Enhancing Efficiency of Water Supply – Product Market Competition versus Trade

Reto Foellmi* Urs Meister**

October 05, 2004

Abstract

This paper analyses and compares potential efficiency gains induced by the introduction of product market competition and cross boarder trade in the piped water market. We argue that due to the specific circumstances in the water sector product market competition, i.e. competition by common carriage is not expected to be very intensive. The connection of networks could alternatively be used for cross boarder trade between neighboured water utilities. We show that competition by common carriage leads to production incentives for the inefficient supplier. This implies that the retail prices tend to be lower than with cross border trade. However, the efficiency effect dominates and resulting welfare is higher in case of trade.

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

JEL Classification: L95, L43, D21, Q25

* MIT, Department of Economics, 50 Memorial Drive, Cambridge MA 02142, Tel +1-617-253 85 56, Fax +1-617-253 13 30, email: foellmi@mit.edu.

** University of Zurich, Institute for Strategy and Business Economics, Plattenstrasse 14, CH-8032 Zürich, Tel: +41-1-634 29 62, Fax: +41-1-634 43 48, email: urs.meister@isu.unizh.ch.

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 neighboured 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 that welfare gains tend to be higher in case of unregulated, voluntary trade. Obviously such result impairs the potential benefits of competition.

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

[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).

telecommunication, electricity or gas. However, due to difficulties in the regulation of access prices and the physical characters of water, competition is expected to be weak and very local.[3] A second way to enhance efficiency might be increasing cooperation between neighboured 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 neighboured 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 neighboured utilities. Obviously an increasing and systematic implementation of trade could induce extensive efficiency and therefore welfare gains.

However, such model of cross border trade obviously resembles the above described model of competition by common carriage. The connection of networks could rather be used for water trade than for competition by common carriage. In both models local and neighboured 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. Indeed we show that simple cross boarder trade has similar or even stronger positive effects on welfare than competition – even when retail prices are higher. The reason is that competition by common carriage leads to stronger production incentives for the inefficient supplier.

There is little literature addressing the issue of competition *in* the market applied to the piped water sector. For instance Cowan (1993 and 1997), Webb and Erhardt (1998), Grout (2002) or Scheele (2000) describe and discuss the opportunity of competition by common carriage in the water sector. Foellmi and Meister (2003) analyse potential efficiency gains of product market competition but they do not consider trade. There is a wide range of literature related to the trade of *water rights*.[4] 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 and Calatrava and Garrido (2003) show that spot water markets allow farmers to reduce their risk exposure caused by unstable water supply. Carey and Zilberman (2002) investigate farmers' investment into

[3] 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.

[4] Hearn 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.

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, these literature addresses in particular water trade related to agricultural issues while our paper rather discusses trade between neighboured water utilities rendering water services to final customers such as households or industry. David M. Newbery (1996) introduced a model which combines competition and trade in the network industry. The model assumes two suppliers that 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 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 this paper 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. Under these assumptions retail prices are lower in competition. However, the sum of consumer and producer surplus is higher in the trade case. In the same section we investigate the effects of regulation – 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 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

Several European countries such as France, Italy, England and Wales introduced at least some degree of competition in the piped water sector. France and since recently Italy applied a concession model, based on the idea of competition *for* the market. The municipalities auction a monopoly concession for a defined time period and for a given set of performance parameters – in accordance with the franchise bidding model originally proposed by Demsetz (1968). However, England and Wales have chosen a different way, based on competition *in* the market, called product market competition. 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, boarder 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. 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.[5] Boarder line competition allows customers that are located at the boarder of a supply area to purchase water from an existing neighboured 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. In such a competition model 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, upstream services such as raw water extraction, treatment and storing and further services such as billing or collecting payments are done by a market entrant.

So far the main source of competition in England and Wales has been the inset appointments. However, competition has not been very intense – up to 2001 only 6 inset appointments were applied (see Kurukulasuriya 2001, p. 21). The implementation of the Competition Act 1998 which came into effect March 2000 was intended to boost the degree of rivalry. In particular competition by common carriage should be strengthened by facilitating access to the pipe networks. Based on the Act the regulator Ofwat published in 2002 guidance on the development of access codes (see Ofwat 2002, p. 1) that defines the terms of access.

However, due to the specific technical issues in the water sector, product market competition by common carriage is not expected to be as efficient as in sectors like telecommunication or electricity (see BMWi 2001, p. 24). In contrast to telecommunication

[5] The 30-meter rule was removed in 1992. 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)

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 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 unrealistic high access prices. However, one could argue that a regulator can enforce lower access prices, e.g. prices based on the incumbent's long run incremental network costs. In fact 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. And since these costs vary significantly between local networks, 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 would therefore be large. Actually the regulator Ofwat does not explicitly regulate access charges ex ante.[6] Based on these circumstances the effectiveness of competition in the market would be 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).

2.2 Trade

Cross border trade between neighboured water suppliers is more common than competition by access. Treated water is exchanged between independent neighboured water utilities or – which is more common – between utilities that are members of partnerships of convenience, in Germany called Zweckverbaende. Partnerships of convenience 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

---

[6] 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).

German water suppliers are organised in such partnerships (see BGW 1999). According to Ludin et al. (2000) these partnerships are mainly motivated by insufficient enterprise scales on the one side and technical aspects such as hydrologic and hydrogeologic conditions on the other side. A partnership of conveniences usually has a self-contained legal form of organisation and acts as public corporation. Hence, in most cases it describes rather a merger of neighboured 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 (BWV), Harzwasserwerke or Gelsenwasser with extended treatment capacities sell water to neighboured or even distant water utilities. BWV is the largest German water supplier that provides about 4 million inhabitants. It is basically organised as a partnerships of convenience that sells treated water to its members and to third parties. The 177 members of the partnership are communities, local authorities association, partnerships of convenience themselves or other public bodies such as public water companies. They possess their own network and storage facilities but they can buy treated water and further services such as consulting, planning, laboratory services etc. from the BWV (see ZVBWV 2003, p 1-3). In order to sell water to its members, BWV builds and operates facilities for extraction, treatment and storage. Furthermore it builds and operates the necessary supply pipes that allow the water transmission into the member's local pipe networks. However, BWV is not a profit-oriented company. It sells water and further services based on costs, conditions are for all members the same.[7]

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 420'000 inhabitants.[8] These 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

---

[7] In contrast, the smaller water suppliers Harzwasserwerke Ltd. and Gelsenwasser inc. are organised as private and profit-oriented companies.

[8] 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.

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 neighboured 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:

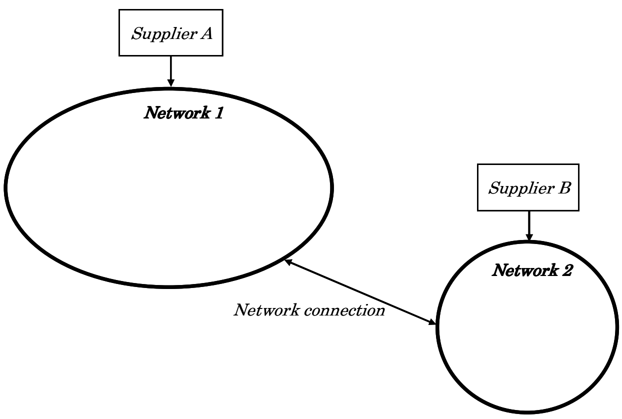

Figure 1 : Connection of two neighboured water networks

By connecting their networks 1 and 2, two suppliers A and B are able to exchange treated water. As shown in figure 1 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 can differ significantly.[9] Since water supply is very capital intensive, we assume that utilities choose rather quantities and capacities than prices. Our

[9] 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 that range 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).

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 loss of generality we assume that utility *B* has lower marginal costs than utility *A*. We assume that the more efficient utility *B* does not face relevant capacity constraints due to sufficient availability of high quality raw water resources. Utility *B*s marginal costs are therefore assumed to be constant, $C_B' = c_B$. On the other hand supplier *A*'s marginal costs are assumed to be increasing, $C_A' > 0$ and $C_A'' \geq 0$.[10]

We restrict our analysis to a pure linear pricing regime. Access and trade prices are assumed to be linear. Of course the analysis could be extended to a non-linear pricing regime. However, results would not change fundamentally. But one would get the well-known result of highest possible production efficiency (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 *B*s marginal costs are constant, its decision problem can be fully described by considering its profits from market 1. Such profit from market 1 is given as follows:

[10] 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.

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

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.[11] In order to compare welfare between the competition and the trade model 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}.:

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

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

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 the access price a_1:

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

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

$$\frac{dq_{1B}}{da_1} = \frac{1}{p_1'' q_{1B} + 2p_1'} \quad (6).$$

Note that $q_{1B} p_1'' + 2p_1' < 0$ follows from the second order conditions of profit maximization. The less efficient supplier A has incentives to reduce its own production volume and to give up some market share to its competitor B. In order to compare welfare between the competition and the trade model we have to analyse the relevant effects on retail prices and production efficiency. We firstly analyse p_1 under the assumption that utility A still

[11] 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.

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.

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

where $q_1 = q_{1A} + q_{1B}$. Of course (7) holds only if the implied value of p_1 is larger than $C_A'(0)$. Otherwise, when the implied market price p_1 is equal or smaller than A's marginal costs, A decides to stop own production. In that case the price p_1 follows directly from (4) and (5) and $q_{1A} = 0$.

$$p_1 = -q_{1B}(q_{1B} p_1'' + 3p_1') + c_B \qquad (8)$$

Because in both cases the high-cost utility A reduces own production and the low-cost utility B increases production, 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 would be monopolist in market 1, according to the Amoroso Robinson equation he would set $p_1 = -p_1' q_{1B} + c_B$ which is smaller than the p_1 in equation (8), since $-p_1' q_{1B} + c_B < -q_{1B} p_1' - q_{1B}(q_{1B} p_1'' + 2p_1') + c_B$ and $q_{1B} p_1'' + 2p_1' < 0$ according to equation (6).

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

3.2 Trade

In section 3.1 we showed that introducing product market competition between neighboured 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 neighboured utilities. It is obvious that a high cost utility A has 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. B can therefore generate revenues by selling water to customers connected to its network 1 on the one side and by selling water to its neighboured water utility A on the other side. Due to the constant marginal costs c_B we focus our analysis to Bs trading activities. Again due to the constant marginal costs c_B the decision problem of B reduces to the analysis of its trading activities. The profit from these activities can be calculated as follows:

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

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. A's production costs consist of increasing marginal treatment costs $C_A(q_{1A})$ and of payments for purchased water q_T. 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 $q_1 = q_A + q_T$.

The above described trade model implies the existence of three different market places: On the one side the retail markets 1 and 2, on the other side the wholesale market for treated water resources. Since both utilities act as independent monopolists in their retail markets 1 respectively 2, p_1 and p_2 result from monopolistic profit maximisation behaviour of A respectively B. The wholesale respectively trade market is characterised by a bilateral monopoly. One seller and one buyer bargain over the trade price respectively the traded water quantity and therefore the allocation of potential gains from trade. As mentioned above gains from trade are expected to be positive, since Bs marginal costs are assumed to be lower than A's marginal costs.

According to Nash (1950) fully informed players would agree on a contract that maximises total gains from trade. The relevant bargaining solution is Pareto efficient. Assuming completely symmetric players would induce a contract that yields equal payoffs for both players. However, our model describes trade between fully informed but unequal players. It follows that the relevant bargaining power of the two parties can be different. According to several empirical studies addressing the issue of bargaining over prices in bilateral monopolies (e.g. Chipty and Snyder, 1999, Kauf, 1999, Kajisa and Sakurai, 2000) relative power depends on various individual characteristics of buyer and seller. Kajisa and Sakurai examine these characteristics for water trade in the agrarian sector in India.[12] According to their analysis seller's power is for instance positively correlated with its physical capital respectively total amount of investment into the water production facilities.

For simplicity we assume in the following that bargaining weights are exogenous. In particular we focus on the two polar cases, where only the seller respectively the buyer has the entire bargaining power. Of course, in the above described bilateral monopoly situation one could expect bargaining power to be more evenly distributed, but these extreme cases allow simple and illustrative conclusions.

3.2.1 Utility B has the entire Bargaining Power

First we focus a situation where the more efficient utility B has the entire bargaining power on the wholesale market. Since large water suppliers with extensive production capacities usually provide more than one utility with treated water, there are good reasons to assume that the utility which sells water resources has the main bargaining power on each of these single water markets. We assume the polar case, where utility B has the entire bargaining power. That means 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:

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

[12] Kajisa and Sakurai analyse the price determination in water transactions between neighboured farmers in Madhya Pradesh in India. Farmers which do not own irrigation systems consisting of electric pumps, wells and water conveyance systems have to buy water resources from farmers owning such systems.

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

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 can define slope of the demand curve, dq_T / dp_T.

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

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 inequation (12), since $q_A = 0$. Total differentiation of (13) and solving for dq_T / dp_T yields to

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

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.

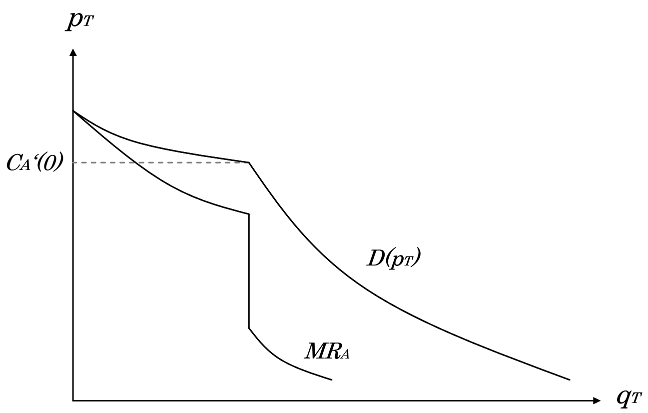

Figure 2: Demand for traded water

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 neighboured 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 $p_T = C_A'(0)$.

After defining *A*'s demand curve we are able to compare the trade model with the competition model. In order to compare all possible states of competition and trade, we have to take into consideration that in both models *A* can decide to keep own water production ($q_{1A} > 0$) or to give it up completely ($q_A = 0$). Effects regarding welfare can be different in these two states. Therefore we have to analyze the following three cases in order to compare the trade with the competition model:

	Case 1 $C_A'(0) \geq \hat{p}_1$	*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

$\hat{p}_1$ respectively $\hat{p}_T$ denote the equilibrium values for the retail price in market 1 respectively the trade price on the wholesale market. In Table 1 we reduce *A*'s marginal costs from case 1 to case 3[13]. According to equation (3) in the competition model A produces a positive amount of water if and only if $\hat{p}_1 > C_A'(0)$. And according to equation (13) and (12) in the trade model A produces a positive amount of water only if $\hat{p}_1 > \hat{p}_T$ respectively $C_A'(0) < \hat{p}_1$. Obviously A's incentives to produce a positive amount of water are stronger in the competition than in the trade model.[14] 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).

Case 1 compares competition to trade when A decides to give up completely its own production. In both models only B produces a positive amount of water. In order to evaluate this case regarding welfare, we define the relevant prices p_1 on market 1. Using equation (5) in (4) and taking into account that there are no effects on quantities in market 2 since c_B stays constant, we can give a relation for the retail price p_1 on market 1 in the competition model as follows:

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

In order to solve for the price p_1 on market 1 in the trade model we use equations (14) and (15) in (11):

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

Since A does not produce any amount of water by itself, q_T corresponds to q_1 respectively q_{1B}. In this case retail prices on market 1 are identical in the competition and the trade model. And since only B produces a positive amount of water, marginal costs of production are in both models similar, namely c_B. Therefore in both models highest possible production efficiency can be achieved. Obviously the resulting welfare corresponds in both models to the same level. Furthermore consumers are indifferent between competition and trade.

Case 2a compares the competition model, where A keeps its own water production, to the trade model, where A completely gives up its water production. Since the trade model

[13] Comparing the different cases in table 1 the reader should note that the prices (may) change when we vary $C_A'(0)$. It is easy to see that the separation into the different cases is still applicable. Let us start in case 1 where $C_A'(0)$ is high. When $C_A'(0)$ decreases 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.

[14] Consider, A has high marginal costs and does not produce any amount of water. However, technical invention reduces A's marginal costs. According to equation (3) A starts to produce a positive amount of water when $p_1 > C_A'(0)$. In case of trade A starts to produce when $p_1 > p_T$ and $p_T > C_A'(0)$. Because of this double marginalisation argument A's incentives to produce a positive amount of water are stronger in case of competition.

in case 2a is similar as in case 1, equation (17) still holds. However, prices in the access model are defined different since both utilities produce a positive amount of water. By inserting equation (5) into (4) and taking into consideration that $q_1 = q_{1A} + q_{1B}$ we derive the retail price p_1 in market 1 for the competition model:

$$p_1 = -q_1(q_1 p_1'' + 3p_1') + q_{1A}[2p_1' + p_1''(q_1 + q_{1B})] + c_B \tag{18}$$

Comparing equation (18) to (17) respectively (16) we can define the difference of prices in the competition and trade model. Obviously such difference is caused by the following term[15]: $q_{1A}[2p_1' + p_1''(q_1 + q_{1B})]$. This term can be positive or negative, depending on the curvature of the demand curve in market 1, which is determined by p_1''. Price p_1 in the competition model is smaller in the competition case, if the demand curve is concave or linear or only minor convex. Only in case of a strong convex demand curve p_1 tends to be smaller in the trade case. However, independent from the demand's curvature, the net effect regarding welfare is apparently not clear. Production efficiency in the trade model must be higher since only B produces a positive amount of water at marginal costs c_B. In the competition model both utilities produce a positive amount of water. And since $c_B < C_A'(\hat{q}_{1A})$ overall production costs are not minimised in case of competition.

Consumers in market 1 are solely interested in their surplus which determined by the level of the retail price p_1. Obviously they prefer the introduction of competition in case of a concave, linear or only minor convex demand curve even when overall production efficiency would be lower. However, they prefer the trade model in case of a strong convex demand curve. In this case both p_1 and overall efficiency would be higher in the trade than in the competition model.

Case 2b is basically similar to case 2a. A keeps its production in the competition model but stops production in the trade model. But now the relative difference between $C_A'(0)$ and c_B has become smaller 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 profit similar to an independent monopolist facing marginal costs p_T. The relevant retail price in the trade model reads now:

$$p_1 = C_A'(0) - q_T p_1' \tag{19}$$

---

[15] Of course the equilibrium values of the first terms in the equations (18) and (16) can vary, since the relevant equilibrium quantities can be different. However, if one would define $q_{1A}[2p_1' + p_1''(q_1 + q_{1B})] = 0$ in equation (18), prices and therefore sold quantities in market 1 would be similar in cases 1 and 2a of the competition model. An increasing value of this term obviously increases the equilibrium retail price in case 2a and therefore reduces the equilibrium quantity.

Obviously this price lies between the trade price of the trade model in case 2a and 3. Similar to case 2a production efficiency tends to be higher in the trade model than in the competition model since only the more efficient utility B produces a positive amount of water.

Case 3 compares the trade model to the competition model when both utilities keep their water production. Since the competition model has a similar outcome as in case 2, equation (18) still holds. However, prices in the trade model are defined different now, since A and B produce a positive amount. The demand curve for water on the trade market is now defined by equation (14). Using equations (11), (13) and (14) we can derive price p_1 in the trade model:

$$p_1 = -q_1(q_1 p_1'' + 3p_1') + q_1(q_1 p_1'' + 2p_1')(1-\mu) + q_A(q_1 p_1'' + 2p_1')\mu + c_B \qquad (20),$$

where $\mu = C_A''(q_A)/[C_A''(q_A) - (2p_1' + q_1 p_1'')]$. The term $(2p_1' + q_1 p_1'')$ must be negative since it corresponds to the second order condition for A's profit maximum.[16] Therefore μ must be smaller than one.[17] And since $q_1 > q_A$ price p_1 in the trade model tends to be smaller than in cases 1 and 2a (see equation [17]). This result induces that the relative performance of the trade model in case 3 tends to be more advantageous than in 2a. However, it is not obvious if p_1 tends to be lower than in the competition model of 2b.

And it is not obvious if in case 3 the retail price p_1 in the trade model is still above the price level in the competition model. The price differential depends now on the curvature of the demand on the one side and the value of $q_1(1-\mu) + q_A\mu$ on the other side. An increasing weighted sum of q_1 and q_A improves the relevant performance of the trade model, i.e. the retail price tends to be lower compared to the price in the competition model. Furthermore the relative performance of the trade model can be improved by using a strong convex demand curve, since $[2p_1' + p_1''(q_1 + q_{1B})] > 0$.

Independent from the curvature of the demand curve, production efficiency in the trade model is higher than in the competition model – similar to case 2. As already mentioned above, A's incentives to produce a positive amount of water are stronger in the competition model than in the trade model. 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 model a higher part of the entire water

[16] $\partial^2 \Pi_A / \partial q_A^2 = 2p_1' + q_1 p_1'$

[17] Only if A does not produce any water $(q_{1A} = 0)$ μ amounts to 1. In this case (20) is similar to (18).

quantities sold in market 1 and 2. Total production costs are therefore lower than in the competition model.

Apart from the effects regarding retail price and efficiency it is worth to analyse effects regarding distribution. One should have in mind, that the roles of *A* and *B* differ fundamentally in the competition and trade model. In the trade model the less efficient utility *A* acts as a downstream monopolist while in the competition model *A* is an upstream monopolist. 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 Utility A has the entire Bargaining Power

In order to complete our analysis we assume that the less efficient utility *A* has the entire bargaining power on the wholesale market. That means the buyer *A* defines the relevant trade price and makes a “take it or leave it” offer to utility *B*.[18] 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* would offer a trade price $p_T = c_B$. Since the trade price exactly covers *B*s marginal costs, *B* has no incentives to reject *A*’s offer. 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).

Purchasing water from *B* at a linear price c_B allows *A* to reduce its own water production and therefore marginal costs. In order to maximise profit *A* reduces its own water production q_A until C_A' is equal to p_T respectively c_B. If $C_A'(0)$ exceeds p_T, *A* gives up own production and becomes a pure water broker. Again the relevant production costs in both markets amount to c_B. Due to the resulting equalisation of marginal costs overall production efficiency in market 1 and 2 and therefore aggregated profit can be improved compared to the autarky situation.[19] In fact, the equalisation of marginal costs guarantees highest possible overall efficiency. 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.

[18] One might object that such setting is not very intuitive, since it assumes a less efficient utility having all the bargaining power. Nevertheless, Kajisa and Sakurai (2000) found some empirical evidence for a weak sellers’ bargaining position in the Indian water market. They argue that social constraints may hinder sellers to enjoy unacceptable amounts of excess profits. Of course such constraints might not be very intuitive in a trade model with profit-maximising water companies.

[19] Due to decreased marginal costs in market 1 an additional profit can be realised compared to the autarky situation. Since c_B stay constant, profit in market 2 does not change.

Similar to the trade model 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 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 model where the more efficient utility *B* has some positive bargaining power. However, it is not obvious if p_1 is lower than in the competition model.

The distribution of the additional profit is different than in a trade model where *B* has the entire bargaining power. Now, the downstream company *A* is able to extract the entire rent, in the trade model in section 3.2.1 the upstream company *B* skimmed the main part of the rent.

4 Linear Example

In order to illustrate the results derived in section 3.2.1 (where *B* has the entire bargaining power in the trade model) more detailed, we consider a linear model. Beside the linear access respectively trade prices we assume 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 model since *A*'s constant marginal production costs (denoted by c_A) always exceeds 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:

$$p_1 = k - bq_1 \tag{21}$$

First we define retail price p_1 and production quantity q_1 in the status quo, which is defined by the monopoly. We can use the model of independent monopolists as a benchmark for the following analysis. Using equation (21) and setting marginal revenues equal to marginal costs we can derive p_1 and q_1:

$$p_1 = \frac{k + c_A}{2} \tag{22}$$

$$q_1 = \frac{k - c_A}{2b} \tag{23}$$

We define the relevant prices and production quantities in the competition model. We therefore have to distinguish two different regimes: case 1 where A stops own water production ($q_{1A} = 0$), and case 2 where A keeps own production ($q_{1A} > 0$). By total differentiation of equation (4) and using equation (21) we can define $dq_{1B} / da_1 = -1/(2b)$. And by using equations (3), (4) (5) and (21) we derive the following results for case 1 in the competition model:

$$p_1 = \frac{3k + c_B}{4} \tag{24}$$

$$q_1 = q_{1B} = \frac{k - c_B}{4b} \tag{25}$$

$$a_1 = \frac{k - c_B}{2} \tag{26}$$

However, if the resulting retail price p_1 in market 1 exceeds A's marginal costs c_A, A keeps its own production in the competition model (cases 2 and 3).

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

Obviously A's incentives to produce a positive amount of water itself are increasing in B's marginal costs c_B and the reservation price k in market 1. Increasing marginal costs c_A lower A's incentives to produce a positive amount. In order to derive retail price p_1 and production quantities q_{1A}, q_{1B} in case 2 of the competition model we use equations (3), (4), (5) and (21) again:

$$p_1 = \frac{3k + 2c_A + c_B}{6} \tag{27}$$

$$q_{1A} = \frac{3k + c_B - 4c_A}{6b} \tag{28}$$

$$q_{1B} = \frac{c_A - c_B}{3b} \tag{29}$$

$$q_1 = q_{1A} + q_{1B} = \frac{3k - 2c_A - c_B}{6b} \tag{30}$$

$$a_1 = \frac{k - c_B}{2} \tag{31}$$

We analyse cases 1 and 2 of the trade model where the less efficient utility *A* stops own production and purchase the entire water quantity q_1 from utility *B*. Therefore $q_A = 0$ respectively $q_1 = q_T$. Using equation (15) and (21) allows us to determinate the relevant slope of the demand curve for traded water: $\partial q_T / \partial p_T = -1/(2b)$. Using equations (13), (17) and taking into account that q_1 equals q_T, we can define p_1, q_1 and p_T in cases 1 and 2a as follows:

$$p_1 = \frac{3k + c_B}{4} \tag{32}$$

$$q_1 = q_T = \frac{k - c_B}{4b} \tag{33}$$

$$p_T = \frac{k + c_B}{2} < c_A \tag{34}$$

As already stated in section 3.2.1 the resulting retail price p_1 and quantity q_1 correspond to the relevant values in the competition model where only *B* produces a positive amount of water. Obviously in case 1 the resulting welfare corresponds in both models to the same level.

Now we consider case 2b where $\hat{p}_T = c_A$. In such case *B*s marginal cost curve cuts its marginal profit curve from trading activities in its vertical range. Then it is profit maximising for *B* to set $p_T = c_A$. Using equation (13) and (21) we can define p_1 and q_1 as follows:

$$p_1 = \frac{k + c_A}{2} \tag{35}$$

$$q_1 = q_T = \frac{k - c_A}{2b} \tag{36}$$

$$p_T = c_A \tag{37}$$

Price p_1 in case 1 and in the range of the bend would correspond to the same value when $(3k + c_B)/4 = (k + c_A)/2$ respectively $(k + c_B)/2 = c_A$.

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

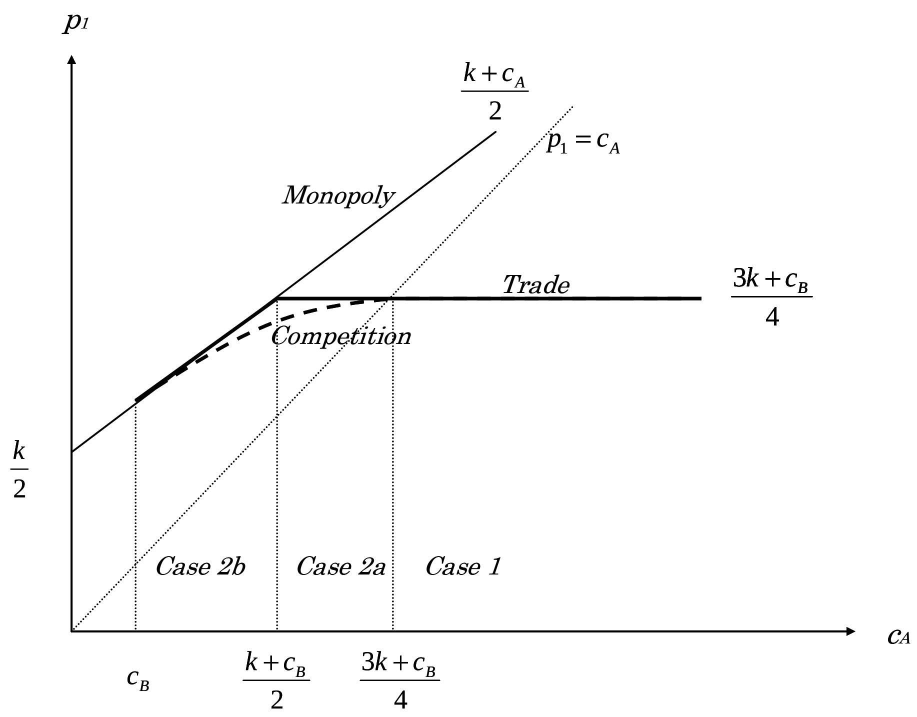

Figure 3: Retail price in market 1: Monopoly, trade and competition

4.1 Monopoly versus Trade

First we compare the monopoly model with the trade model. In cases 1 and 2a where $c_A > (k+c_B)/2$, p_1 is lower in the trade than in the monopoly model. According to equation (34), B charges $p_T = (k+c_B)/2 < c_A$ to the downstream monopolist A. Since p_T is lower than A's marginal production costs c_A, it is profit maximising for A to charge a retail price p_1 which is lower than the one charged by an independent monopolist. Obviously welfare must be higher in the trade model since p_1 is lower and production efficiency higher than in the monopoly case. Consumers profit from lower prices and utilities from higher aggregated profit. Due to its position as an upstream company B is able to skim two third of the aggregated profit.

In case 2b where $c_B < c_A \leq (k+c_B)/2$ the relevant price p_1 is equal in both models. In this range the downstream monopolist A purchases water from B at price $p_T = c_A$. Obviously A faces exactly the same maximisation problem as an independent monopolist. Therefore price p_1 and quantity q_1 correspond in both models monopoly and trade to the same level.[20] Nevertheless, net welfare must be higher in the trade model: Since in the trade model only the more efficient utility *B* produces a positive amount of water, aggregated profit must be higher due to higher production efficiency. And since *B* charges $p_T = c_A$, *B* is able to skim the entire rent of this additional efficiency.

4.2 Trade versus Competition

As mentioned above the roles of *A* and *B* change in these models fundamentally. *A* acts in the trade model as a downstream company, in the competition model as an upstream company. For *B* the reverse holds. Figure 4 illustrates this fact.

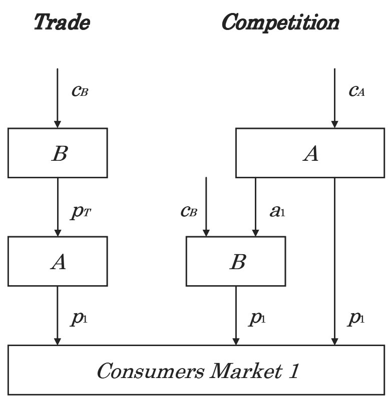

Figure 4: Market structure: trade versus competition

Figure 3 shows that p_1 in the competition and trade model correspond to the same level in case 1 where $(3k + c_B)/4 \leq c_A$. In both models only the more efficient utility *B* produces a positive amount of water. However, in the trade model consumers are exclusively served by the downstream company *A*, in the competition model by the downstream company *B*. Their relevant marginal costs correspond to the same level since $p_T = a_1 + c_A$. Since both downstream companies face similar profit maximisation problems, in equilibrium p_1 and q_1 and therefore consumer rent correspond to the same level.[21] And since water is only produced by the more efficient utility *B*, aggregated profit must as well be similar. We conclude that the resulting welfare is the same in both models. However, the *distribution* of the aggregated profit[22] between *A* and *B* is different. Being an upstream monopolist in the

[20] See equations (21) and (34) respectively equations (22) and (35).
[21] See equations (24) and (32) respectively equations (25) and (33).
[22] $\Pi_{Aggregated} = 3(k - c_B)^2 / 16b$

competition model enables A to skim two third of the aggregated profit. Being a downstream monopolist in the trade model allows A to skim only one third of the entire profit.

The equilibrium value of p_1 in the trade model exceeds p_1 in the competition model only if $c_B < c_A < (3k + c_B)/4$. Such range is defined by cases 2a and 2b. In these cases the upstream company in the competition model generates income from two sides: allowing access to B and selling water directly. By setting a_1 in the first stage of the game A not only optimise income from the access business. A decides as well about Bs relevant marginal costs (a_1 + c_B) and therefore about the terms of the second stage of the game, where A and B set production quantities. Obviously the determination of a_1 has external effects on the performance of A's direct business. Raising a_1 increases Bs marginal costs and reduces its incentives to engage in market 1.[23] However, a lower engagement of B increases the relevant retail price p_1 and supports A's incentives to engage in market 1 directly.[24] In equilibrium A sets $a_1 = (k - c_B)/2$. The downstream company B in the competition model faces total marginal costs of $a_1 + c_B = (k + c_B)/2$. These costs exactly correspond to p_T in the trade model. In both models downstream companies face similar costs. However, their profit maximising behaviour must be different, since in the competition model B faces direct competition from A. And since total production quantities are higher in Cournot duopoly than in a monopoly, the resulting retail price p_1 must be lower in the competition model. In fact, p_1 in equation (27) is lower than p_1 in equation (32) respectively (35).

However, net effect regarding welfare is not obvious, because average production efficiency must be lower in the competition model, since we assumed $c_B < c_A$. We can define welfare as follows:

$$W = \frac{1}{2}(k - p_1)q_1 + q_{1A}(p_1 - c_A) + q_{1B}(p_1 - c_B) = \frac{1}{2}(k + p_1)q_1 - c_A q_{1A} - c_B q_{1B} \quad (38),$$

where $q_{1A} = 0$ and $q_1 = q_{1A} + q_{1B}$ in case of competition and $q_1 = q_{1B}$ in case of trade. Equation (38) illustrates the above mentioned trade off: in the competition model welfare tends to be higher due to a lower p_1 respectively a higher q_1; but it tends to be lower due to higher average production costs. In order to compare these welfare effects more detailed, we analyse them at the margin between cases 1 and 2a. Starting at $c_A = (3k + c_B)/4$ and reducing c_A by an infinitesimal amount brings us from case 1 to case 2. Figure 3 shows that p_1 respectively q_{1A} and q_{1B} only change in the competition model. Due to lower costs A gets

[23] Such relation can be illustrated apparently by equation (4) of the general model.
[24] Equation (5) in the general model shows that A sets a lower access price a_1 in case of $q_{1A} = 0$.

incentives to produce itself a positive amount of water and due to arising competition B reduces its engagement in market 1. By differentiating equations (28) and (29) to c_A we define these reactions at the margin: $\partial q_{1A} / \partial c_A = -2/3b$ and $\partial q_{1B} / \partial c_A = 1/3b$. Reducing c_A increases q_{1A} two times stronger than it reduces q_{1B}. The resulting welfare in the competition model would be higher than in the trade model if $(p_1 - c_A) > 1/2(p_1 - c_B)$. However, at the point where A just begins production p_1 equals c_A. The relevant welfare gains from increased production are of second order whereas the welfare losses from a reduction in Bs production are of first order. Hence the effect regarding higher production efficiency in the trade model exceeds the effect regarding a lower p_1 in the competition model. Obviously this result also holds with general demand functions and is not due to the assumption of linear demand. This is a well-known result from the traditional Cournot analysis. The Cournot equilibrium does not equalize marginal costs – except in the symmetric case. The industry's cost of production is therefore not minimised.

Again, the upstream monopolist skims the main part of the aggregated profit in both models. In the trade model B skims two third of the aggregated profit. However, due to the lower production efficiency aggregated profit must be lower in the competition model. Obviously A is able to skim more than two third of this aggregated profit – otherwise A would not have any incentives to produce itself.

4.3 Shifting the Bargaining Power

The linear analysis can easily be extended to the trade model 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 $c_A > p_T$. As mentioned in section 3.2.2 A therefore faces exactly the same maximisation problem as an independent monopolist with marginal costs c_B. In order to determine the retail price in market 1 we use equation (22) and substitute the marginal costs by c_B.

$$p_1 = \frac{k + c_B}{2} \qquad (39)$$

Since $k > c_A > c_B$ such retail price must be lower than the relevant retail prices in the competition model (see equation [27]) and the trade model where B has the entire bargaining power (see equation [32] and [35]). The relevant quantity q_1 reads:

$$q_1 = \frac{k - c_B}{2b} \tag{40}$$

Figure 5 illustrates the relevant retail prices.

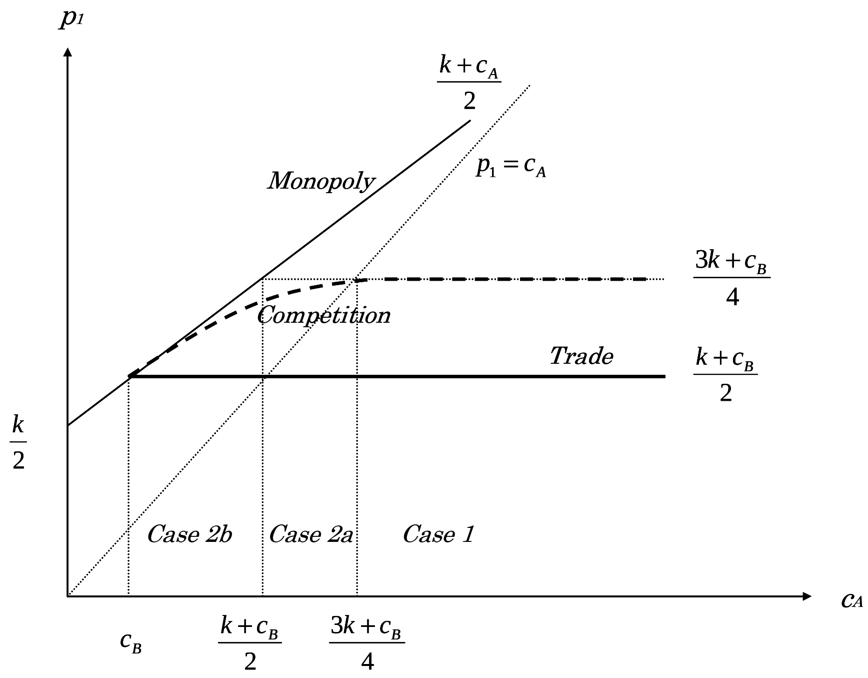

Figure 5: Retail price in market 1: Monopoly, competition and trade where *A* has the entire bargaining power

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 model. And since the relevant retail price p_1 is lower than in the competition model and the trade model where *B* has the entire bargaining power, welfare can be improved.

4.4 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 *B*s 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. Using equation (21) we derive the relevant inverse demand in market 1:

$$p_1 = k - bq_{1A} - bq_{1B} \tag{41}$$

In a Cournot duopoly where players simultaneously decide about their production quantities, we derive the Nash equilibrium production quantities.

$$q_i = \frac{1}{3}\left(\frac{k + c_j - 2c_i}{b}\right) \tag{42}$$

where $i, j \in \{A, B\}$ and $i \neq j$. Using equations (41) and (42) we get the relevant retail price p_1 in market 1:

$$p_1 = \frac{k + c_B + c_A}{3} \tag{43}$$

In figure 6 the retail price is drawn as a function of c_A.

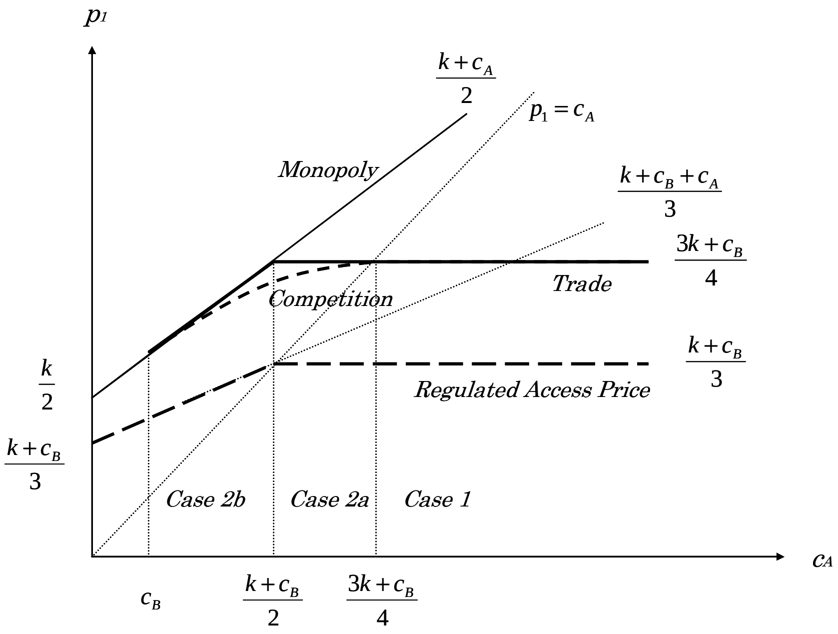

Figure 6: Retail price in market 1: Monopoly, competition, trade and competition with 1st best regulated access price

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 model the less efficient utility *A* does not have any production incentives in cases 1 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[25]. 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. That can be realised by charging an additional lump sum fee to the market entrant or by charging a mark up over marginal costs. 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). However, introducing a mark up over short run marginal costs reduces the relative performance of the regulated access price regime. Since $a_1 > 0$, *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

[25] 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 $c_B > c_A$.

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. Additionally the regulation of access prices in the water industry is expected to be very complex and costly (see section 2.1). One can follow that water suppliers' freedom to set access prices is significant.

Finally, consider the regulation of retail prices. Ex ante retail price regulation by price cap is applied for instance in England and Wales.[26] 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 models competition and trade. Using such price cap implies that consumer surplus must be equal in both models. Regulation therefore withdraws the benefit of the competition model describes above. The only source of welfare differences can therefore be due to differences in production efficiency. Obviously the introduction of the price cap in a trade model does not change the overall production efficiency. Again, in the relevant cases 1, 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 production efficiency in the competition model. 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 model 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 production efficiency in the competition model 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 production and welfare efficiency in the trade model is still higher or equal than in the competition model.

5 Simulation

In section 4 we showed that welfare tends to be higher in the trade than in the unregulated competition model. Welfare is equal in both models in case 1 and is higher in the trade model at the point where the inefficient utility A enters market 1 (switching from case 1 to 2a). However, we did not explicitly examine welfare when A produces a strict positive

[26] 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.

amount, i.e. interior of cases 2a and 2b. Therefore we simulate in the following the (unregulated) model of section 3 and perform some comparative statics. Assuming a more general model than in section 4 we allow for non-linear demand and increasing marginal costs of *A*. Since the relative performance of the trade model tends to be stronger when *A* has the entire bargaining power we restrict our analysis to a situation where the more efficient utility has the bargain power. And since welfare in the trade model tends to be stronger when *A* produces a positive amount of water (case 3),[27] we restrict our analysis to situations where *A* stops own production in the trade model but keeps its production in the competition model (case 2). First we define the demand for water in market 1:

$$p_1 = k - bq_1^{\eta} \qquad (43),$$

where η determines the curvature of water demand. Marginal costs of utility *A* are defined as follows:

$$C_A'(q_A) = c_0 + c_1 q_A \qquad (44)$$

*B*s marginal costs c_B are assumed to be linear. First we apply comparative statics by varying *A*'s marginal costs. We assume $b = 1$, $\eta = 1$, $k = 12$, $c_1 = 1$ and $c_B = 2$. Since only cases 2 is of our interest, we consider $\hat{p}_1 > C_A'(0) \geq \hat{p}_T$ and $c_0 > c_B$.

	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	9.000	1.000	3.000	20.000	91.4
7.5	9.500	7.000	2.500	21.875	9.100	0.800	2.900	20.075	91.8
8.0	9.500	7.000	2.500	21.875	9.200	0.600	2.800	20.300	92.8
8.5	9.500	7.000	2.500	21.875	9.300	0.400	2.700	20.675	94.5
9.0	9.500	7.000	2.500	21.875	9.400	0.200	2.600	21.200	96.9
9.5	9.500	7.000	2.500	21.875	9.500	0.000	2.500	21.875	100.0

Table 2: Varying the cost differential

[27] In section 3.2.1 we showed that p_1 in case 3 of the trade model is smaller than in cases 1 and 2. The relative performance regarding welfare must be higher in case 3.

Similar to our linear model in section 4, the relative performance regarding welfare is higher in the trade model, even when retail price p_1 is lower in the competition model. However, increasing the marginal cost differential by increasing c_0 reduces such welfare differential. Higher marginal costs reduce A's incentives in the competition model to engage in market 1 by itself. A reduces own production volume and leaves the market to its competitor B. The increasing engagement of B increases the overall production efficiency. The negative effect of a higher p_1 is overcompensated by the higher production efficiency. The net effect regarding welfare is positive. At the end where $c_0 = 9.5$ A decides in both models to stop own production and welfare is equal in both models (case 1).

In section 4 we showed that an increasing concavity of the demand curve increases retail price p_1 in the competition model less strong than in the trade model. In case of a strong concave demand curve consumers would prefer a competition model because of a lower retail price compared to the trade model. From equation (18) we know that with a concave demand the price differential between the competition and the trade case is larger. However, this means that the inefficient production of A will also be higher compared to the case with linear demand. Therefore a higher concavity of demand reduces the overall production efficiency in the competition model. The net effect regarding welfare is shown in Table 3. 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.

	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*	*8.086*	*0.069*	*9.721*	*73.014*	*99.7*
0.7	*8.540*	*6.118*	*5.890*	*46.915*	*8.473*	*0.336*	*6.054*	*45.910*	*97.9*
0.8	*8.914*	*6.444*	*4.091*	*33.894*	*8.770*	*0.482*	*4.331*	*32.528*	*96.0*
0.9	*9.230*	*6.737*	*3.102*	*26.499*	*9.006*	*0.560*	*3.383*	*24.980*	*94.3*
1.0	*9.500*	*7.000*	*2.500*	*21.875*	*9.200*	*0.600*	*2.800*	*20.300*	*92.8*
1.1	*9.732*	*7.238*	*2.105*	*18.776*	*9.365*	*0.620*	*2.413*	*17.187*	*91.5*
1.2	*9.934*	*7.455*	*1.831*	*16.588*	*9.509*	*0.629*	*2.140*	*15.001*	*90.4*
1.3	*10.110*	*7.652*	*1.632*	*14.979*	*9.635*	*0.633*	*1.939*	*13.399*	*89.5*
1.4	*10.264*	*7.833*	*1.483*	*13.757*	*9.749*	*0.632*	*1.785*	*12.185*	*88.6*
1.5	*10.400*	*8.000*	*1.368*	*12.804*	*9.851*	*0.631*	*1.665*	*11.239*	*87.8*

Table 3: Varying the curvature of the demand curve

Total welfare in the trade model is always higher than in the competition model. As mentioned above, the ratio p_1^{Comp} to p_1^{Trade} decreases with increased concavity of the demand curve (higher η). Nevertheless, welfare decreases stronger in the competition model than in the trade model. Obviously the effect regarding lower production efficiency due to an increasing production of *A* dominates.

6 Conclusions

We showed that both, the introduction of competition by 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 relevant retail price. Both competition and trade allow less efficient suppliers to reduce own production volume and/or to overcome their capacity constraints while more efficient suppliers enhance production volume by raising their treatment facilities' rate of capacity utilisation. Significant welfare gains can be achieved. However, welfare gains are not the same in the two models. Depending on bargaining power and the slope of the demand curve effects on production efficiency, retail prices, resulting welfare and the distribution of additional profits can differ. Welfare tends to be higher in the trade case.

The average efficiency of production is lower in the competition model since the less efficient utility keeps own production. However, aggregate production may rise in the competition model due to the entry of the inefficient utility. The net effect on welfare is therefore a priori unclear. But we showed that the relevant welfare gains from an increased production are of second order whereas the welfare losses from reduced production efficiency are of first order. Therefore the introduction of trade causes higher or at least similar welfare gains than the introduction of competition. In both models the upstream company skims the main part of the additional profit. But one should have in mind that the role of *A* and *B* change fundamentally in these models. *A* is the upstream company in the competition model but the downstream company in the trade model. Obviously the less efficient utility *A* tends to prefer the competition model while the more efficient utility *B* prefers the trade model. Consumers in contrast prefer the competition model when retail prices are lower.

The trade model's relative performance regarding welfare can even be increased by enhancing *A*'s bargaining power. We analysed welfare and distribution of profits in a second polar case where the less efficient utility *A* has the entire bargaining power. Then *A* purchases water from B at $p_T = c_B$. Such price must be lower than in the trade model where B has the entire bargaining power: due to the lower relevant marginal costs caused by the lower trade price, A enhances its engagement in market 1 and reduces the retail price p_1. Now, A can extract the full rent of the additional efficiency. This shows that the relative performance of these two models significantly depends on the utilities' bargaining power. An interesting extension would be applying the concept of bargaining power to the competition model. For example Bs bargaining power and therefore market position can be improved by implementing an effective access price regulation. However, as mentioned in section 4.4 the regulation of access prices in the water industry would be very complex and costly in practice. One can except that an incumbent's freedom to set the access price would still be significant. A further extension is the regulation of retail prices. Introducing a price cap into the model improves the production efficiency in the competition model. Nevertheless, welfare still tends to be higher in the trade model.

Although we designed our model to examine a – 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 neighboured monopolies is possible. Obviously relevant 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.

From a broader perspective the results of the model relativise the benefits of common carriage in the water market. Due to its local extension and the regulation difficulties welfare gains of competition are expected to be minor. Allowing simple trade between neighboured water suppliers could lead to similar or even higher welfare gains – without any regulation effort. And 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 boarder trade, whereas competition needs extensive and complex economic regulation. And in contrast to competition political resistance against trade would be minor. Opponents of privatisation and competition in the water sector emphasise the importance of water as base for live. According to their argumentation water is rather a common than an economic good that could be provided by a private and therefore profit oriented company (see e.g. WWF 2003, Section 2). In the line of this argumentation the European Commission 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". Based on this fundamental statement the Water Framework Directive does not include any guidelines or recommendations about privatisation or competition. 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 neighboured 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. Obviously an extension of water trade would lead to further welfare gains. But local water suppliers are often not profit-oriented since they are part of the public authority. As a result they try to be as independent as possible. Our model showed that profit-maximising utilities would have incentives to introduce voluntarily cross boarder trade, since profits can be improved. However, there are several arguments against profit-maximisation in the piped water industry. Further research could examine how to promote efficient trade between non-profit oriented water suppliers.

References

Andersen, Christoph; Reichhard, Christoph: *Kommunale Dienstleistungen im Wettbewerb*, Kommunalwissenschaftliches Institut der Universität Potsdam, under: http://www.kommune-im-wettbewerb.com/dlfiles/GOW.pdf, February 19, 2003.

Becker, Nur: Value of moving from central planning to a market system: lessons from the Israeli water system, *Agricultural Economics*, 12, 1995, 11-21.

BGW (Bundesverband der deutschen Gas- und Wasserwirtschaft): *109. Wasserstatistik*, Bonn 1999.

BMWi, Bundesministerium für Wirtschaft und Arbeit; *Optionen, Chance und Rahmenbedingungen einer Marktöffnung für eine nachhaltige Wasserversorgung*, BMWi-Forschungsvorhaben (11/00), Vorläufiges Thesenpapier, Berlin 2001.

Calatrava, Javier; Garrido, Alberto: *The effects of spot water markets on the economic risk derived from variable water supply*, Universidad Politécnica de Cartagena /Universidad Politécnica de Madrid Contributed paper selected for presentation at the 25th International Conference of Agricultural Economics, August 16-22, 2003, Durban/South Africa.

Carey, Janis M.; Zilberman David: A Model of Investment under Uncertainty: Modern Irrigation Technology and Emerging Markets in Water, *American Journal of Agricultural Economics*, 84(1), February 2002, 171-183.

Chipty, Tasneem; Snyder, Christopher M.: The role of firm size in bilateral bargaining: A study of the cable television industry, *The review of Economics and Statistics,* 81(2), May 1999, 326-340.

Correia, Francisco Nunes; Kraemer, Andreas; *Institutionen der Wasserwirtschaft in Europa – Länderberichte*, Springer, Berlin, 1997.

Cowan, Simon; Competition in the Water Industry, *Oxford Review of Economic Policy*, Vol. 13, No. 1, 1997, 83 - 92.

Cowan, Simon; Regulation of Several Market Failures: The Water Industry in England and Wales, *Oxford Review of Economic Policy*, Vol. 9, No. 4, 1993, 14 - 23.

Demsetz, Harold; Why Regulate Utilities? *Journal of Law and Economics,* 11, 1968, 55 - 65.

Dwr Cymru Welsh Water; *Water Resources and Treatment Cost Drivers*, Montgomery Watson (Report), London 1999.

EEB, European Environmental Bureau, *A Review of Water Services in the EU under liberalisation and privatisation pressures*, EEB Publication Number: 2002/012, Brussels 2002.

European Commission: *Directive 2000/60/EC*, under: http://europa.eu.int/eur-lex/pri/en/oj/dat/2000/l_327/l_32720001222en00010072.pdf, February 19, 2003.

Feigenbaum, Susan; Teeples Ronald: Public Versus Private Water Delivery: A Hedonic Cost Approach, The *Review of Economics and Statistics*, Vol. 65, No. 4, November 1983, 672 - 678.

Foellmi, Reto; Meister, Urs; *Product-Market Competition in the Water Industry: Voluntary Nondiscriminatory Pricing*, IEW Working Paper Series No. 115, University of Zurich 2003.

Grout, Paul A.; *Competition Law in Telecommunications and its Implications for Common Carriage of Water*, CMPO Working Paper Series No. 02/056, University of Bristol 2002.

Hearne, Robert R.; Easter, William K.: The Economic and Financial Gains from Water Markets in Chile, *Agricultural Economics*, 15(3), January 1997, 187-199.

Howitt, Richard E.: *Spot prices, option prices, and water markets: an analysis of emerging markets in California*, in: *Markets for Water: Potential and performance* (Editors: Easter, K.W.; Rosengrant, M.; Dinar, A.), Kluwer Academic Publishers, New York 1998.

Kajisa, Kei; Sakurai, Takeshi; *Price Determination under Bilateral Bargaining with Multiple Modes of Contracts: A Study of Groundwater Markets in India*, Working Paper National Graduate Institute for Policy Studies (GRIPS) / Japan International Research Center for Agricultural Sciences (JIRCAS), Japan 2000.

Kauf, Teresa L.; Price discrimination and bargaining power in the U.S. vaccine market: Implications for childhood immunization policy, *The Quarterly Review of Economics and Finance,* 39(2) 1999, 249-265.

Kurukulasuriya, Pradeep; *Water Privatization in the UK – Lessons learnt and the way ahead*, School of Forestry and Environmental Studies, Yale University, New Haven 2001.

Ludin, Daniela; Rahmeyer, Fritz; Wörner, Daniela: *Nachhaltige Wasserwirtschaft durch Synergie – Mögliche Kooperationen bei der Wasserver- und Entsorgung*, Working Paper Universität Augsburg in Zusammenarbeit mit der Arbeitsgemeinschaft der Wasserver- und Entsorgungsunternehmen in Schwaben, Augsburg 2000.

Meinzen-Dick, Ruth; *Groundwater markets in Pakistan: Participation and Productivity*, Research Report No. 105, International Food Policy Research Institute, Washington D.C. 1997.

Morgan, James N.: *Bilateral Monopoly and the Competitive Output*, The Quarterly Journal of Economics, Vol. 63, No. 3, August 1949, 371-391.

Newbery, David M.: Allocating Bottleneck Capacity with Liberalised Access, Working Paper, University of Cambridge, Cambridge, 1996.

Nash, John F.; The Bargaining Problem, *Econometrica*, Vol. 18, No. 2, April, 1950, 155-162.

Ofwat (Office of Water Services); *Access Codes for Common Carriage – Guidance*, Birmingham, 2002.

Pilgram, John J.; Property Rights and Water Markets in Australia: An Evolutionary Process toward Institutional Reform, *Water Resources Research*, 29(4), April 1993, 1313-1319.

Renzetti, Steven; Evaluating the welfare effects of reforming municipal water prices, *Journal of Environmental Economics and Management*, 22, 1992, 147-63.

Rosengrant, Mark W.; Binswanger, Hans P.: Markets in tradable water rights: Potential for efficiency gains in developing country water resource allocation, *World Development* 22(11) 1994, 1613-1623.

Saleth, R. Maria; W*ater markets in India: Economic and institutional aspects*, in: Markets for Water: Political and Performance (Editors: William, E. K., Rosengrant, M.W.; Dinar, A.; Kluwer Academic Publishers, Massachusetts 1998.

Scheele, Ulrich: *Auf dem Wege zu neuen Ufern? Wasserversorgung im Wettbewerb*, Working-Paper Nr. V.-214-2000, Universität Oldenburg 2000.

Shah, Tushar; Ground Water markets and Irrigation Development. Oxford University Press, Bombay 1993.

Tintner, Gerhard: The Problem of Bilateral Monopoly: A Note, *The Journal of Political Economy*, Vol. 47, No. 2, April 1939, 263-270.

Webb, Michael; Ehrhardt, David; *Improving Water Services through Competition,* Public Policy for the Private Sector / The World Bank Group, Note No. 164, Washington 1998.

WVZ, Wasserversorgung Zuerich, *Zahlen und Fakten*, under: http://www.stzh.ch/wvz/welcome.asp, February 19, 2003.

WWF, World Wildlife Funds, *Für eine nachhaltige Siedlungswasserwirtschaft in der Schweiz*, under: http://www.wwf.ch/de/presse/PosPap_Wasser_D.pdf, February 19, 2003.

ZVBWV, Zweckverband Bodensee-Wasserversorgung: *Verbandssatzung*, (Version 2003), under: http://www.zvbwv.de/upload/mediapool/FREI_Informationsmaterial _Satzung_Hauptteil.pdf; February 19, 2003.

ZVBWV, Zweckverband Bodensee-Wasserversorgung: *Wasserabgabeverordnung* (Version 2001) under: http://www.zvbwv.de/upload/mediapool/Verbandssatzung_pdf., February 19, 2003.