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Price and Quality Regulation in a Physical Network Industry

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Abstract - Our paper models the relationship between price and quality regulation in a physical network industry. The analysis is closely inspired by some of the major regulatory features of the current organisation of the British railways industry, even though its insights have more general implications. Our model focuses on the combination of price and quality regulation and accounts for the existence of entry costs which create a competitive advantage for the incumbents in the competitive franchise bidding. We show that the effectiveness of the quality control is nonmonotone in the quality standard set by the Regulator. Moreover, we advance that price regulation negatively affects the extent to which the service quality can be controlled. By partially subsidising the entry costs, the Regulator can intensify the competition for the market and improve the regulation of the service quality. Nevertheless, since entry costs subsidisation involves social costs (e.g., distortionary taxation), the Regulator faces a trade-off between price regulation, on the one hand, and quality regulation and entry costs subsidisation, on the other hand.

JEL Classification: D44, L5, L9

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1 Introduction

The present work models the relationship between price and quality regulation in a physical network industry. Our analysis is closely inspired by some of the major regulatory features of the current organisation of the British railways industry, even though its insights have more general implications.

In 1993 the former monopoly of British Railways was privatised and replaced by a multitude of firms, operating in a context of both vertical and horizontal separation. Competition for the market was introduced in the organisation of passengers transport, with the operating companies contending the franchises through periodic bids. Moreover, the franchisees were vertically separated from the companies owning the rolling stock. Finally, price regulation was established with respect to one portion of tickets fares.

Price regulation is one of the issues considered in our model. The reformed UK railways contemplates a hybrid fares system. In order to limit the temporary monopoly power of the franchisee, the Government regulates the fares of the services with a most rigid demand. For instance, commuters fares are typically regulated.[1] On the contrary, operators are free to set the ticket fares for the complementary portion of the services they provide. Clearly the degree of ticket regulation implemented by the Government can be seen as a policy tool.

The competitive bidding is the second organisational feature analysed in the paper. The British network currently includes several geographical areas, each of them supplied by a franchisee (Train Operating Company). The reallocation of franchises through competitive bids inevitably entails some entry costs, to which the extent of the competitive pressure on the incumbent operators is crucially related. For instance, the entrant must negotiate the utilisation of the infrastructure (e.g., stations), implement marketing policies, train the crew, convert the trains according to the new franchise's design. All this kind of costs are sunk for the incumbent who afforded them when it was granted the franchise at first place. Since part of these entry costs depends on the obligations included by the Regulator in the franchise contract, entry costs can be regulated, at least partially, through the definition of the franchise contract and/or the public subsidisation of these obligations. Hence, in our model, we focus on the entry costs subsidy as a second policy tool under the control of the regulatory authority.[2]

Finally, the service quality standard which affects the franchise renewal is the third

[1]A further reference to price regulation as a mechanism limiting the monopolistic power of the operating firm can be found in Bös (1999).

[2]The issue of the competitive advantage of the incumbent in franchise bidding is also highlighted in Williamson (1976).

policy tool considered in the paper. Franchise agreements include the specification of the service performance regime (in terms of timetable accomplishment) and a number of Key Performance Indicators, such as train cleanliness, information provision, etc.[3]

We formally analyze the interaction between price, quality and entry costs regulation in a simple two-period model. At the outset, the Regulator sets the portion of regulated fares in each area of the network and the associated price, the amount of entry cost subsidy, and the minimum quality standard for the passenger service. In the first period, a train operating company, who has already been assigned the franchise to operate the service in a given area of the network, decides its (irreversible) investment in service quality and operates the service. In the second period, the company's franchise is automatically renewed if its service quality satisfies the minimum quality requirement. The franchise is auctioned to all the operating companies of the network otherwise.[4] If the incumbent wins the auction, it retains the franchise and operates the service also in the second period after having paid the Regulator the second highest bid. On the contrary, if the auction is won by an entrant, the franchise is reallocated to a new provider who must pay the Regulator the second highest bid and bear the portion of the entry costs which is not subsidised by the Regulator.

Our main findings are as follows. When price regulation is partial (i.e., the service provider can freely set a portion of the fares), the effectiveness of the quality regulation is non-monotone in the minimum quality standard. If the quality standard is low, the quality control is not effective because the train operating company guarantees the renewal of its franchise by simply setting the quality level that maximise its profits in each operating period. If the quality standard is high, the quality control is not effective because the loss in the first period profits due to the high investment in service quality necessary to comply with the quality control offsets the gain in the second period profits due to the avoidance of the competitive pressure for the market (i.e., the pre-emption of the franchise bidding in the second period).

Next, we focus on the interplay among the regulatory tools: i.e., the extent of price regulation, the quality standard and the entry costs subsidy, for an optimal (second-best) regulation policy, where social welfare increases with the service quality but decreases with the ticket fares and the entry costs subsidy.[5] We find that price regulation has

[3]More details on this topic can be found in Strategic Rail Authority (2002).

[4]We model the competitive bidding for the service franchise as a second price auction open to operating companies in the other areas of the network. However, our main results also hold under alternative assumptions on the competitive bidding process, such as first price auctions.

[5]We anticipate that the social welfare function reflects a distributive concern on consumers' welfare. Even in absence of any deadweight loss due to monopolistic pricing, the welfare decreases with the service price because consumers' surplus has a higher social value than profits. Social welfare clearly

a negative effect on the controllability of the service quality *via* the minimum quality standard and the competitive pressure for the market. The Regulator can contrast this effect with higher subsidisation to the entry costs, in order to reduce the incumbent's advantage in the competitive bidding for the service franchise. However, this intervention is socially costly in terms of distortionary taxation. Hence, there exists a trade-off between price regulation, on the one hand, and quality regulation and entry costs subsidisation, on the other hand.

The paper is organised as follows. Section 2 outlines the model, which is further developed in Section 3. Section 4 shows that the effectiveness of quality control is non-monotone in the quality standard set by the Regulator. Section 5 analyzes the role played by price regulation and entry costs on the controllability of the service quality. The results of the second-best analysis are presented in Section 6. Finally, Section 7 contains the concluding remarks. Some technical parts of the paper are relegated in the appendix.

2 The Model

We model the interaction between a firm franchised to provide passenger transport services in a given area (TOC hereafter) and the Regulator. In the background, we assume the existence of a sufficiently high number of TOCs in the industry, so that ex ante collusion in the bidding process is ruled out.

Preferences and Technology

In the geographical area where the TOC initially holds a franchise and operates passenger services, there is a unit mass of identical customers. Each customer purchases one unit of train services per period, and his/her willingness to pay for the service increases with the service quality, set by the TOC in the normalised interval $[0, 1]$. More precisely, the utility gained by each customer from one unit of train service of quality q bought at price p is:

$$U(q) = rq - p,$$

whereby r measures the willingness to pay for a unit of quality. Given inelastic (unit) demand and identical preferences for quality, if free to set the tickets price, the TOC will exploit its monopoly power and reap all consumers surplus by setting $p = rq$. In

increases with the service quality because consumers' surplus increases with quality. Finally, funding the entry cost subsidy involves social costs due to distortionary taxation.

order to limit the TOC's monopoly power, the Regulator directly sets the unit price $R < r$ on a fraction of the services, leaving the TOC free to price the complementary fraction of services $(1-\alpha)$.

On the cost side, we assume that the TOC's operating costs, C, are quadratic in the quality:

$$C = \frac{1}{2}q^2 c.$$

The TOC's profits flow for one period of service operation at the quality level q, is therefore given by:

$$\pi(q) = \alpha R + r(1-\alpha)q - \frac{1}{2}q^2 c. \tag{1}$$

We assume that the regulated fare, R, will never impose a loss to the TOC, even when the quality level is very high. On the other hand, most of our results simply requires that the TOC's operating profits are sufficiently small when the level of service quality is close to the upper bound of its range, i.e., $q = 1$. Formally, we will assume that $\pi(1) = \alpha R + r(1-\alpha) - \frac{1}{2}c$ is close to zero when $\alpha = 0$, and equals zero when $\alpha = 1$, which implies the parametric restriction: $R = \frac{1}{2}c < r$.[6] According to this parametric restriction, the upper bound for R is r. Nevertheless, we will later show that is not optimal for the Regulator to set R so that $\frac{R}{r}$ is close to 1.

The profit function (1) is maximised for:

$$q = \frac{r(1-\alpha)}{c} \equiv q_M. \tag{2}$$

We assume that q_M is in the interior of the range $[0,1]$, that is, $r(1-\alpha) < c$.

Social Welfare

The policies implemented by the Regulator aim at promoting the service quality standard q_m and increasing the consumers surplus (CS) through the limitation of the temporary monopoly power of the incumbent. Let us recall the utility function previously specified: $U(q) = rq - p$. Without price regulation consumers would pay $p = rq$, because the TOC would be in the position of exploiting its monopoly power. Thanks to the partial price regulation implemented by the Regulator, consumers pay $\alpha R + r(1-\alpha)q$ instead. The consumer surplus, CS, as a function of α, R and q, is therefore:

$$CS = rq - [\alpha R + r(1-\alpha)q].$$

[6] Obviously, R can be equal to zero, in which case the unit price for those ticket fares that are regulated is zero.

Ultimately, the objective function of the Regulator (social welfare function) is:

$$SW = \pi + \beta CS - \lambda(\kappa' - \kappa). \tag{3}$$

The coefficient $\beta > 1$ formalises the Regulator's distributive concern on consumers welfare: the weight of the TOC's profit in the welfare function (that is, one) is lower than the weight of the consumer surplus (that is, β). The negative term of the social welfare function represents the social cost of entry costs subsidisation. More precisely, $(\kappa' - \kappa)$ is the subsidy of the entry costs granted by the Regulator to one potential entrant. That is the difference between a given amount of entry costs, κ', and the portion of these costs that is actually afforded by the entrant, κ. The loss of welfare arises from the distortionary taxation needed to finance the entry costs subsidy: $\lambda > 0$ is the measure of the unit social cost of taxation.

Next, it is worth to anticipate some implications of the assumption that the Regulator is more concerned of the consumer surplus than profits, i.e., $\beta > 1$. Notice first that the set of Regulator's policy tools is sufficiently complete to allow for non distortionary surplus transfers from the TOC to consumers.[7] Therefore, $\beta > 1$ implies that the Regulator will never implement a policy leading to a negative consumer surplus.

The condition requiring the consumer surplus to be strictly positive generates the following constraint on the implemented level of service quality:

$$q > \frac{R}{r}.$$

The Regulator will never violate this restriction when setting up its quality control policy. As it will become clear later, when the quality regulation is effective, the equilibrium level of q equals the minimum quality standard. Therefore, the Regulator's relative preference for the consumer surplus will induce it to respect the constraint above by setting:

$$q_m > \frac{R}{r}, \tag{4}$$

in order to avoid a negative consumer surplus.

Timing

We consider a two-period model. At the beginning of the first period, the Regulator sets: the fraction of regulated fares, α; the regulated fare, R; the minimum quality

[7] In particular, the Regulator can adjust the unit price of the regulated fares R, causing no distortion for the social welfare.

requirement, q_m, according to condition (4); and the subsidy of the entry costs $(\kappa' - \kappa)$ (so that κ is the entry costs left to the entrant after the subsidy). After all policy tools are set by the Regulator, the TOC decides the service quality q to offer to its customers. Once set at the beginning of the first period, the TOC's service quality remains fixed for both periods. In other words, we assume that the service quality involves sunk costs which cannot be quickly reversed: the TOC's choice on service quality affects its second period franchise. If the TOC decides to comply with the quality standard set by the Regulator, i.e., if it selects $q \geq q_m$, its franchise is automatically renewed for the second period. On the contrary, if the TOC sets $q < q_m$ (no compliance), the franchise is auctioned. As explained in more details below, we model a second-price auction.

3 The Industry Equilibrium

We solve the model by backward induction.

3.1 Second Period Equilibrium

In the second period two alternative types of equilibrium are possible. If the TOC decides to comply with the regulatory standard in the first period, in the second period its franchise is automatically renewed and the line is not auctioned. The TOC's second-period profit in this case is

$$\pi(q_m) = \alpha R + r(1-\alpha)q_m - \frac{1}{2}q_m c^2.$$

On the contrary, if the TOC does not comply with the Regulator's requirement and sets a quality level below the regulatory standard, the line is auctioned. The auction is designed as a second-price auction open to all companies operating in the network. As it is well known, the bidders dominant strategy in a second-price auction is to bid the entire private value. In our case, this translates in bidding the entire expected profit from operating the franchise. In the auction, the entry costs left on the entrant, κ, act as a competitive advantage for the incumbent. We mainly focus on the case of partial subsidisation, i.e., $\kappa > 0$. This is consistent with the idea that the information on the entry costs is likely to be asymmetric between the Regulator and the entrant, so that the former does not provide full coverage for the entry costs eventually reported by the entrant. A second reason for not focusing on the case where $\kappa = 0$, is that the full subsidisation may lead to an undesirable level of distortionary taxation.

The bid of the incumbent is:

$$B_i = \alpha R + r(1-\alpha)q_i - \frac{1}{2}q_i^2 c,$$

whilst the bid of the potential entrant is:

$$B_e = \alpha R + r(1-\alpha)q_e - \frac{1}{2}q_e^2 c - \kappa.$$

The service quality level of a potential entrant, q_e, can be observed by the Regulator: it has been set in the first period on the line where the potential entrant operates the service.[8]

Note that the reason why the franchise is auctioned is that the incumbent selected a no compliance strategy in the first period. As we show in the next section, this means that q_i is equal to q_M, i.e., the incumbent selects the level of service quality that maximises its first period profits. Provided that the level of quality is observable, if the franchise is auctioned, all the potential bidders anticipate that $q_i = q_M$. This means that there is no quality level such that the entrant's profits before the entry costs are greater than the incumbent's expected profits. In other words, in the first period, all service providers anticipate a zero profit from participating to any auction. Since the TOCs enjoy a symmetric position in the market, they all set $q = q_M$ in the first period, in order to maximise their profit functions. Hence, a symmetric equilibrium with respect to the level of service quality is established, i.e., $q_i = q_e$. Obviously, since one line is auctioned, because the compliance strategy is not optimal, then all lines are auctioned.

Given B_i and B_e above, in a symmetric equilibrium the incumbent wins the auction as long as $\kappa > 0$.[9] The incumbent pays B_e, according to the second-price rule, so that its net payoff is

$$B_i - B_e = \kappa.$$

Hence, as long as the entry costs are positive, the incumbent wins the auction and collects a payoff equal to the entry costs.

[8]This assumption is realistic. The requirements for companies entering a franchise bidding include the provision of records about their experience in rail transport operations. By observing q_e, the Regulator is aware that the company is able to provide that specific level of service quality, and that the necessary expertise is available.

[9]If $\kappa = 0$, the incumbent and one potential entrant have both 50% probability of winning. However, since the winner payoff is zero in this case, the anticipated payoff from the auction is zero for any entrant and for the incumbent.

3.2 First Period TOC's Choice of Service Quality

At the beginning of the first period, after the Regulator has calibrated all its regulatory tools, the TOC selects the service quality it would offer in the first and the second period. The TOC faces a trade-off between:

1. Maximising the profit flow in the first period, but facing an auction in the second period;

2. Complying with the quality standard set by the Regulator, at the cost of over-investing in quality (relatively to the quality level that maximises its first period profits).

This trade-off applies provided that the quality control effectively constraints the TOC's inter-temporal optimisation problem. As shown in the following lemma, this is not the case when $q_m < q_M$.

Lemma 1. *If $q_m < q_M$, the optimal choice for the TOC is $q = q_M$.*

Proof. The proof is straightforward. If $q_m < q_M$, by selecting q_M the TOC maximises the profit flow *and* complies with the regulatory requirement. The franchise is renewed in the second period and the two-period profits are maximised. □

On the contrary, when $q_m > q_M$, the trade-off is effective and the TOC must choose between the two alternative strategies of complying and not complying with the regulatory requirement. Lemmas 2 and 3 below characterise the optimal quality levels that the TOC would implement in each strategy.

Lemma 2. *If $q_M < q_m$, and the TOC decides not to comply with the regulatory standard, its optimal choice is $q = q_M$.*

Proof. As shown before, the TOC anticipates to win the auction for the franchise in the second period, receiving a payoff equal to k, which is independent of q. Hence, the optimal level of service quality for the TOC is the one that maximises its first period profits. □

Lemma 3. *If $q_M < q_m$, and the TOC decides to comply with the regulatory standard, its optimal choice is $q = q_m$.*

Proof. If the TOC complies with the quality standard, the franchise is automatically renewed for the second period. Since $q_m > q_M$, the cost of guaranteeing the renewal represents an over-investment in quality with respect to the profit maximising level of quality. The TOC will clearly select the minimum quality level that allows compliance, that is q_m. □

The three lemmas above imply:

Proposition 1. *For any value of* $q_m \in [0,1]$*, the optimal choice of the TOC is either* q_m *or* q_M*.*

The previous analysis shows that, according to the values assumed by the policy tools and by the parameters, three kinds of equilibrium can arise in the first period. We label them as Uncontested Monopoly, Pre-emption of Entry and Contested Market.

Uncontested Monopoly

The Uncontested Monopoly equilibrium arises when $q_m \in [0, q_M]$ and the TOC selects q_M. In this case, the Regulator can achieve any quality level in the interval $[0, q_m]$ by simply altering the fraction of regulated fares, α, which directly affects $q_M = \frac{r(1-\alpha)}{c}$. The present value of the TOC's profits is therefore given by

$$\Pi_{UM} = (1+\delta)\pi(q_M), \tag{5}$$

where we allow for time discounting at the rate δ.

Pre-emption of Entry vs. Contested Market

According to Lemmas 2 and 3, when $q_m \in [q_M, 1]$, the TOC must choose between q_m (*compliance*) and q_M (*no compliance*). None of the two options is able to guarantee *both* first period profit maximisation and franchise renewal. In order to assess the TOC's optimal strategy, we compare the present value of the TOC's profits under the two alternative strategies. The TOC's expected profit if it choses $q = q_m$ is:

$$\Pi_{PE} = (1+\delta)\pi(q_m), \tag{6}$$

while the TOC's expected profit if it choses $q = q_M$ is:

$$\Pi_{CM} = \pi(q_M) + \delta\kappa, \tag{7}$$

whereby $\kappa > 0$ is the second period expected payoff from the franchise bidding.

Lemma 4. *When:*

$$\pi(q_M) > \kappa, \tag{8}$$

if q_m *is sufficiently low in* $[q_M, 1]$*, then the industry equilibrium is a Pre-emption equilibrium. The TOC complies with the quality standard set by the Regulator by choosing* $q = q_m$*.*

When:

$$\pi(q_m = 1) \approx 0, \tag{9}$$

if q_m is sufficiently high in $[q_M, 1]$, then the industry equilibrium is a Contested Market equilibrium. The TOC does not comply with the quality standard and selects $q = q_M$.

Proof. In order to prove the first part of Lemma 4, we recall that $q_m > q_M$. Let q_m converge to q_M from the right. Accordingly, $\pi(q_m)$ tends to $\pi(q_M)$. Therefore, the inequality

$$\pi(q_M) + \delta\kappa < (1 + \delta)\pi(q_m) \tag{10}$$

becomes:

$$\pi(q_M) + \delta\kappa < (1 + \delta)\pi(q_M),$$

which holds true under condition (8). The proof for the second part of Lemma 4 is straightforward. If $\pi(q_m)$ is sufficiently low when q tends to 1, then for sufficiently high values of q_m in the interval $[q_M, 1]$, it must be:

$$\pi(q_M) + \delta\kappa > (1 + \delta)\pi(q_m).$$

□

As we formally proof in Appendices 1, 2 and 3, equations (8) and (9) assure that the range of $q_m \in [0, 1]$ is partitioned into three sub-ranges, each of them corresponding to a different industry equilibrium (Uncontested Monopoly, UM, Pre-emption of Entry, PE, and Contested Market, CM). The partition is formally described in the following proposition.

Proposition 2. *If conditions (8) and (9) hold, then*

i) *For $q_m \in [0, q_M]$, where $q_M = \frac{r(1-\alpha)}{c}$, the industry equilibrium is Uncontested Monopoly (UM);*

ii) *For $q_m \in [q_M, q_M + \Delta]$, where*

$$\Delta = \left(\frac{\delta}{1 + \delta} \frac{2}{c} \left(\pi(q_M) - \kappa \right) \right)^{\frac{1}{2}}, \tag{11}$$

the industry equilibrium is Pre-emption of Entry (PE);

iii) *For $q_m \in [q_M + \Delta, 1]$, the industry equilibrium is Contested Market (CM).*

The figure below illustrates Proposition 2 which is formally proved in Appendices 1, 2 and 3.

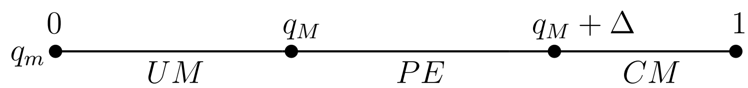

Figure 1: The partition of the range of the quality standard and the corresponding industry equilibria.

4 Quality Regulation Effectiveness

In this section we discuss the effectiveness of quality regulation. Building upon Proposition 2, we proof that the effectiveness of the quality regulation is non-monotone in the minimum quality standard.

Proposition 3. *The effectiveness of the service quality control is non-monotone in the minimum quality requirement.*

The proof of Proposition 2 is straightforward. Let us refer to Figure 1. The figure illustrates that the range of $q_m \in [0, 1]$ is partitioned in three segments, each of them corresponding to a different type of equilibrium. Starting from zero and moving forward, the first segment, where $q_m \in [0, q_M]$, implies the UM equilibrium: the optimal strategy for the TOC is $q = q_M$. Moving toward the right, the second segment, where $q_m \in [q_M, q_M + \Delta]$, corresponds to the PE equilibrium: the optimal strategy for the TOC is $q = q_m$. Finally, the last segment on the right, where $q_m \in [q_M + \Delta, 1]$, represents the CM equilibrium: the optimal strategy for the TOC is again $q = q_M$. Hence, the compliance with the quality standard set by the Regulator is an optimal strategy for the TOC only in the intermediate part of the range, corresponding to the PE equilibrium.[10]

As shown in Lemma 1, in the segment on the left (UM equilibrium), the regulatory quality standard does not effectively constraint the behaviour of the temporary monopolist. That is, the TOC is in the position of re-confirming its franchise just by selecting the quality standard that maximises its profits. As shown in Lemma 2, in the segment on the right (CM equilibrium) the TOC prefers going through the auction. The profit sacrifice required to comply with the regulatory standard is high, while the existence of positive entry costs allows the incumbent to win the auction and reap positive profits

[10]We note that in some other trivial cases, the range of $q_m \in [0, 1]$ is not partitioned in three segments. For instance, if $q_M + \Delta = 1$, the range of $q_m \in [0, 1]$ is only divided into two segments. More precisely, the UM equilibrium holds when $q_m < q_M$, while the PE equilibrium holds when $q_m > q_M$. Moreover, when $\Delta = 0$, since $\alpha = 1$, $q_M = 0$ and $\kappa = R$, only the CM equilibrium applies. Finally, we avoid considering the case of $\Delta^2 < 0$, since, according to the expression of Δ, this means that entry costs must be higher than the monopoly profit. Clearly, this assumption is not interesting for an entry model.

in the second period.[11]

5 The Combination of Policy Tools

In this section we focus on the interaction between the policy tools under the control of the Regulator in pursuing a second-best optimal policy and maximise the social welfare. Recall that the Regulator takes its decisions about the regulatory policy at the beginning of the first period. The set of policy tools available includes: q_m, α, κ, and to a certain extent, R.

5.1 Ticket Price Regulation

We first discuss the consequences on the industry equilibrium exerted by the constraint (4) on the regulated fare R, for given values of the other regulatory tools. According to our characterisation of the social welfare function, and to the distributive concern of the Regulator with regard to consumers, q_m is set in order to satisfy condition (4). That is, the Regulator sets the quality standard above the ratio $\frac{R}{r}$, so that if the TOC complies, the consumers surplus will be strictly positive.

We must, therefore, modify Figure 1 with q_m varing in the support $[\frac{R}{r}, 1]$ and not in $[0, 1]$ any longer. This is represented in Figure 2. This restriction of the range of q_m affects the first period industry equilibrium. When $q_m \in [0, 1]$, three alternative first period industry equilibria may occur (UM, PE, CM). On the contrary, when $q_m \in [\frac{R}{r}, 1]$, according to the position of $\frac{R}{r}$ with respect to q_M and $q_M + \Delta$, and assuming that $q_m > \frac{R}{r}$, we shall distinguish three scenarios:

Scenario A If $\frac{R}{r} \in [0, q_M]$, three kinds of equilibria, UM, PE and CM, may occur. The TOC's optimal strategy will be compliance if $q_m \in [q_M, q_M + \Delta]$, and no compliance otherwise;

Scenario B If $\frac{R}{r} \in [q_M, q_M + \Delta]$, only the equilibria PE and CM may occur. The TOC's optimal strategy will be compliance if $q_m \in [\frac{R}{r}, q_M + \Delta]$, and no compliance if $q_m \in [q_M + \Delta, 1]$;

Scenario C If $\frac{R}{r} \in [q_M + \Delta, 1]$, only the CM equilibrium may occur, and compliance is never optimal for the TOC.

[11] Notice that in the UM equilibrium segment the market is not contestable, whilst in both the PE and the CM segments the market is contestable.

Figure 2 illustrates the three scenarios.

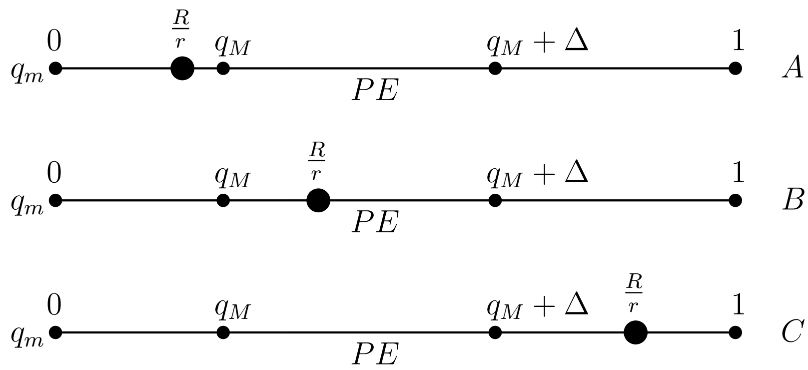

Figure 2: The outcome of the application of condition (4) to the partition of the range of the quality standard.

Although the three scenarios may all occur in theory, scenario C is not realistic given the Regulator's concern for the consumers surplus. In fact, there is no reason why the Regulator might want to set R so high that the ratio $\frac{R}{r}$ is greater than both q_M and $q_M + \Delta$. If that was the case, according to condition (4), the Regulator would select a value of q_m between $\frac{R}{r}$ and the upper bound 1 (see Figure 2) to assure that the consumer surplus is strictly positive, and the TOC will always choose not to comply with the quality regulation. In other words, for any possible value of q satisfying the regulatory quality standard, the consumer surplus would be negative, while the TOC's profit would be positive. Given the Regulator's relative preference for the consumers surplus over profits, and the existence of a sufficiently complete set of regulatory tools to implement non distortionary transfers, we conclude that scenario C will never be implemented by the Regulator. Accordingly, from now on we will consider only scenarios A and B.

5.2 The Tools at Work

In this section we focus on how the fraction of regulated fares, α, and the entry costs left to the entrant, k, affect the regulation of service quality through the minimum quality standard, q_M. Our discussion will concentrate on the influence of α and κ on the effectiveness of the quality control. To this end, it is useful to recall that quality control is effective only in the PE equilibrium.

Proposition 4. *An increase in the subsidy, i.e., a decrease in κ, will improve the effectiveness of the quality regulation by enlarging the PE equilibrium interval $[q_M, q_M + \Delta]$. More specifically, a decrease in κ does not affect q_M, while it rises $q_M + \Delta$.*

Proof. The proof that a decrease of κ doesn't affect q_M is straightforward, given that κ does not enter $q_M = \frac{r(1-\alpha)}{c}$. In order to prove the second part of Proposition 4, recall first that:

$$\Delta = \left(\frac{\delta}{1+\delta} \frac{2}{c} \left(\pi(q_M) - \kappa\right) \right)^{\frac{1}{2}}.$$

Then, we calculate:

$$\frac{d}{d\kappa}(q_M + \Delta) = -\frac{\delta}{c(1+\delta)} \left(\frac{\delta}{1+\delta} \frac{2}{c} \left(\pi(q_M) - \kappa\right) \right)^{-\frac{1}{2}}.$$

By condition (8), this is negative for any value of δ, c and κ. As $q_M + \Delta$ increases when κ decreases, the PE segment enlarges, as represented in Figure 2. □

Proposition 5. *An increase in the fraction of regulated fares negatively affects the effectiveness of the quality control by reducing the maximum level of service quality that can be achieved. More specifically, an increase in α reduces both q_M and $q_M + \Delta$.*

Proof. To prove that q_M fells with α, we calculate

$$\frac{d}{d\alpha}(q_M) = -\frac{r}{c},$$

that is negative for any values of r and c. This means that the lower extreme of the PE segment in Figure 2 shifts left as α increases. We next consider

$$\frac{d}{d\alpha}(q_M + \Delta) = \frac{d}{d\alpha} q_M + \frac{d}{d\alpha}\Delta,$$

and focus on $\frac{d\Delta}{d\alpha}$. From (11), we have

$$\frac{d}{d\alpha}\Delta = \Delta^{-1} \frac{\delta}{c(1+\delta)} \left(R - r q_M\right), \tag{12}$$

implying that $\frac{d}{d\alpha}\Delta$ is positive if $\frac{R}{r} > q_M$, while it is negative if $\frac{R}{r} < q_M$.

The overall variation of $q_M + \Delta$, corresponding to an increase in α, is positive if and only if $\frac{d}{d\alpha}\Delta$ is positive, i.e., $\frac{R}{r} > q_M$, and it offsets the negative change in q_M. In other words, it should be

$$\frac{d}{d\alpha}\Delta > \left|\frac{d}{d\alpha} q_M\right|,$$

that is,

$$\Delta^{-1}\frac{\delta}{c(1+\delta)}\left(R - rq_M\right) > \frac{r}{c}, \tag{13}$$

leading to the inequality:

$$\frac{R}{r} - q_M > \frac{1+\delta}{\delta}\Delta. \tag{14}$$

Rearranging condition (14), we obtain the parametric condition:

$$\frac{R}{r} > q_M + \Delta + \frac{1}{\delta}\Delta,$$

which clearly corresponds to scenario C, that we have already excluded from our analysis.

Concluding, in both scenarios A and B, the possible positive variation of Δ corresponding to an increase in α does never offset the negative variation of q_M. As a result, an increase in α negatively affects $q_M + \Delta$.

$\square$

The intuition of condition (14) is as follows. Let $q_M < \frac{R}{r}$ and, according to condition (4), $q_m > \frac{R}{r}$, so that $q_M < q_m$. More specifically, assume that $q_m = q_M + \Delta$, so that the TOC is indifferent between the compliance and the no compliance strategy:[12]

$$\pi(q_m) + \delta\pi(q_m) = \pi(q_M) + \delta\kappa. \tag{15}$$

Let a marginal increase in α now occur. We want to find out how equality (15) turns into an inequality.

A marginal increase in α, evaluated at $q_M = q_m$ generates a marginal gain of $(1 + \delta)(R - rq_m)$ with the compliance strategy.[13] On the contrary, a marginal gain of $(R - rq_M)$ is guaranteed under the no-compliance strategy.[14] Given that $q_m > q_M$, other things being equal, a very high value of R could cause the first effect to prevail on the second. However, this would lead to scenario C, discussed above. On the contrary, when R is not too high, the second effect prevails on the first if δ is sufficiently small. In this case, the two-period marginal gain associated to the no compliance strategy prevails on the two-period marginal gain associated to the compliance strategy. The upper bound of the compliance area, $q_M + \Delta$, moves toward the left, so that some of the service quality levels previously achieved *via* quality control, become feasible through the Contested Market equilibrium.

[12]See also Figure 2.

[13]This is the derivative of the left-hand side of (15) with respect to α evaluated for $q_M = q_m$.

[14]This is the derivative of the right-hand side of (15) with respect to α evaluated for $q_M = q_m$.

More specifically, when the Regulator increases α, a redistribution of the weight from the unregulated to the regulated portion of the revenues occurs. In the first period the TOC's profits increase under both strategies of compliance ($q = q_m$) and no compliance ($q = q_M$). However, in the case of compliance, the increase in revenue associated to an increase in α is lower. In the second period, on the contrary, the revenue is not affected by a change in α under the compliance strategy: the TOC gains once again the same increase in revenue (which is however discounted by the factor $\delta < 1$).

Hence, an increase in α affects the comparison between the two strategies as follows: profits increase relatively more in the first period under the no compliance strategy, while they increase relatively more in the second period under compliance. Finally, the identity (15) turns into an inequality where no compliance becomes the TOC's preferred strategy.

To further qualify the statement of Proposition 5, we note from the expression of q_M that if α increases, q_M decreases. This means that the quality regulation now is needed in order to achieve low levels of service quality, previously guaranteed by the private incentives of the TOC. While this effect is quite intuitive, it is not particularly interesting because these levels of q can, in any case, materialise. Nevertheless, we proof in Appendix 4 that an increase in the portion of regulated tickets will decrease more $q_M + \Delta$ than q_M, implying that the interval where the quality control is effective, also shrinks.

6 The Side-Effect of Price Regulation

An immediate corollary of Proposition 4 and Proposition 5 is that the price regulation and the entry costs subsidy must be used as complementary instruments if the Regulator wants to mantain the same degree of control of the quality standard.

Corollary 1. *Price regulation reduces the controllability of the service quality as a side-effect, and the subsidisation tool needs to be implemented to offset the loss of controllability.*

While it is intuitive that the necessity of quality regulation increases with the intensity of price regulation, the corollary above states the less immediate result that price regulation decreases the effectiveness of the mechanism of quality control based on competition for the market and the minimum quality standard. Furthermore, the corollary indicates that the Regulator may use entry cost subsidisation to contrast the decrease in the quality control effectiveness due to more price regulation. Finally, the reduction of the competitive advantage of the incumbent, i.e., the subsidisation of a larger part of the entry costs for the entrant, represents the policy tool that the Regulator must use in order to contrast this negative side-effect of price regulation.

However, the fact that subsidisation is costly for the society (because of distortionary taxation) generates a second-best trade-off between price regulation, on the one hand, and quality regulation and and entry costs subsidisation, on the other hand.

7 Conclusions

We modelled a regulated environment and focused on the relationship between price and quality regulation for a physical network industry like railways. More precisely, we considered the effectiveness of the service quality regulation and how this can be affected by the interplay with other policy tools, namely, the portion of regulated tickets fares, their price and the entry costs subsidy.

Our first original result showed that the effectiveness of the service quality control is non-monotone with respect to the quality standard set by the Regulator. That is only by selecting levels of quality standard which fall into the intermediate part of the support of q_m, the Regulator provides sufficient incentives to the operating company, the TOC, to comply with the quality standard. On the contrary, when the quality standard is too low, the quality control is not effective because the threat that the franchise is not renewed is not effective, given that the TOC can get the renewal of its franchise contract by simply maximising its private profits. When the quality standard is too high the quality control is not effective because the big effort required to comply makes it more attractive for the TOC to maximise its first period profit and face the franchise bidding in the second period.

Furthermore, we found that price regulation has a negative effect on the controllability of the service quality provided by the TOC. Price regulation works against quality regulation. More precisely, price regulation negatively affects the effectiveness of competition for the market linked to a minimum quality standard, i.e., the mechanism selected by the Regulator to implement the quality control. The Regulator can contrast this side-effect of price regulation by providing a higher subsidisation to the entry costs. However, entry costs subsidisation is socially costly (e.g., distortionary taxation), and this generates a trade-off between price regulation, on the one hand, and quality regulation and entry costs subsidisation, on the other hand.

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Appendix 1

Inequality (10) holds for values of $q_m \in [q_M, q_M + \Delta]$.

Recalling that $q_M = \frac{r(1-\alpha)}{c}$ from (2), we rearrange (10) into the following second-degree inequality in q_m:

$$\frac{1}{2}q_m^2 c(1+\delta) - q_m r(1-\alpha)(1+\delta) - \delta(\alpha R - \kappa) + \frac{r^2(1-\alpha)^2}{2c} < 0. \tag{16}$$

Provided that:

$$\frac{c(\alpha R - k)}{r^2(1-\alpha)^2} > -\frac{1}{2}, \tag{17}$$

the following values of $q_m \in \mathbb{R}$ annul the inequality:

$$q_m = \frac{r(1-\alpha)}{c} \pm \frac{r(1-\alpha)}{c}\left(1 - \frac{1}{1+\delta} + \frac{2c\delta(\alpha R - \kappa)}{r^2(1-\alpha)^2(1+\delta)}\right)^{\frac{1}{2}}.$$

Suppose

$$\Delta = \frac{r(1-\alpha)}{c}\left(1 - \frac{1}{1+\delta} + \frac{2c\delta(\alpha R - \kappa)}{r^2(1-\alpha)^2(1+\delta)}\right)^{\frac{1}{2}}.$$

Accordingly, the inequality is satisfied in the interval $[q_M - \Delta, q_M + \Delta]$. Anyway, provided that $\Delta > 0$, we note that $q_m = q_M - \Delta$ lies in $[0, q_M]$. Concluding, in the range of q_m that is relevant to the present analysis, that is $[q_M, 1]$, inequality (16) holds for values of $q_m \in [q_M, q_M + \Delta]$.

■

Appendix 2

Condition (17) is equivalent to condition (8).

The proof is straightforward. It is sufficient to rearrange Δ by recalling that $\pi(q_M) = \alpha R + \frac{r^2(1-\alpha)^2}{2c}$. Hence, we get the representation provided in (11):

$$\Delta = \left(\frac{\delta}{1+\delta}\frac{2}{c}\left(\pi(q_M) - \kappa\right)\right)^{\frac{1}{2}}.$$

According to (11), there are solutions $\in \mathbb{R}$ for Δ if $\pi(q_M) > \kappa$, that is condition (8).

■

Appendix 3

If conditions (8) and (9) hold, then $q_M + \Delta < 1$.

We prove the Lemma by contradiction. Suppose that $\pi(q_M) > \kappa$ and $q_M + \Delta > 1$. Accordingly, since the compliance occurs when $q_m \in [q_M, q_M + \Delta]$, as it is proved in Appendix 1, the PE equilibrium segment includes $q_m = 1$. Condition (10) establishes that the compliance strategy is preferred by the TOC to the non-compliance, when $\pi(q_M) + \delta\kappa < (1+\delta)\pi(q_m)$. Anyway, (10) cannot be satisfied in $q_m = 1$, provided that condition (9) applies. In fact, (9) requires that $\pi(q_m = 1) \approx 0$, so that the present value of the profits associated to the compliance strategy for the TOC also approximates zero. Therefore, we conclude that when both conditions (8) and (9) hold, $q_M + \Delta$ cannot be greater than 1.

$\blacksquare$

Appendix 4

The compliance area shrinks when α *increases.*

In order for the compliance area to get larger following an increase in α, it must turn out that the variation affecting q_M is greater than the variation affecting $q_M + \Delta$ (both taken as absolute values). More precisely, the condition that has to be satisfied in order to witness an enlargement of the complianace area is:

$$|\frac{d}{d\alpha} q_M| > |\frac{d}{d\alpha} q_M + \frac{d}{d\alpha}\Delta|,$$

which leads to

$$|\frac{d}{d\alpha}\Delta| < 0, \tag{18}$$

and thus results to be impossible.

$\blacksquare$