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Quality competition with profit constraints: Do non-profit firms provide higher quality than for-profit firms?

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Abstract

In many markets, such as education, health care and public utilities, firms are often profit-constrained either due to regulation or because they have non-profit status. At the same time such firms might have altruistic concerns towards consumers. In this paper we study semi-altruistic firms' incentives to invest in quality and cost-reducing effort when facing constraints on the distribution of profits. Using a spatial competition framework, we derive the equilibrium outcomes under both quality competition with regulated prices and quality-price competition. Profit constraints always lead to lower cost-efficiency, whereas the effects on quality and price are ambiguous. If altruism is high (low), profit-constrained firms offer higher (lower) quality and lower (higher) prices than firms that are not profit-constrained. Compared with the first-best outcome, the cost-efficiency of profit-constrained firms is too low, while quality might be over- or underprovided. Profit constraints may improve welfare and be a complement or substitute to a higher regulated price, depending on the degree of altruism.

Keywords: Profit constraints, Quality competition, Semi-altruistic providers

JEL classification: D21, D43, L13, L30

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1 Introduction

In many markets, goods or services are provided by firms that face constraints on profit distribution. The most extreme example is non-profit firms, whose profits cannot be distributed to persons that exercise control over the firm, but must be reinvested in the firm or spent on 'perquisites'. In regulated markets, such as health, education or public utilities, it is also common that (for-profit) firms face weaker forms of profit constraints, such as profit caps, which limit the amount of profits that can be distributed.

In this paper we ask how the presence of such profit constraints affects market outcomes. Do profit-constrained firms offer higher quality than firms that do not face such constraints? Do they offer lower prices? Are they more cost-efficient? We address these questions in a theoretical setting of spatial competition with semi-altruistic firms, where consumers make their purchasing decisions based on travelling distance, quality and price. Firms compete by choosing the quality, and possibly the price, of the good offered. The firms can also become more cost-efficient by investing in cost-containment effort. We analyse two different scenarios: (i) quality competition under price regulation, and (ii) quality-and-price competition.

We model profit constraints as being equivalent to a tax on profits.[1] The basic underlying assumption is that owners prefer compensation in cash over alternative modes of compensation, such as perquisites.[2] Thus, for non-profit firms, the implied 'profit tax' corresponds to the difference in valuation between cash and perquisites. For firms that are subject to profit cap regulation, the implied profit tax will be lower, since part of the net revenues can be distributed as profits, but still positive if the profit cap is binding. Obviously, our analysis also applies to actual profit taxation.

We also allow firms to be semi-altruistic by assuming that they care about profits and (to some extent) consumers' benefit. This is a more general formulation of firms' objectives with pure profit maximisation as a special case. Altruism is commonly associated with the non-profit

[1] A similar approach is used by Glaeser and Shleifer (2001) and Ghatak and Mueller (2011) in the context of non-profit firms. See also Hansmann (1980, p. 873-875) for anecdotal support for this formulation. Lakdawalla and Philipson (2006) model the distribution constraint on non-profit firms as a (potentially binding) profit cap, whereas in Easley and O'Hara (1983) the non-profit firm's profit is set in a contract between the firm and the society.

[2] Non-pecuniary compensation ('perquisites') may involve different types of improvement in the working environment, such as lower effort levels, free meals, shorter workdays, longer vacations, better office facilities, etc.

sector.[3] Allowing firms to care about consumers' benefit implies some non-cash costs to the firms of choosing lower quality and/or higher prices.[4] The concern for consumers' benefit of the goods and services offered might reflect motives of the owners (or founders) of profit-constrained firms or even the motivation of workers in such firms. In order to focus exclusively on the effect of profit constraints, we assume that the degree of altruism is independent of such constraints. This implies that profit-constrained firms are not assumed to be more altruistic than firms with no constraints on the distribution of profits.[5]

Although the framework of our analysis is fairly general and not tailor-made to fit any particular industry, our analysis can be applied to several markets, like education, health care, long-term care, child care, etc. In all these markets, quality is an important competition variable, whereas prices might be regulated or not. Travelling costs also play a potentially important role in determining demand, e.g., distance to nearest school, hospital, kindergarten, nursing home, etc.[6] Furthermore, semi-altruistic provider preferences are generally acknowledged to be a relevant characteristic of such markets.[7] Finally, in many countries, a significant share of education, health care, long-term care and child care services is provided either by non-profit institutions or by for-profit ones that are subject to some form of profit regulation.[8]

Our analysis sheds some light on several important issues related, in particular, to health care

[3]See Rose-Ackerman (1996) for an excellent overview and discussion of altruism and the non-profit sector. She also provides many examples of why altruism is important and relevant for understanding non-profit, and sometimes also for-profit, firms' behaviour.

[4]This approach is close to Glaeser and Shleifer (2001) who model altruism as a (non-cash) cost of delivering suboptimal quality ('shirking') to consumers. It is also related to Lakdawalla and Philipson (2006), though they model altruism by assuming that firms value output directly in addition to profits.

[5]It is sometimes argued that non-profit firms are more altruistic than for-profit firms (see Rose-Ackerman, 1996, for an overview of the earlier literature). Indeed, Lakdwalla and Philipson (2006) assume that the non-profit firms are altruistic, whereas for-profit firms are not. Non-profit firms are altruistic in the sense that they maximise output (and profits), and this gives them a competitive advantage (due to lower *effective* marginal costs) against for-profit firms.

[6]Empirical studies of the US health care market show that travelling distance and quality are the main predictors of hospital choice (Kessler and McClellan, 2000; Tay, 2003).

[7]In the literature on health care provision, the assumption that health care providers are, at least to some extent, altruistic, is widely used and recognised. See, e.g., Ellis and McGuire (1986), Chalkley and Malcolmson (1998a, 1998b), Eggleston (2005), Heyes (2005), Jack (2005), Brekke, Siciliani and Straume (2008), Kaarbøe and Siciliani (2010), and Choné and Ma (forthcoming). There is also a recent literature on 'motivated agents' in the broader public sector. For example, Besley and Ghatak (2006) study school competition and optimal incentive payment in the presence of motivated teachers. See Francois and Vlassopoulos (2008) for an extensive review of the motivated agents literature.

[8]Rose-Ackerman (1996) reports figures showing that health and education institutions constitute well over 70 percent of the non-profit sector in the US, while the equivalent average figure for a group of 7 Western countries is close to 50 percent. A similar (slightly lower) figure for a different group of Western countries (excluding the US) is reported by Salamon et al. (2007).

and education markets. For example, there is a rich empirical literature dealing with the question of whether non-profit hospitals provide better quality of care than their for-profit counterparts. Sloan (2000) offers an extensive review of this literature and concludes that the evidence appears to be mixed.[9] A recent meta-analysis by Eggleston et al. (2008) on US hospitals reports that the results depend on the context (region, data source, period), but concludes that "studies representative of the US as a whole tend to find lower quality among for-profits than private nonprofits".[10] An interesting study is provided by Picone, Shin-Yi and Sloan (2002).[11] Rather than relying on cross-sectional evidence, they investigate whether the change in status from non-profit to for-profit had an impact on quality. They show that mortality rates increased within two years of the change. In contrast, for-profit hospitals who changed to government or non-profit status had similar levels of quality before and after the change.[12]

We also contribute to the question of whether owners of private firms that receive public funding should be allowed to distribute profits. This is often a hotly contested policy issue and regulatory practices vary across countries. To give an example from education markets, in 1992, Sweden embarked on a radical education reform programme, which has become the subject of intense debate in the UK.[13] The Swedish reform introduced free school choice and liberalised entry by removing school ownership restrictions, including the ban on private for-profit schools. Private schools receive public funding corresponding to the average cost per student for each student from the municipality in which the school is located, but are not allowed to charge any top-up fees or 'cherry pick' pupils according to background. The Conservatives claim that the Swedish experiment has been successful and consider introducing school choice and removing the ban on for-profit schools in the UK. Labour, in contrast, claims that the Swedish reform has failed, and in April 2010, Ed Balls (then Secretary of State for Education) wrote a letter to Michael Gove (the current Secretary of State for Education), stating the following: '*Parents*

[9] Sloan (2000) also reviews the theoretical literature related to non-profit firms in general and discusses its relevance for the hospital market.

[10] For most studies they find that hospital mortality rates or adverse events are not statistically significant. Moreover, government hospitals have either higher or similar mortality rates and adverse events as private not-for-profits.

[11] See also Shen (2002).

[12] There are also other studies that report mixed results on the relationship between ownership and quality, see e.g., Milcent (2005), Lien et al. (2008), Jensen, Webster and Witt (2009).

[13] See, for instance, the article 'Swedish-Style "Free Schools" Won't Improve Standards' in the Guardian (9 February 2010).

and taxpayers across the country will be rightly shocked that you are willing to allow taxpayers' money to be diverted from its intended purpose - the education of our children - to the profits of the private companies you want to prove it, even more so because the evidence from Sweden is that this very policy caused educational standards across the country to fall.'[14]

The results from our analysis show that, while a constraint on profit distribution always leads to less cost-efficiency, the effect on quality and prices are generally ambiguous. In the case where prices are regulated and firms compete only on quality, profit-constrained firms provide higher quality in equilibrium if the degree of altruism is sufficiently high. A similar result emerges in the case quality-and-price competition, where the imposition of a profit constraint may lead to both higher quality and lower prices if the firms have sufficiently altruistic preferences. On the other hand, for low (or zero) levels of altruism, profit-constrained firms offer not only lower quality but also higher prices in equilibrium.

In the welfare analysis, we derive the first-best outcome that maximises social welfare and show that cost-efficiency is too low for profit-constrained firms, while quality may be over- or underprovided in the market equilibrium. If prices are set by the firms, profit constraints may improve welfare for low degrees of altruism. On the other hand, if prices are set by a regulator, but not necessarily at the first-best optimal level, profit constraints may improve welfare for low or intermediate degrees of altruism, depending on the price level. If price regulation is optimal, we show that price and profit constraints can be either complements or substitutes, depending on the degree of altruism. For example, markets with non-profit (as opposed to for-profit) firms should optimally face a lower (higher) price if the degree of altruism is sufficiently high (low).

Our paper clearly relates to the literature on non-profit versus for-profit firms, which constitute one of the main applications of our model. The paper in this strand of the literature that is perhaps most closely related to ours is Glaeser and Shleifer (2001), as they consider quality choices by non-profit versus for-profit firms.[15] They find that non-profit firms always provide higher quality. Our analysis, by contrast, shows that profit-constrained firms offer higher quality only if they are sufficiently altruistic. The difference in results is due to very different underlying

[14] Balls, Ed. 'Profit-Making Schools - My Letter to Michael Gove'. 11 April, 2010 (http://www.edballs.co.uk)

[15] The study by Glaeser and Shleifer (2001) builds on the seminal work by Hansmann (1980, 1996), where the benefit of non-profit firms is to mitigate 'contract failure' problems. Another paper in this strand of literature is Easley and O'Hara (1983) who stress more speficially asymmetric information between consumers and firms (output cannot be observed).

assumptions, where Glaeser and Shleifer assume that the market transaction takes place prior to the quality choice. With the added assumption that quality is non-verifiable, this creates a moral hazard problem with firms having an incentive to shirk on quality. Since non-profit firms cannot distribute the profits from shirking, they have a lower incentive to shirk and will therefore choose a higher quality level. In our model, quality is observable and is chosen prior to the consumption decisions, and there is no scope for ex post moral hazard. Also differently from our paper, the main purpose of Glaeser and Shleifer (2001) is to analyse entrepreneurs' choices of non-profit versus for-profit status. A similar focus is found in Lakdawalla and Philipson (2006) and Ghatak and Mueller (2011). Lakdawalla and Philipson study the interaction between non-profit and for-profit sectors in a competitive model with free entry and exit of firms. Ghatak and Mueller, on the other hand, use an agency approach and show that the choice of non-profit versus for-profit status can arise from competition for motivated workers. Quality is not an issue in either of these two papers.

Our paper should also be seen as a contribution to the literature on quality competition in regulated markets, particularly the strand of literature focusing on spatial competition with applications to health and education. General contributions that share many features of our modelling framework include Ma and Burgess (1997), Wolinsky (1997) and Brekke, Nuscheler and Straume (2006), while similar papers focusing more exclusively on competition in health care markets include Gravelle (1999), Lyon (1999), Beitia (2003), Brekke, Nuscheler and Straume (2007), Karlsson (2007) and Brekke, Siciliani and Straume (forthcoming). To our knowledge, the present paper is the first attempt to analyse quality competition in regulated markets when firms face profit constraints. Moreover, with the exception of Brekke, Siciliani and Straume (forthcoming), this strand of the literature has generally not considered semi-altruistic provider preferences.[16]

The remainder of the paper is organised as follows. In Section 2 we present the model, which is then analysed for the cases of price regulation (Section 3) and price competition (Section 4). In Section 5 we study the case of a mixed duopoly, where a profit-constrained firm competes against a firm that does not face any constraints on the distribution of profits. Welfare issues

[16] In a framework of spatial competition, Del Rey (2001) analyses quality competition between state universities that maximise objective functions that could be intepreted as reflecting altruistic preferences.

are analysed and discussed in Section 6, before Section 7 closes the paper with some concluding remarks.

2 Model

Two firms are located at the endpoints of the line segment $S = [0, 1]$. Firm 1 is located at the left endpoint while Firm 2 is located at the right endpoint. Consumers are uniformly distributed on S with total mass equal to one. Each consumer demands one unit from the most preferred firm. The utility of a consumer located at z and buying from Firm i is given by

$$U(z,i) = \begin{cases} v + q_i - \gamma p_i - tz & if \quad i = 1 \\ v + q_i - \gamma p_i - t(1-z) & if \quad i = 2 \end{cases}, \tag{1}$$

where $v > 0$ is the gross utility of consuming the good, q_i is the quality of the good, p_i is the price of the good, $\gamma \in [0, 1]$ is the share of the price paid by the consumer (the coinsurance rate) and $t > 0$ is a transportation cost parameter. From the consumers' utility-maximising problems we derive the demand functions:

$$x_1(p_1, p_2, q_1, q_2) = \begin{cases} 0 & if & q_1 - q_2 \leq \gamma(p_1 - p_2) - t \\ \overline{z} & if & \gamma(p_1 - p_2) - t < q_1 - q_2 \leq \gamma(p_1 - p_2) + t \\ 1 & if & q_1 - q_2 > \gamma(p_1 - p_2) + t \end{cases}, \tag{2}$$

$$x_2(p_1, p_2, q_1, q_2) = \begin{cases} 1 & if & q_1 - q_2 \leq \gamma(p_1 - p_2) - t \\ 1 - \overline{z} & if & \gamma(p_1 - p_2) - t < q_1 - q_2 \leq \gamma(p_1 - p_2) + t \\ 0 & if & q_1 - q_2 > \gamma(p_1 - p_2) + t \end{cases}, \tag{3}$$

where

$$\overline{z} = \frac{1}{2} + \frac{1}{2t}(q_1 - q_2 - \gamma(p_1 - p_2)) \tag{4}$$

is the location of the consumer who is indifferent between the two firms.

The monetary cost of supplying the good is given by $c(x_i, q_i, e_i)$, where e_i is the amount of cost-containment effort expended by Firm i. We assume that the cost function has the following general characteristics: $c_x > 0$, $c_q > 0$, $c_{xx} \geq 0$, $c_{qq} > 0$, $c_{xq} \gtreqless 0$, $c_{xe} < 0$ and $c_{qe} \leq 0$. Notice that we allow for output and quality to be either cost substitutes ($c_{xq} > 0$) or cost complements ($c_{xq} < 0$). Profits are then given by

$$\pi_i(x_i, q_i, e_i) = p_i x_i - c(x_i, q_i, e_i), \quad i = 1, 2. \tag{5}$$

In addition to cost-containment effort, we also assume that there is a non-monetary (effort) cost associated with supplying quality above a minimum level (which is normalised to zero).[17] The non-monetary costs of Firm i are given by the function $g(e_i, q_i)$, where $g_e > 0$, $g_{ee} > 0$, $g_q > 0$, $g_{qq} > 0$ and $g_{eq} = 0$. We also allow firms to have semi-altruistic preferences by assuming that they care about the utility of their consumers. The objective function of Firm i is given by

$$\Omega_i(x_i, q_i, e_i; \delta, \alpha) = (1-\delta)\pi_i(x_i, q_i, e_i) + \alpha b_i(q_i, x_i) - g(e_i, q_i), \tag{6}$$

where

$$b_1 = \begin{cases} 0 & if \quad q_1 - q_2 \leq \gamma(p_1 - p_2) - t \\ \int_0^{\bar{z}} (v + q_1 - \sigma\gamma p_1 - ts)\, ds & if \quad \gamma(p_1 - p_2) - t < q_1 - q_2 \leq \gamma(p_1 - p_2) + t \\ \int_0^1 (v + q_1 - \sigma\gamma p_1 - ts)\, ds & if \quad q_1 - q_2 > \gamma(p_1 - p_2) + t \end{cases} \tag{7}$$

and

$$b_2 = \begin{cases} \int_0^1 (v + q_2 - \sigma\gamma p_2 - t(1-s))\, ds & if \quad q_1 - q_2 \leq \gamma(p_1 - p_2) - t \\ \int_{\bar{z}}^1 (v + q_2 - \sigma\gamma p_2 - t(1-s))\, ds & if \quad \gamma(p_1 - p_2) - t < q_1 - q_2 \leq \gamma(p_1 - p_2) + t \\ 0 & if \quad q_1 - q_2 > \gamma(p_1 - p_2) + t \end{cases}. \tag{8}$$

The parameter $\alpha \in (0, 1)$ measures the degree of altruism on the part of the firms. We also allow for some flexibility in the formulation of the semi-altruistic preferences by weighting the altruistic consideration towards the price paid by consumers by $\sigma \in [0, 1]$. If $\sigma = 0$, the firms care only about gross consumer utility and do not take consumers' purchasing expenditures into account. On the other hand, if $\sigma = 1$, the firms' altruistic considerations are perfectly aligned with consumer preferences. In the latter case, b_i is equal to the aggregate utility of consumers

[17] This is a commonly used assumption in the context of health care providers. See, e.g., Ma (1994) and Chalkley and Malcomson (1998a, 1998b).

buying from Firm i.[18]

The parameter $\delta \in [0, 1)$ plays a key role in our analysis, as it measures the degree to which the firm is profit-constrained. In the context of for-profit versus non-profit firms, the former is captured by $\delta = 0$ while the latter is characterised by $\delta > 0$. Owners of non-profit firms cannot distribute profits in cash but have to spend any positive net revenues on perquisites. Under the assumption that owners prefer compensation in cash over compensation in perquisites, a monetary net surplus (profit) has lower value for the owner of a non-profit firm than for the owner of a for-profit firm, i.e., $\delta > 0$.[19] More generally, the above formulation of the firms' objective function is relevant for any market where a regulator places a constraint on the firms' ability to distribute profits.

3 Quality competition with price regulation

We consider first the case where prices are regulated and thus exogenous to the firms; i.e., $p_1 = p_2 = p$. We assume that quality and cost-containment effort are chosen simultaneously and independently. The first-order conditions for the optimal choices by Firm i are given by

$$\frac{\partial \Omega_i}{\partial q_i} = (1-\delta)\left[(p - c_x)\frac{\partial x_i}{\partial q_i} - c_q\right] + \alpha \frac{\partial b_i}{\partial q_i} - g_q = 0, \tag{9}$$

$$\frac{\partial \Omega_i}{\partial e_i} = -(1-\delta)\, c_e - g_e = 0. \tag{10}$$

Notice that each firm chooses the optimal level of quality by balancing three different consideration: net revenues (π), consumer benefit (b) and effort of quality provision (g). Quality is optimal when the sum of the marginal financial benefit from quality and the non-financial benefit arising from concerns for consumers' utility is equal to the marginal monetary and non-monetary (disutility) cost. All else equal, the presence of semi-altruistic preferences pushes the optimal quality above (below) the profit maximising level. Profit constraints reduce the relative weight

[18] In the context of health care, the case of $\sigma < 1$ implies that health care providers are more concerned about the quality of care given to patients than about the price patients have to pay. Our flexible formulation ($\sigma \in [0, 1]$) is partly motivated by the contrasting empirical evidence on this. For example, while Hellerstein (1998) finds that physicians' drug-prescription choices do not seem to reflect differences in patient copayment, Lundin (2000) finds that patients who face larger copayments are more likely to be prescribed a cheaper drug.

[19] This is way of modelling the difference between non-profit and for-profit firms is also used by Glaeser and Shleifer (2001) and Ghatak and Mueller (2011).

given to financial considerations as opposed to non-financial ones.

Using (2) and (7) to calculate the marginal effects of quality investments on demand and aggregate consumer utility, and subsequently setting $q_i = q$ and $e_i = e$ for $i = 1, 2$, quality and cost-containment effort in the unique symmetric pure-strategy Nash equilibrium, (q^*, e^*), are given by the following pair of equations:

$$(1-\delta)\left[\frac{p-c_x}{2t} - c_q\right] + \frac{\alpha}{2}\left(\frac{1}{2} + \frac{v + q^* - \sigma\gamma p}{t}\right) - g_q = 0, \tag{11}$$

$$-(1-\delta)\, c_e - g_e = 0. \tag{12}$$

By the implicit function theorem, the effect of profit constraints on the equilibrium choices of quality and cost-containment effort are given by

$$\frac{\partial q^*}{\partial \delta} = -\frac{1}{\Delta}\left[c_e (1-\delta)\left(c_{eq} + \frac{c_{ex}}{2t}\right) + \left(\frac{p-c_x}{2t} - c_q\right)((1-\delta)\, c_{ee} + g_{ee})\right], \tag{13}$$

$$\frac{\partial e^*}{\partial \delta} = -\frac{1}{\Delta}\left[c_e\left(-(1-\delta)\left(\frac{c_{xq}}{2t} + c_{qq}\right) + \frac{\alpha}{2t} - g_{qq}\right) - (1-\delta)\, c_{eq}\left((p-c_x)\frac{1}{2t} - c_q\right)\right], \tag{14}$$

where

$$\Delta := \left((1-\delta)\left(\frac{c_{xq}}{2t} + c_{qq}\right) - \frac{\alpha}{2t} + g_{qq}\right)((1-\delta)\, c_{ee} + g_{ee}) - (1-\delta)^2 c_{eq}\left(c_{eq} + \frac{c_{ex}}{2t}\right) > 0. \tag{15}$$

As an instructive way to analyse the effects of profit constraints on quality and effort incentives, we will first consider four special cases:

1. Assume that $\alpha = c_e = g_q = 0$. This corresponds to the case where: i) altruism is zero; ii) there is no (marginal) disutility of providing quality; iii) there is no cost-containment effort (or, equivalently, higher effort does not reduce monetary costs, so that optimal effort is zero). The expression in (13) is then reduced to

$$\frac{\partial q^*}{\partial \delta} = \frac{-\left[\frac{p-c_x}{2t} - c_q\right]}{(1-\delta)\left(\frac{c_{xq}}{2t} + c_{qq}\right)}. \tag{16}$$

From (11), $\alpha = g_q = 0$ implies that $\frac{p-c_x}{2t} - c_q = 0$, which means that $\partial q^*/\partial \delta = 0$. Thus, in the absence of altruism and any non-monetary costs, equilibrium quality is unaffected by profit constraints.

2. Assume that $\alpha = c_e = 0$ and $g_q > 0$. Differently from the previous case, we now assume the presence of disutility from providing quality but maintain the assumption of no altruism and cost-containment effort. Under these assumptions, (13) reduces to

$$\frac{\partial q^*}{\partial \delta} = \frac{-\left[\frac{p-c_x}{2t} - c_q\right]}{(1-\delta)\left(\frac{c_{xq}}{2t} + c_{qq}\right) + g_{qq}} \tag{17}$$

However, (11) now becomes

$$(1-\delta)\left[\frac{p-c_x}{2t} - c_q\right] - g_q = 0,$$

implying that $\frac{p-c_x}{2t} - c_q > 0$ in equilibrium. Since the denominator in (17) is positive (by the second-order condition), this means that profit-constrained firms provide less quality: $\partial q^*/\partial \delta < 0$. The intuition is that profit constraints reduce the marginal profit gain of providing quality while the marginal disutility (non-monetary) cost in terms of quality remains unchanged, thereby reducing the firms' incentives to provide quality.

3. Assume that $\alpha = g_q = 0$ and $c_e < 0$. In this case altruism and disutility from quality provision are zero, but higher effort reduces costs. Equation (11) is reduced to

$$(1-\delta)\left[\frac{p-c_x}{2t} - c_q\right] = 0,$$

which implies that (13) and (14) reduce to, respectively,

$$\frac{\partial e^*}{\partial \delta} = \frac{1}{\Delta} c_e (1-\delta)\left(\frac{c_{xq}}{2t} + c_{qq}\right) < 0 \tag{18}$$

and

$$\frac{\partial q^*}{\partial \delta} = -\frac{1}{\Delta} c_e (1-\delta)\left(c_{eq} + \frac{c_{ex}}{2t}\right) < 0. \tag{19}$$

Thus, placing a profit constraint on the firms leads to lower equilibrium quality also in this case. The reason is that a profit constraint reduces the incentive for cost containment and therefore lowers the equilibrium level of cost-containment effort. With a lower price-cost margin, $(p - c_x)$, the incentive for providing quality is correspondingly reduced.

4. Assume that $\alpha > 0$ and $c_e = g_q = 0$. This case implies positive altruism and no (marginal) disutility of effort and quality. As in Case 1 above, (13) reduces to (16). However, (11) is now reduced to

$$(1-\delta)\left[\frac{p-c_x}{2t} - c_q\right] + \frac{\alpha}{2}\left(\frac{1}{2} + \frac{v + q^* - \sigma\gamma p}{t}\right) = 0,$$

implying that $\frac{p-c_x}{2t} - c_q < 0$ in equilibrium. Consequently, profit-constrained firms provide a higher level of quality: $\partial q^*/\partial\delta > 0$. Semi-altruistic firms choose a level of quality provision where the marginal net revenue loss is balanced against the marginal altruistic benefit. Placing a profit constraint on the firms reduces the marginal net revenue loss while leaving the marginal altruistic benefit unchanged, implying that the objective function of each firm is maximised at a higher level of quality.

In the general case, with semi-altruistic preferences and non-monetary costs of quality and cost containment, the effect of profit constraints on the firms' incentives for quality provision depends qualitatively on the sum of the two terms in the square brackets in (13). The first term is positive while the second term has an *a priori* ambiguous sign. If the degree of altruism is sufficiently low, so that $\frac{\alpha}{2}\left(\frac{1}{2} + \frac{v+q^*-\sigma\gamma p}{t}\right) - g_q < 0$ at the equilibrium level of quality, the second term is also positive (since $\frac{p-c_x}{2t} > c_q$), implying that the equilibrium level of quality is always lower when firms face a profit constraint. However, if the degree of altruism is sufficiently high, the second term in (13) is negative and might dominate the first term, thus reversing the relationship between profit constraints and incentives for quality provision.

We can further explore this trade-off by assigning some specific parametric forms to the cost and effort functions. Suppose that the monetary costs take the following linear-quadratic form

$$c_i = (c - e_i)\, x_i + \frac{k}{2} q_i^2, \tag{20}$$

while the non-monetary (effort) costs are assumed to be given by

$$g_i = \frac{w}{2} e_i^2 + \frac{\theta}{2} q_i^2. \tag{21}$$

We assume that $w > \frac{1}{2c}$, which ensures that the Nash equilibrium outcome is an interior solution (i.e., $c - e^* > 0$). We also assume that $p \in \left(c, \frac{v-t}{\gamma}\right)$. The lower and upper bounds on p ensure, respectively, that the firms have a positive price-cost margin and that the net utility of any consumer is non-negative when buying from either firm, at any quality level $q_i \geq 0$.

Applying (20)-(21) in (11)-(12), equilibrium quality and cost-containment effort are given by

$$q^* = \frac{(1-\delta)(p-(c-e^*)) + \alpha\left(\frac{t}{2} + (v - \sigma\gamma p)\right)}{2t(\theta + k(1-\delta)) - \alpha} \tag{22}$$

and

$$e^* = \frac{(1-\delta)}{2w}. \tag{23}$$

Uniqueness and stability of the Nash equilibrium requires

$$\alpha < \overline{\alpha} := 2t(\theta + k(1-\delta)). \tag{24}$$

While the effect of profit constraints on equilibrium cost-containment effort is clearly negative, we can establish, from (22), an exact condition for profit constraints to increase quality incentives in equilibrium:

Proposition 1 *Under quality competition with price regulation, there exists a non-empty set $A = (\widehat{\alpha}, \overline{\alpha})$, where*

$$\widehat{\alpha} := \frac{kt(1-\delta)^2 + 2t\theta(1-\delta) + 2tw\theta(p-c)}{(1-\delta) + w(p-c) + kt^2w + 2ktw(v - \sigma\gamma p)}, \tag{25}$$

such that placing a constraint on profits leads to higher quality if $\alpha \in A$, and lower quality otherwise. Profit constraints always lead to less cost containment in equilibrium.

Proof. From (22), the effect of a (stronger) profit constraint on equilibrium quality is given by

$$\begin{aligned}\frac{\partial q^*}{\partial \delta} &= \frac{(\alpha - 2t\theta)(1 - \delta + w(p-c)) + ktw\alpha(t + 2(v - p\gamma\sigma)) - kt(\delta-1)^2}{w(2t(\theta + k(1-\delta)) - \alpha)^2} \\ &< (>)\, 0 \quad if \quad \alpha < (>)\, \widehat{\alpha} := \frac{kt(1-\delta)^2 + 2t\theta(1-\delta) + 2tw\theta(p-c)}{(1-\delta) + w(p-c) + kt^2w + 2ktw(v - \sigma\gamma p)}.\end{aligned}$$

A is non-empty since

$$\overline{\alpha}-\widehat{\alpha}=kt\frac{2w\left(t\left(2\left(v-p\sigma\gamma\right)+t\right)\left(k\left(1-\delta\right)+\theta\right)+\left(1-\delta\right)\left(p-c\right)\right)+\left(1-\delta\right)^{2}}{1-\delta+w\left(kt\left(2\left(v-p\sigma\gamma\right)+t\right)+p-c\right)}>0.$$

■

Thus, placing a profit constraint on firms leads to higher quality provision in equilibrium as long as the firms are sufficiently altruistic. The intuition follows from the discussion of the more general case above. The added insight from the parametric example is that the possibility of a positive relationship between profit constraints and incentives for quality provision always exists in equilibrium. From (25) it can also be shown that $\widehat{\alpha}=0$ if $w\rightarrow\infty$ and $\theta=0$, while $\widehat{\alpha}>0$ otherwise. This confirms the results from the special cases outlined above.

4 Quality and price competition

Let us now extend the model to allow also for price competition between the firms. We assume here that all decisions are made simultaneously and independently. In Appendix we show that the relationship between profit constraints and equilibrium quality is qualitatively similar if we instead let the firms commit to their quality choices before making their price and cost-containment decisions.

The first-order condition for the optimal price chosen by Firm i is

$$\frac{\partial\Omega_i}{\partial p_i}=\left(1-\delta\right)\left[x_i+\left(p_i-c_x\right)\frac{\partial x_i}{\partial p_i}\right]+\alpha\frac{\partial b_i}{\partial p_i}=0, \tag{26}$$

while the first-order conditions for optimal quality and cost-containment effort are given by (9) and (10), respectively. The optimal price is such that the marginal revenue is equal to the marginal cost, where the latter also includes the reduction in consumers' utility due to altruism. We can also write the price-cost margin as:

$$p_i-c_x=\left(x_i+\frac{\alpha}{1-\delta}\frac{\partial b_i}{\partial p_i}\right)\frac{1}{-\partial x_i/\partial p_i}. \tag{27}$$

With zero altruism, the price mark up is proportional to the inverse of the price elasticity of demand, $(p_i - c_x)/p_i = \frac{x_i/p_i}{-\partial x_i/\partial p_i}$. With positive altruism, for a given quality and effort, higher altruism implies a lower price since the provider is willing to charge a lower price the more she cares about the consumers. Notice that the price effect of altruism is stronger for profit-constrained firms. The cost of reducing the price (for altruistic reasons) is a loss of profits, but these lost profits are less valuable for a profit-constrained firm. Such a firm is consequently willing to reduce the price more.

Substituting (27) into (9) the optimal condition for quality can be rewritten as:

$$(1-\delta)\, x_i \frac{\partial x_i/\partial q_i}{-\partial x_i/\partial p_i} + \alpha \left(\frac{\partial b_i}{\partial q_i} + \frac{\partial b_i}{\partial p_i} \frac{\partial x_i/\partial q_i}{-\partial x_i/\partial p_i} \right) = (1-\delta)\, c_q + g_q, \tag{28}$$

The marginal benefit of quality is such that the marginal benefit from higher revenues and higher consumers' utility is equal to the marginal monetary and non-monetary cost. Notice that the altruism parameter is multiplied by two terms with opposite signs. On the one hand, higher altruism implies a higher direct incentive to increase quality because the provider benefits from higher consumer utility ($\partial b_i/\partial q_i > 0$). On the other hand, higher altruism also implies a lower price (as argued above), which compresses the marginal financial benefit (through higher revenues) to increase quality. An interesting special case is when $\sigma = 1$, i.e., when the provider gives the same altruistic weight to price and quality. In this case, $\frac{\partial b_i}{\partial q_i} = \frac{\partial b_i}{\partial p_i} \frac{\partial x_i/\partial q_i}{\partial x_i/\partial p_i}$ and the two effects cancel each other out. This implies that, for a given level of effort, the optimal provision of quality does not depend on altruism and profit constraints always imply lower quality.

If $\sigma < 1$, i.e., the provider cares more about quality than price in consumers' utility, then $\frac{\partial b_i}{\partial q_i} + \frac{\partial b_i}{\partial p_i} \frac{\partial x_i/\partial q_i}{-\partial x_i/\partial p_i} = x_i(1-\sigma) > 0$, and the first effect dominates the second one. The optimality condition (28) reduces to

$$(1-\delta) \left[\frac{x_i}{\gamma} - c_q \right] + \alpha\,(1-\sigma)\, x_i = g_q.$$

Now, for a given level of effort, higher altruism leads to higher quality.[20] If altruism is zero and there are non-monetary costs of quality provision, profit constraints always reduce quality since marginal revenues decrease more than marginal costs. However, if the firms are sufficiently

[20]Notice that, in the symmetric equilibrium, we have $(1-\delta)\left[\frac{1}{2\gamma} - c_q\right] + \frac{\alpha(1-\sigma)}{2} = g_q$.

altruistic, they will optimally choose a quality level where marginal profits ($\frac{x_i}{\gamma} - c_q$) are negative. In this case, profit constraints will reduce the marginal profit loss of quality investments and the firms will optimise at a higher quality level.

The above analysis holds for a given level of effort. Applying the specific cost and effort functions given by (20)-(21), and using the derived demand and consumer benefit functions, (2)-(3) and (7)-(8), respectively, the symmetric Nash equilibrium outcome is

$$q^* = \frac{1-\delta+\alpha\gamma(1-\sigma)}{2\gamma(\theta+k(1-\delta))}, \tag{29}$$

$$e^* = \frac{(1-\delta)}{2w}, \tag{30}$$

$$p^* = \frac{(2(1-\delta)(t+\gamma(c-e^*)) - \alpha\gamma(2v+t(2\sigma-1)))(\theta+k(1-\delta)) - \alpha(1-\delta+\alpha\gamma(1-\sigma))}{2\gamma(1-\delta-\sigma\alpha\gamma)(\theta+k(1-\delta))}. \tag{31}$$

Uniqueness and stability of the Nash equilibrium require

$$\alpha < \overline{\overline{\alpha}} := \frac{1-\delta}{\sigma\gamma}. \tag{32}$$

Equilibrium cost containment is the same as under price regulation. Each firm optimally chooses the level of cost-containment effort such that the marginal benefit, $(1-\delta)x_i$, equals the marginal cost, we_i. Due to the assumptions of unit demand and full market coverage, which imply that total demand is perfectly inelastic, the marginal benefit of cost-containment effort is given by $(1-\delta)/2$ in any symmetric equilibrium and does not depend on the quality and price levels. This explains why price competition does not affect the equilibrium level of cost-containment effort. Correspondingly, the effect of profit constraints on equilibrium cost-containment effort is qualitatively and quantitatively independent of whether prices are regulated or subject to competition.

However, under price competition, the effect of profit constraints on equilibrium quality might be qualitatively different than under price regulation, as discussed above. The following proposition summarises the effects of δ on p^*, q^* and (for completeness) e^*:

Proposition 2 *Under quality and price competition, placing a constraint on profits leads to a* *higher level of quality in equilibrium if* $\alpha \in \overline{A} = \left(\widehat{\alpha}_q, \overline{\overline{\alpha}}\right)$ *and lower quality otherwise, where*

$$\widehat{\alpha}_q := \frac{\theta}{k\gamma\left(1-\sigma\right)}$$

and $\overline{A}$ *is non-empty if* $\frac{(1-\sigma)}{\sigma} > \frac{\theta}{k(1-\delta)}$. *The equilibrium price increases (decreases) if the degree of altruism is below (above) a strictly positive threshold level* $\widehat{\alpha}_p < \overline{\overline{\alpha}}$. *Profit constraints always lead to less cost containment in equilibrium.*

Proof. Using (29), the effect of a (stronger) profit constraint on equilibrium quality is given by

$$\frac{\partial q^*}{\partial \delta} = -\frac{1}{2}\frac{\theta - \alpha k\gamma\left(1-\sigma\right)}{\gamma\left(\theta + k\left(1-\delta\right)\right)^2} < (>)\, 0 \quad if \quad \alpha < (>)\, \frac{\theta}{k\gamma\left(1-\sigma\right)}.$$

From (31), the effect on equilibrium prices is given by

$$\frac{\partial p^*}{\partial \delta} = \frac{\gamma\left(1-\delta\right)^2\left(\theta + k\left(1-\delta\right)\right)^2 - \alpha\Phi}{2w\gamma\left(1-\delta-\sigma\alpha\gamma\right)^2\left(\theta + k\left(1-\delta\right)\right)^2},$$

where

$$\begin{aligned}\Phi \quad : \quad &= \gamma\left(w\left(2\left(v-\sigma\gamma c\right)-t\right) + 2\sigma\gamma\left(1-\delta\right)\right)\left(\theta + k\left(1-\delta\right)\right)^2 \\ &+ w\left(k\left(1-\delta\right)^2 + \alpha\gamma\left(\theta + k\left(1-\sigma\right)\left(2\left(1-\delta\right)-\alpha\sigma\gamma\right)\right)\right).\end{aligned}$$

The sign of $\frac{\partial p^*}{\partial \delta}$ is given by the sign of the numerator. This is clearly positive for $\alpha = 0$, while setting α at the highest permissible level, $\alpha = \overline{\overline{\alpha}}$, yields

$$-\left(1-\delta\right)\left(\theta + k\left(1-\delta\right)\right)\frac{w\left(1-\delta\right) + \sigma\gamma\left(\theta + k\left(1-\delta\right)\right)\left(\sigma\gamma\left(1-\delta\right) + w\left(2\left(v - c\sigma\gamma\right) - t\right)\right)}{\sigma^2\gamma} < 0.$$

The results stated in the proposition is confirmed by noticing that $\alpha\Phi$ is monotonically increasing in α, since

$$\frac{\partial \Phi}{\partial \alpha} = w\gamma\left(\theta + 2k\left(1-\sigma\right)\left(1-\delta-\alpha\sigma\gamma\right)\right) > 0.$$

■

We have already discussed why profit constraints lead to lower cost-containment effort in equilibrium, as this relationship is independent of whether prices are fixed or flexible.

How do profit constraints affect equilibrium quality? To pinpoint the exact mechanisms, we summarise the previous discussion as follows. In the absence of altruism ($\alpha = 0$), profit constraints always lead to lower equilibrium quality as long as there are non-monetary costs of quality provision. If the firms can appropriate less profits, the marginal revenues from quality investments are correspondingly reduced, which tends to reduce the optimal provision of quality. This result can be overturned only if the firms choose a quality level that implies negative marginal profits in equilibrium; i.e., a quality level that is sufficiently higher than the equilibrium quality level for $\alpha = 0$. If $\alpha > 0$ and $\sigma = 1$, this can never happen, as equilibrium quality is independent of the degree of altruism in this particular case.[21]

However, if $\alpha > 0$ and $\sigma < 1$, i.e., if firms do not take consumers' purchasing expenditures fully into account, equilibrium quality is increasing in α and yields negative marginal profits if the degree of altruism is sufficiently high. If this is the case, profit constraints have two counteracting effects on quality. One the one hand, profit constraints lead to less cost efficiency, which increases the marginal profit loss (due to higher marginal production costs) of quality provision. On the other hand, profit constraints also reduce the firms' *valuation* of this marginal profit loss. If the second effect dominates, profit-constrained firms will choose a *higher* level of quality in equilibrium. Proposition 2 confirms that this outcome requires sufficiently altruistic firms. Notice also that the scope for a positive relationship between profit constraints and equilibrium quality is decreasing in θ, since higher non-monetary costs of quality provision increase the threshold level of altruism above which marginal profits are negative in equilibrium.

How do profit constraints affect the equilibrium price? There are two counteracting incentives at work. On the one hand, profit constraints imply that the price-reducing effect of altruism is stronger, as previously discussed. On the other hand, profit constraints lead to less cost-containment effort, implying higher marginal production costs with a corresponding higher optimal price. If altruism is sufficiently low, the second effect dominates and equilibrium prices

[21] From (29) and (31) it is easily confirmed that

$$\frac{\partial q^*}{\partial \alpha} = 0$$

and

$$\frac{\partial p^*}{\partial \alpha} = -(1-\delta)\frac{1-\delta+\gamma(\theta+k(1-\delta))(2(v-\gamma(c-e^*))-t)}{2\gamma(1-\delta-\alpha\gamma)^2(\theta+k(1-\delta))} < 0$$

for $\sigma = 1$.

are higher under profit constraints. This is perhaps surprising, as intuitively we may expect profit constraints to reduce prices since the firm can less easily appropriate the profits from higher prices. However, the profit constraints also affect the optimal choice of cost-containment effort. The reduction in effort translates into higher production costs, which ultimately lead to an increase in equilibrium prices.

5 Mixed markets

Suppose that the market outlined in the previous section consists of one firm that is profit-constrained and one that is not; for example, a market where a non-profit firm competes against a for-profit firm.[22] This scenario raises some interesting questions. What is the nature of the strategic interaction between non-profit and for-profit firms? Which firm will offer higher quality? Will the profit-constrained firm be less efficient than the firm that is not profit-constrained?

The analysis will be conducted in two steps. First, we assume that (variable) production costs are exogenous and derive the equilibrium quality levels in the mixed market structure. Second, we endogenise the production costs by allowing firms to invest in cost-containment effort and derive the quality-effort equilibrium. For simplicity, we focus on the regulated-price scenario.

5.1 Quality competition with exogenous production costs

The two firms set qualities simultaneously and independently to maximise their objectives, defined by (6). One of the firms is assumed to be profit constrained ($\delta > 0$) and is denoted by subscript PC, while the other firm does not face any profit constraints ($\delta = 0$) and is denoted by subscript NC. Using the derived demand and consumer benefit functions, (2)-(4) and (7)-(8), and the specific cost and effort functions, (20)-(21), we obtain the following interior quality equilibrium:[23]

$$q_{NC}^{*} = \frac{2\lambda_{PC}\widetilde{p}_{NC} - 2\alpha\left(1-\delta\right)\widetilde{p}_{PC} + \alpha\mu\left(\lambda_{PC} - \alpha\right)}{\lambda_{NC}\lambda_{PC} - \alpha^{2}}, \tag{33}$$

[22] Rose-Ackerman (1996) shows that in sectors where non-profit firms operate, they tend to coexist with for-profit firms.

[23] An interior equilibrium requires that $q_i^* > 0$ and $\left(q_i^* - q_j^*\right) \in (-t, t)$, $i, j = PC, NC$; $i \neq j$. These conditions are satisfied if the cost difference $|e_i - e_j|$ is not too large, otherwise the less efficient firm is driven out of the market. The exact conditions can be provided upon request.

$$q_{PC}^{*} = \frac{2(1-\delta)\lambda_{NC}\widetilde{p}_{PC} - 2\alpha\widetilde{p}_{NC} + \alpha\mu(\lambda_{NC}-\alpha)}{\lambda_{NC}\lambda_{PC}-\alpha^2}, \tag{34}$$

where $\widetilde{p}_i := p - (c - e_i) > 0$ is the price-cost margin of Firm i, while $\mu := 2(v - \sigma\gamma p) + t$, $\lambda_{NC} := 4t(\theta + k) - 3\alpha$ and $\lambda_{PC} := 4t[\theta + (1-\delta)k] - 3\alpha$. The last three expressions are all positive by the full market coverage assumption (μ) and the second-order conditions (λ_{NC} and λ_{PC}). Notice also that $\lambda_{NC} > \lambda_{PC}$. Uniqueness and stability of the Nash equilibrium requires that

$$\lambda_{NC}\lambda_{PC} - \alpha^2 > 0. \tag{35}$$

What is the relationship between cost efficiency and quality provision? First, each firm's quality choice increases with the level of cost-efficiency, i.e.,

$$\frac{\partial q_{NC}^{*}}{\partial e_{NC}} = \frac{2\lambda_{PC}}{\lambda_{NC}\lambda_{PC}-\alpha^2} > 0, \quad \frac{\partial q_{PC}^{*}}{\partial e_{PC}} = \frac{2(1-\delta)\lambda_{NC}}{\lambda_{NC}\lambda_{PC}-\alpha^2} > 0.$$

The reason is that a lower marginal production cost increases the profit margin and thus the incentive to improve quality to attract consumers. This effect is weaker for the profit-constrained firm, since it only captures a fraction of the higher profit margin. Second, if a firm becomes more efficient, the competing firm's quality incentives are discouraged, i.e.,

$$\frac{\partial q_{NC}^{*}}{\partial e_{PC}} = \frac{-2\alpha(1-\delta)}{\lambda_{NC}\lambda_{PC}-\alpha^2} < 0, \quad \frac{\partial q_{PC}^{*}}{\partial e_{NC}} = \frac{-2\alpha}{\lambda_{NC}\lambda_{PC}-\alpha^2} < 0.$$

This effect is due to firms' quality investments being *strategic substitutes.*[24] A priori, this strategic relationship is surprising. If one firm increases its quality, we would perhaps expect the competing firm to respond by also increasing its quality in order to mitigate the loss of demand. Instead the competing firm responds by *reducing* its quality. This is explained by the firms' semi-altruistic preferences.[25] A quality increase by one firm leads (all else equal) to a demand drop for the competing firm. Since lower demand reduces the marginal consumer benefit of quality, the optimal response for a semi-altruistic firm is therefore to reduce its quality. Thus,

[24] This can easily be verified by observing that

$$sign\left(\frac{dq_i^*}{dq_j}\right) = sign\left(\frac{\partial^2\Omega_i}{\partial q_j \partial q_i}\right) = -\frac{\alpha}{4t} < 0.$$

[25] Notice that quality investments are strategic substitutes only if the firms are to some degree altruistic ($\alpha > 0$).

quality investments generate a *negative externality* between the firms. This strategic effect is stronger for the profit-constrained firm, since the competing firm, which is not profit-constrained, responds more aggressively to a higher margin (lower cost) in terms of quality investments.

Which firm offers higher quality? Using (33)-(34), the condition for the profit-constrained firm to choose a higher level of quality in equilibrium is given by

$$\widetilde{p}_{NC}\left(\lambda_{PC}+\alpha\right)<\widetilde{p}_{PC}\left(1-\delta\right)\left(\lambda_{NC}+\alpha\right)+2\mu\alpha kt\delta. \tag{36}$$

Notice that $\lambda_{PC} > (1-\delta)\,\lambda_{NC}$, due to the second-order conditions. In general, the quality ranking depends on the tightness of the profit constraint (δ), the degree of altruism (α) and the (relative) efficiency levels (e_i). Once more, it is instructive to consider some special cases.

1. Assume that $\delta = 0$, which implies $\lambda_{NC} = \lambda_{PC}$. Without any profit constraints, only relative cost efficiency matters for the equilibrium quality ranking and the profit-constrained firm provides higher quality if $\widetilde{p}_{PC} > \widetilde{p}_{NC}$, or $e_{PC} > e_{NC}$. In other words, the more cost-efficient firm offers higher quality in equilibrium. Notably, altruism does not play a role in this case.

2. Assume that $\alpha = 0$. If the firms are pure profit-maximisers, the profit-constrained firm will provide a higher quality level if $\widetilde{p}_{NC}\lambda_{PC} < \widetilde{p}_{PC}\,(1-\delta)\,\lambda_{NC}$. Since $\lambda_{PC} > (1-\delta)\,\lambda_{NC}$, the profit-constrained firm needs to be sufficiently more cost-efficient than than its competitor in order to provide the higher quality level in equilibrium.

3. Assume that $e_{NC} = e_{PC} = 0$, which implies $\widetilde{p}_{NC} = \widetilde{p}_{PC}$. If the firms are equally efficient, the profit-constrained firm provides the higher quality level if $\widetilde{p}_i\,(2t\theta-\alpha) < \mu\alpha kt$. This condition holds only if the degree of altruism is sufficiently high, for reasons provided by the discussion in Section 3.

From the above special cases it follows that, in the general case, the profit-constrained firm will provide a higher level of quality in equilibrium only if (i) the firms are sufficiently altruistic and the profit-constrained firm's relative cost efficiency is not too low, or if (ii) the profit-constrained firm is sufficiently more cost efficient than its competitor.

How do the firms respond to a tightening of the profit constraint? The comparative statics of (33)-(34) with respect to δ reveals that

$$\frac{\partial q_{NC}^*}{\partial \delta} = -\frac{\lambda_{NC}}{\alpha}\frac{\partial q_{PC}^*}{\partial \delta}, \tag{37}$$

which implies

$$\partial q_{PC}^*/\partial \delta < (>)\, 0 \Longleftrightarrow \partial q_{NC}^*/\partial \delta > (<)\, 0.$$

Thus, if a tightening of the profit constraint leads to an increase in the quality supplied by the profit-constrained firm, the competing firm will respond by lowering its quality level, and vice versa. This inverse relationship reflects that quality investments are *strategic substitutes*, as discussed above.

5.2 Quality competition with endogenous production costs

Let us now endogenise the efficiency levels, by assuming that the firms simultaneously and independently decide on quality and cost-containment effort. The best-response functions for each firm are given by

$$e_{NC} = \frac{2(p-c) + t\lambda_{NC} + \mu\alpha - q_{PC}(\lambda_{NC}+\alpha)}{2(tw\lambda_{NC}-1)}, \tag{38}$$

$$q_{NC} = \frac{t + tw(2(p-c)+\alpha\mu) - q_{PC}(tw\alpha+1)}{tw\lambda_{NC}-1}, \tag{39}$$

$$e_{PC} = (1-\delta)\frac{2(1-\delta)(p-c) + t\lambda_{PC} + \alpha\mu - q_{NC}(\lambda_{PC}+\alpha)}{2\left(tw\lambda_{PC}-(1-\delta)^2\right)}, \tag{40}$$

$$q_{PC} = \frac{t(1-\delta)^2 + tw(2(1-\delta)(p-c)+\alpha\mu) - q_{NC}\left(tw\alpha+(1-\delta)^2\right)}{tw\lambda_{PC}-(1-\delta)^2}. \tag{41}$$

Notice that, for each firm, neither the optimal quality choice nor the optimal choice of cost-containment effort depends directly on the cost-containment effort chosen by the competing firm. This implies that all strategic interaction goes through the quality choices. However, with endogenous cost efficiency, altruism is no longer the only source of strategic interaction.

As in the case of exogenous cost efficiencies, qualities are strategic substitutes. In addition, we see from (38) and (40) that, all else equal, the optimal choice of cost-containment effort depends negatively on the quality provision of the competing firm. This is due to a demand effect. A quality increase by one of the firms leads, all else equal, to lower demand for the rival firm, which, consequently, has less incentives to invest in cost-containment effort.[26] Thus, a unilateral increase in the quality level provided by one of the firms implies that the rival firm has lower incentives to invest, not only in quality but also in cost-containment effort.

Simultaneously solving (38)-(41), we derive the equilibrium levels of quality and cost-containment effort:

$$e_{NC}^{*}=\frac{2\left(p-c\right)w\delta\left(4t\theta-2\alpha\right)+tw\left(\lambda_{NC}\lambda_{PC}-\alpha^{2}\right)-2\left(1-\delta\right)^{2}\left(\lambda_{NC}+\alpha\right)-4kt\delta\mu w\alpha}{2w\left(tw\left(\lambda_{NC}\lambda_{PC}-\alpha^{2}\right)-\left(\lambda_{PC}+\alpha\right)-\left(1-\delta\right)^{2}\left(\lambda_{NC}+\alpha\right)\right)},\qquad(42)$$

$$e_{PC}^{*}=\left(1-\delta\right)\frac{wt\left(\lambda_{NC}\lambda_{PC}-\alpha^{2}+4k\delta\mu\alpha\right)-2\left(\lambda_{PC}+\alpha\right)-4w\delta\left(2t\theta-\alpha\right)\left(p-c\right)}{2w\left(tw\left(\lambda_{NC}\lambda_{PC}-\alpha^{2}\right)-\left(\lambda_{PC}+\alpha\right)-\left(1-\delta\right)^{2}\left(\lambda_{NC}+\alpha\right)\right)},\qquad(43)$$

$$q_{NC}^{*}=\frac{\left[\begin{array}{c}2w\left(p-c\right)\left(wt\left(\lambda_{PC}-\left(1-\delta\right)\alpha\right)-\left(1-\delta\right)\left(2-\delta\right)\right)\\+tw\left(\lambda_{PC}-\left(1-\delta\right)^{2}\alpha\right)-2\left(1-\delta\right)^{2}-\alpha\mu w\left(1+\left(1-\delta\right)^{2}-tw\left(\lambda_{PC}-\alpha\right)\right)\end{array}\right]}{w\left(tw\left(\lambda_{NC}\lambda_{PC}-\alpha^{2}\right)-\left(\lambda_{PC}+\alpha\right)-\left(1-\delta\right)^{2}\left(\lambda_{NC}+\alpha\right)\right)},\qquad(44)$$

$$q_{PC}^{*}=\frac{\left[\begin{array}{c}2w\left(p-c\right)\left(wt\left(\left(1-\delta\right)\lambda_{NC}-\alpha\right)-\left(1-\delta\right)\left(2-\delta\right)\right)\\+tw\left(\left(1-\delta\right)^{2}\lambda_{NC}-\alpha\right)-2\left(1-\delta\right)^{2}-\alpha\mu w\left(1+\left(1-\delta\right)^{2}-tw\left(\lambda_{NC}-\alpha\right)\right)\end{array}\right]}{w\left(tw\left(\lambda_{NC}\lambda_{PC}-\alpha^{2}\right)-\left(\lambda_{PC}+\alpha\right)-\left(1-\delta\right)^{2}\left(\lambda_{NC}+\alpha\right)\right)}.\qquad(45)$$

The complexity of these expressions necessitates the use of numerical simulations for further analysis. We focus on our two main parameters of interest, namely the degree of altruism (α) and the tightness of the profit constraint (δ). The remaining parameters are fixed as follows: $v=4$, $p=w=2$, $c=g=k=\theta=t=\sigma=1$, and $\gamma=0.3$. The parameter values are set such that they do not violate any of the conditions required for the interior equilibrium outcome

[26] From (20), notice that the marginal benefit of cost-containment effort is proportional to demand.

given by (42)-(45).

Table 1. Quality competition in a mixed duopoly									
	$\alpha = 0$			$\alpha = 0.25$			$\alpha = 0.5$		
	$\delta = 0.1$	$\delta = 0.5$	$\delta = 0.8$	$\delta = 0.1$	$\delta = 0.5$	$\delta = 0.8$	$\delta = 0.1$	$\delta = 0.5$	$\delta = 0.8$
e_{NC}	0.26	0.28	0.31	0.25	0.26	0.26	0.25	0.22	0.17
e_{PC}	0.22	0.11	0.04	0.22	0.12	0.05	0.23	0.14	0.07
q_{NC}	0.31	0.32	0.33	0.59	0.60	0.60	0.91	0.90	0.87
q_{PC}	0.29	0.19	0.09	0.58	0.56	0.55	0.93	1.02	1.18
x_{NC}	0.51	0.57	0.62	0.51	0.52	0.53	0.49	0.44	0.35
π_{NC}	0.60	0.68	0.76	0.46	0.48	0.48	0.20	0.13	0.03
π_{PC}	0.55	0.46	0.39	0.43	0.38	0.35	0.19	0.12	0.01
$b_{NC} + b_{PC}$	3.45	3.41	3.37	3.74	3.73	3.72	4.07	4.12	4.20
Ω_{NC}	0.48	0.55	0.61	0.69	0.72	0.73	0.72	0.58	0.33
Ω_{PC}	0.41	0.20	0.07	0.63	0.47	0.36	0.73	0.68	0.69

Consider first the case of no altruism. An increase in δ induces the profit-constrained firm to choose a lower level of quality and cost-containment effort since it appropriates less of the profit margin. The competing firm, which is not profit-constrained, responds by increasing its quality and effort levels due to the strategic substitutability explained above.[27] Consumer surplus decreases because of the quality reduction by the profit-constrained firm and the corresponding increase in travelling costs due to the marginal consumer being shifted away from the market centre.

Altruism ($\alpha > 0$) shifts up the quality levels for both firms, but the effect is stronger for the profit-constrained firm. Indeed, for high levels of altruism ($\alpha = 0.5$), the quality ranking is reversed and the profit-constrained firm offers higher quality than its competitor. This resembles one of our main findings in the previous sections. Consequently, the profit-constrained firm has a higher market share when altruism is sufficiently high. This also implies that the profit-

[27] It is straightforward to show that these results ($e^*_{NC} > e^*_{PC}$ and $q^*_{NC} > q^*_{PC}$) hold for all valid parameter configurations when $\alpha = 0$.

constrained firm has the higher payoff (i.e., $\Omega_{PC} > \Omega_{NC}$ for $\alpha = 0.5$). Moreover, a tightening of the profit-constraint reduces the payoff of the firm that is not profit-constrained. In other words, for high levels of altruism, the firm that is not profit-constrained suffers from competing with a profit-constrained firm. Nevertheless, the profit-constrained firm always remains the less efficient in equilibrium.[28]

How are consumers affected by a tightening of the profit constraint? This depends on the degree of altruism. For low levels of altruism, a stronger profit constraint reduces consumers' surplus. The reason is that the marginal consumer is distorted away from the market centre, and this is not offset by higher quality levels. However, for high levels of altruism ($\alpha = 0.5$), a tighter profit constraint improves consumer surplus, despite the fact that the marginal consumer is located even further away from the market centre. Thus, the quality improvements more than offset the higher travelling costs.

6 Welfare analysis

As a welfare benchmark with which to compare the previously derived Nash equilibria, we define the first-best outcome as the one that maximises aggregate gross consumers' utility net of the monetary and non-monetary costs of quality, output and cost containment. That is, we define the first-best outcome as the one that would ensue if a welfarist regulator produces the good himself, using the available technology (given by the cost functions and firm locations).

Since consumers are uniformly distributed on S, total transportation costs are minimised by letting each firm serve half the market. The maximisation problem is thus

$$\max_{q_1,q_2,e_1,e_2} \quad W = \int_0^{\frac{1}{2}} (v + q_1 - tx)\, dx + \int_{\frac{1}{2}}^1 (v + q_2 - t(1-x))\, dx - \sum_{i=1}^{2} \left[c\left(\frac{1}{2}, q_i, e_i\right) + g(q_i, e_i) \right]. \tag{46}$$

Using the cost and disutility functions given by (20) and (21) we obtain the first-best quality

[28] This result is hard to prove analytically, but extensive numerical simulations indicate that $e^*_{NC} > e^*_{PC}$ for parameter values within the valid range.

and cost-containment effort:

$$q_1 = q_2 = q^{FB} = \frac{1}{2(k+\theta)}, \tag{47}$$

$$e_1 = e_2 = e^{FB} = \frac{1}{2w}. \tag{48}$$

Comparing (48) with (23) or (30), notice that, whether prices are regulated or not, the market provides the optimal level of cost containment only in the absence of profit constraints. Otherwise (for $\delta > 0$) the degree of cost efficiency is suboptimally low. Equilibrium quality, on the other hand, might be underprovided or overprovided in either regime, as we will discuss below.

6.1 Price regulation

For the case of regulated prices, we ask two separate questions. First, what is the first-best price and how does it vary with the profit constraints? Second, for a given price, under which conditions is the imposition of profit constraints welfare increasing or welfare reducing?

6.1.1 The first-best price

By setting p such that the equilibrium quality, given by (22), coincides with the first-best quality, given by (47), we obtain

$$p^{FB} = \frac{(1-\delta)(c-e^*) + t\frac{\theta+k(1-\delta)}{(k+\theta)} - \alpha\left(\frac{1}{2(k+\theta)} + \frac{t}{2} + v\right)}{1-\delta-\alpha\sigma\gamma}, \tag{49}$$

where $e^* = \frac{(1-\delta)}{2w}$. Notice that, if $\alpha = \delta = 0$, then $p^{FB} = c - e^* + t$. Without altruism and profit constraints, the optimal first-best price is equal to the marginal production costs plus the transportation cost parameter t. Higher transportation costs reduce quality which needs to be compensated with a higher price.

If $\alpha = 0$ and $\delta > 0$, then

$$p^{FB} = (c-e^*) + t\left[\frac{(1-\delta)k+\theta}{(1-\delta)(k+\theta)}\right] > c - e^* + t. \tag{50}$$

With no altruism, profit constraints imply a higher optimal price. Since profit constraints reduce quality and increase the marginal cost of provision (through lower effort e^*), a higher price is needed to achieve the first-best outcome, i.e., $\partial p^{FB}/\partial\delta > 0$.

In the presence of altruism, constraints on profit appropriation do not necessarily lead to a higher first-best price. The reason is that profit constraints can increase quality for sufficiently high altruism (cf. Proposition 1), which may induce a lower first-best price. From (49) we find that $\partial p^{FB}/\partial\delta < (>)\, 0$ if $\alpha > (<)\, \alpha_1$, where[29]

$$\alpha_1 := \frac{(k+\theta)(1-\delta)^2 + 2tw\theta}{w(1+(t+2v)(\theta+k)) + 2\sigma\gamma((k+\theta)(1-\delta) - w(k(c+t)+c\theta))} > 0. \tag{51}$$

Thus:

Proposition 3 *Profits constraints increase (reduce) the first-best regulated price if the degree of altruism is sufficiently low (high).*

This result implies that price and profit constraints can be regulatory complements or substitutes. If altruism is low, they are complements: the imposition of profit constraints leads to a higher price. If altruism is high, they are substitutes: profit constraints are accompanied by a lower price.

6.1.2 Welfare effects of profit constraints

Evaluating social welfare at the equilibrium level of quality and cost containment under price regulation, but where the price is not necessarily at the first-best level given by (49), yields

$$W(q^*(p,\delta), e^*(p,\delta)) = 2\left[\int_0^{\frac{1}{2}} (v+q^*-tx)\,dx - c\left(\frac{1}{2}, q^*, e^*\right) - g(q^*, e^*)\right]. \tag{52}$$

The welfare effect of imposing profit constraints is thus given by

$$\frac{\delta W}{\delta\delta} = \frac{\partial W}{\partial q^*}\frac{\partial q^*}{\partial\delta} + \frac{\partial W}{\partial e^*}\frac{\partial e^*}{\partial\delta}. \tag{53}$$

Notice that $\partial W/\partial e^* = 0$ for $\delta = 0$, since cost containment is at the first-best level in the absence of profit constraints. This means that the imposition of a sufficiently small profit constraint will always improve social welfare if it brings quality closer to the first-best level, i.e., if $\frac{\partial W}{\partial q^*}\frac{\partial q^*}{\partial\delta} > 0$.

[29] The positive sign of (the denominator of) α_1 is established by imposing the parameter restriction $v \geq \gamma c + t$ (which combines the conditions that secure full market coverage and non-negative mark-ups).

Comparing (22) and (47), there is underprovision (overprovision) of quality when altruism is sufficiently low (high). Analytically,

$$q^*(p) < (>)\, q^{FB} \quad if \quad \alpha < (>)\, \alpha_2,$$

where

$$\alpha_2 := \frac{2t\left(\theta + k\left(1-\delta\right)\right) - 2\left(k+\theta\right)\left(1-\delta\right)\left(p - c + e^*\right)}{1 + 2\left(k+\theta\right)\left(\frac{t}{2} + \left(v - \sigma\gamma p\right)\right)}. \tag{54}$$

From Proposition 1 we know that profit constraints increase (reduce) equilibrium quality if $\alpha > (<)\, \widehat{\alpha}$. It is straightforward to confirm (by a simple numerical example) that the ranking of α_2 and $\widehat{\alpha}$ is ambiguous within the valid parameter space. Now consider the imposition of a sufficiently small profit constraint. There are four possible regimes:

1. If $\alpha > \max\{\alpha_2, \widehat{\alpha}\}$, quality, which is overprovided, increases even further and welfare is reduced.

2. If $\alpha < \min\{\alpha_2, \widehat{\alpha}\}$, quality, which is underprovided, reduces even further and welfare is reduced.

3. If $\widehat{\alpha} < \alpha < \alpha_2$, quality, which is underprovided, increases and welfare improves.

4. If $\alpha_2 < \alpha < \widehat{\alpha}$, quality, which is overprovided, reduces and welfare improves.

Notice that $\alpha_2\,(>) < 0$ if p is sufficiently low (high). Thus, for a 'high' regulated price (such that $\alpha_2 < 0$), only the first and last of the above regimes exist, implying that quality is always overprovided. We summarise the four possible regimes as follows:

Proposition 4 *Consider the imposition of a sufficiently small profit constraint on firms that are subject to price regulation. (i) For a sufficiently low price, there exist strictly positive lower and upper threshold levels of α, such that the profit constraint improves welfare for intermediate levels of altruism. (ii) For a sufficiently high price, there exists a strictly positive upper threshold level of α, such that the profit constraint improves welfare if the degree of altruism is below this level.*

The analysis would be slightly different in the case of a tightening of an existing profit constraint (where $\delta > 0$ to begin with). This is more likely to reduce welfare as $\partial W/\partial e^* > 0$ and $\partial e^*/\partial \delta < 0$. Even if profit constraints bring equilibrium quality closer to the first-best level, the welfare effect is ambiguous since the reduction in quality distortion is counteracted by the welfare loss of lower cost efficiency. Substituting for $\frac{\partial W}{\partial e^*}\frac{\partial e^*}{\partial \delta}$, the overall welfare effect is given by

$$\frac{\delta W}{\delta \delta} = \frac{\partial W}{\partial q^*}\frac{\partial q^*}{\partial \delta} - \frac{\delta}{4w}. \tag{55}$$

Since the first term does not depend on the marginal disutility of effort, w, it follows that the result stated in Proposition 4 holds qualitatively also for a tightening of an existing profit constraint if the marginal disutility of effort is sufficiently high. Intuitively, if cost containment is sufficiently costly, distortions along this dimension will be small and the welfare effect of tighter profit constraints will mainly be determined by the quality response.

6.2 Quality and price competition

In this section we analyse whether quality is under- or overprovided when firms compete in terms of quality and price. Comparing (29) and (47), quality is underprovided (i.e., $q^* < q^{FB}$) if the following condition is satisfied:

$$\theta\delta - (1-\gamma)(\theta + k(1-\delta)) - \alpha(k+\theta)\gamma(1-\sigma) > 0. \tag{56}$$

Once more, it is instructive to start by investigating some special cases. If altruism is zero ($\alpha = 0$) or the firm gives the same weight to quality and price in the altruistic component ($\sigma = 1$), and consumers pay the full price ($\gamma = 1$), then quality is underprovided when there is a constraint on profit distribution: the condition reduces to $\theta\delta > 0$. Equilibrium quality is the first-best one only if there are no constraints on profits ($\delta = 0$). With $\alpha = \delta = 0$ and $\gamma = 1$ our model corresponds to the one analysed by Ma and Burgess (1993), who conclude that the market provides the optimal level of quality if quality and price decisions are made simultaneously.[30]

If altruism is zero ($\alpha = 0$) or $\sigma = 1$, and consumers pay less than the full price (i.e., $\gamma < 1$),

[30] Brekke, Siciliani and Straume (2010) show that this result does not hold in the presence of income effects in demand.

then quality can be either under- or overprovided depending on the proportion of the price paid by consumers. On the one hand, profit constraints reduce quality in the absence of altruism. On the other hand, if consumers pay less than full price, firms compete more fiercely on quality. If γ is sufficiently high (low), the first (second) effect dominates and quality is overprovided (underprovided). Notice that quality is always overprovided in the absence of profit constraints, as long as $\gamma < 1$.

With a positive degree of altruism, the above comparison remains the same as long as the provider gives the same weight to quality and price in the altruistic component, i.e., $\sigma = 1$. As we have seen in Section 4, quality does not depend on altruism under this assumption. If altruism is positive and the provider assigns a lower weight to price than to quality, i.e., $\sigma < 1$, then quality increases with altruism. In this case, the presence of altruism tilts the comparison towards overprovision. To illustrate the main point, suppose that consumers pay the full price, i.e., $\gamma = 1$. Then, in the absence of profit constraints ($\delta = 0$), there is always overprovision of quality. However, in the presence of profit constraints ($\delta > 0$), there is overprovision of quality only if altruism is sufficiently high. If consumers pay less than the full price, then the case for overprovision is reinforced.

What is the effect of introducing profit constraints on welfare? On general form, the effect is given by (53). Now, define

$$\alpha_3 := \max \left\{ 0, \frac{\theta\delta - (1-\gamma)(\theta + k(1-\delta))}{(k+\theta)\gamma(1-\sigma)} \right\} \tag{57}$$

as the threshold level of altruism above (below) which there is overprovision (underprovision) of quality. From the analysis in Section 4, we know that profit constraints increase (decrease) quality if α is above (below) $\widehat{\alpha}_q$, which is defined in Proposition 2. It is straightforward to show that $\widehat{\alpha}_q > \alpha_3$, i.e., the altruism threshold level which characterises overprovision is more stringent than that which characterises higher levels of quality associated with profit constraints.

To compare welfare, we will once more consider a sufficiently small constraint on profits, so that the welfare effects only depend the equilibrium quality response. Since $\alpha_3 = 0$ for $\delta = 0$, quality is always overprovided in the absence of profit regulation and the introduction of a (small) profit constraint will increase welfare only if it leads to a reduction of equilibrium quality.

Proposition 5 *Consider the imposition of a sufficiently small profit constraint on firms that compete on prices and quality. This will increase welfare if the degree of altruism is sufficiently low, $\alpha < \widehat{\alpha}_q$, and reduce welfare otherwise.*

Notice that the case where profit constraints increase both quality and welfare cannot arise. This contrasts with the case of price regulation, where profit constraints improve welfare by increasing quality for intermediate levels of altruism if the regulated price is sufficiently low. However, under price competition, the degree of altruism which ensures that profit constraints increase quality always implies overprovision of quality.

As in the case of price regulation, the above analysis holds for the introduction of a sufficiently small profit constraint. For a tightening of an already positive profit constraint, this will improve welfare only if $\alpha \in (\alpha_3, \widehat{\alpha}_q)$ and w is sufficiently high.

7 Concluding remarks

In this paper we have analysed the impact of profit constraints on (semi-altruistic) firms' incentives to invest in quality and cost-efficiency. Using a spatial competition approach, where consumers choose providers based on travelling distance, quality and price, we derived the market equilibrium under quality competition with regulated prices and quality-price competition. We also analysed a mixed market structure, where a profit-constrained firm competes with a firm that is not profit constrained. Finally, we analysed the welfare effects of price regulation and profit constraints.

Our analysis has offered two sets of insights. In terms of *market outcomes*, we showed that a constraint on profit distribution always leads to less cost-efficiency, whereas the effect on quality and prices are generally ambiguous. If the firms are sufficiently altruistic, profit-constrained firms offer higher quality and lower prices (if not regulated) than firms that are not profit-constrained. However, for low (or zero) levels of altruism, profit-constrained firms offer lower quality and higher prices (if not regulated). In a mixed market structure we showed that quality investments are strategic substitutes given that firms put some weight on consumer welfare (semi-altruism). Thus, if a tighter profit constraint induces the profit-constrained firm to increase its quality, the firm that is not profit-constrained would respond by reducing its quality. Numerical simulations suggested that a profit-constrained firm is less cost-efficient but might offer higher quality if sufficiently altruistic.

In terms of *welfare outcomes*, we showed that profit constraints lead to too low levels of cost-efficiency, while quality may be over- or underprovided in the market equilibrium depending on the degree of altruism. Under optimal price regulation, profit constraints increase (reduce) the regulated price if altruism is sufficiently low (high), implying that price and profit constraints are either complements or substitutes. For example, markets with non-profit (as opposed to for-profit) firms should optimally face a lower (higher) price if the degree of altruism is sufficiently high (low). On the other hand, if prices are set by the firms (or regulated, but not optimal), the imposition of profit constraints may improve welfare for low or intermediate degrees of altruism.

One of our main applications is non-profit versus for-profit firms. One might argue that there are other features that distinguish these two types of firms apart from the ability to distribute profits. In particular, it could be argued that non-profit firms are likely to be more altruistic than their for-profit counterparts. However, the effect of altruism on equilibrium quality is fairly straightforward: all else equal, more altruistic firms will generally provide higher quality. In our analysis, in order to keep potentially counteracting effects separate, we have preferred to keep all other factors constant and analyse the isolated effect of profit constraints on firm behaviour. If non-profit firms are also more altruistic, this just increases the scope for a positive quality difference between non-profit and for-profit firms.

Appendix: Quality-then-price competition

Here we show that the relationship between profit constraints and equilibrium quality under price competition (see Section 4) is qualitatively unaffected by the assumed sequence of the quality and price decisions. Suppose that, in contrast to the assumptions used in Section 4, firms can commit to a certain level of quality before setting prices. More specifically, consider the following sequence of moves:

1. The firms choose qualities,

2. The firms choose prices and cost-containment efforts.

Solving the game by backwards induction, the subgame perfect Nash equilibrium outcome is:[31]

$$q^* = \frac{(1-\delta+\alpha\gamma(1-\sigma))\left(tw(4(1-\delta-\alpha\sigma\gamma)+\alpha\gamma)-\gamma(1-\delta)^2\right)}{4\gamma\left(tw(3(1-\delta-\alpha\sigma\gamma)+\alpha\gamma)-\gamma(1-\delta)^2\right)(\theta+k(1-\delta))}, \tag{A1}$$

$$p^* = \frac{2(1-\delta)^2(3tw-\gamma(1-\delta))(2w(t+c\gamma)-\gamma(1-\delta))(\theta+k(1-\delta))+\alpha w\Psi}{4w\gamma(1-\delta-\alpha\sigma\gamma)\left(tw(3((1-\delta)-\alpha\sigma\gamma)+\alpha\gamma)-\gamma(1-\delta)^2\right)(\theta+k(1-\delta))}, \tag{A2}$$

$$e^* = \frac{1-\delta}{2w}, \tag{A3}$$

where

$$\begin{aligned}\Psi \; : \; &= (1-\delta+\alpha\gamma(1-\sigma))\left(\gamma(1-\delta)^2-tw(4(1-\delta-\alpha\sigma\gamma)+\alpha\gamma)\right) \\ &+2\gamma(\theta+k(1-\delta))tw\alpha\gamma(3\sigma-1)(2v+t(2\sigma-1)) \\ &-2\gamma(\theta+k(1-\delta))(1-\delta)tw(6\sigma(2t+c\gamma)+6v-5t-2c\gamma) \\ &+2\gamma^2(\theta+k(1-\delta))(1-\delta)^2(2v+t(5\sigma-2)).\end{aligned} \tag{A4}$$

For all $\sigma \in [0,1]$, non-negative values of q^* and p^* (and thus equilibrium existence) require that

$$\alpha < \frac{1-\delta}{\gamma} \tag{A5}$$

[31] Intermediate calculations are available from the authors upon request.

and

$$tw > \gamma\left(1-\delta\right). \tag{A6}$$

In order to investigate the relationship between δ and q^*, let us consider the two extreme cases of $\sigma = 0$ and $\sigma = 1$.

1) If $\sigma = 1$, it follows from (A1) that

$$\frac{\partial q^*}{\partial \delta} = -\frac{A}{4\gamma\left(\theta + k\left(1-\delta\right)\right)^2 \left(tw\left(3\left(1-\delta-\alpha\gamma\right)+\alpha\gamma\right)-\gamma\left(1-\delta\right)^2\right)^2}, \tag{A7}$$

where

$$\begin{aligned} A \quad : \quad &= \theta\gamma^2\left(1-\delta\right)^4 + tw\left(1-\delta\right)^2\left(\gamma\left(1-\delta\right)\left(k\left(1-\delta\right)-6\theta\right)+12\theta tw\right) \\ &+tw\alpha\gamma\left(\gamma\left(1-\delta\right)^2\left(3\theta-2k\left(1-\delta\right)\right)+tw\left(\left(1-\delta\right)\left(k\left(1-\delta\right)-16\theta\right)+6\theta\alpha\gamma\right)\right). \end{aligned} \tag{A8}$$

The sign of $\partial q^*/\partial\delta$ depends on the sign of A. We can determine the sign of A by considering

$$\frac{\partial A}{\partial \theta} = \gamma^2\left(1-\delta\right)^4 + 6tw\left(1-\delta\right)^2\left(2tw-\gamma\left(1-\delta\right)\right) - \widetilde{A} \tag{A9}$$

where

$$\widetilde{A} := tw\alpha\gamma\left(\left(1-\delta\right)\left(16tw-3\gamma\left(1-\delta\right)\right)-6tw\alpha\gamma\right). \tag{A10}$$

Further,

$$\frac{\partial \widetilde{A}}{\partial \alpha} = tw\gamma\left[16tw\left(1-\delta\right)-3\gamma\left(1-\delta\right)^2-12tw\alpha\gamma\right]. \tag{A11}$$

The expression in square brackets is monotonically decreasing in α. At the upper limit of α, $\alpha = \left(1-\delta\right)/t$, we have

$$16tw\left(1-\delta\right)-3\gamma\left(1-\delta\right)^2-12tw\alpha\gamma = \left(1-\delta\right)\left(4tw-3\gamma\left(1-\delta\right)\right) > 0, \tag{A12}$$

where the positive sign follows from (A6). Consequently, $\partial\widetilde{A}/\partial\alpha > 0$. It follows that $\partial A/\partial\theta$

reaches its minimum when α is at its upper limit. Setting $\alpha = (1-\delta)/t$ yields

$$\frac{\partial A}{\partial \theta} = (1-\delta)^2 (tw - \gamma (1-\delta)) (2tw - \gamma (1-\delta)) > 0, \tag{A13}$$

where the positive sign is confirmed by (A6). Thus, A is monotonically increasing in θ and reaches its minimum value for $\theta = 0$. Inserting $\theta = 0$ in (A8) yields

$$A = ktw\gamma (1-\delta)^2 (tw\alpha + (1-\delta)(1-\delta-2\alpha\gamma)) > 0, \tag{A14}$$

where the positive sign is confirmed by applying (A5) and (A6) in conjunction. Using (A13), this implies that A is positive for all $\theta \geq 0$ and therefore, $\partial q^*/\partial \delta < 0$. Thus, for $\sigma = 1$, imposing a profit constraint on the firms will always lead to lower quality in equilibrium.

2) If $\sigma = 0$, it follows from (A1) that

$$\frac{\partial q^*}{\partial \delta} = -\frac{B}{4\gamma (\theta + k(1-\delta))^2 \left(tw (3(1-\delta) + \alpha\gamma) - \gamma (1-\delta)^2\right)^2}, \tag{A15}$$

where

$$\begin{aligned} B \;=\; & \theta\gamma^2 (1-\delta)^4 + tw (1-\delta)^2 (12\theta tw - \gamma (1-\delta)(6\theta - k(1-\delta))) \\ & + \alpha\gamma tw (1-\delta)(tw (8\theta - 11k(1-\delta)) - \gamma (1-\delta)(\theta - 8k(1-\delta))) \\ & + \alpha^2\gamma^2 tw \left(2k\gamma (1-\delta)^2 + tw (2(\theta - 3k(1-\delta)) - k\alpha\gamma)\right) \\ & - \alpha\gamma^3 k (1-\delta)^4 . \end{aligned} \tag{A16}$$

The sign of $\partial q^*/\partial \delta$ depends on the sign of B. We can determine the sign of B by considering

$$\begin{aligned} \frac{\partial B}{\partial \theta} \;=\; & \gamma^2 (1-\delta)^4 + tw6 (1-\delta)^2 (2tw - \gamma (1-\delta)) \\ & + tw\alpha\gamma \left(2tw (4(1-\delta) + \alpha\gamma) - \gamma (1-\delta)^2\right) \\ > \; & 0, \end{aligned} \tag{A17}$$

where the positive sign is confirmed by using (A6). Thus, B reaches its minimum value for

$\theta = 0$. Inserting $\theta = 0$ in (A16) yields

$$B = -k\gamma\widetilde{B}, \tag{A18}$$

where

$$\widetilde{B} = \left(\alpha\gamma^2 - tw\right)(1-\delta)^4 + tw\alpha\left((1-\delta)^2\left(11tw - 2\gamma\left(4(1-\delta) + \alpha\gamma\right)\right) + tw\alpha\gamma\left(6(1-\delta) + \alpha\gamma\right)\right). \tag{A19}$$

Using (A6), it is straightforward to confirm that $\widetilde{B}$ is monotonically increasing in α :

$$\begin{aligned} \frac{\partial \widetilde{B}}{\partial \alpha} &= \gamma^2(1-\delta)^4 + tw(1-\delta)^2\left(11tw - 8\gamma(1-\delta)\right) \\ &\quad + tw\alpha\gamma\left(3tw\left(4(1-\delta) + \alpha\gamma\right) - 4\gamma(1-\delta)^2\right) \\ &> 0. \end{aligned} \tag{A20}$$

Inserting $\alpha = 0$ in (A19) yields

$$\widetilde{B} = -tw(1-\delta)^4 < 0, \tag{A21}$$

which implies $B > 0$ and consequently $\partial q^*/\partial\delta < 0$. Inserting $\alpha = (1-\delta)/t$ in (A19) yields

$$\widetilde{B} = \frac{1}{\gamma}(1-\delta)^3\left(2tw - \gamma(1-\delta)\right)\left(9tw - \gamma(1-\delta)\right) > 0, \tag{A22}$$

which implies $B < 0$ and consequently $\partial q^*/\partial\delta > 0$. Thus, for $\sigma = 0$, placing a profit constraint on firms will increase quality in equilibrium if non-monetary quality costs are sufficiently low and the degree of altruism is sufficiently high. Otherwise, quality will be lower in equilibrium.

References

[1] Beitia, A., 2003. Hospital quality choice and market structure in a regulated duopoly. Journal of Health Economics, 22, 1011–1036.

[2] Besley, T., Ghatak, M., 2006. Sorting with motivated agents: implications for school competition and teacher incentives. Journal of the European Economics Association (Papers and Proceedings), 4, 404–414.

[3] Brekke, K.R., Nuscheler, R., Straume, O.R., 2006. Quality and location choices under price regulation. Journal of Economics & Management Strategy, 15, 207–227.

[4] Brekke, K.R., Nuscheler, R., Straume, O.R., 2007. Gatekeeping in health care. Journal of Health Economics, 26, 149–170.

[5] Brekke, K.R., Siciliani, L., Straume, O.R., 2010. Price and quality in spatial competition. Regional Science and Urban Economics, 40, 471–480.

[6] Brekke, K.R., Siciliani, L., Straume, O.R., forthcoming. Hospital competition and quality with regulated prices. Scandinavian Journal of Economics.

[7] Chalkley, M, Malcomson, J.M., 1998a. Contracting for health services with unmonitored quality. Economic Journal, 108, 1093–1110.

[8] Chalkley, M, Malcomson, J.M., 1998b. Contracting for health services when patient demand does not reflect quality. Journal of Health Economics, 17, 1–19.

[9] Choné, P., Ma, C.A., forthcoming. Optimal health care contracts under physician agency. Annales d'Economie et de Statistique.

[10] Del Rey, E., 2001. Teaching versus research: a model of state university competition. Journal of Urban Economics 49, 356–373.

[11] Easley, D., O'Hara, M., 1983. The economic role of the nonprofit firm. RAND Journal of Economics 14, 531–538.

[12] Eggleston, K., 2005. Multitasking and mixed systems for provider payment. Journal of Health Economics, 24, 211–223.

[13] Eggleston, K., Shen, Y.-C., Lau, J., Schmid, C.H., Chan, J., 2008. Hospital ownership and quality of care: what explains the different results in the literature? Health Economics, 17, 1345–1362.

[14] Ellis, R.P., McGuire, T., 1986. Provider behavior under prospective reimbursement: Cost sharing and supply. Journal of Health Economics, 5, 129–151.

[15] Francois, P., Vlassopoulos M., 2008. Pro-social motivation and the delivery of social services. CESifo Economic Studies, 54, 22–54.

[16] Ghatak, M., Mueller, H., 2011. Thanks for nothing? Not-for-profits and motivated agents. Journal of Public Economics 95, 94–105.

[17] Glaeser, E.L., Shleifer, A., 2001. Not-for-profits entrepreneurs. Journal of Public Economics, 81, 99–115.

[18] Gravelle, H., 1999. Capitation contracts: access and quality. Journal of Health Economics, 18, 315–340.

[19] Hammond, P., 1987. Altruism. In: Eatwell, J., Milgate, M., Newman, P. (Eds.), The New Palgrave: A Dictionary of Economics. Macmillan, London, pp. 85–87.

[20] Hansmann, H.B., 1980. The role of nonprofit enterprise. Yale Law Journal, 89, 835–901.

[21] Hansmann, H., 1996. The Ownership of Enterprise. Harvard University Press, Cambridge, MA.

[22] Hellerstein, J.K., 1998. The importance of the physician in the generic versus trade-name prescription decision. RAND Journal of Economics, 29, 108–136.

[23] Heyes, A.G., 2005. The economics of vocation or 'why is a badly paid nurse a good nurse'? Journal of Health Economics, 24, 561–569.

[24] Jack, W., 2005. Purchasing health care services from providers with unknown altruism. Journal of Health Economics, 24, 73–93.

[25] Jensen, P.H., Webster, E., Witt, J., 2009. Hospital type and patient outcomes: an empirical examination using AMI readmission and mortality records. Health Economics, 18, 1440–1460.

[26] Kaarbøe, O., Siciliani, L., 2010. Multitasking, quality and Pay for Performance. Health Economics, 20, 225–238.

[27] Karlsson, M., 2007. Quality incentives for GPs in a regulated market. Journal of Health Economics, 26, 699–720.

[28] Kessler, D., McClellan, M., 2000. Is hospital competition socially wasteful? Quarterly Journal of Economics, 115, 577–615.

[29] Lakdawalla, D., Philipson, T., 2006. The nonprofit sector and industry performance. Journal of Public Economics, 90, 1681–1698.

[30] Lien, H.-M., Chou, S.-Y., Liu, J.-T., 2008. Hospital ownership and performance: Evidence from stroke and cardiac treatment in Taiwan. Journal of Health Economics, 27, 1208–1223.

[31] Lundin, D., 2000. Moral hazard in physician prescription behavior. Journal of Health Economics, 19, 639–662.

[32] Lyon, T.P., 1999. Quality competition, insurance, and consumer choice in health care markets. Journal of Economics & Management Strategy, 8, 545–580.

[33] Ma, C.A., Burgess, J.F., 1993. Quality competition, welfare, and regulation. Journal of Economics, 58, 153–173.

[34] Ma, C.A., 1994. Health care payment systems: cost and quality incentives. Journal of Economics and Management Strategy, 3, 93–112.

[35] Milcent, C., 2005. Hospital ownership, reimbursement systems and mortality rates. Health Economics, 14, 1151–1168.

[36] Picone, G., Shin-Yi, C., Sloan, F., 2002. Are for-profit hospital conversions harmful to patients and to Medicare? RAND Journal of Econonomics, 33, 507–523.

[37] Rose-Ackerman, S., 1996. Altruism, nonprofits, and economic theory. Journal of Economic Literature, 34, 701–728.

[38] Salamon, L. M., Haddock, M. A., Sokolowski, S. W., Tice, H., 2007. Measuring civil society and volunteering: initial findings from implementation of the UN Handbook on Nonprofit Institutions. Working Paper No. 23. The Johns Hopkins Center for Civil Society Studies, Baltimore.

[39] Shen, Y., 2002. The effect of ownership choice on patient outcomes after treatment for acute myocardial infarction. Journal of Health Economics, 21, 901–922.

[40] Sloan, F., 2000. Not-for-profit ownership and hospital behavior. In Culyer, A., Newhouse, J., (eds.). Handbook of Health Economics, Elsevier, Chapter 17, 1141–1174.

[41] Tay, A., 2003. Assessing competition in hospital care markets: the importance of accounting for quality differentiation. RAND Journal of Economics, 34, 786–814.

[42] Wolinsky, A., 1997. Regulation of duopoly: managed competition vs. regulated monopolies. Journal of Economics and Management Strategy, 6, 821–847.

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