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Abstract

This paper analyses welfare gains in the piped water industry when introducing competition or trade between local utilities. The connection of neighbouring networks can be used for both, voluntary cross border trade and product market competition by common carriage. Using a game theoretic model we show that common carriage induces stronger production incentives for inefficient suppliers. This implies that production efficiency but also retail price tend to be lower than with trade. The net effect regarding welfare depends on the efficiency differential. At higher cost differentials welfare is higher under competition – even in a lower bound benchmark case without regulation.

Key Words: Water, Networks, Product-Market Competition, Trade, Bargaining

JEL Classification: L95, L43, D21, Q25

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1. Introduction

The existing organisation of piped water supply in Europe is very heterogeneous. In most countries water supply is organised on a local level. Historically, the communities are responsible for water supply systems such as treatment and storage facilities or pipe networks since water supply is widely seen as a natural monopoly. In addition, local authorities choose the form of organisation and the permitted degree of private sector participation. Due to these decentralised structures water supply in most European countries is characterised by a high number of locally operating monopolies.[1] Such local operators often face very different marginal production costs due to differences in production scales and the use of different raw water resources such as surface, ground or spring water (see e.g. Correia and Kraemer 1997). As a result retail prices vary significantly – even between neighbouring water utilities. The obvious question is how to overcome this puzzling inefficiency. Some countries such as England and Wales or France introduced a process of privatisation in the water industry. However, as Feigenbaum and Teeples (1983) showed, different ownership structures do not explain efficiency differentials in communal water supply. That means, the pure changing of ownership structures does not necessarily enhance the efficiency of water supply. Rather such process has to be combined with further measures. *Prima facie* there are three ways to improve productive efficiency: concentration, competition or increased trade (see also Ludin et. al., p. 3). In fact there has been a progressive concentration process in countries such as Belgium or the Netherlands.[2] However in most other countries concentration is not a feasible opportunity due to political, legal or geographical restrictions. Taking this into account, it is the purpose of this paper to compare welfare gains of the latter two alternatives, e.g. competition *in* the market and trade. In a model that assumes privatised ownership structures and therefore profit maximising companies we show we show that welfare gains may be higher in case of unregulated competition when assuming high efficiency differentials between water utilities.

Only a few European countries such as France, Italy or England and Wales introduced some degree of competition in the water sector. France and since recently Italy implemented competition by the model of franchise bidding based on the idea of competition *for* the market. England and Wales have chosen a model of product market competition based on competition *in* the market. One main element of such competition is common carriage. The concept is based on the interconnection of networks, similar to telecommunication, electricity or gas. However, due to difficulties in the regulation of access prices and the physical characters of water,

[1] There are more than 6500 local operators in Germany, about 8000 in Italy, 3000 in Switzerland and about 2000 in Sweden (see EEB 2002, p. 24 - 28).

[2] In Belgium there are currently 109 waterworks, 93 percent of total production is concentrated in the hands of only 10 companies. And the Netherlands reduced the number of its government-owned water utilities from 111 to only 24 companies (see EEB 2002, p. 26).

competition is expected to be weak and very local. Nevertheless, the English water regulator Office of Water Services (Ofwat) intends to strengthen competition by the model of common carriage trough the Competition Act 1998 and the guidance on the development of access codes which were published in 2002. A second way to enhance efficiency might be increasing cooperation between neighbouring utilities. One main element of such cooperation model is the exchange of treated water resources based on trade. Since water utilities often use different raw water qualities and therefore face different marginal production costs, trade between neighbouring suppliers is expected to reduce total costs. In fact water trade is already practiced in several countries. However, in most cases trade is only used in order to balance peaks of demand, since the non-profit oriented communal water utilities usually try to be as independent as possible. Hence, trade does not happen even when costs vary significantly between neighbouring utilities. Obviously an increasing and systematic implementation of trade could induce extensive efficiency and therefore welfare gains.

However, such regime of cross border trade obviously resembles the above described regime of competition by common carriage. The connection of networks could rather be used for water trade than for competition by common carriage. In both regimes local and neighbouring water suppliers connect their networks and exchange water. Both, trade and competition causes the more efficient utilities to increase and the less efficient utilities to reduce production volume. One could raise the question whether competition is very useful since welfare gains are expected to be small due to the limited degree of competition and the emerging regulation costs. Using a game theoretic model we show that competition by common carriage induces stronger production incentives for the inefficient supplier. This implies that production efficiency but also the retail price tend to be lower than with cross border trade. The net effect regarding welfare depends on the efficiency differential. At higher cost differentials welfare is higher under common carriage – even in a lower bound benchmark case without regulation of access charges.

There is some literature addressing the issue of competition *in* the market by common carriage applied to the piped water sector. For instance Cowan (1993 and 1997), Webb and Erhardt (1998), Grout (2002), Klein (1996) or Scheele (2000) discuss the opportunity of common carriage in the water sector from an economic and regulatory perspective. Due to technical problems and regulation difficulties most authors indicate that common carriage will *not* be a major opportunity to introduce effective rivalry into the water sector. Saal and Parker (2001) analyse empirically the efficiency effects of privatisation and liberalisation in England and Wales. They follow that total factor productivity growth has not been improved after privatisation. Additionally privatisation raised retail prices and water suppliers' profits. However, Saal and Parker analyse the post privatisation period 1990-1999 where competition by common carriage still plays a minor role. Using a game theoretic model Foellmi and Meister

(2003) analyse potential efficiency gains of common carriage. They follow that competition may increase efficiency even when regulation is absent. However, they do not analyse the effects of cross boarder trade. There is a wide range of literature related to the trade of *water rights*.[3] However, there are few authors analysing spot water markets. Howitt (1998) shows that spot markets are better than water rights markets to stabilise water availability. Calatrava and Garrido (2005) consider the risk dimension of water markets under uncertain water supply. They show that spot water markets may allow farmers to reduce their risk exposure caused by unstable water supply. Additionally they show that centralised water markets lead to more efficient allocation and resource use than decentralised markets. Carey and Zilberman (2002) investigate farmers' investment into irrigation technology under uncertainty and follow that farmers having access to a spot water market. Due to price uncertainty the option to delay investment has a positive value, thus farmers will not invest until the expected present value of investment sufficiently exceeds the cost of investment. There is some literature analysing bargaining processes and bargaining power on water markets: Kajisa and Sakurai (2000) examine water markets in India, Meinzen-Dick (1997) groundwater markets in Pakistan. However, this literature addresses in particular water trade related to agricultural issues while our paper rather discusses trade between neighbouring water utilities rendering water services to final customers such as households or industry. Newbery (1999) introduces a model which combines competition and trade in the network industry. Two suppliers compete in a single downstream gas market. Both pay a fee for using the network which connects the market to the upstream gas producers. Newbery shows that if the suppliers can trade capacity rights amongst each other, they can use the price of these rights to support the joint profit-maximising downstream price. However, such a setting is not usable in the piped water market with vertically integrated water utilities. To the best of our knowledge there is no literature addressing the analysis respectively the comparison of trade and competition between local water utilities.

Section 2 of provides evidence on competition and trade in the European water market. In section 3 we set up a general model that considers the physical restrictions in the water sector, the difficulties of regulation and different bargaining power to analyse the effects of competition and trade. We then compare the effects of competition and trade on productive efficiency, retail prices and welfare, and the distribution of profits between firms. In section 4 we consider an example with linear demand and constant marginal costs. In the same section we investigate the effects of regulation of access prices on the one side and regulation of retail prices on the other side. In section 5 we present a simulation of the model. It shows that the result of the linear case holds as well for more general demand and cost functions: welfare

[3] Hearne and Easter (1997) describe gains from the trading of water rights in Chile, Rosengrant and Binswanger (1994) present potential efficiency gains in developing countries, Pigram (1993) analyses property rights and water markets in Australia and Becker (1995) discusses potential gains from trade in Israel.

tends always to be higher in trade, since the productive efficiency effect dominates. Section 6 concludes.

2 Competition and Trade in the Water Industry

2.1 Product Market Competition

So far product market competition or competition *in* the piped water market has only been introduced in England and Wales. After the entire privatisation of water service companies in 1989, competition *in* the market was established through three basic channels (see Scheele, 2000 or Kurukulasuriya, 2001): inset appointments, border line competition, and common carriage. Inset appointments – licensees issued by the water regulator Ofwat – allow new entrants to supply customers in a defined geographical area.[4] Border line competition allows customers that are located at the border of a supply area to purchase water from an existing neighbouring utility. Finally common carriage is the model of interconnection. Two or more rival companies render water services in the same area and customers are free to choose their water supplier. The former monopolists connect their water networks in order to allow each other access to their distribution pipes – analogous to telecommunication, electricity or gas (see BMWi 2001, p. 11-28). Companies are therefore able to serve customers connected to another company's network. Obviously a market entrant has to use the incumbent's water pipe network to serve these customers. Providing such distribution services allows the incumbent to charge a so called access fee to the market entrant – analogous to the interconnection fee in the telecommunication sector.

However, due to the specific technical issues in the water sector, product market competition by common carriage is not expected to be as effective as in sectors like telecommunication or electricity (see BMWi 2001, p. 24). In contrast to telecommunication or electricity water networks are rather local than national since there are limitations of network connection due to specific technical aspects in the water sector. On the one side there are limitations of mixing different water qualities, 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). On the other side there are limitations of transport. In contrast to electricity the transportation of water causes significant marginal costs due to

[4] However, initially Ofwat limited the permission of inset appointments for sites that were not already connected and that ware more than 30 meters away from the local water supplier's pipe network. Today inset appointments are available for new customers (not yet connected) or major customers (consuming more than 100'000 m^3 per year). Moreover customer of every scale can change their supplier provided that their previous supplier agrees on it (see Scheele, 2000, p. 14).

pumping requirements. Furthermore transportation over long distances affects the quality of the water in a negative way (see BMWi 2001, p. 24). To sum up, due to this limitations competition by common carriage tends to occur only at a regional or even local level.

Furthermore competition in the water sector could be restricted by market power of incumbents. They could defend their monopoly position by charging very high access prices because effective regulation of access charges in the water sector is very complex, since the costs of using water pipe networks depend on various technical aspects such as age or material of pipes, pumping requirements, water pressure etc. In addition, these costs vary significantly between local networks. Hence the access fees would have to be set in an individual manner – other than in telecommunications. Simon Cowan (1997, p. 91) follows that the regulatory burden of assessing access prices for different companies' networks is large.[5] Based on these circumstances the effectiveness of competition in the market is doubtful. The World Bank even raises the question whether efficiency gains from competition outweigh the costs of these (see Webb and Ehrhardt 1998, p. 5). Beside these provisos against the effectiveness of the competition in the market there is political opposition against the introduction of any kind of competition and privatisation in the piped water sector. There is fear that private companies rather optimise short term profits instead of long-term welfare (see BMWi 2001). 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. Additionally the EC defined in its Water Framework Directive (Directive 2000/60/EC): "Water is not a commercial product like any other but, rather, a heritage which must be protected, defended and treated as such". The Water Framework Directive does not include any guidelines or recommendations about privatisation or competition.

2.2 Trade

Cross border trade between neighbouring water suppliers is more common than competition by access. Treated water is exchanged between independent neighbouring water utilities or – which is more common – between utilities that are members of partnerships of convenience (PC), in Germany called Zweckverbaende. PCs are voluntary associations between independent municipalities that intend to fulfil a certain public task such as water supply or waste water disposal as a collective. About 17 percent of German water suppliers are organised in PCs (see BGW 1999). According to Ludin et al. (2000) PCs are mainly motivated by insufficient

[5] Indeed the regulator Ofwat does not explicitly regulate access charges ex ante. It rather defines general terms for the calculation of access prices. On the basis of the guidance water companies have to publish their specific access codes including indicative or standard prices for access. Ofwat require companies to not to set indicative prices unrealistically high to deter entrants. Prices can be calculated on the basis of average accounting costs, long run marginal costs or based on the efficient component pricing rule (see Ofwat 2002, p. 20-22).

enterprise scales on the one side and technical aspects such as hydrologic and hydrogeologic conditions on the other side. A PC has a self-contained legal form of organisation and acts as public corporation. Hence, in most cases it describes rather a merger of neighbouring water utilities than trade between independent water suppliers. However, purer forms of water trade between utilities exist as well. German water suppliers such as Bodenseewasserversorgung, Harzwasserwerke or Gelsenwasser with extended treatment capacities sell water to neighbouring or even distant water utilities. Water trade between utilities is also practiced in other countries, e.g. Switzerland. Switzerland's largest water supplier is the Zurich water utility (WVZ). It provides about 460'000 inhabitants of the Zurich city directly, furthermore it sells water to contractual partners, represented by 67 communities in the nearer region of Zurich with additional 420'000 inhabitants.[6] The latter communities have their own local public water suppliers. However, only in case of demand peaks they buy treated water from the WVZ that disposes of extended treatment capacities due to the use of surface water. The relevant price is based on costs and is calculated identical for each partner. Approximately 20 Percent of WVZ's total water production is sold to contractual partners (see WVZ 2004). Obviously the extension of trade is restricted by the same specific technical issues as product market competition. Limitations of mixing different water qualities, extensive coordination requirements for the exchange of treated water and diseconomies of scales due to pumping requirements and quality losses over long distances limit the exchange of water between utilities significantly.

3 A Model of Competition and Trade

As we explained above both competition and trade are expected to occur on a regional or even local level. The above mentioned specifications in the water industry limit the number of networks that can be connected in order to exchange water. To keep the following analysis simple, we assume a network connection of only two neighbouring utilities. And since favourable raw water resources such as spring and groundwater are limited and the construction of new treatment facilities causes high sunk costs, we exclude the entrance of new water suppliers and focus only existing water utilities. Figure 1 describes the basic setting of the model. By connecting their networks 1 and 2, two suppliers A and B are able to exchange treated water. The vertically integrated suppliers A and B can be asymmetric. Depending on production scale and the quality of used raw water resources, water supplier's marginal costs

[6] The large number of partners might be surprising, since mixing different water qualities usually needs extensive coordination effort. However, none of the WVZ's partners use complex treatment technologies. They exclusively use spring or ground water and do not need the addition of any chemicals. Mixing their water with the WVZ's treated water is therefore unproblematic and requires only a minimum coordination effort.

may differ significantly – even between neighbouring water suppliers. Using spring water usually needs no treatment and is therefore less expansive than ground or surface water. These raw water resources need extensive treatment such as screening, flocculation, clarification, filtration, the addition of chemicals or the use of ultraviolet light. In fact marginal costs vary significantly between water suppliers. Renzetti (1992) estimates marginal costs of waterworks in Vancouver ranging from \$0.53/m^3 to \$0.85/m^3. Existing cost differentials are in practice often reflected in a wide range of water tariffs. E.g. in France tariffs varied between 0.42 FF and 10.92 FF per cubic meter (see Correia and Kraemer 1997). Since water supply is very capital intensive, we assume that utilities choose rather quantities and capacities than prices. Our model is therefore based on a Cournot competition. And since the treated water of both suppliers is mixed within the water pipe system, we assume homogenous goods. Due to water treatment and pumping requirements the production of water causes variable costs $C_j(\bullet)$, $j \in \{A, B\}$. Fixed costs such as network investment and maintenance costs are omitted since they are irrelevant for the optimisation problem under concern. Without loosing generality we assume the more efficient utility B to have lower marginal treatment costs than utility A.

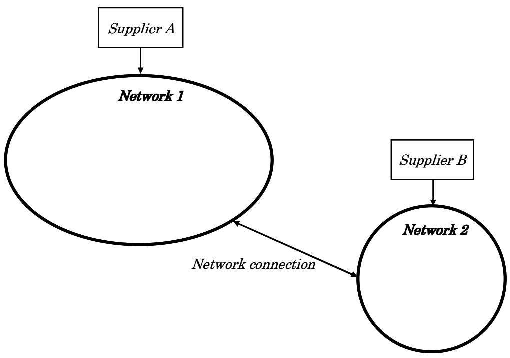

Figure 1 : Connection of two neighbouring water networks

In order to ease the exposition, marginal costs of the (efficient) supplier B are equal to c_B and constant. Instead, supplier A faces increasing marginal costs, $C_A'(0) > c_B$ and $C_A'' \geq 0$.[7] Hence, the more efficient utility B does not face relevant capacity constraints due to sufficient availability of high quality raw water resources. The introduction of increasing marginal costs for B does not change the results in network 1 qualitatively. However, the analysis would be more complex since we would have to consider price and quantity changes in both networks 1

[7] The assumption of increasing marginal costs is appropriate for utilities facing relevant capacity constraints because of the production structure in the water industry. According to a study of Dwr Cymru Welsh Water (1999) water supplier's operative costs are mainly influenced by the complexity of water treatment. In order to minimise treatment costs, utilities firstly use raw water resources of high quality such as spring water. To overcome capacity constraints they use further resources with poorer quality and therefore higher treatment requirements such as groundwater or surface water. Due to this reasoning, marginal costs of drinking water production are obviously increasing in output.

and 2. Further, we only allow for linear access and trade prices. Of course the analysis could be extended to a non-linear pricing regime. The qualitative predictions of the model remain the same. However, the reader would obtain the well known result that highest possible production efficiency can be achieved (see Foellmi and Meister, 2003).

3.1 Competition

Supplier A with higher marginal costs generates earnings in two different ways: Selling water to customers connected to the own network and levying an access charge. It can be shown (Foellmi and Meister, 2003) that the inefficient supplier will not sell water to customers connected to the low-cost-competitor's network. The profit of a supplier A is given as follows:

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

where p_1 denotes the retail prices in market 1. q_{1A} stands for the quantity of sold water produced by A to customers connected to network 1, q_{1B} stands for the quantity of sold water produced by B to customers connected to network 1. Utility A levies an access charge which consists of a variable access price a_1. As there is no regulation, A is free to set the access charge. And as Bs marginal costs are constant, its decision problem can be fully described by considering its profit from market 1. Such profit is given as follows:

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

The model consists of two stages. In a first stage supplier A chooses the access prices a_1. Given the access charge A and B simultaneously set production quantities q_{1A} and q_{1B} in the second stage.[8] In order to compare welfare between the competition and the trade regime we have to analyse the relevant effects on retail prices and production efficiency. We solve the model by backwards induction. Given a_1, the firms choose their quantities q_{1A} and q_{1B}.:

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

[8] Obviously supplier A would be able to prevent any competition by charging extensive high access charges in the first stage. On the second stage A and B would choose q_{2A} respectively q_{1B} equal to zero – access would not take place. Allowing common carriage would not have any positive welfare effects compared to a situation, where two independent monopolists act in their own markets. However, it can be shown (see Foellmi and Meister, 2003), that the inefficient utility A voluntarily opens its network to the low-cost competitor B.

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

where $\partial p_1(\cdot)/\partial q_{1A} = \partial p_1(\cdot)/\partial q_{1B} \equiv p_1'$. In the first stage, monopolist A sets a_1:

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

As usual the optimal access price depends on the quantity reaction of B, captured by the dq_{1B}/da_1 term. Considering the term $p_1' q_{1A}$, A perceives that a reduction of q_{1B} increases prices in the retail market. Note that the quantity reaction of A does not affect marginal profits because of the Envelope theorem. The quantity reaction of B can be determined by differentiation of equations (3) and (4), whereas the former only has to taken into consideration if $q_{1A} > 0$. We get

$$\frac{dq_{1B}}{da_1} = \left[q_{1B} p_1'' + 2p_1' - \frac{\left(q_{1A} p_1'' + p_1'\right)\left(q_{1B} p_1'' + p_1'\right)}{q_{1A} p_1'' + 2p_1' - C_A''} \right]^{-1} \qquad \text{if} \qquad q_{1A} > 0 \qquad \text{and}$$

$$\frac{dq_{1B}}{da_1} = \left[q_{1B} p_1'' + 2p_1' \right]^{-1} \qquad \text{if} \qquad q_{1A} = 0 \qquad (6).$$

We assume that the reaction curves (in quantities) are falling, so $q_{1j} p_1'' + p_1' < 0$. We note that the absolute value dq_{1B}/da_1 is larger when $q_{1A} > 0$ than for the case $q_{1A} = 0$. The quantity reaction of B is therefore stronger when A produces. This result is due to the strategic complementarity of quantities. An increase in a_1 reduces q_{1B} (direct effect). This leads in turn to an increase in the quantity of the competitor q_{1A}, which induces B to produce even less (indirect effect). We first analyse p_1 under the assumption that utility A still produces a positive amount of water itself. By using equation (6) in (5), solving it for a_1 and inserting the result into (4) we can derive the relevant retail price in market 1.

$$p_1 = -q_1\left(q_1 p_1'' + 3p_1'\right) + q_{1A}\left[2p_1' + \left(q_1 + q_{1B}\right)p_1''\right] + q_{1B}\frac{\left(q_{1A} p_1'' + p_1'\right)\left(q_{1B} p_1'' + p_1'\right)}{q_{1A} p_1'' + 2p_1' - C_A''} + c_B \qquad (7),$$

if $\quad q_{1A} > 0 \quad$ and where $q_1 = q_{1A} + q_{1B}$.

Equation (7) only holds if $q_{1A} > 0$, or equivalently, the implied value of p_1 is larger than $C_A'(0)$. Considering the regularity assumptions above, an increase in $C_A'(0)$ implies a reduction of q_{1A}. According to equation (3) A *stops* the own production exactly where $p_1 = C_A'(0)$. In this case, A becomes a pure network operator. If marginal costs $C_A'(0)$ increase further it is optimal for A to increase the access fee[9] a_1 such that the retail price p_1 rises (but p_1 increases less than $C_A'(0)$ as our regularity assumptions guarantee uniqueness). Taken together, the retail price p_1 is smaller than or equal to $C_A'(0)$ if $q_{1A} = 0$ and follows directly from (4), (5) and (6):

$$p_1 = \min\left\{C_A'(0),\ -q_{1B}(q_{1B}p_1''+3p_1')+c_B\right\} \quad \text{if} \quad q_{1A}=0 \qquad (8)$$

In both cases the high-cost utility A reduces own production (if it was not already zero before) and the low-cost utility B increases production, so the differential of A's and Bs marginal costs diminishes and overall efficiency in the water market increases. Due to decreasing marginal production costs in market 1 the introduction of competition reduces retail prices and raises sold water volume. Obviously welfare must be higher than in the status quo, where the two utilities act as independent monopolists. However, since A levies a positive linear access price a_1, welfare is negatively affected by a double marginalisation problem. In its decisions about quantities and therefore prices utility B faces relevant marginal costs of (c_B + a_1). Hence B will limit its engagement q_{1B} in market 1 below the socially optimal amount, which would guarantee efficiency of production. In fact if B were a monopolist in market 1, according to the Amoroso Robinson equation he would set $p_1 = -p_1'q_{1B} + c_B$. This is smaller than p_1 in equation (8) since $-p_1'q_{1B} + c_B = p_1 - a_1 < C_A'(0)$ according to equation (4) and since $-p_1'q_{1B} + c_B < -q_{1B}p_1' - q_{1B}(q_{1B}p_1''+2p_1') + c_B$ since $q_{1B}p_1''+2p_1' < 0$ according to equation (6).

In both cases supplier A and B share the additional profit resulting from the introduction of competition. In our general analysis we forbear from doing a more detailed analysis regarding the profit distribution between A and B.

3.2 Trade

We have shown that introducing product market competition between neighbouring water utilities can lead to significant efficiency and therefore welfare gains in the water industry. However, one could argue that similar effects could result from introducing unregulated cross border trade amongst neighbouring utilities. It is obvious that a high cost utility A has

[9] Since $q_{1A} = 0$ the above mentioned strategic effect is no longer existent. Hence it is optimal for A to raise a_1 since B will reduce its engagement in market 1 less strongly.

incentives to buy treated water from the more efficient utility B that faces lower marginal costs of water treatment. Buying inexpensive water from B allows A to reduce own water treatment respectively to reduce the use of inferior raw water resources and therefore cost of production. B on the other side can earn additional profit by these trading activities. Due to the constant marginal costs c_B the decision problem of B reduces to the analysis of its trading activities. The reduced profit is given by:

$$\Pi_B = q_T(p_T)p_T - c_B q_T(p_T) \qquad (9),$$

where q_T stands for the quantity of water that B sells to A and p_T describes the trade price. A on the other side derives revenues solely from selling water to customers located in network 1. Own production of A is now denoted by q_A to avoid confusion with the competition case. A's profit can therefore be defined as follows:

$$\Pi_A = p_1(q_1)(q_A + q_T) - C_A(q_A) - p_T q_T \qquad (10),$$

where $q_1 = q_A + q_T$. Cross border trade implies three different market places: On the one side the retail markets 1 and 2, where the utilities act as monopolists, and on the other side the wholesale market for treated water resources. The latter market is characterised by a *bilateral monopoly*. One seller and one buyer bargain over the trade price and quantity and therefore the allocation of gains from trade (which are positive because marginal costs of A are higher than those of B). We assume that the equilibrium amount of trade is the outcome of a Nash bargaining between A and B with exogenously given bargaining power. As our model describes trade between fully informed but unequal players the relevant bargaining power of the two parties can be different. There are several empirical studies addressing the issue of bargaining power in bilateral monopolies (e.g. Chipty and Snyder, 1999, Kauf, 1999, Kajisa and Sakurai, 2000). Kajisa and Sakurai analyse it for water trade in the agrarian sector in India. According to their analysis seller's power is positively correlated with its physical capital respectively total amount of investment into the water production facilities. They also found some empirical evidence in support of a weak sellers' bargaining position in the Indian water market. Social constraints may hinder sellers to enjoy unacceptable amounts of excess profits. In order to make the impact of different bargaining power apparent, we focus in the following analysis the two polar cases, where only the seller respectively the buyer has the entire bargaining power.

3.2.1 Full Bargaining Power of Utility B

We first consider the perhaps more intuitive case where the more efficient utility B has the entire bargaining power on the wholesale market. Seller B defines the relevant trade price and makes a "take it or leave it" offer to utility A. Obviously B sets a trade price that maximises its profit from trading activities described by equation (9). Maximization of Bs trade profit with respect to p_T yields to the following first order condition:

$$\frac{\partial \Pi_B}{\partial p_T} = q_T + (p_T - c_B)\frac{\partial q_T}{\partial p_T} = 0 \qquad (11).$$

In order to define $\partial q_T / \partial p_T$ which describes the slope of A's demand function for treated water on a trading market we need to analyse its profit, which is described by equation (10). Maximization of A's profit with respect to q_A and q_T yields the following first order conditions:

$$\frac{\partial \Pi_A}{\partial q_A} = q_1 p_1' + p_1 - C_A' \leq 0 \qquad (12) \quad \text{and}$$

$$\frac{\partial \Pi_A}{\partial q_T} = q_1 p_1' + p_1 - p_T = 0 \qquad (13).$$

In case of utility A decides to produce itself a positive amount of water ($q_A > 0$) inequation (12) turns into an equation. Total differentiation of (12) and (13) and applying Cramer's rule we derive the slope of the demand schedule, dq_T / dp_T.

$$\frac{\partial q_T}{\partial p_T} = \frac{q_1 p_1'' + 2p_1' - C_A''}{(q_1 p_1'' + 2p_1')(-C_A'')} = \frac{1 - \left[\frac{\partial MR_A}{\partial q_1} \Big/ C_A''\right]}{\frac{\partial MR_A}{\partial q_1}} \qquad (14) \qquad \text{if} \quad q_A > 0$$

where $MR_A = \partial \Pi_A / \partial q_1$ denotes A's marginal revenues ($\partial MR_A / \partial q_1 < 0$). Note that the above defined slope of the demand curve is only valid when utility A produces water as well ($q_A > 0$). If $C_A'(0)$ exceeds p_T, A gives up own production and becomes a pure water broker. In this case A purchases the entire amount of water which is necessary to cover demand in market 1. Obviously this can happen when A is very inefficient compared to B. In order to define now the slope of the demand curve we can neglect equation (12), since $q_A = 0$. Total differentiation of (13) and solving for dq_T / dp_T yields

$$\frac{\partial q_T}{\partial p_T} = \frac{1}{q_1 p_1'' + 2 p_1'} = \frac{1}{\frac{\partial MR_A}{\partial q_1}} \qquad (15) \qquad \text{if} \qquad q_A = 0\ .$$

The demand curve is less elastic after utility A decides to stop own production ($q_A = 0$), since the right hand side of equation (15) is less negative than the right hand side of (15). A is therefore more sensitive to changes in p_T when it still produces itself ($q_A > 0$). If A still produces own water, an increasing trade price p_T would make A expand its own production – A would substitute q_T by q_A. A higher C_A'' reduces A's opportunities to substitute q_T by q_A since own water production would be too costly. A steeper marginal cost curve reduces therefore price elasticity of demand.

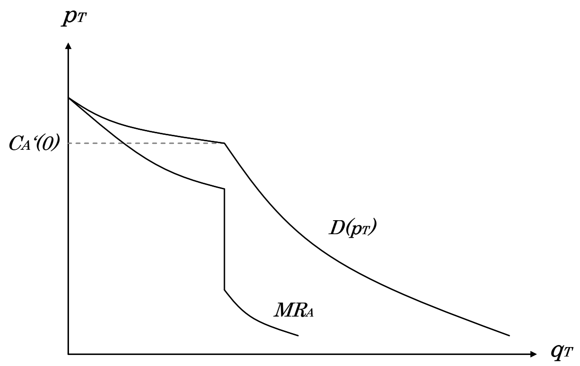

Figure 2: Demand for traded water

A decides to stop own production when $C_A'(0) > p_T$. In this case own production is more expensive than purchasing water from the neighbouring utility B. As mentioned above, the demand curve changes its slope depending whether A produces a positive amount of water or not (see Figure 2). The relevant bend in the demand curve for traded water must therefore be at a trade price $p_T = C_A'(0)$.

3.2.1.1 Competition versus trade

After defining A's demand curve we are able to compare the trade regime with the competition regime. In order to carry out the comparison for all parameter values, it turns out useful to separate the cases whether – for both regimes – A keeps own water production or gives it up completely. The sign of the welfare comparisons may be different depending on whether A produces or not. The possible outcomes when comparing trade with competition are given in the following Table 1.

	Case 1a $C_A'(0) > \hat{p}_1$	*Case 1b* $C_A'(0) = \hat{p}_1$	*Case 2a* $\hat{p}_1 > C_A'(0) > \hat{p}_T$	*Case 2b* $C_A'(0) = \hat{p}_T$	*Case 3* $C_A'(0) < \hat{p}_T$
Trade	$q_A = 0$		$q_A = 0$		$q_A > 0$
Competition	$q_{1A} = 0$		$q_{1A} > 0$		$q_{1A} > 0$

Table 1: Cases to compare

To read Table 1 note that we reduce A's marginal costs as we move from case 1 to case 3. We divide case 1 in 1a and 1b to account for the discrete change in dq_{1B} / da_1 which occurs at $q_{1A} = 0$ (see equation (6)). We divide case 2 in 2a and 2b in order to consider different trade prices due to the bend in the demand curve for traded water (see Figure 2). The equilibrium values for the retail price in market 1 and the trade price on the wholesale market are denoted by $\hat{p}_1$ and $\hat{p}_T$, respectively. Of course, prices depend on C_A' in general. However it is easy to see that the case ordering in Table 1 is still applicable.[10] According to equation (3) in the competition regime, utility A produces a positive amount of water if and only if $\hat{p}_1 > C_A'(0)$. With trade, equations (13) and (12) apply; we see that A produces only if $\hat{p}_T < \hat{p}_1$ respectively $C_A'(0) < \hat{p}_T$ where $\hat{p}_T < \hat{p}_1$. Because of this double marginalisation argument A's incentives to produce a positive amount of water are stronger in case of competition.

We start analysing case 1a where A decides to give up completely its own production. From equation (8) we know that the retail price is given by:

$$p_1 = -q_{1B}(q_{1B}p_1'' + 3p_1') + c_B \qquad (16)$$

In the trade regime we apply equations (14) and (15) in (11) to get

$$p_1 = -q_T(q_T p_1'' + 3p_1') + c_B \qquad (17).$$

[10] Let us start in case 1 where $C_A'(0)$ is high. When $C_A'(0)$ decreases, $\hat{p}_1$ remains fixed as long as $q_A = q_{1A} = 0$. When we enter Case 2a – where $q_{1A} > 0$ – price p_1 begins to fall. However it cannot fall below $C_A'(0)$ again. Otherwise A would choose $q_{1A} = 0$ and p_1 would be equal to that in case 1. But this price is higher than $C_A'(0)$ contradicting our assumption. For case 2b and 3 the argument is analogous.

Proposition 1: *In case 1a retail price, production efficiency and resulting welfare are equal in the trade and competition regime.*
Proof: *Equations (16) and (17) imply $q_{1B} = q_T$ since $q_{1A} = q_A = 0$. As water is produced within the efficient utility B only, the production costs and thus welfare are equal for both regimes.*

When $C_A'(0)$ equals the retail price p_1 given by (16), we enter case 1b. Now, the retail price is given by $C_A'(0)$ (see equation (8)). Obviously p_1 in the competition regime begins to fall, as $C_A'(0)$ falls further. However, the lower retail price implies a lower access price than in case 1a. This is an interesting result: *A*'s profit declines when he becomes more efficient. The reason is that *A* cannot credibly commit not to produce on his own at the second stage when he would set the access price too high. The thread that *A* will start own production makes *B*s quantity reaction to an access price change more elastic which implies that *A* will set lower access prices in equilibrium. This implies that in case 1b welfare is strictly higher in the competition regime. Prices are lower and production is still efficient since only *B* produces.

Proposition 2: *In case 1b welfare is always higher in the competition regime.*
Proof: *The reduced level of $C_A'(0)$ implies a lower retail and access price in the competition regime compared to case 1a. However, since $q_{1A} = 0$ production efficiency is the same. In the trade regime nothing changes to case 1a.*

Case 2a compares the competition regime, where *A* keeps (parts of) its own production, to the trade regime, where *A* completely gives up its water production. The formulae for the trade regime are the same for both cases 1 and 2a, so equation (17) still holds. However, in the competition regime the retail price is given by equation (7). It is shown in proposition 3 that the retail price is always lower in the competition regime. The intuition can be grasped as follows: in case of trade only one monopolistic firm is present in market 1 (in case 2). In the access regime the retail price tends to be lower since there are two utilities engaged in Cournot competition and hence do not take the change in their competitor's profits into account when setting their quantities. However, even when prices are lower in the competition regime, welfare could still be higher with trade. The reason is higher production efficiency with trade. In the competition regime the inefficient utility produces a positive amount of water – as a result average production costs must be higher than in the trade regime. Therefore competition tends to work better when *A*'s marginal cost are relatively high – because in such a case *A*'s own production stays small (or equals zero as in case 1b). In fact our simulations in section 5 show that the productive efficiency effect dominates the consumer surplus effect when the marginal cost differential between A and B is smaller ceteris paribus.

Proposition 3*: For case 2a the welfare comparison is ambiguous. The retail price p_1 is always lower under competition, but production efficiency is higher in the trade regime.*
Proof: *The price in the case 2a is strictly lower for the competition case. The right hand side of (7) is strictly lower than that of (17) because* $q_{1j}p_1''+p_1'<0$.

Obviously, from a consumer's viewpoint competition is always more favourable, since consumer surplus is determined by the level of the retail price p_1.

Since cases 2b and 3 do not raise any qualitatively new issues, we keep their discussion short. The only distinctive feature is that – compared to the competition regime – the relative prices with trade are lower than in cases 1 and 2a. In case 2b the relative difference between $C_A'(0)$ and c_B is small enough such that the marginal costs of B cross the marginal revenue curve at the vertical segment (see Figure 2). Hence $p_T = C_A'(0)$. Therefore A maximises its profits similar to an independent monopolist facing constant marginal costs p_T. The relevant retail price in the trade regime reads now:

$$p_1 = C_A'(0) - q_T p_1' \qquad (18)$$

Obviously this price lies between the trade price of the trade regime in case 2a and 3. In Case 3 both utilities keep their water production. The demand curve for water on the trade market is now defined by equation (14). Using equations (11), (13) and (14) we derive price p_1 in the trade regime

$$p_1 = -q_1(q_1p_1''+3p_1') + (\mu q_A + (1-\mu)q_1)(q_1p_1''+2p_1') + c_B \qquad (19),$$

where $\mu = C_A''(q_A)/[C_A''(q_A) - (2p_1'+q_1p_1'')] < 1$. Since $q_1 > q_A$ the retail price p_1 in the trade regime tends to be smaller than in cases 1 and 2a. This result induces that the relative performance of the trade regime in case 3 tends to be more advantageous than in 2a. However, it is still not obvious whether p_1 is lower than in the competition regime. The price differential is now determined both by the curvature of the demand and the value of $q_1(1-\mu)+q_A\mu$. To sum up, the trade regime performs "better" in comparison to the competition regime when A's marginal costs are at lower levels. The reason is that the price setting possibilities for B are now limited which dampens the double marginalisation effect of trade pricing.

Independent from the curvature of the demand curve, production efficiency in the trade regime is still higher although the inefficient utility *A* produces also in the trade regime when case 3 is relevant. However, and as mentioned above, *A*'s incentives to produce a positive amount of water are always stronger under competition than under trade. The amount of traded water must therefore be higher than the amount of water sold by *B* trough access, $q_T > q_{1B}$. This means that the more efficient utility *B* produces in the trade regime a higher part of the entire water quantities sold in market 1 and 2. Total production costs are therefore lower than in the competition regime.

Apart from the effects regarding retail price and efficiency it is worth mentioning the distribution of profits. The roles of *A* and *B* differ fundamentally in the competition and trade regime. In the trade regime the less efficient utility *A* acts as a downstream monopolist while in the competition regime *A* is an upstream monopolist. For most demand functions an upstream monopolist is able to skim the main part of the overall profit – e.g. two thirds in case of a linear demand function.

3.2.2 Full Bargaining Power of Utility A

Let us now analyse the other polar case where less efficient utility *A* has the entire bargaining power on the wholesale market. This means the buyer *A* defines the relevant trade price and makes a "take it or leave it" offer to utility *B*. Having the entire bargaining power utility *A* maximises its own profit represented by equation (9) subject to *B*s participation constraint denoted by $p_T q_T \geq c_B q_T$. Obviously *A* will offer a trade price $p_T = c_B$. Offering a higher trade price would reduce *A*'s profit since it causes higher costs, offering a smaller trade price would violate *B*s participation constraint. In such a setting *B*s marginal cost curve represents the supply curve on the wholesale market for treated water. Of course this is a well-known result which goes back at least to Tintner (1939) and Morgan (1949).

The equilibrium production structure is quickly determined. *A* reduces its own water production q_A until C_A' is equal to $p_T = c_B$. If $C_A'(0)$ exceeds p_T, *A* gives up own production and becomes a pure water broker. Due to the resulting equalisation of marginal costs overall production efficiency in market 1 and 2 is maximised and therefore aggregated profits rise compared to the autarky situation. Purchasing water resources from *B* at price $p_T = c_B$ allows the less efficient utility *A* to extract the full rent of the additional profit induced by the increased efficiency. Similar to the trade regime in cases 1 and 2 of section 3.2.1 highest possible production efficiency can be achieved. However, due to the marginal cost pricing at the wholesale market the problem of double marginalisation can be totally removed. *A* therefore faces exactly the same maximisation problem as an independent monopolist with marginal costs c_B und sets $p_1 = -q_1 p_1' + c_B$. Due to the non-existent double marginalisation the relevant retail price must be lower and welfare higher than in a trade regime where the more efficient utility B has some positive bargaining power. However, it is in general not clear whether p_1 is lower than in the competition regime as under trade A acts as a monopolist on its home market.

4 Linear Analysis

In order to illustrate the results derived for general demand functions in section 3.2.1 (where B has the entire bargaining power in the trade regime) more detailed, we use an example with linear demand and cost functions. However, using linear costs for both utilities excludes case 3 because a less efficient utility A would never have any incentives to produce a positive amount of water in a trade regime since A's constant marginal production costs (now denoted by c_A) always exceed c_B. Therefore our linear example analyses and compares competition and trade in cases 1 and 2. We define the inverse demand in market 1 as follows:

$$p_1 = k - bq_1 \qquad (20)$$

Using equations (3), (4), (5), (13), (15), (17) and (20) we obtain explicit expressions for the equilibrium prices and production quantities in the two different regimes. We know from our general analysis that there are three possible states in the competition regime: case 1a and case 1b, where A stops own production and case 2, where A keeps its own production. The equilibrium will be in case 2 if and only if the resulting retail price p_1 in market 1 exceeds marginal costs c_A

$$q_{1A} > 0 \quad \text{if} \quad p_1 = \frac{3k + c_B}{4} > c_A .$$

As mentioned above, in the trade regime one has to consider only one possible state: A does not produce a positive amount of water. However, one has to differentiate case 2b, the bend of the demand curve, from cases 1 and 2a. In case 2b Bs marginal cost curve cuts its marginal profit curve from trading activities in its vertical range. Hence for $c_A \le (k + c_B)/2$ it is profit maximising for B to set $p_T = c_A$. To derive the relevant equilibrium values in cases 1 and 2a the slope of the demand curve for traded water has to be determined. Using equations (15) and (20) we get $\partial q_T / \partial p_T = -1/(2b)$. Table 1 illustrates the relevant equilibrium values for both the competition and the trade regime. Additionally it shows the equilibrium values for a monopoly regime in order to create a benchmark case.

	p_1	q_1	q_{1A}	q_{1B}	a_1 or p_T
Monopoly	$\frac{k+c_A}{2}$	$\frac{k-c_A}{2b}$	$\frac{k-c_A}{2b}$	-	-
Competition (Case 1a)	$\frac{3k+c_B}{4}$	$\frac{k-c_B}{4b}$	-	$\frac{k-c_B}{4b}$	$a_1=\frac{k-c_B}{2}$
Competition (Case 1b)	c_A	$\frac{k-c_A}{b}$	-	$\frac{k-c_A}{b}$	$a_1=2c_A-k-c_B$
Competition (Cases 2a & 2b)	$\frac{5k+3c_A+2c_B}{10}$	$\frac{5k-3c_A-2c_B}{10b}$	$\frac{5k-7c_A+2c_B}{10b}$	$\frac{2(c_A-c_B)}{5b}$	$a_1=\frac{5k-c_A-4c_B}{10}$
Trade (Cases 1 & 2a)	$\frac{3k+c_B}{4}$	$\frac{k-c_B}{4b}=q_T$	-	$\frac{k-c_B}{4b}$	$p_T=\frac{k+c_B}{2}<c_A$
Trade (Case 2b)	$\frac{k+c_A}{2}$	$\frac{k-c_A}{2b}=q_T$	-	$\frac{k-c_A}{2b}$	$p_T=c_A$

Table 2: Retail prices, quantities and access respectively trade prices.

Figure 3 illustrates and compares the above derived results regarding the retail price. The figure defines retail price p_1 as a function of marginal costs c_A in the monopoly, trade and competition regime.

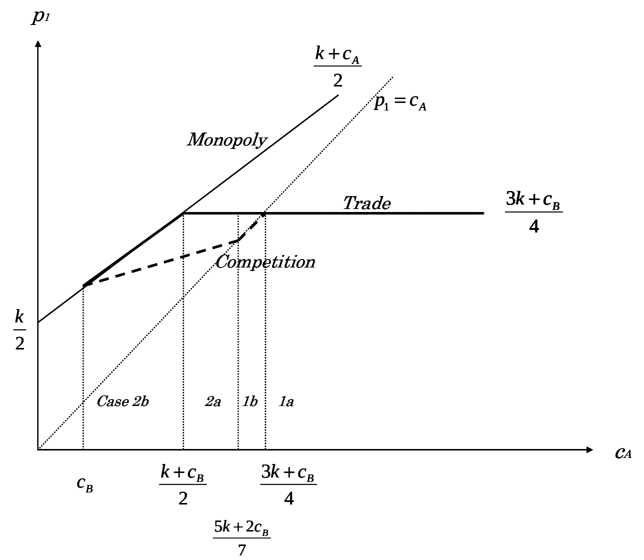

Figure 3: Retail price in market 1: monopoly, trade and competition

4.1 Trade versus Competition

As mentioned above the roles of A and B change when moving from competition by access to trade. A acts in the trade regime as a downstream company, in the competition regime as an upstream company. For B the reverse holds. Figure 4 illustrates this fact.

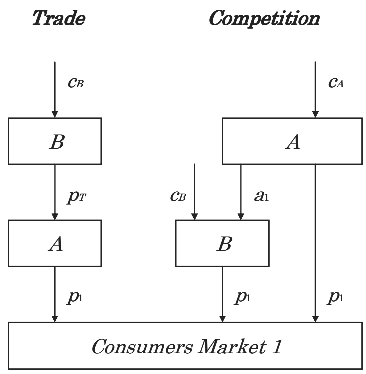

Figure 4: Market structure: trade versus competition

The linear analysis allows us to extract more intuition of the general result stated in proposition 1. For case 1a we derived the result that p_1 is the same for both the competition and trade regime. However, in the trade regime consumers are exclusively served by the downstream company A, in the competition regime by the downstream company B. Their relevant marginal costs correspond to the same level since $p_T = a_1 + c_B$. Since both downstream companies face isomorphic profit maximisation problems, in equilibrium p_1 and q_1 and therefore consumer rent correspond to the same level. And since water is only produced by the more efficient utility B, aggregate profits must be equal as well. We conclude that the resulting welfare is the same in both regimes. However, the *distribution* of the aggregate profits between A and B is different. With linear demand, the corresponding upstream monopolist receives two thirds of aggregate profits. Hence, the inefficient utility A is better off in the competition regime. In case 1b the retail and the access price in the competition regime are lower than in case 1a. Obviously A's engagement must be higher than in case 1a. Similar to case 1a only the more efficient B produces. As stated in proposition 2 we can follow that in case 1b welfare is always higher in the competition regime.

The result may change when moving to case 2. As stated in proposition 3 the retail price p_1 is still lower under competition than under trade. The lower retail price is due to A's engagement in market 1 which implies a higher overall production quantity in market 1 (see Table 2). Again, the lower retail price positively affects welfare in the competition regime. However, since $c_B < c_A$ average production costs are higher with competition which negatively affects welfare. At high levels of c_A where A's production is still small, the price effect dominates. However, when the neighbouring water utilities' cost differential becomes smaller, the production inefficiency effect becomes relatively more important since the price difference between competition and trade declines (see Figure 3). Our simulations in section 5 show that welfare is higher in the trade regime when c_A is lower. How are profits distributed? With linear demand, the upstream monopolist skims two thirds of the aggregate profits in both regimes. In the trade regime B gets two thirds of aggregate profits. In the competition regime aggregate profits are lower due to lower productive efficiency. Obviously A is able to skim more than two thirds of aggregate profits because A also acts as a producer in the downstream market.

4.2 Shifting the Bargaining Power

The linear analysis can easily be extended to the trade regime in section 3.2.2 where the entire bargaining power is shifted to the less efficient utility A. Now, utility A can buy treated water at a trade price $p_T = c_B$. A stops own production completely and purchases the entire water from B since $c_A > p_T$. A therefore faces exactly the same maximisation problem as an independent monopolist with marginal costs c_B. The retail price is therefore determined as follows: $p_1 = (k + c_B)/2$. Since $k > c_A > c_B$ such retail price must be lower than the relevant retail prices in the competition regime. The relevant quantity q_1 is given by $q_1 = (k - c_B)/2b$. Figure 5 illustrates the relevant retail prices.

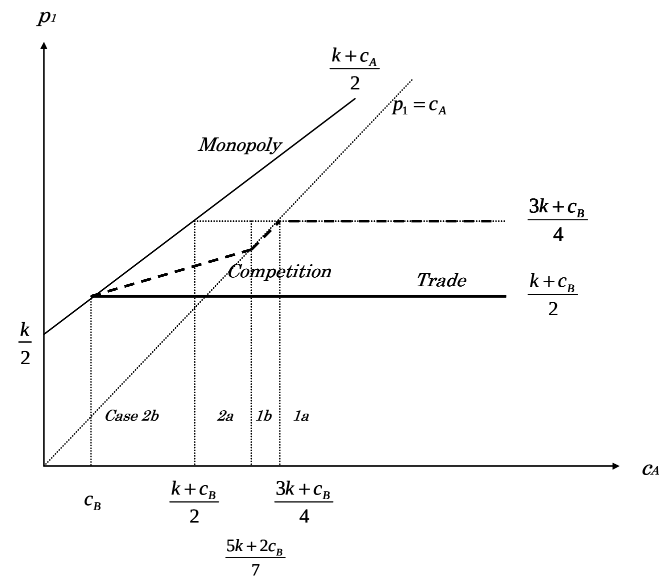

Figure 5: Retail price in market 1 (A has the entire bargaining power)

Since the entire water sold in market 1 is produced at marginal costs c_B highest possible production efficiency can be achieved in the trade regime. And since the relevant retail price p_1

is lower than in the competition regime and than in the trade regime where B has the entire bargaining power, welfare can be improved.

4.3 Introducing Price Regulation

In most European countries water supply is provided by public utilities or regulated private companies. In both cases it is assumable that water suppliers' freedom to set prices is significantly restricted. Up to this point the model does not consider any kind of regulation. One might wonder if the above derived results fundamentally change when price regulation is taken into account. Price regulation can basically be applied for access and retail prices. First we examine the effects of an access price regulation and then the effects of a retail price cap.

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. The relevant retail price is illustrated in Figure 6:

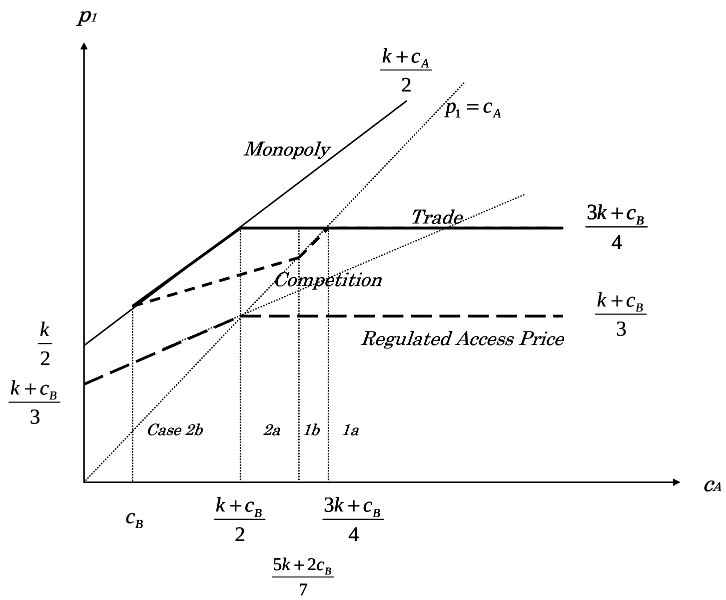

Figure 6: Retail price in market 1 (with 1st best regulated access price)

The regulation of the access price increases the degree of competition in market 1 and therefore reduces the relevant retail price compared to unregulated competition and trade. Similar to the trade regime the less efficient utility A does not have any production incentives in cases 1a, 1b and 2a because only B produces a positive amount of water when $c_A > (k + c_B)/2$. Welfare is then the highest in the regulated access price regime[11]. However, marginal cost pricing does not allow the incumbent to cover fixed network costs such as costs for investment and maintenance. If the incumbent cannot be compensated by subsidies, access prices are required to consider fixed costs. This can be realised by charging an additional lump sum fee to the market entrant or by charging a mark up over marginal costs.[12] However, introducing a mark up over short run marginal costs reduces the relative performance of the regulated access price regime. When $a_1 > 0$, B faces marginal costs of access and reduces its engagement in market 1. The resulting retail price p_1 would be higher than illustrated in Figure 6. To regulate access prices in practice, sufficient accounting data must be available and physical depreciation must be measured adequately. But due to asymmetric information an incumbent firm may be able to manipulate such data: While an incumbent itself is able to assess costs accurately, the regulator as an outsider cannot observe and verify them properly. In addition the regulation of access prices in the water industry is expected to be very complex and costly (see section 2.1). Henceforth water suppliers' freedom to set access prices is significant and it is difficult to achieve the first best access price.

Finally, consider the regulation of retail prices. Ex ante retail price regulation by price cap is applied for instance in England and Wales.[13] The regulator fixes the retail price at $\overline{p_1}$. Demand in market 1 is then given by $q_1(\overline{p_1}) = \overline{q_1}$. In order to analyse the potential effects of regulation we assume that $\overline{p_1}$ is below the equilibrium retail prices in both regimes. Using such a price cap implies that consumer surplus must be equal in both regimes. Regulation therefore withdraws the benefit of the competition regime described above. The only source of welfare differences can therefore be due to differences in productive efficiency. Obviously the introduction of the price cap in a trade regime does not change the overall productive efficiency. Again, in the relevant cases 1a, 1b, 2a and 2b only the more efficient utility B produces a positive amount of water. In contrast, the introduction of a price cap may change the productive efficiency under competition. Now, the less efficient supplier A faces lower production incentives in case 2a and 2b than in an unregulated model, since we assumed $(3k + c_B)/4 > \overline{p_1}$. A keeps its own production in the competition regime only when c_A is below the relevant retail price in market 1. A reduction of the retail price due to regulation therefore reduces the less efficient utility's production incentives. Hence the productive efficiency in the

[11] However, since A does not charge a variable access price, there is a hazard for inefficient market entry: A would enter market 1 even when $c_B > c_A$.

[12] In practice, usually the latter alternative is chosen. In its guidance for the access price calculation the English water regulator Ofwat suggests three different methodologies: average accounting costs (AAC), long run marginal costs (LRMC) and the efficient component pricing rule (ECPR) (see Ofwat 2002, p. 22).

[13] Several other countries such as Switzerland use a different approach. Water utilities operating independently from the municipal body calculate their tariffs autonomously and communal authorities are required to approve them ex post. Of course, such difference in regulation practice leads to the same outcome in our model.

competition regime can be improved by the implementation of a price cap. However, as long as $\overline{p_1} > c_A$ the less efficient utility A still produces a positive amount of water. Therefore productive efficiency and welfare are still higher (or equal) with trade than with competition.

5 Simulation

In section 4.1 we indicated that welfare is higher in the trade regime when the cost differential between the two firms is small. With larger cost differences, welfare is higher in the unregulated competition regime or equal in both regimes. One may ask whether these results are robust when assuming a more general demand or increasing marginal costs. In this section we simulate the (unregulated) model of section 3 and perform some comparative statics. We allow for non-linear demand and increasing marginal costs of A. Demand is defined as $p_1 = k - bq_1^{\eta}$, where η determines the curvature of water demand, and A's marginal costs as $C_A'(q_A) = c_0 + c_1 q_A$. Bs marginal costs c_B are assumed to be linear. Since the relative performance of trade is stronger when A has the entire bargaining power we restrict our analysis to a situation where the more efficient utility has the bargain power. First we apply comparative statics by varying A's marginal costs (see Table 3). We assume $b = 1$, $\eta = 1$, $k = 12$, $c_1 = 1$ and $c_B = 2$.

	Trade				*Competition*				*W^{Comp} (W^{Trade}/100)*
c_0	*p_1^{Trade}*	*p_T*	*q_1^{Trade}*	*W^{Trade}*	*p_1^{Comp}*	*q_{1A}^{Comp}*	*q_1^{Comp}*	*W^{Comp}*	
7.0	*9.500*	*7.000*	*2.500*	*21.875*	*8.852*	*0.926*	*3.148*	*21.468*	*98.1*
7.5	*9.500*	*7.000*	*2.500*	*21.875*	*8.944*	*0.722*	*3.056*	*21.654*	*99.0*
8.0	*9.500*	*7.000*	*2.500*	*21.875*	*9.037*	*0.519*	*2.963*	*21.994*	*100.5*
8.5	*9.500*	*7.000*	*2.500*	*21.875*	*9.130*	*0.315*	*2.871*	*22.488*	*102.8*
9.0	*9.500*	*7.000*	*2.500*	*21.875*	*9.222*	*0.111*	*2.778*	*23.136*	*105.8*
9.273	*9.500*	*7.000*	*2.500*	*21.875*	*9.273*	*0.000*	*2.727*	*23.554*	*107.8*
9.5	*9.500*	*7.000*	*2.500*	*21.875*	*9.500*	*0.000*	*2.500*	*21.875*	*100.0*

Table 3: Varying the cost differential

Note first that for $c_0 \geq 9.5$ A decides in both regimes to stop own production and welfare is equal in both regimes (case 1a). For $9.5 > c_0 \geq 9.273$ we are in case 1b. We see that the welfare of the competition case is strictly higher than in the trade regime. As we decrease A's marginal costs further, the welfare advantage of the competition regime begins to shrink because the inefficient utility increases its own production. For c_0 smaller than 8 the productive inefficiency is so high such that welfare is higher under trade.

	Trade				*Competition*				*W^{Comp} (W^{Trade} /100)*
η	p_1^{Trade}	p_T	q_1^{Trade}	W^{Trade}	p_1^{Comp}	q_{1A}^{Comp}	q_1^{Comp}	W^{Comp}	
0.6	*8.094*	*5.750*	*9.689*	*73.233*	*8.003*	*0.002*	*10.068*	*75.511*	*103.1*
0.7	*8.540*	*6.118*	*5.890*	*46.915*	*8.357*	*0.254*	*6.341*	*48.261*	*102.9*
0.8	*8.914*	*6.444*	*4.091*	*33.894*	*8.631*	*0.397*	*4.565*	*34.646*	*102.2*
0.9	*9.230*	*6.737*	*3.102*	*26.499*	*8.852*	*0.475*	*3.576*	*26.869*	*101.4*
1.0	*9.500*	*7.000*	*2.500*	*21.875*	*9.037*	*0.519*	*2.963*	*21.994*	*100.5*
1.1	*9.732*	*7.238*	*2.105*	*18.776*	*9.196*	*0.542*	*2.553*	*18.725*	*99.7*
1.2	*9.934*	*7.455*	*1.831*	*16.588*	*9.335*	*0.553*	*2.263*	*16.415*	*99.0*
1.3	*10.110*	*7.652*	*1.632*	*14.979*	*9.459*	*0.559*	*2.049*	*14.716*	*98.2*
1.4	*10.264*	*7.833*	*1.483*	*13.757*	*9.571*	*0.560*	*1.885*	*13.424*	*97.6*
1.5	*10.400*	*8.000*	*1.368*	*12.804*	*9.672*	*0.560*	*1.756*	*12.415*	*97.0*

Table 4: Varying the curvature of the demand curve

Table 4 varies the curvature of the demand curve. We assume $b = 1$, $k = 12$, $c_0 = 8$ $c_1 = 1$, $c_B = 2$ and vary the curvature of the demand curve, which is described by η. In cases 1b and 2 the retail price p_1 is always lower in the competition regime than in the trade regime. The intuition from Ramsey pricing suggests that the positive welfare effect of lower prices should be stronger in the case of a more elastic demand (lower η). As Table 4 shows, this holds true in the numerical simulation. For elastic demand, competition works better whereas in the inelastic case trade prevails.

6 Conclusions

We showed that both, the introduction of (unregulated) common carriage on the one side and trade on the other side, enhance the efficiency of water supply. Since water utilities often face very different marginal costs due to the use of different raw water resources or different production scales, the exchange of treated water increases the efficiency of the overall water production and reduces the retail price. Both competition and trade allow less efficient suppliers to reduce own production and/or to overcome their capacity constraints while more efficient suppliers enhance production by raising their treatment facilities' rate of capacity utilisation. Welfare gains can be achieved. However, using a simple model that considers water markets specificities we showed that the relevant welfare gains in the two regimes may differ. Productive efficiency tends to be lower in the competition regime since the less efficient utility has stronger production incentives. But aggregate production rises under competition due to the entry of the inefficient utility. At low cost differentials between the neighbouring water utilities the efficiency effect dominates: welfare is higher under a trade regime. At higher efficiency differentials the effect of a higher quantity respectively lower retail price effect dominates: welfare is higher under competition. The optimal choice of the institutional framework therefore depends on the initial efficiency differential between neighbouring utilities. In practice significant cost differentials even between neighbouring water utilities often occur, for instance due to capacity constraints, due to the use of different raw water qualities such as spring and surface water or due to local raw water contamination that requires additional treatment effort.

However, it is important to note that both regimes' performance can be improved. The competition model assumes a lower bound benchmark case, where regulation does not exist. Of course the regulation of the access price increases the relative performance of the competition regime since it reduces the problem of vertical foreclosure respectively double marginalisation. A further extension is the regulation of retail prices. Introducing a price cap into the model improves the production efficiency in the competition regime (see section 4.3). The trade regime's relative performance can be improved by enhancing A's bargaining power; again the double marginalization problem of trade pricing is reduced.

In both regimes the upstream company skims the main part of additional profit. A is the upstream company in the competition regime but the downstream company in the trade regime. Obviously the less efficient utility prefers competition while the more efficient utility prefers trade. Consumers in contrast prefer competition due to lower prices.

Although we designed our model to examine an – in our view – important feature in the water industry, our analysis might also be applicable to other industries as well. In general, it applies to market structures (i) that are characterized by geographically separated natural monopolies and (ii) where access to the incumbent's infrastructure by neighbouring monopolies is possible. Examples are local network based services. It is important to note that our model is not applicable for two-way networks such as railroad and for industries where customers' utility depends on how many customers are connected to this network. This is the main difference of the present analysis to the existing network models of the telecommunications industry.

Our model analysed welfare effects of competition and trade in the piped water industry under a pure microeconomic analysis. However, in practice it may be useful to consider additional political and legal aspects. Obviously trade between utilities can be implemented much easier in practice than competition by common carriage. Profit-maximising utilities have incentives to introduce voluntarily cross border trade, whereas competition may need extensive and complex economic regulation. And in contrast to competition political resistance against trade would be minor. Beside political resistance there is a wide range of legal barriers for competition in the water sector. In countries such as Germany or Switzerland the principle of territorial exclusivity (Oertlichkeitsprinzip respectively Territorialprinzip) hinders the introduction of common carriage (see Andersen and Reichhard 2000, p. 29). Of course trade between neighbouring utilities is already practiced by existing water utilities in several countries. However, in most cases trade is only used in order to balance peaks of demand – efficient spot water markets usually do not exist. One can follow that trade is applied in particular in case of *significant* cost differentials. An extension of water trade or even the introduction of common carriage would lead to further welfare gains. However, trade does not occur since local water suppliers are often not profit-oriented since they are part of the public authority. And common carriage is not applied due to the legal framework.

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