \gamma_A(\alpha_B + \delta)}{(\alpha_A\alpha_B - \delta^2)2t}. \tag{A.11}$$

$\widetilde{\Lambda}(\gamma_A, \lambda)$ has the following properties. (i) $\frac{\partial\widetilde{\Lambda}(\gamma_A,\lambda)}{\partial\lambda} > 0$ if and only if $\gamma_A > \widetilde{\gamma}_A$, ($ii$) $\widetilde{\Lambda}(0, \lambda) = \frac{\alpha_A}{(\alpha_A\alpha_B - \delta^2)2t} > 0$ and (ii) $\widetilde{\Lambda}(1, \lambda) = \frac{\alpha_B}{(\alpha_B\alpha_B - \delta^2)2t} > 0$.

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