Do welfare maximising water utilities maximise welfare under common carriage?

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Abstract

Due to the increasing discussion about liberalisation in the piped water industry municipal authorities in several European countries consider modifications of their water utilities' structure such as legal constitution, business objectives or private participation. The purpose of this paper is to evaluate the extent to which it is socially optimal to compose water utilities as welfare or profit maximising companies when assuming the introduction of competition *in* the market based on common carriage – as applied in England and Wales. Using a game theoretic model of mixed oligopolies that contains water markets specificities we show that welfare tends to be higher in a regime, where utilities are instructed to maximise profits rather than welfare.

Key Words: Water, Networks, Corporate Governance, Mixed Oligopoly

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1 Introduction

Privatisation and liberalisation in the piped water industry are not very popular. Opponents of such processes fear that private companies rather optimise short term profits instead of long-term welfare (see WWF 2003 or BMZ 2001). According to a poll almost the entire Austrian population defeats any privatisation steps in the piped water sector. The German city of Potsdam retracted the water utility privatisation in 2000 since it feared increasing water and waste water fees (see Schoenbaeck et al. 2003, p. 1 and 391). And in several Swiss municipalities the public voted against formal privatisation which intended to adjust the water utilities' legal constitution. The concerns about privatisation and liberalisation might root in the fact that water supply is widely seen as a natural monopoly. Hence, it tends be socially optimal to run a water monopoly as public welfare maximising utility instead of a private profit maximising company. In fact private participation in Europe is not very developed, water supply is usually provided by municipal authorities (see Schoenbaeck et. al., 2003 or EEB, 2002). Extended subsidies from local governments indicate rather welfare than profit maximisation in the piped water sector (see Gordon-Walker and Marr 2002, p. 31).[1] However, due to recent changes in the European legislation one can expect an increasing discussion about liberalisation. Before 2000 the European Community (EC) excluded the water industry from its competition law – in contrast to other network utilities such as postal services, gas or electricity. Today, water services are neither explicitly included nor excluded in the EC competition law. Nevertheless, in their report for the attention of the European Commission Gordon-Walker and Marr (2002) follow, "there is considerable scope of application of the EC competition rules to increase competition in the water sector".

Considering the *introduction of competition* it might be useful to re-evaluate water utilities' objectives. In a competitive environment it could be

[1] However, the new European Water Framework Directive requires full cost recovery when calculating water fees. But the directive leaves significant room for its application in practice since municipalities are free to account for additional aspects such as social, ecological or political issues (see Schoenbaeck et al. 2003, p. 457).

appropriate to change the utility's legal structure for instance into to a public limited company and/or to enhance private participation. Obviously such steps tend to change the utility's objective from a welfare to a rather profit maximising approach. The purpose of this paper is to evaluate the extent to which it is *socially optimal* to compose water utilities as *welfare or profit maximising* when considering the introduction of competition. Such competition can be introduced in two ways: competition *for* the market and competition *in* the market.[2] We focus the latter, which corresponds to the common carriage approach that is used in the water market in England and Wales. Common carriage is basically equivalent to interconnection that has already been applied in several other network industries such as telecommunication, gas or electricity. Using a game theoretic model of mixed oligopolies that contains water markets specificities this paper reveals the surprising result that welfare tends to be higher in a regime, where the utilities are instructed to maximise profits rather than welfare.

There is a broad literature about mixed oligopolies, which describes the effects of different governance structures in oligopoly competition. Early literature assumes competition between a public welfare maximising company and private profit maximising companies, where the public company acts as a Stackelberg leader – see Bös (1986), Rees (1984) or Hagen (1979). The authors of this so called "second best analysis literature" investigate how the public firm should deviate from marginal cost pricing in order to maximise welfare. Harris and Wiens (1980) assume a dominant public firm that is able to announce its output policy to the private firms that react to this policy. With such setting they show how the dominant government firm can impose a first-best allocation of resources within the industry. The public firm announces that it will make up any quantity difference between the competitive output and the private firms output. As a result the private firms face a given market price – now it is optimal to equalise marginal costs and price. However, there is no serious justification for a public Stackelberg leadership. Beato and Mas-Colell (1984)

[2] For an overview about common carriage implemented in England and Wales see for instance Cowan (1997), Cowan (1993) or Webb and Erhardt (1998). For an overview about franchise bidding in France see for instance Clark and Mondello (2000) or Elnaboulsi (2001) or Furrer (2004).

changed the roles of the firms. In their duopoly model they assume a reverse model structure, where the public firm takes as given the private company's output. They show that welfare may be higher than under the assumptions made in the second best literature. De Fraja and Delbono (1989) extend the analysis by assuming different settings, where the public and the private firms play simultaneously or not. They show that welfare is higher in a pure oligopoly where the public firm acts as profit maximising company than when the public firm is welfare maximising. If the public firm has the Stackelberg leadership it is always optimal to set the price above marginal costs. Cremer et al. (1989) extend this analysis and ask whether it is socially optimal to have a public welfare maximising company in a Cournot oligopoly, and if so, how many public firms are socially wanted. Their analysis contains several different assumptions such as increasing returns to scale (based on fixed and variable costs), public firms' budget constraints or wage differences between public and private firms. However, from their analysis no clear answer emerges. De Fraja (1991) introduced a model that contains competition between a less efficient public firm and more efficient private firms. He shows that the presence of the relatively inefficient public firm with no budget constraint may enhance the overall efficiency, since the lower market price stimulates the private producers to improve their efficiency. Fjell and Pal (1996) examine mixed oligopolies in the context of international competition. In their model a state-owned public firm competes with both domestic and foreign private firms. They show that the public firm reduces its market engagement in case of the entrance of a domestic private firm. And they show that the entrance of the domestic private firm enhance welfare, whereas entrance of foreign firms may enhance or reduce (domestic) welfare.

The model in this paper follows the mixed oligopoly literature, where the public and the private firm simultaneously decide about production quantities in a Cournot oligopoly. We extend the existing settings by taking the specificities of a network competition in the piped water industry into account. The applied common carriage model basically corresponds to a model designed by Foellmi and Meister (2004). The potential market entrant can be assumed as a neighboured water utility that connects its own with the incumbent's network physically. The incumbent applies an access fee for the use of its infrastructure – similar to the interconnection price in the telecommunication industry. The model is basically designed as a three stage game. At the first stage, an incumbent A in market 1 and the potential market entrant B decide about their objective function: welfare or profit maximisation. In a second stage the incumbent *or* a regulator decides about the access fee – depending on the applied regulation regime. In the third stage the incumbent and the market entrant decide about production quantities. The model shows, that welfare tends to be higher in a profit maximisation regime, in particular when assuming significant efficiency differentials between the incumbent A and the entering water supplier B. The reason is obvious: welfare maximisation enhances A's output but reduces Bs engagement incentives in market 1. Hence, welfare maximisation increases consumer surplus compared to the profit maximisation regime but reduces A's profit due to a lower retail price, reduced access income and reduced overall production efficiency. The net effect on welfare in market 1 tends to be negative. By the introduction of access price regulation the degree of competition in market 1 can be enhanced. However, the model shows that welfare in the incumbent's municipality does not necessarily benefit from regulation.

First the paper explains the water market's specificities that have to be considered when designing a model of common carriage. Section 2.2 examines the model's basic settings and the players' objective functions. In Section 2.3 we analyse the players' interactions based on a general demand function. Section 3 introduces a linear model that allows to calculate and to compare welfare in the different regimes explicitly.

2 The model

2.1 Water market specificities

When designing a competition model based on common carriage one has to consider several technical aspects concerning the piped water industry. First, water networks are not expected to generate any network externalities: consumer X does not profit directly from the existence of any additional consumer Y connected to the same network[3]. Secondly, water networks are assumed to be one-way networks, since water suppliers do not receive any direct and network based feedback from their customers (see Economides 2000, p. 4). Thirdly, the geographical extension of water networks is expected to be regional or even local due to transport costs arising from pumping requirements and water quality losses that increase with the transport distance (see BMWi 2001, p. 24). Additionally there are limitations of mixing different water qualities in one network since it raises the possibility of leaching and corrosion of pipes, sedimentation and suspension of particles and it affects microbial quality (see Kurukulasauiya 2001, p. 24). Obviously these specificities hinder the geographical extension of a common carriage competition in the water industry: Transport costs on the one side and the limitations of mixing different water qualities on the other side significantly limit the opportunity of connecting neighboured water networks. One can follow that competition is expected to occur only between a restricted number of neighboured water suppliers. The geographic extension of a competition based on common carriage in the piped water industry tends to be regional or even local and not very intense.

The basic setting of this model follows Foellmi and Meister (2004), since they consider the above described aspects in their water network competition model that analyses the effects of common carriage. They assume that only two neighboured water utilities A and B connect their pipe networks 1 and 2. The

[3] Obviously the existence of Y in the network does not change Xs utility directly. However, X might profit from indirect effects, such us economies of scale.

physical connection allows A and B to exchange treated water resources within their networks. As a result, the connection allows A to serve customers connected to Bs network 2 and it allows B to serve customers connected to A's network 1. Obviously the introduction of such competition requires an access regime that allows the utilities to use their competitor's pipe network to supply customers with treated water. Foellmi and Meister (2004) forego designing an explicit access regime with regulated access prices. They argue that in practice the regulation of access prices in the water sector tends to be difficult due to the high number of different water networks and the variance of networks costs. The argumentation is based on Cowan's (1997, p. 91) critique, that the regulatory burden of assessing access prices for different companies' networks would be large. In fact, the regulator Ofwat in England and Wales does not explicitly regulate access charges ex ante. Obviously such lack of regulation causes the danger of inexistent competition. Without any ex ante regulation A can charge a sufficient high access price in order to prevent the more efficient Bs access and to defend its monopoly position. Nevertheless, one can show that under certain circumstances voluntary access can occur even in an unregulated regime. Such voluntary access requires differentials in marginal treatment costs. A less efficient utility A with higher marginal treatment costs than its competitor B has incentives to allow third party access and therefore to admit competition. By allowing access A is able to reduce own production quantity and therefore production costs. The reduced income can be compensated by charging an access fee. In fact, marginal treatment costs differ significantly between water suppliers – even between neighboured water utilities. Foellmi and Meister assume that the involved water utilities A and B are both profit maximising private companies. However, in practice it is rather assumable, that water utilities are owned by the public – usually by the municipalities. Utilities are therefore not assumed to be exclusively profit maximising. They rather face an objective function that maximises the relevant community's welfare. The following model considers this issue by changing the utilities' objective functions. We compare two different regimes: the incumbent is profit maximising or welfare maximising. Additionally the model accounts for two different access price regulation systems: unregulated and regulated access.

2.2 The general setting

The model is basically designed as a three stage game. Since the determination of the governance structure can be seen as very long term oriented, we assume that utilities decide in stage 0 about their objective functions. Given the governance structures and therefore their objective functions A and B decide in the following stages about short term variables. In case of an unregulated access price regime (as assumed by Foellmi and Meister) the incumbent A decides in stage 1 about the access price a_1. In case of a regulated regime, it is a regulatory agency that decides about a_1. In such regulated case, the access price is exogenously given in the model. Since we assume a Cournot Duopoly the incumbent A and the (potential) market entrant B decide in a second stage simultaneously about their engagement in market 1. Given A's governance structure and the relevant access price a_1 they decide simultaneously about the quantities they want to sell to customers connected to A's network 1. We denote A's production quantity sold to the customers in network 1 as q_{1A} and Bs production quantity for customers in network 1 as q_{1B}. Total water sold to customers in market 1 amounts to $q_1 = q_{1A} + q_{1B}$. The inverse demand function in market 1 is given as $p_1(q_1)$. The general time frame of the model can therefore be described as follows:

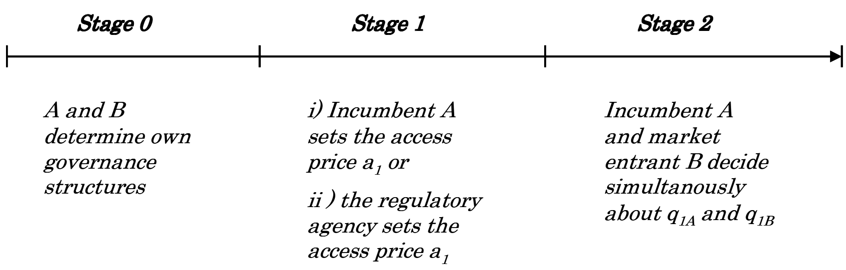

Figure 1 : Time frame of the model

Water treatment and pumping requirements causes variable costs $Cj(\bullet), j \in \{A, B\}$. Since not relevant in our optimisation problem we can omit fixed costs such as network investment and maintenance. As mentioned above, one can assume that – even neighboured – water utilities face different marginal costs. In our model we assume that *A* is less efficient than be. As a result, *A* faces higher marginal treatment costs than its competitor *B*, $C_A' > C_B'$. Obviously we analyse the case, where *A* has incentives to open its market for *B*. Additionally we assume that the more efficient utility *B* does not face any relevant capacity constraints, marginal costs are therefore assumed to be constant, $C_B' = c_B$. Such assumption eases the analysis, since we do not have to consider impacts on *B*s behaviour in its own network 2.

After determining the time frame and the model's variables, one can define the suppliers' objective functions. First let us determine *A*'s objective function under the assumption of profit maximisation. Such objective function exactly corresponds to the one used by Foellmi and Meister (2004, p. 9):

$$\Pi_A = p_1(q_1)q_{1A} + a_1 q_{1B} - C_A(q_{1A}) \qquad (1),$$

where Π_A denotes *A*'s profit and p_1 the retail prices in market 1. Obviously *A* does not only generate earnings from selling water quantity q_{1A} to customers connected to network 1. Additionally *A* can generate income from allowing *B* access to the network 1. The relevant income is given by the term $a_1\, q_{1B}$. *B*s objective function in a profit maximising regime can be defined as follows:

$$\Pi_B = p_2(q_{2B})\, q_{2B} + p_1(q_1)q_{1B} - a_1 q_{1B} - c_B\,(q_{2B} + q_{1B}) \qquad (2),$$

where p_2 denotes the retail price in market 2. We solve the model by backwards induction. Therefore we derive the players' first order conditions regarding their production quantities q_{1A} and q_{1B} given the access price a_1:

$$\frac{\partial \Pi_A}{\partial q_{1A}} = p_1'(q_1)\,q_{1A} + p_1(q_1) - C_A' = 0 \qquad (3)$$

$$\frac{\partial \Pi_B}{\partial q_{1B}} = p_1'(q_1)\,q_{1B} + p_1(q_1) - a_1 - c_B = 0 \qquad (4),$$

where $\partial p_1(\cdot)/\partial q_{1A} = \partial p_1(\cdot)/\partial q_{1B} \equiv p_1'(q_1)$. We do not have to consider Bs first order condition regarding q_{2B}, since we exclusively analyse market 1. And since we assumed linear costs c_B the profit maximising production quantity q_{2B} does not vary with an increased or reduced q_{1B}. Assuming an unregulated access price regime, the incumbent A sets the access price a_1 in stage 1 as follows:

$$\frac{\partial \Pi_A}{\partial a_1} = q_{1B} + \frac{dq_{1B}}{da_1}\left[p_1'(q_1)q_{1A} + a_1\right] = 0 \qquad (5),$$

where the quantity reaction of B, dq_{1B}/da_1, can be determined by the total differentiation of equation (4). It is given by

$$\frac{dq_{1B}}{da_1} = \frac{1}{p_1''(q_1)q_{1B} + 2p_1'(q_1)} \qquad (6),$$

where $q_{1B}p_1''(q_1) + 2p_1'(q_1) < 0$, in a profit maximum. Note that in a regime where the access price a_1 is determined by a public regulatory agency, equations (5) and (6) would be irrelevant, since a_1 can be seen as exogenous. In such regime, the access price in equation (4) would be exogenously given at $\overline{a_1}$.

However, public water utilities might pursue additional objectives beside profit. We can assume that a public firm rather maximise welfare than profit. Such extension basically corresponds to the mixed oligopoly model designed by Fraja and Delbono (1989), where a public firm competes in a Cournot competition model with private profit maximising companies. However, in such a setting A would not only maximise the sum of the own profit and the consumer surplus in market 1, additionally *A* would consider its neighbour's profit. One might concern that such objective function is not appropriate in our model, where a domestic public firm competes with foreign companies. A municipal owned water utility should exclusively concern about domestic welfare: consumer surplus in its municipality and profit which can be allocated to the own municipal financial statement. Such extension was made by Pal and White (1998) who analyse an international mixed oligopoly with one domestic public firm and a number of *n* foreign private firms. We adapt their idea and define *A*'s objective function as follows:

$$W_1 = \int_0^{q_1} p_1(q_1)\, dq_1 - p_1(q_1)\, q_1 + q_{1A} p_1(q_1) + a_1 q_{1B} - C_A(q_{1A}) \qquad (7)$$

Using such objective function *A* maximises the sum of the consumer surplus in market 1 and the own profit. Of course we could allow *B* to change its objective function as well.

$$W_2 = \int_0^{q_{2B}} p_2(q_{2B})\, dq_{2B} - p_2(q_{2B})\, q_{2B} + q_{2B} p_2(q_{2B}) + p_1(q_1) q_{1B} - a_1 q_{1B} - c_B(q_{1B} + q_{2B}) \qquad (8),$$

where q_{2B} denotes *B*s production quantity for customers connected to network 2. *A*'s engagement in market 2 must be zero in equilibrium, therefore $q_2 = q_{2B}$. Note, from *A*'s perspective nothing changes compared to a regime where *B* faces a profit maximisation objective function. Since *B* maximises domestic welfare in market (or municipality) 2, it maximises the sum of domestic consumer surplus, the profit from market 2 and additionally its profit from market 1. Obviously from *A*'s perspective *B* acts as a profit maximisation company in market 1. As a result equation (4) which describes *B*s first order condition regarding its engagement in market 1 is still relevant in the welfare maximisation regime. However, we have to redefine *A*'s first order condition in such regime. Using the rule of Leibnitz we get:

$$\frac{\partial W_1}{\partial q_{1A}} = - p_1'(q_1)q_1 + p_1(q_1) + q_{1A}p_1'(q_1) - C_A'(q_{1A}) = 0 \qquad (9)$$

Since *A* still has incentives to maximise access income and since *B* still maximise income from its engagement in market 1 the equations (5) and (6) still hold in a regime of welfare maximisation. However, in a system of access price regulation, equation (4) changes. Again, the access price would be exogenously given at $\overline{a_1}$.

2.3 Strategic interactions

After defining the model's setting, the objective functions and the first order conditions in the regime of profit maximisation on the one side and welfare maximisation on the other side, we are able to analyse the strategic interactions between *A* and *B*. On the one side, we analyse the players' strategic interactions regarding their quantity decisions. On the other side, we analyse their behaviour in case of exogenous access price shifts. The strategic interactions are analysed under the assumption of profit maximising and welfare maximising.

We firstly analyse *A*'s reaction function on an exogenous change of *B*'s engagement in market 1. For this reason we consider the profit maximisation regime. We can derive dq_{1A} / dq_{1B} by using the total differentiation of *A*'s first order condition, equation (3):

$$\frac{dq_{1A}}{dq_{1B}} = \frac{-\frac{\partial^2 \Pi_A}{\partial q_{1A} \partial q_{1B}}}{\frac{\partial^2 \Pi_A}{\partial q_{1A}^2}} = -\frac{p_1''(q_1)q_{1A} + p_1'(q_1)}{p_1''(q_1)q_{1A} + 2p_1'(q_1) - C_A''(q_{1A})} \qquad (10)$$

The right hand side of equation (10) tends to be negative. It is negative in case of a concave, linear or minor convex demand. It is only positive in case of a strong convex demand, where $p_1''(q_1) > 0$ and $p_1''(q_1)\, q_{1A} > -p_1'(q_1)$. We can derive

A's reaction to an exogenous change in *B*s engagement analogously in a regime of welfare maximisation:

$$\frac{dq_{1A}}{dq_{1B}} = \frac{-\frac{\partial^2 W_1}{\partial q_{1A} \partial q_{1B}}}{\frac{\partial^2 W_1}{\partial q_{1A}^2}} = \frac{q_{1B} p_1''(q_1)}{p_1'(q_1) - q_{1B} p_1''(q_1) - C_A''(q_{1A})} \qquad (11)$$

Now, the right hand side of equation (11) can be zero, positive or negative. It is zero in case of a linear demand. It is negative in case of a convex demand and it is positive in case of concave demand. Note that the linear case is of high interest in the welfare maximisation regime, since it is exactly the boarder between a positive and a negative reaction on *B*s reduced engagement.

Obviously *A*'s incentives to reduce its own water production in case of an increased engagement of *B* tend to be stronger in the profit maximisation regime than in the welfare maximisation regime. To illustrate this issue we can analyse the linear case. In the profit maximisation regime *A* reduces q_{1A} when *B* increases q_{1B}. Obviously the production quantities are strategic substitutes. The increased engagement of *B* reduces the relevant market price p_1, as a result it is profit maximising for *A* to answer with a reduction of its own engagement. However, in the welfare maximisation regime *A* would not change its production quantity q_{1A} when *B* increases q_{1B}. Such behaviour reduces *A*'s profit but it increases domestic consumer surplus since the relevant market price decreases. Obviously welfare maximising is now a very strong commitment: the incumbent *A* sets its production quantity independent from *B*s engagement in market 1. The welfare maximisation regime then corresponds to a Stackelberg duopoly, where *A* defines its capacities before *B*. An additional finding is the fact that changing *A*'s objective function reverses the sign of *A*'s reaction on a change of q_{1B}. In the profit maximisation regime that uses a concave demand, *A* reduces its own production when *B* increases q_{1B}. However, in the welfare maximisation regime *A* increases q_{1A} in case of a concave demand.

After defining A's reaction functions in the profit and welfare maximising regimes, we turn to the player Bs strategic behaviour. However, since B always acts as a profit maximising company in market 1, we can reduce our analysis to one regime. We can derive dq_{1B} / dq_{1A} analogously as above:

$$\frac{dq_{1B}}{dq_{1A}} = \frac{-\frac{\partial^2 \Pi_B}{\partial q_{1B} \partial q_{1A}}}{\frac{\partial^2 \Pi_B}{\partial q_{1B}^2}} = -\frac{q_{1B} p_1''(q_1) + p_1'(q_1)}{q_{1B} p_1''(q_1) + 2 p_1'(q_1)} \qquad (12)$$

The right hand side of equation (12) tends to be negative. It is negative in case of a concave, linear or minor convex demand. It is only positive in case of a strong convex demand, where $p_1''(q_1) > 0$ and $p_1''(q_1)\ q_{1\mathrm{A}} > -p_1'(q_1)$. Not surprisingly the result corresponds to A's reaction function in the regime of profit maximisation.

We turn to the analysis regarding the player's reactions on exogenous changes of the access price. Obviously such analysis is of higher relevance when the access price is determined by a separate regulation agency. In such case the access price is in fact exogenous from A's and Bs point of view. Bs reaction on exogenous shifts in a_1 is already determined by equation (6). The analysis can be focused on A's reaction on an exogenous change of a_1. Since a_1 is set before A determines its production quantity q_{1A}, we analyse the change of A's optimal quantity setting given an exogenous change of a_1. This is the evaluation of the second order partial derivative of A's objective function at $q_{1A} = q_{1A}^*$. Again, we firstly evaluate the profit maximising regime:[4]

$$\frac{\partial}{\partial a_1}\left(\frac{\partial \Pi_A}{\partial q_{1A}}\right)\Big|_{q_{1A}=q_{1A}^*} = \frac{\partial q_{1A}}{\partial a_1}\left[p''(q_1) q_{1A} + 2p'(q_1) - C''(q_{1A})\right] + \frac{\partial q_{1B}}{\partial a_1}\left(q_{1A} p''(q_1) + p'(q_1)\right) \qquad (13)$$

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[4] Equation (13) shows, how the optimal choice q_{1A}^* changes when assuming an exogenous change of a_1 at a given level of q_{1B}. For this reason we differentiate A's first order condition regarding q_{1A} at q_{1A}^* with respect to a_1. If the result is positive, one can follow that the peak of a function $\Pi_A(q_{1A}(a_1), q_{1B})$ shifts to the right, to higher levels of q_{1A}.

In order to determine if the right hand side of equation (13) is positive or negative, we evaluate $\partial q_{1A} / \partial a_1$. However, this relation must be zero, since for a given q_{1B} A would not change its own q_{1A} when a_1 is increased or decreased exogenously.[5] We can rewrite (13) as follows:

$$\frac{\partial}{\partial a_1}\left(\frac{\partial \Pi_A}{\partial q_{1A}}\right)\bigg|_{q_{qA}=q_{1A}*} = \frac{\partial q_{1B}}{\partial a_1}\left(q_{1A} p''(q_1) + p'(q_1)\right) \qquad (14)$$

Due to equation (6) we know that $\partial q_{1B} / \partial a_1 < 0$. As a result the right hand side of (14) is positive in case of a linear or minor convex demand. As a result, A's optimal quantity tends to increase with an exogenously increased a_1. A's reaction is only negative in case of a strong convex demand, where $p_1''(q_1) > 0$ and $p_1''(q_1)\ q_{1A} > -p_1'(q_1)$. The result corresponds to the findings above: in case of a linear or minor convex demand A would increase q_{1A} when B reduces its own production quantity. Since $\partial q_{1B} / \partial a_1 < 0$ A can expect that B reduces its engagement q_{1B} (for a given q_{1A}), when a_1 is exogenously increased. Similar to our analysis above we evaluate A's reaction on an exogenous change of a_1 in the welfare maximisation regime. For this reason we can rewrite equation (14) as follows:

$$\frac{\partial}{\partial a_1}\left(\frac{\partial W_1}{\partial q_{1A}}\right)\bigg|_{q_{qA}=q_{1A}*} = -\,p''(q_1)\, q_{1B} \frac{\partial q_{1B}}{\partial a_1} \qquad (15)$$

The right hand side of equation is zero in case of a linear demand. It is positive in case of a convex demand and negative in case of a concave demand. Again, the finding corresponds with the result above. And again, the linear case is of high interest in the welfare maximisation regime, since it is exactly the boarder between a positive and a negative reaction on the exogenous change of the access price. In case of a linear demand, A does not change its optimal production quantity when a_1 is exogenously increased. Indeed B faces incentives

[5] The same result can be derived by using the total differentiation of A's first order condition.

to reduce its engagement in market 1 A does not change its optimal q_{1A}. According to equation (11), A would not answer the reduced q_{1B}.

3 Linear analysis

3.1 Overview

In section 2.3 we analysed the strategic interactions between the incumbent A and the market entrant B for given governance structures. We used a general demand function that allows us to evaluate these interactions in detail. We can show that varying the governance structure significantly changes the strategic interaction between A and B. However, up to now A did not choose its governance structure strategically. Obviously such decision requires more detailed information about the effects on profit and welfare. In this section we extend the analysis to stage 0 of our model, where the incumbent chooses its governance structure strategically. Since the general demand function does not allow us to evaluate and to compare profits and welfare in the two regimes, we use a simple linear demand function. The use of linearity is very common in the literature of mixed oligopolies, since it allows an explicit evaluation of A's profit and welfare in market 1 in different regimes. We follow de Fraja and Delbono (1989, p. 304) or Pal and White (1998, p. 266) and define the inverse demand as follows:

$$p_1 = k - bq_1 = k - bq_{1A} - bq_{1B} \qquad (16),$$

where k stands for the reservation price and b determines the demand elasticity. Similar to the general analysis we assume a more efficient supplier B. To ease the analysis we assume linear cost functions for both utilities, whereby $k > c_A > c_B$. In the following sections we determine short run variables such as production quantities q_{1A} and q_{1B}, retail price p_1 and access price a_1

under the assumption of profit or welfare maximisation. Using these variables allows the calculation of *A*'s profit and welfare in market 1. The comparison of welfare in profit in the two regimes allows *A* to decide about its governance structure in period 0. As showed above, at stage 0 there is no strategic interaction with player *B*, since from *A*'s point of view *B* always acts profit maximising. The proposed procedure implies that profit maximisation not necessarily maximises *A*'s profit and welfare maximisation not necessarily welfare in market 1.

3.2 Unregulated Access

In order to analyse and compare the two different regimes, we have to calculate the quantities, prices, profit, consumer surplus and welfare explicitly. In order to differentiate the regimes, we add the index π in case of profit maximisation and the index θ in case of welfare maximisation. First, let us determine the model's results in a regime of profit maximisation. Using equation (15) in (3), (4), (5) and (6) allows to determine the player's production quantities for market 1, the retail price and the relevant access price. The results are illustrated in Table 2. Using these equations we can determine *A*'s profit on the one side and consumer surplus in market 1 on the other side, whereby consumer surplus can be calculated as follows: $CS_1^\pi = 0.5(k - p_1^\pi)q_1^\pi$. The results are illustrated in Table 3. Adding *A*'s profit and consumer surplus allows us to determine welfare in a regime of profit maximisation:

$$W_1^\pi = \frac{9k^2 - 16kc_A - 2kc_B - 8c_A c_B + 12c_A^2 + 5c_B^2}{24b} \qquad \text{if} \qquad q_{1A}^\pi > 0 \qquad (17)$$

Note that the analysis above assumes $q_{1A} > 0$. However, such assumption requires that the efficiency difference between *A* and *B* is not too high and / or the reservation price *k* is high enough. Only in such case, the less efficient incumbent faces positive production incentives. However, *A* stops its own water production when its marginal cost c_A exceeds the resulting retail price:

$$q_{1A}^{\pi} = 0 \quad \text{if} \quad \frac{3k + c_B}{4} < c_A$$

Now, it is profit maximising for the incumbent A to stop its own production. However, the relevant income loss can be compensated by charging the access fee. Utility B is then the sole supplier in market 1. Obviously B acts as a monopolist. However, its relevant marginal costs are determined by the own marginal production costs c_B and the access price a_1 charged by A. Bs production quantity and the resulting market price can be determined similar to the monopoly case (see Table 2). A's profit is now determined by the multiplication of the access price with Bs engagement in market one. In equilibrium such access price does not differ from the access price in the profit maximisation regime, where both utilities produce a positive amount of water (see Table 2). Table 3 shows A's profit and the relevant consumer surplus in market 1. Again, we add these two components and calculate the relevant welfare:

$$W_1^{\pi} = \frac{5(k - c_B)^2}{32b} \quad (18) \quad \text{if} \quad q_{1A}^{\pi} = 0$$

The above derived results from the profit maximisation regime can be compared with the welfare maximisation regime, where the incumbent utility A maximises welfare rather than profit. Again, we firstly assume, that A decides to produce a positive amount of water, $q_{1A} > 0$. The player's decisions at stage 3 of the model can be determined by using equation (16) and the equations (4), (5), (6) and (9). Again, the relevant production quantities, the retail price and the access price are illustrated by Table 2. From equation (11) in section 2.3 we know, that in the linear demand case A does not change its own production quantity when B increases or reduces its engagement, $dq_{1A} / dq_{1B} = 0$. This finding obviously corresponds with q_{1A}^{θ} in Table 2:

$$q_{1A}^{\theta} = \frac{k - c_A}{b} \qquad (19)$$

Such behaviour can be interpreted as a very strong commitment, where *A* decides about its production quantity independently from *B*s engagement in market 1. The relevant consumer surplus and *A*'s profit in a profit maximisation regime where both utilities produce a positive amount of water are illustrated in Table 3. Now, we can derive the welfare in such regime:

$$W_1^{\theta} = \frac{13k^2 - 28kc_A + 2kc_B - 12c_Ac_B + 20c_A^2 + 5c_B^2}{32b} \qquad \text{if} \qquad q_{1B}^{\theta} > 0 \qquad (20)$$

Again, *A* might decide to stop the own production. However, according to equation (19) *A* produces a positive amount of water if the reservation price exceeds marginal costs.

$$q_{1A}^{\theta} = 0 \qquad \text{if} \qquad k > c_A$$

With other words: *A* stops the own production if marginal costs equal the reservation price. But we assumed that such reservation price *k* always exceeds marginal costs of *A* and *B* – otherwise *A* did not run the monopoly before introducing common carriage competition. We can follow, that *A* faces always production incentives in the welfare maximisation regime. However, such result does not hold for the more efficient utility *B*. Obviously in the profit maximisation regime, *B* always faces positive production incentives when $c_A > c_B$ – see Table 2. In the welfare maximisation regime *B* is only engaged in market 1, if the market price p_1 exceeds its relevant costs $c_B + a_1$. Or: *B* stops its engagement in market 1 if the relevant marginal costs exceed the retail price:

$$q_{1B}^{\theta} = 0 \qquad \text{if} \qquad \frac{k + 2c_A + c_B}{4} \leq c_B + a_1 = c_B + \frac{k - c_B}{2} \qquad \text{or} \qquad \frac{k + c_B}{2} \geq c_A$$

At high levels of c_B or low levels of c_A utility B decides to leave market 1. Such behaviour can be explained as follows: At relatively low levels of c_A B can expect a high engagement of its competitor A. As a result the retail price in market 1 tends to be low. B skips its engagement when the retail price falls under its relevant marginal costs. Now, the incumbent A is the sole supplier in market 1. Welfare maximisation requires in such situation the equalisation of marginal costs and retail price: $p_1^{\theta} = c_A$. Again, Table 2 illustrates the production quantity in such regime and Table 3 the resulting profit and consumer surplus. Obviously A does not generate any profit, since the retail price equals marginal costs. Welfare equals consumer surplus and can be determined as follows:

$$W_1^{\theta} = \frac{(k - c_A)^2}{2b} \qquad (21) \qquad \text{if} \qquad q_{1B}^{\theta} = 0$$

After defining quantities, prices, profit and welfare in each situation of the two regimes, we can compare them. Obviously we have to compare three different cases. In a case 1 A's marginal costs are high. As a result, in the profit maximisation regime the less efficient incumbent decides to stop the own production. However, in the welfare maximisation regime A still has production incentives. In case 2 A's marginal costs are lower than in case 1. In both regimes the less efficient incumbent produces a positive amount of water. In case 3 A's marginal costs are relatively low but still higher than its competitor's costs. In the profit maximisation regime both utilities produce a positive amount of water for customers in market 1. However, in the welfare maximisation regime B stops the own production, since the retail price p_1 exceeds its relevant costs. Table 1 illustrates these cases.

	Case 1 $c_A \geq \frac{3k + c_B}{4}$	*Case 2* $\frac{k + c_B}{2} < c_A < \frac{3k + c_B}{4}$	*Case 3* $c_A \leq \frac{k + c_B}{2}$
Profit maximisation regime	$q_{1A} = 0$; $q_{1B} > 0$	$q_{1A} > 0$; $q_{1B} > 0$	$q_{1A} > 0$; $q_{1B} > 0$
Welfare maximisation regime	$q_{1A} > 0$; $q_{1B} > 0$	$q_{1A} > 0$; $q_{1B} > 0$	$q_{1A} > 0$; $q_{1B} = 0$

Table 1: Cases to compare

Using the above derived results (see Table 2) we can illustrate aggregated water supply respectively the utilities' production incentives in the three relevant cases graphically. Figure 2 shows aggregated water supply in market 1 under a profit maximisation regime (q_1^{Π}) and under a welfare maximisation regime (q_1^{θ})[6]. Additionally it shows the amount of water sold by utility B (q_{1B}^{Π} respectively q_{1B}^{θ}).

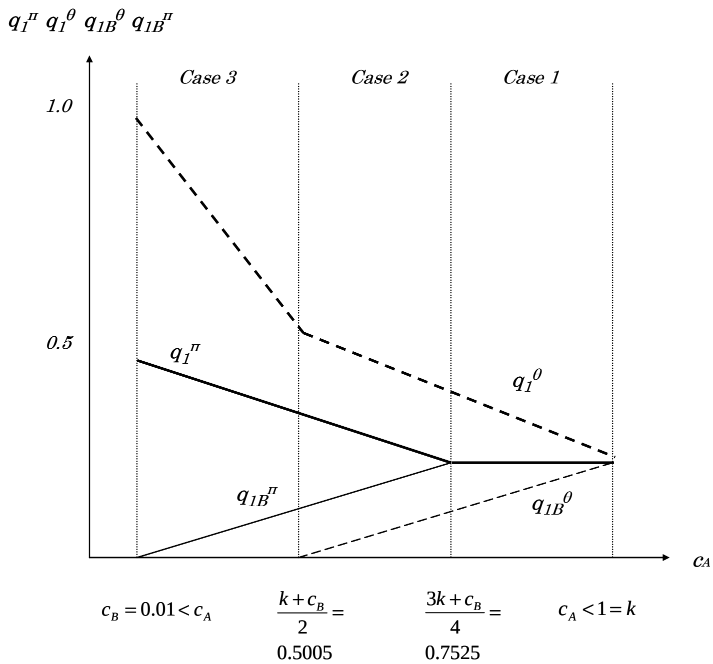

Figure 2 : Production quantities

[6] The variables k and b are held constant at a level of 1. Bs marginal costs are assumed to be 0.01.

Figure 2 shows that aggregated production is higher under the welfare maximisation regime. However, *B*s production incentives tend to be higher in the profit maximisation regime. Under the welfare maximisation regime the more efficient utility *B* only produces in cases 1 and 2. Now, we can turn to the comparison of welfare.

Case 1 compares the profit maximisation regime, where only the more efficient utility *B*, produces a positive amount of water, with the welfare maximisation regime where both utilities are engaged in market 1. First we compare *A*'s profit in these two regimes:

$$\Pi_1^{\theta} - \Pi_1^{\pi} = \frac{2k^2 - 7kc_A + 3kc_B - 3c_A c_B + 5c_A^2}{8b} \qquad (22)$$

One can show for any values of k, c_A and c_B and b that the right hand side of equation (22) is negative. As a result, *A*'s profit in case 1 is higher in the profit maximisation regime. From Table 3 we know, that consumer surplus is higher in the welfare maximisation regime, since $k < 3k - 2c_A$. And the welfare difference is defined as follows:

$$W_1^{\theta} - W_1^{\pi} = \frac{-4kc_A + 4kc_B - 4c_A c_B + 4c_A^2 - c_B^2}{32b} \qquad (23)$$

Considering $c_A \geq (3k + c_B)/4$ for case 1 we can show that such difference is negative for any values of k, c_A and c_B and b. That means, welfare is higher in a regime of profit maximisation. Such result seems to be very puzzling, since the regime of profit maximisation generates higher welfare than welfare maximisation. Such effect can be explained by a *profit-overcompensation-effect*. Obviously in the regime of profit maximisation *A* generates higher profit than in the welfare maximisation regime, but consumer surplus is higher in the welfare maximisation regime. However, the additional domestic profit in the profit maximisation regime arising from the access business overcompensates for the disadvantage regarding domestic consumer surplus. The net effect is positive: welfare tends to be higher in the profit maximisation regime. The rational behind is obvious: *A*'s profit is higher due to the higher production efficiency in market 1. Since the less efficient supplier *A* stops own production, the overall production efficiency can be improved. However, the welfare difference decreases with higher levels of c_A or lower levels of c_B. In such case, welfare maximisation gets relatively more attractive, since *B* increases its engagement in market 1 in case of lower levels of c_B, and *A* reduces its own engagement in case of higher levels of c_A.

Case 2 compares profit and welfare maximisation under the assumption that both utilities are engaged in market 1. From our results in Table 1 we know that *A* determines the access price at the same level in both regimes. Additionally we know that *A*'s engagement in the regime of welfare maximisation is higher than under profit maximisation: $q_{1A}^{\pi} < q_{1A}^{\theta}$. However, *B*s engagement is lower in case of welfare maximisation. Such result is not very surprising, since we know from equation (12) that *B* reduces its own engagement at higher levels of q_{1A}. Nevertheless, the net effect regarding the total amount of sold water in market 1 is still positive. In the welfare maximisation regime total quantity q_1 is higher than in the profit maximisation regime. Hence, the resulting retail price in market 1 is lower in the welfare maximisation regime. Again, up to this point the result is not surprising, since welfare maximisation increases the amount of sold quantity and it reduces prices. Consumer surplus must be higher in the welfare maximisation regime. In fact Table 2 shows that $CS_1^{\pi} < CS_1^{\theta}$. Introducing welfare maximisation into the model increases consumer surplus in market 1. However, as stated above the increased engagement of *A* in a welfare maximisation regime reduces the engagement of *B* in market 1. Such crowding out effect directly affects *A*'s profit, since it reduces *A*'s income from the access business.

	A's engagement	*B's engagement*	*Total quantity*	*Retail price*	*Access price*
Cases 2 and 3: *Profit maximisation regime (A and B produce)*	$q_{1A}^{\pi} = \frac{3k + c_B - 4c_A}{6b}$	$q_{1B}^{\pi} = \frac{c_A - c_B}{3b}$	$q_1^{\pi} = \frac{3k - 2c_A - c_B}{6b}$	$p_1^{\pi} = \frac{3k + 2c_A + c_B}{6}$	$a_1^{\pi} = \frac{k - c_B}{2}$
Case 1: *Profit maximisation regime (A stops own production)*	$q_{1A}^{\pi} = 0$	$q_1^{\pi} = q_{1B}^{\pi} = \frac{k - c_B}{4b}$	$q_1^{\pi} = \frac{k - c_B}{4b}$	$p_1^{\pi} = \frac{3k + c_B}{4}$	$a_1^{\pi} = \frac{k - c_B}{2}$
Cases 1 and 2: *Welfare maximisation regime (A and B produce)*	$q_{1A}^{\theta} = \frac{k - c_A}{b}$	$q_{1B}^{\theta} = \frac{2c_A - k - c_B}{4b}$	$q_1^{\theta} = \frac{3k - 2c_A - c_B}{4b}$	$p_1^{\theta} = \frac{k + 2c_A + c_B}{4}$)	$a_1^{\theta} = \frac{k - c_B}{2}$
Case 3: *Welfare maximisation regime (B stops production for market 1)*	$q_{1A}^{\theta} = \frac{k - c_A}{b}$	$q_{1B}^{\theta} = 0$	$q_1^{\theta} = \frac{k - c_A}{b}$	$p_1^{\theta} = c_A$	

Table 2: Quantities, retail price and access price

	A's profit	*Consumer surplus in market 1*
Cases 2 and 3: *Profit maximisation regime (A and B produce)*	$\Pi_A^{\pi} = \frac{9k^2 - 18kc_A + 16c_A^2 - 14c_A c_B + 7c_B^2}{36b}$	$CS_1^{\pi} = 0.5(k - p_1^{\pi})q_1^{\pi} = \frac{(3k - 2c_A - c_B)^2}{72b}$
Case 1: *Profit maximisation regime (A stops own production)*	$\Pi_A^{\pi} = a_1^{\pi} q_{1B}^{\pi} = \frac{(k - c_B)^2}{8b}$	$CS_1^{\pi} = \frac{(k - c_B)^2}{32b}$
Cases 1 and 2: *Welfare maximisation regime (A and B produce)*	$\Pi_A^{\theta} = \frac{k^2 - 4kc_A + 2kc_B + 4c_A^2 - 4c_A c_B + c_B^2}{8b}$	$CS_1^{\theta} = \frac{(3k - 2c_A - c_B)^2}{32b}$
Case 3: *Welfare maximisation regime (B stops production for market 1)*	$\Pi_A^{\theta} = 0$	$CS_1^{\theta} = \frac{(k - c_A)^2}{2b}$

Table 3: Profit and consumer surplus

We can show, that *A*'s profit in the welfare maximisation regime is lower than under profit maximisation for any values of *k*, c_A and c_B and *b*: $\Pi_{1A}^{\pi} > \Pi_{1A}^{\theta}$ (see Table 3). However, we should determine the net effect regarding social welfare. Welfare in the regime of welfare maximisation profits from a higher consumer surplus. Welfare in the regime of profit maximisation profits from a higher domestic profit. Equation (24) compares welfare in these two regimes:

$$W_1^{\theta} - W_1^{\pi} = \frac{3k^2 - 20kc_A + 14kc_B - 4c_Ac_B + 12c_A^2 - 4c_B^2}{96b} \qquad (24)$$

Under the restriction $(k + c_B)/2 < c_A < (3k + c_B)/4$ we can show that the right hand side of equation (24) is always negative. Welfare is higher in a regime of profit maximisation. The welfare difference is higher at lower levels of *k* and/or lower cost differentials. Obviously higher levels of *k* increase *A*'s engagement in market 1. However, *B*'s engagement is not affected by *k* in the profit maximising regime (see Table 2). Higher levels of *k* increase *A*'s engagement more significant in the regime of welfare maximisation, *B* on the other side reduces its own engagement as an answer – which supports *A*'s quantity enhancement. Welfare is positively affected by a higher overall quantity but negatively affected by lower profits due to lower production efficiency. Since the effect regarding consumer surplus dominates a higher level of *k* increases welfare in the welfare maximisation regime relatively. As stated above, lower levels of c_B at unchanged levels of c_A reduce welfare in the welfare maximisation regime relatively. We can illustrate this issue by reducing the level of c_B. In the welfare maximisation regime *A* does not change its own production volume. Due to this strong commitment *B* increases its own engagement less significant than in a profit maximisation regime, where *A* reduces its own production quantity at lower levels of c_B. As a result the additional consumer surplus in the welfare maximisation regime is only of second order. However, the effect regarding access price income is of first order: in the profit maximisation regime access price income can be increased stronger. We can summarise that welfare is higher in a profit maximisation regime since *A*'s higher profit overcompensates for lower consumer surplus.

Case 3 compares profit maximisation where both utilities are engaged in market 1 with welfare maximisation where only the less efficient utility is engaged in market 1. In this case *A*'s marginal costs are relatively low. As a result *A*'s engagement is higher than in the other cases. But *A*'s extended engagement lowers the equilibrium retail price and therefore *B*s incentives to engage in market 1. In the welfare maximisation regime *B* skips its engagement in market 1, only *A* supplies customers connected to network 1. In order to maximise welfare, *A* sets $p_1^\theta = c_A$. From the relevant equations in Table 2 and the assumption $c_A \leq (k + c_B)/2$ one can easily show that such price is lower than the equilibrium price in the welfare maximisation regime. As a result, total quantity of water sold in market 1 in the welfare maximisation regime exceeds the total quantity in the profit maximisation regime. Since *A*'s does not generate any profit in the welfare maximisation regime, we can follow that consumer surplus in such regime exceeds consumer surplus in a regime of profit maximisation. Again, we compare the relevant welfare in these two regimes:

$$W_1^\theta - W_1^\pi = \frac{3k^2 - 8kc_A + 2kc_B + 8c_A c_B - 5c_B^2}{24b} \qquad (25)$$

Again, we consider $c_A \leq (k + c_B)/2$. The right hand side of equation (24) can be positive or negative. It tends to be positive at higher levels of k and/or lower levels of c_A. Obviously in such case *A* produces relatively more efficient, the resulting consumer surplus tends to be higher and can overcompensate for non-profit. Such result basically corresponds to a result derived by de Fraja and Delbono (1989). They show that *nationalisation* (a public monopoly that maximises welfare) is socially always better than Stackelberg leadership of the public company in a competitive environment under profit maximisation. In their model additional profit can not compensate for lower consumer surplus. However, they assume that the players face similar costs. In our model the player face different marginal treatment costs. At higher levels of c_A, but still $c_A \leq (k + c_B)/2$, the profit maximisation gets relatively more attractive regarding social welfare. Obviously overall production efficiency is higher in the profit maximisation regime. Profit compensates now for a lower consumer surplus.

The welfare in these three cases can be illustrated graphically. The horizontal axis in Figure 3 defines *A*'s marginal costs. Holding *B*s marginal costs constant, varying c_A determines the three different cases:[7]

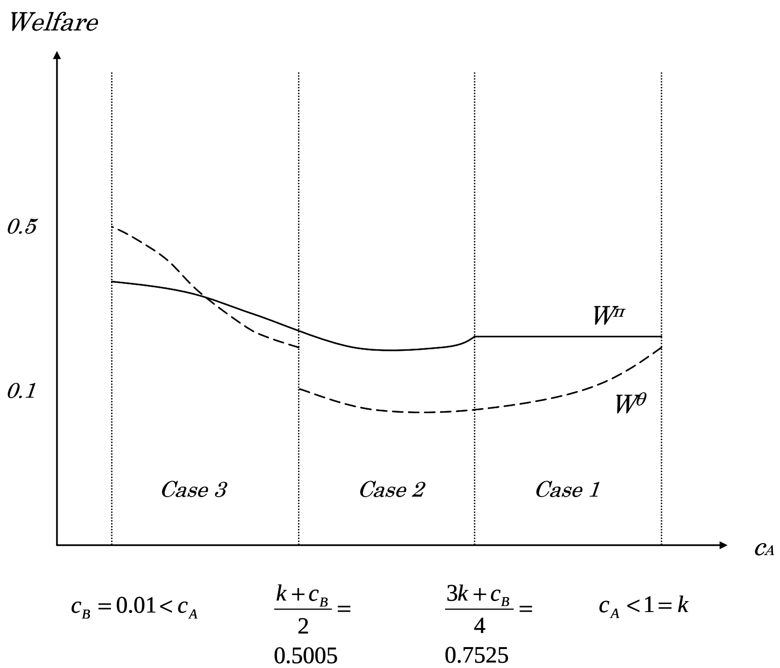

Figure 3 : Welfare comparison

In *case 1* the welfare in the profit maximisation regime is higher than in the welfare maximisation regime. However, the difference is lower at higher levels of c_A. Obviously W^{Π} is unaffected from c_A. From equation (18) we know that $\partial W^{\pi} / \partial c_A = 0$. However, $\partial W^{\theta} / \partial c_A$ can be positive or negative.[8] At higher levels of c_A it tends to be positive. In *case 2* both $\partial W^{\theta} / \partial c_A$ and $\partial W^{\pi} / \partial c_A$ can be positive or negative. They are positive at higher levels of c_A and negative in case of lower

[7] Again, in the graphic the variables *k* and *b* are held constant at a level of 1. *B*s marginal costs are assumed to be 0.01.

[8] $\partial W^{\theta} / \partial c_A = (1/32b)(-28k - 12c_B + 40c_A)$

levels of c_A.[9] In *case 3* both $\partial W^{\theta} / \partial c_A$ and $\partial W^{\pi} / \partial c_A$ are negative.[10] Note that the absolute value of the welfare in the welfare maximisation regime is not continuous. In case 3 the incumbent does not care about *B* since *B* does not have any incentives to enter the market. In cases 2 and 1 *A* takes *B*s behaviour into account.

We can show that the absolute gap between welfare in the profit and the welfare maximisation regime is decreasing at higher levels of *b*. From equations (23), (24) and (25) we know that the absolute gap is lower at higher levels of *b*. The reason for this is obvious, since higher levels of *b* at constant levels of *k* reduce consumer surplus and profit. At very high levels of *b* welfare converges to zero in both regimes. However, it is easily to show that the relative gap (welfare in the welfare maximisation regime as a percentage of the welfare in the profit maximisation regime) does not change with an increased or reduced level of *b*.[11] However, higher levels of the consumer's reservation price *k* increase both, welfare in the profit and the welfare maximisation regime. But the relative performance may change. Increasing levels of *k* enhance the relative performance of the welfare maximisation regime: the increased *k* reduces profit but increases consumer rent more significant – the net effect is positive. Additionally the net effect is stronger than the additional welfare gain in the profit maximisation regime. Nevertheless, when taking the cases' cost restrictions into account, welfare in cases 2 and 3 is always higher in the profit maximisation regime.[12]

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[9] $\partial W^{\pi} / \partial c_A = (1/72b)(-48k - 24c_B + 72c_A)$

[10] $\partial W^{\vartheta} / \partial c_A = (1/2b)(-2k + 4c_A)$

[11] From equations (17), (18), (20) and (21) we know that a ten percent increase in *b* reduces welfare in each equation by ten percent.

[12] One can show this relations by differentiating the relevant welfare functions regarding the variable *k* and considering the cost restrictions (regarding c_A and c_B) in Table 1.

3.3 Regulated access – an extension

The section above assumed the absence of any access price regulation. A is fully free to set any level of a_1. But the introduction of competition by third party access in network industries such as telecommunications, railways, gas or electricity usually assumes some kind of access price regulation. However, the relevant network costs in local and decentralised water networks vary significantly (see section 2.1), an effective access price regulation tends to be difficult and expensive. Nevertheless, in this section we extend the model by the introduction of effective regulation. Traditional regulation theory suggests marginal cost pricing for access in order to maximise welfare. Since such a pricing regime describes a first best solution we use it as a benchmark. In our model we assumed no marginal costs of water transport and allocation. The regulator should therefore set $a_1 = 0$. Again we analyse the effects of Bs entrance in market 1. Since B does not face any marginal costs of using network 1, the problem of double marginalisation is removed. Competition in network 1 can be described as an ordinary Cournot duopoly competition model. In order to keep this analysis simple, we assume $k = b = 1$. Now, we can easily derive quantities and retail price in the profit maximisation regime. Again, we have to consider that in the regulated profit maximisation regime A stops the own production when $c_A \geq (1+c_B)/2$. Again, we differentiate two different cases in order to compare the two regimes (see Table 4). In order to differentiate the cases from above, we call them *case R.1* and *R.2*.

	Case R.1 $c_A \geq \frac{1+c_B}{2}$	***Case R.2*** $c_A < \frac{1+c_B}{2}$
Regulated profit maximisation regime	$q_{1A} = 0$; $q_{1B} > 0$	$q_{1A} > 0$; $q_{1B} > 0$
Regulated welfare maximisation regime	$q_{1A} > 0$; $q_{1B} > 0$	$q_{1A} > 0$; $q_{1B} > 0$

Table 4: Relevant cases

First, we evaluate *case R.1*, where *A* stops the own production in the regulated profit maximisation regime when its marginal costs exceed $(1+c_B)/2$. Due to *A*'s reduced engagement the total amount of sold water is higher in the regulated welfare maximisation regime (see Table 5). As a result the retail price is lower and the consumer surplus higher in the regulated welfare maximisation regime. However, profit in the regulated welfare maximisation regime is always negative (see Table 6), since $1 < c_A$ and $c_B < c_A$ Again, we analyse the net effect regarding social welfare. Social welfare in the regulated profit maximisation regime is defined as follows:

$$W_1^{\pi} = \frac{(1-c_B)^2}{8} \qquad (26)$$

It corresponds to the consumer surplus in market 1, since *A*'s profit is zero. And in the regulated welfare maximisation regime welfare is defined as follows:

$$W_1^{\theta} = \frac{4(1-c_A)(c_B-c_A)+(2-c_B-c_A)^2}{8} \qquad (27)$$

At a sufficient high level of c_B welfare tends to be higher in the profit maximisation regime. In such case, the additional consumer surplus in the regulated welfare maximisation regime can not compensate for *A*'s loss. Of course higher welfare in the profit maximisation regime is basically a result of the higher production efficiency – similar to the findings in 3.2. However, at lower levels of c_A such loss can be overcompensated by the additional consumer surplus: at lower levels of c_A welfare tends to be higher in the regulated welfare maximisation regime. Obviously the efficiency effect gets less relevant at lower levels of c_A.

	A's engagement	*B's engagement*	*Total quantity*	*Retail price*
Case R.2: *Regulated profit maximisation regime*	$q_{1A}^{\pi}=\frac{1+c_B-2c_A}{3}$	$q_{1B}^{\pi}=\frac{1+c_A-2c_B}{3}$	$q_1^{\pi}=\frac{2-c_A-c_B}{3}$	$p_1^{\pi}=\frac{1+c_A+c_B}{3}$
Case R1: *Regulated profit maximisation regime where A stops production*	$q_{1A}^{\pi}=0$	$q_{1B}^{\pi}=\frac{1-c_B}{2}$	$q_1^{\pi}=\frac{1-c_B}{2}$	$p_1^{\pi}=\frac{1+c_B}{2}$
Cases R1 and R2: *Regulated welfare maximisation regime*	$q_{1A}^{\theta}=1-c_A$	$q_{1B}^{\theta}=\frac{c_A-c_B}{2}$	$q_1^{\theta}=\frac{2-c_A-c_B}{2}$	$p_1^{\theta}=\frac{c_A+c_B}{2}$

Table 5: Quantities and retail price

	A's profit	*Consumer surplus in market 1*
Case R.2: *Regulated profit maximisation regime*	$\Pi_A^{\pi}=\frac{(1+c_B-2c_A)^2}{9}$	$CS_1^{\pi}=\frac{(2-c_B-c_A)^2}{18}$
Case R1: *Regulated profit maximisation regime where A stops production*	$\Pi_A^{\pi}=0$	$CS_1^{\pi}=\frac{(1-c_B)^2}{8}$
Cases R1 and R2: *Regulated welfare maximisation regime*	$\Pi_A^{\theta}=\frac{(1-c_A)(c_B-c_A)}{2}$	$CS_1^{\theta}=\frac{(2-c_B-c_A)^2}{8}$

Table 6: Profit and consumer surplus

In *case R.2* both utilities produce a positive amount of water since *A*'s marginal costs are lower than $(1+c_B)/2$. Again, the total amount of water sold in market 1 is higher in the regime of *regulated welfare maximisation*. As a result the retail price in market 1 is lower in the welfare maximisation regime. And again, one can follow, that consumer surplus must be higher under welfare maximisation. And similar to case R.1 *A* always suffers a loss in the regulated welfare maximisation regime. Social welfare in the regulated welfare maximisation regime is defined similar to equation (27). However, welfare in the regulated profit maximisation regime is now defined as follows:

$$W_1^{\pi} = \frac{2(1+c_B-2c_A)^2+(2-c_B-c_A)^2}{18} \qquad (28)$$

We can easily show that the difference between equations (27) and (28) defined as $W_1^{\theta} - W_1^{\pi}$ is always positive when assuming $c_B < c_A < 1$. As a result, in case R.2 welfare is always higher in the welfare maximisation regime. Again, the effect of a higher consumer surplus is stronger than the negative impact of *A*'s loss. The higher production efficiency in the profit maximisation regime can not compensate for lower prices. Additionally, in contrast to the unregulated regimes, welfare in market 1 does not directly profit from *B*s engagement through the access price income. As a result the effect of a higher consumer surplus is even more dominant.

3.4 Comparing the regimes – a simulation

One may ask if from a welfare maximisation point of view it is useful to introduce any kind of access price regulation. For this reason, we compare equations (26) and (27) from the regulated regimes with equations (17), (18), (20) and (21) from the unregulated regimes. Again, we consider the different cases when assuming different c_A. To ease the analysis, we compare the regimes by using a simple simulation where $k = b = 1$, $c_B < c_A < 1$, $c_B = 0.01$.

The simulation (see Table 7) clearly shows that overall welfare decreases with higher levels of c_A. In the unregulated case welfare tends to be higher under profit maximisation, except for low levels of c_A (case 3). However, consumer surplus is always higher in the regime of welfare maximisation. In the unregulated case welfare tends to be higher in the profit maximisation regime only for higher levels of c_A (case R.1). Consumer surplus is always higher in the welfare maximisation regime. Additionally, welfare can be higher or lower under the assumption of regulation or non-regulation. At lower levels of c_A welfare is the highest in the unregulated and regulated welfare maximisation regime. At higher levels of c_A welfare tends to be the highest in an unregulated profit maximisation regime.

	Unregulated regime				***Regulated regime***			
	Consumer Surplus		*Welfare*		*Consumer Surplus*		*Welfare*	
c_A	CS_1^{Π}	CS_1^{θ}	W_1^{Π}	W_1^{θ}	CS_1^{Π}	CS_1^{θ}	W_1^{Π}	W_1^{θ}
0.10	0.11	0.41	0.31	0.41	0.20	0.45	0.27	0.41
0.15	0.10	0.36	0.28	0.36	0.19	0.42	0.24	0.36
0.20	0.09	0.32	0.26	0.32	0.18	0.40	0.22	0.32
0.25	0.09	0.28	0.24	0.28	0.17	0.38	0.20	0.29
0.30	0.08	0.25	0.22	0.25	0.16	0.36	0.18	0.26
0.35	0.07	0.21	0.20	0.21	0.15	0.34	0.16	0.23
0.40	0.07	0.18	0.19	0.18	0.14	0.32	0.15	0.20
0.45	0.06	0.15	0.17	0.15	0.13	0.30	0.13	0.18
0.50	0.06	0.13	0.16	0.13	0.12	0.28	0.12	0.16
0.55	0.05	0.11	0.16	0.11	0.12	0.26	0.12	0.14
0.60	0.04	0.10	0.15	0.10	0.12	0.24	0.12	0.12
0.65	0.04	0.09	0.15	0.10	0.12	0.22	0.12	0.11
0.70	0.04	0.08	0.15	0.10	0.12	0.21	0.12	0.10
0.75	0.03	0.07	0.15	0.10	0.12	0.19	0.12	0.10
0.80	0.03	0.06	0.17	0.15	0.12	0.18	0.12	0.10
0.85	0.03	0.05	0.18	0.15	0.12	0.16	0.12	0.10
0.90	0.03	0.04	0.19	0.15	0.12	0.15	0.12	0.10
0.95	0.03	0.04	0.20	0.15	0.12	0.14	0.12	0.11
0.99	0.03	0.03	0.22	0.15	0.12	0.13	0.12	0.12

Table 7: Simulation

4 Conclusions

Using a competition model of common carriage in the water industry we can show that social welfare can be higher in a regime of profit maximisation. We follow that from a welfare maximisation perspective it might be suboptimal for a municipality to instruct its utility to maximise welfare instead of profit. According to the model's results welfare tends to be higher in a profit maximisation regime when assuming higher efficiency differentials between the incumbent A and the entering water supplier *B*. Only at very low efficiency differentials welfare maximisation may generate a higher level of welfare. The reason is obvious. In a welfare maximisation regime the incumbent acts like a Stackelberg leader and announces a hard commitment about its production quantity due to its objective function. We can easily show that the optimal production quantity exceeds optimal production quantity in a profit maximisation regime. Since the profit maximising firm *B* has a downward sloping reaction curve, *B* reduces its own engagement when *A* commits a higher level of engagement in market 1 – obviously the higher engagement of *A* reduces prices and therefore potential benefits in market 1. Since the overall production quantity tends to be higher in the welfare maximisation regime, consumer surplus is also higher. However, the incumbent faces a lower profit due to the lower retail price on the one side and due to lower access income incurred by *B*s reduced engagement on the other side. The lower consumer surplus in the profit maximisation regime is overcompensated by *A*'s higher profit. The net effect is positive: welfare tends to be higher under profit maximisation. Additionally production efficiency is higher in such regime, since the more efficient *B*s engagement is higher in market 1. Due to the higher efficiency we expect higher overall profits – *A* benefits from the higher overall profits by charging the access fee.

By the introduction of effective access price regulation the degree of competition in the market can be enhanced. However, welfare in municipality 1 does not necessarily benefits from such regulation, since it allows *B* to skim more of the aggregated profit. However, now the retail price tends to be the lowest and the consumer surplus the highest in the regime of welfare maximisation – expect for very high levels of c_A, where *A* decides to quit and *B* acts as a pure monopolist. However, only when assuming very low cost differentials, where *A* can act as a competitive firm, welfare can be the highest in a regulated welfare maximisation regime. At higher levels of efficiency differentials *A* looses market share and therefore profit. Domestic welfare is only determined by consumer surplus. However, in practice the regulation of access prices in the decentralised water sector tends to be very difficult. We can assume that the incumbent faces significant freedom to determine or to influence access prices.

The model basically extends existing mixed oligopoly models by the introduction of the network interconnection and therefore by the access price business. Obviously such extensions slightly alter the results of the existing models. De Fraja and Delbono (1989) for instance follow from their analysis that nationalisation (one public welfare maximising monopoly) is always better than Stackelberg leadership which is in turn socially better than Cournot Nash behaviour. However, they assume that the involved firms have the same technology. Nevertheless, De Fraja and Delbono show that under certain circumstances (large number of firms) welfare tends to be higher in a profit maximisation regime, since the higher consumer surplus in a welfare maximisation regime is not high enough to compensate the lower private profits. Such result strongly resembles to the results derived in the model above.

Finally one might concern that the model is still very general, even when it is applied in the piped water market. Of course one could image to apply the same interconnection model in another local network industry, for instance waste water. Results might be similar. The model could be extended by allowing for cross boarder trade between the neighboured water utilities. Such extension was made by Foellmi and Meister (2004). We might analyse the effects of a changed governance structure when utilities rather trade water resources than compete with each other.

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