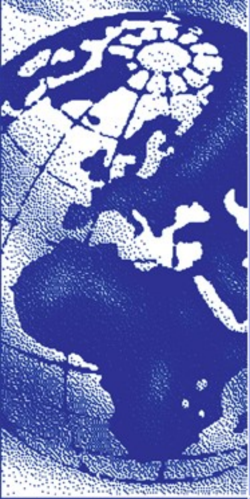

Markt- und Unternehmensentwicklung
Hrsg.: Arnold Picot, Ralf Reichwald und Egon Franck

Urs Meister

Introducing Competition into the Piped Water Market

A Theoretical Analysis of Common Carriage and Franchise Bidding

DUV GABLER EDITION WISSENSCHAFT

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Herausgegeben von
Professor Dr. Dres. h.c. Arnold Picot,
Professor Dr. Professor h.c. Dr. h.c. Ralf Reichwald und
Professor Dr. Egon Franck

Der Wandel von Institutionen, Technologie und Wettbewerb prägt in vielfältiger Weise Entwicklungen im Spannungsfeld von Markt und Unternehmung. Die Schriftenreihe greift diese Fragen auf und stellt neue Erkenntnisse aus Theorie und Praxis sowie anwendungsorientierte Konzepte und Modelle zur Diskussion.

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With a foreword by Prof. Dr. Egon Franck

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Foreword

The continuing growth of the world population, pollution problems etc. contribute to increased water scarcity in the future. This development calls for substantial improvements in the efficiency of water supply. Such improvements are not only a matter of technical progress but also a question of institutional design. Which institutional structures provide the right incentives to ensure efficient water supply? In general economists recommend privatization and liberalization as a means of reducing retail prices and increasing customer satisfaction. Do these recommendations derived from the analysis of other network industries such as airlines, telecommunications or electricity work in the piped water industry? To what extent do they work? Which other solutions more tailored to the specific requirements of the piped water industry are available?

Urs Meister analyses the welfare effects related to privatization and liberalization in the piped water industry and addresses these issues in a clear and comprehensive way. Based on microeconomic models he focuses on the effects of competition on production efficiency, retail prices, investment behaviour and political acceptance. Urs Meister makes an important contribution to a largely neglected field. His theoretical analyses of Common Carriage and Franchise Bidding in this specific context are state of the art. Furthermore, the book provides a clear framework and an excellent theoretical basis for future empirical research in the field. Hopefully, this book achieves substantial circulation.

Prof. Dr. Egon Franck

Preface

Water is a base for life. How to organise water supply is a very important issue – today and in the future. To deal with this issue from a scientific point of view was a very exciting and enriching experience. My research was financially supported by the Research Fund of the University of Zurich. I am very happy to have pursued my research at a very good and stimulating institution, namely at the Institute for Strategy and Business Economics, respectively at the Chair of Business Management and Policy at the University of Zurich. Special thanks then go to my supervisor, Prof. Dr. Egon Franck. He afforded my research in this field and offered opportunities to participate in international conferences, where I could present my results and exchange my experience with other researchers. Additionally, I would like to thank to the co-advisor, Prof. Dr. Helmut Dietl. With both, Prof. Dr. Egon Franck and Prof. Dr. Helmut Dietl, I had lots of fruitful discussions in a wide range of economic subjects. A very special thanks goes to Dr. Reto Foellmi from the Institute for Empirical Research in Economics. Together with him I worked very intensively on several projects related to the water issue. Additionally, I want to say thanks to Men-Andri Benz from the Chair of Business Management and Policy, who strongly supported me in analytical problems related to the models. Finally I want to thank my parents, Adolf und Marie-Louise Meister-Kaufmann. They made it possible that I write a dissertation. Additionally, I had lots of interesting and fruitful discussions with them. Especially my father, who has gained a wide range of experience in the field of water as a manager of a water utility, gave me lots of helpful suggestions and provided me early a critical view on this topic.

Wasser ist eine notwendige Lebensgrundlage. Wie und von wem die Versorgung mit Trinkwasser sichergestellt wird, ist heute und auch in Zukunft eine ganz zentrale Frage. Die Auseinandersetzung mit dem Thema stellte für mich eine ausserordentlich bereichernde Erfahrung dar. Die Dissertation wurde unterstützt und finanziert durch einen Forschungskredit der Universität Zürich. Ich hatte das Glück, am Institut für Strategie und Unternehmensökonomik bzw. am Lehrstuhl für Unternehmensführung und -politik hierzu ideale Bedingungen vorzufinden. Mein spezieller Dank gilt daher dem Betreuer meiner Doktorarbeit, Prof. Dr. Egon Franck. Er ermöglichte mir die Forschung in diesem Bereich und gewährte mir die Möglichkeit, die Resultate der Forschung an internationalen Konferenzen mit anderen Wissenschaftlern auszutauschen. Daneben gilt der Dank auch dem Koreferenten meiner Arbeit, Prof. Dr. Helmut Dietl. Mit ihnen genoss ich zahlreiche bereichernde Diskussionen in den unterschiedlichsten Gebieten der Ökonomie. Ein ganz spezieller Dank gilt Dr. Reto Föllmi, mit dem ich intensiv zahlreiche Forschungsprojekte bearbeitete. Ausserdem möchte ich mich bei meinem Lehrstuhlkollegen Men-Andri Benz bedanken, der mich bei vielen modelltechnischen Problemen unterstützte. Schliesslich möchte ich mich vor allem bei meinen Eltern, Adolf und Marie-Louise Meister-Kaufmann, bedanken. Sie machten es überhaupt möglich, dass ich eine Dissertation schreiben konnte. Ausserdem möchte ich mich bei ihnen für zahlreiche interessante Diskussionen bedanken. Mein Vater, der viele Jahre eine Wasserversorgung geleitet hatte, gab mir zahlreiche wichtige Ideen und Anregungen.

Urs Meister

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Introduction

"Water is the principle, or the element, of things. All things are water." (Thales of Miletus)

Today, a large share of the world's population faces acute water scarcity. According to the World Bank, about 1 billion people do not have access to clean water (see World Bank, 2004, p. 1). Due to the ongoing growth of demand, water shortage will be an increasing problem in the near future. The World Commission on Water estimates that more than 4 billion people – half of the world's population – will live under conditions of sever water stress by 2025. However, global raw water resources are not scarce. More than two third of the world's surface consists of water. But 97 percent of this water is seawater and 2 percent is locked up in icecaps. As a result, only 1 percent of the world's water is easy accessible drinking water. Nevertheless, from an economic perspective the entire water resources can be used, even seawater – it is a matter of treatment and transportation costs. Increasing the efficiency, respectively reducing the costs of water supply may be one of the major opportunities to solve the problem of global water scarcity. However, it is important to note that efficiency of water supply will not only be an issue in regions with acute water scarcity such as Africa, the Middle East and South Asia. Also developed regions such as Europe or Northern America face increasingly water resources challenges. One main issue is the increasing raw water pollution, which raises treatment effort and the related treatment costs. A further issue concerns dropping ground water tables. Many of the world's major groundwater aquifers are threatened or already permanently damaged by salinization. Using alternative raw water resources as for instance surface water would raise treatment costs significantly.

Improving the efficiency of water supply is not only a matter of technical progress. From an economic perspective it is important to implement market structures which allow and support efficiency improvements. However, the applied market structure should not only minimise costs; it should rather maximise efficiency of supply given a wide range of additional objectives that have to be considered. David Hall (2001, p. 9) gives a broad overview about objectives and challenges in the piped water sector: infrastructure objectives (reducing leakage, replacing and extending networks, improving technology), social and political objectives (improving coverage, affordability, higher standards, transparency, accountability), environment and health objectives (public health needs, environmental management, conservation of water), financial objectives (sustainable and equitable tariffs, effective revenue collection, financing investment) or managerial objectives (improving efficiency and productivity, capacity building, efficient procurement). But which market structure ensures efficiency of supply? How do water markets and water utilities have to be organised in order to meet the above described objectives? Economists point out the inevitable role of privatisation and liberalisation in order to enhance efficiency, to reduce retail prices and to increase customer satisfaction. In fact, there is some positive experience gained in other network industries such as airlines, telecommunications, electricity, railways or gas. But to what extend are such processes applicable and successful in the piped water industry? Using microeconomic based models this book explains and analyses the welfare effects related to privatisation and liberalisation in the piped water industry. Of course, we will not be able to deal with all the above mentioned objectives that may be important in the water industry. We rather analyse a more aggregated level that focuses the effects of competition on production efficiency, retail prices, investment behaviour and political acceptance. Of course, additional issues such as environmental and health objectives are of high relevance considering privatisation and liberalisation. However, in our context it is useful to assume that these issues can be solved by adequate regulation. Such assumption tends to be applicable, since compliance is, in many cases, observable and verifiable by a public regulating agency.

Market structure in the piped water industry Historically, water supply has usually been provided by public enterprises. Participation of private and profit maximising companies still tends to be very low in most European countries. In Germany for instance, only about 7 percent of water suppliers are at least to some extend privately owned, in the Netherlands about 6 percent (see Schoenbaeck et. al. 2003 or EEB, 2002). The reason for the low private participation and the absence of competition may root in the fact that water supply is widely seen as a natural monopoly. Due to the extensive share of fixed costs related to the network investment, it is efficient to have only one network per market. From a welfare point of view, it is useful to compose such monopolist as a public and not-profit oriented water utility. Beside such economic argument, there is a broad political opposition against privatisation and liberalisation in the water sector. Opponents of such processes fear increasing water fees, less attention to water quality aspects, efficiency losses, reduced investment levels, less attention to water pollution control and an extensive use of easy accessible water resources (see WWF 2003 or BMZ 2001). They emphasise the importance of water as a base for live. According to their argumentation, water is rather a common than an economic good that could be provided by a private company (see e.g. WWF 2003). In the line of this argumentation the European Commission defined in its Water Framework Directive (Directive 2000/60/EC) that water is not a commercial product like any other, 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.

Can we conclude that public supply is always a superior model for the water sector? Vickers and Yarrow point out that any form of ownership is inevitably imperfect. They argue: "The effects of ownership changes on welfare will depend upon the relative magnitudes of these imperfections" (Vickers and Yarrow 1991, p. 130). In fact, most privatisation processes in the water industry were mainly motivated by public failure – for instance privatisation in England and Wales, in 1989. Due to budget restrictions, local governments failed to invest into long term water supply assets. Such investments were necessary due to increased requirements of the European environmental protection law. Selling water utilities to private shareholders was seen as an opportunity to uncouple water utilities financial requirements from the public budget. Additionally, the government expected cash flow from selling the utilities' shares. Today, many customers evaluate the privatisation as negative, since water tariffs increased significantly after 1989. However, the higher tariffs were not only caused due to profit maximisation. The privatised and strongly regulated utilities were forced to close the investment lack: until the period 1992/93 the utilities increased their investment level by more than 250 percent compared to 1985/86.[1] All together, it is difficult to evaluate the net effects of the structural changes in England and Wales or other countries such as France or Italy. The welfare effect can only be positive, if higher retail prices are outweighed by higher production efficiency. Renzetti and Dupont (2004) give a broad overview about empirical studies dealing with privatisation and efficiency gains in the water industry. They argue that "empirical literature is lacking in conclusive evidence that privately owned water utilities are more efficient than comparable publicly owned water utilities" (Renzetti and Dupont 2004, p. 16). However, these studies only focus on the isolated effect of the ownership structure. They analyse privatisation, but exclude the role of liberalisation.

The role of competition Following Vickers and Yarrow (1991, p. 130), "the effects of privatization in any particular context will (...) be highly dependent upon the wider market, regulatory and institutional environment in which it is implemented". Vickers et. al. (1986) emphasise the role of incentives for the private management and they show evidence that the success of privatisation is highly dependent on the degree of competition that can be implemented after privatisation. Analysing a wide range of empirical studies they argue that "taken as a whole, the results do point to a presumption in favour of private ownership, provided that other market failures are insignificant or can be adequately corrected by means of alternative policy instruments" (Vickers et. al. 1986, p. 375). Obviously, the sole change of the ownership structure does not necessarily enhance efficiency and welfare in the piped water sector. Efficiency and therefore welfare gains are mainly dependent on the successful implementation of competition. Basically, competition can be implemented by competition for the market (franchise bidding for supply licences), as applied in France, Italy and Argentina, or by competition in the market (common carriage based on interconnection competition), as applied in England and Wales. There may be additional elements of competition that can be applied as for instance yardstick competition, which allows benchmarking based regulation, or border line competition, that allows customers, who are located at the border of a supply area, to purchase water from an existing neighbouring utility. In practice, competition tends to be weak in the water industry, even in countries where privatisation is already applied. Competition still plays a minor role in England and Wales. Today, the regulation of retail prices by price cap and elements of yardstick competition are of higher importance. However, the government tried to increase competition by the implementation of the Competition Act 1998 which came into effect March 2000. Based on the Act, the regulator Ofwat (Office of Water Services) published in 2002 guidance on the development of access codes (see Ofwat 2002, p. 1) that should facilitate competition by common carriage. In particular from France, there is more experience with competition for the market. However, in its 1997 report, the French national audit court (Cour des Comptes 1997) assessed competition as weak and mentioned the role of bribery and corruption.

Overview of the book This book analyses the effects of introducing competition into the piped water market. The analysis is *not* related to a specific water market, for instance in a specific region. It rather describes a general and model based analysis. Microeconomic theories and industrial organisation are the main instruments for this analysis. Chapters 2, 3, 4 and 5 start with a self-contained introduction; they end with a short discussion and draw conclusions. This modular approach should allow the reader to understand a chapter without having read another chapter. Chapter 1 of this book gives a brief introduction into the aspects of demand and supply in the piped water sector. Chapter 2 analyses the effects of product-market competition (common carriage) by considering a simple model of interconnection, where competition is introduced between vertically integrated neighbouring water suppliers. The model contains water markets specificities such as local and decentralised networks and related difficulties of regulating access charges. Even without any regulation, the model shows that: (i) an inefficient incumbent will give up its monopoly position and lower the access price far enough so that the low-cost competitor can enter his home market; (ii) efficiency of production will rise due to liberalisation; (iii) in contrary to prejudicial claims, investment incentives are not destroyed by the introduction of competition. Investments of low-cost firms may even increase. Chapter 3 considers the water utilities objective function. Due to the increasing discussion about liberalisation in the piped water industry, municipal authorities consider modifications of their water utilities' structure

[1] For a broad overview about the privatisation and liberalisation in England and Wales see Correia and Kraemer,

such as legal constitution, business objectives or private participation. Chapter 3 evaluates the extent to which it is socially optimal to compose water utilities as welfare or profit maximising companies, when assuming the introduction of competition based on common carriage. Using a game theoretic model of mixed oligopolies that contains water markets specificities, we show that welfare tends to be higher in a regime, where utilities are instructed to maximise profits rather than welfare. Chapter 4 analyses and compares potential efficiency gains induced by the introduction of common carriage on the one side and cross border trade on the other side. Using a game theoretic model the model shows that the approaches imply different welfare effects depending on the efficiency differential between the utilities. Common carriage induces relatively stronger production incentives for the inefficient supplier. This implies that the retail price tends to be lower than with trade. Production efficiency tends to be higher under trade. At very low efficiency differentials, the efficiency effect dominates, at higher efficiency differentials, the price effect dominates. Chapter 5 analyses investment incentives under franchise bidding. The periodical re-auction of a water monopoly concession causes the danger of underinvestment. If the life-time of specific assets, as for instance water pipes exceeds the contract length and transferring the ownership of assets is difficult, the incumbent franchisee faces a hold-up problem. Using a simple auction model, this chapter shows that investment incentives may vary depending on the applied auction scheme. Investment tends to be higher in sealed bid auctions than in an English auction, since the incumbent benefits from an information advantage. Additionally, investment may vary in a first- and a second-price sealed bid auction depending on several factors such as costs or effectiveness of investment. Finally, Chapter 6 summarises the results of the book and concludes.

1997, Cowan (1997), Cowan (1993), or Webb and Erhardt (1998).

1 Demand and Supply – a Brief Overview

1.1 Demand for Treated Water

Between 1900 and 1995 global water consumption rose six-fold, from 920 to 5'500 billion cubic metres, which is more than double the rate of population growth. One can expect that due to the extended use of irrigation systems in the agricultural sector, global industrial growth and changed individual habits, such development will continue in the nearer future. According to the World Commission on Water, the water use will increase by about 50 percent in the next 30 years (see World Bank, 2004, p. 1). The allocation of water use will continue to vary significantly between regions and nations. Today more than 20 percent of the world's population do not have access to safe drinking water. According to the World Bank approximately one half of the people in the developing world are suffering from a sickness associated with bad water (see World Bank, 2004, p. 1). In contrast, total annual per capita water consumption in the United States amounts to 1'900 m^3. However, consumption varies significantly between industrialised nations. In Luxembourg for instance, per capita consumption amounts to only 160 m^3. Obviously such differences are mainly driven by differences in the economic structure. In industrialised countries, household water consumption amounts to an average of only 5 percent of total consumption, industrial consumption to 65 percent and agricultural consumption to 30 percent (see OECD, 1999, p. 15). In order to have a more detailed view about water consumption, respectively water demand in industrialised countries, it is worth to analyse these three components of water use more detailed. However, this book focuses on the first component, residential use, and only some parts of the second component, industrial, respectively non-residential use. The reason is obvious: only residential water users and small businesses are connected to piped public water supply systems – which is the object of research in this work. Agricultural business and large scale industry with extended water needs such as energy production or steel industry usually use separate, low quality water resources. The separation of water supply is efficient, since in many cases agriculture and industry do not need well treated and therefore expensive water resources.

Household water consumption (domestic / residential use) mainly consists of elements such as flushing the toilet, using the wash machine or shower and bath. It is important to note that water, which is directly used for cooking or drinking, is of minor importance and amounts on average to only 3 percent of total household consumption (see Figure 1). Nevertheless, consumption related to cooking and drinking basically dictates the minimum quality standard and therefore the necessary treatment level. Per capita household water consumption varies significantly between nations. Daily per capita water consumption in droughty rural areas in Africa amounts to about 20 litres. Obviously, consumption tends to be far higher in developed countries: Americans consume 300 litres, average Europeans about 150 litres, whereby daily per capita consumption ranges from 113 litres in Belgium to 214 litres in Finland. However, household consumption continuously decreased in most developed countries after 1980. In Germany for instance, daily per capita household water consumption amounts to 129 litres, ten years ago to 144 litres (see Scheele and Malz, 2004). According to the OECD, (see OECD, 1999, p. 132) such development is mainly due to a real increase of water tariffs in most developed countries. Additionally many countries established quantity dependent water tariffs as a consequence to the increased use of water metering systems after 1980. In Great Britain for instance, water metering reduced household consumption in some areas up to 45 percent. The higher and quantity dependent water tariffs not only changed individual consumption behaviour, but also they supported the increased use of water-saving household appliances.

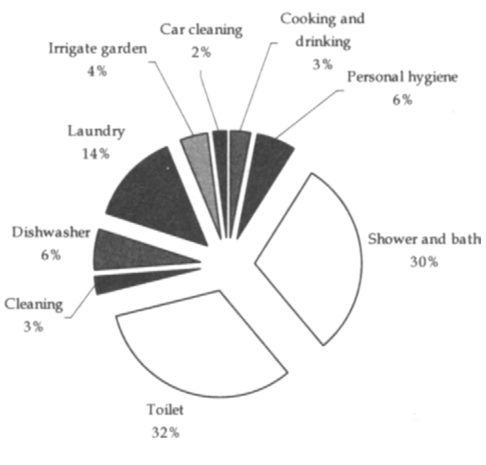

Figure 1: Elements of household water demand (source: Umweltbundesamt, 2001, p. 34)

It can be followed that price elasticity of household water demand tends to be negative. The price elasticity of water demand can be defined as $\eta = (dQ/dP)/(P/Q)$, where Q stands for water demand, P for marginal price. A wide range of empirical studies support the above described evidence concerning negative price elasticity. Dziegielewski et al (2002) give a broad overview about empirical results by analysing 44 water demand studies. 18 of these studies are related to public supply and model either total municipal water use or specific components of municipal use, such as the residential or non-residential sub-sectors. 8 of these studies focus residential, respectively household demand. Municipal water-use models – that include both, households and small business which is connected to public water supply systems – find price elasticities that range from -0.049 to -0.38. Income elasticity ranges from 0.144 to 0.48. Models that focus the sub-sector residential water use find price elasticities that range from -0.06 to -0.568. Income elasticities range from 0.40 to 0.608. In both, municipal and residential models, there is strong evidence that price elasticity tends to be relatively inelastic ($\eta > -1$) and stronger during summer seasons. Moreover, they find strong evidence for positive income elasticities – higher income supports water demand.

Industrial water use amounts to an average of 65 percent of total water consumption in industrialised countries. However, from a global point of view, industrial use is of less importance (only 20 percent) since agricultural use tends to be dominant in less industrialised countries (see Scheele and Malz, 2004, p. 94). The main part of industrial use is due to energy production. Water is either directly used for water power plants or for the purpose of cooling, for instance in nuclear power plants. Obviously, quality needs for such use is of minor importance: water resources used in energy production do not need any kind of treatment. Only a small fraction of industrial water demand is due to water resources that are directly used in the production process. In Europe, average industrial use for production processes are estimated to only 10 percent of total water use. Industries that require extended water resources in their production processes are mainly chemistry, mining, metal treatment, cellulose and paper production, food and beverage production and petrochemical sectors. Due to water saving production technologies, industrial water use in production processes decreases continuously. The production of one tonne of steel for instance, required between 60 and 100 tonnes of water before World War II. Today less than 6 tonnes of water are needed. Additionally, industrial water use tends to decline in industrialised countries due to changes in the economic structure: services such as banking, insurance or high tech industries obviously require less water in their production processes (see Scheele and Malz, 2004, p. 94). In their meta-level study, Dziegielewski et al (2002) evaluate 7 empirical studies that analyse industrial water demand. Again, they find relatively low price elasticities that range from -0.1103 to -0.894. However, the results indicate that industrial demand is more responsive to changes in price than residential demand. De Rooy (1974) shows, price elasticity tends to be the strongest for water that is used for cooling only.

The main part of agricultural water use is due to the use of irrigation systems. Only a small fraction of water in the agricultural sector is used for other reasons, such as cattle watering tanks or fish farming. As a result, the main driver of agricultural water use is the climatic environment. The impact of the climatic environment on agricultural water needs in California has been analysed by Berk et al (1980). Not surprisingly, they find evidence that both rainfall in the present and the past period have a significant negative impact on agricultural water demand while temperature has a significant positive impact – obviously, climate variables performed as expected. However, not only the climatic situation determines agricultural water demand. Again, the water price is a main determinant of water demand. Dziegielewski et al (2002) analyse 7 different studies concerning price elasticities in the agricultural sector. According to these studies, price elasticities range from -0.1982 to -1.502. Dziegielewski et al (2002, p. 13) argue that "these values indicate that the demand for irrigation water is more responsive to price than industrial and residential demand". Similar to the industrial sector, water quality requirements are far below the household's needs. As a result, agricultural water demand is usually not covered by public water utilities. Farms rather use separate untreated water resources. One can expect that a significant fraction of farmers use own water resources such as surface or ground water that can be tapped on their own ground. However, such resources are not expected to be free of charge. Obviously, ground water causes pumping costs. Ogg et al. (1989) analyse the impact of pumping costs on agricultural water use. And they find pumping cost elasticities that ranges from -0.07 to 0.80.

1.2 Water Supply

In this chapter we briefly analyse the value chain of water supply and the related costs. As mentioned above, we focus the piped water industry: utilities supply customers connected to a pipe network. Customers are therefore mainly defined as households and small businesses. Suppliers are local or regional water utilities. Analysing the value chain of water supply we can differentiate few main elements: water extraction, water treatment, water storage, water transportation, water allocation and retailing activities such as billing or marketing (see Figure 2).

The process and therefore the costs of water extraction and water treatment mainly depend on the constitution of the used raw water resources. Basically, water utilities can tap spring water, pumping groundwater or extract surface water. The use of these different raw water resources not only requires different extraction technologies, but also the need for treatment differs due to quality differences. As a result, using different raw water resources causes different fixed costs (due to the use of different extraction and treatment facilities) and different variable costs (due to the use of different treatment and pumping requirements).

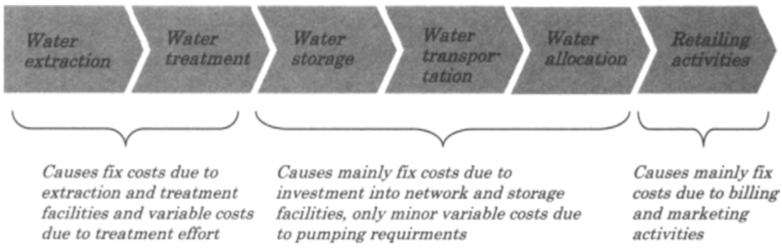

Figure 2: The value chain of water supply (source: own illustration)

According to a study prepared by the British water supplier Dwr Cymnpru Welsh Water (1999, p. 11-13), the used raw water resources are the main cost drivers in water supply. The quality of the raw water affects both, fixed costs and variable costs: low quality induces a higher complexity of extraction and treatment facilities and more extensive treatment effort. Hence, surface water causes highest costs. Since the quality tends to be the lowest, water treatment has to be extensive in order to achieve drinking quality. Usually it requires several steps of treatment such as screening, flocculation, clarification, filtration, addition of chemicals or use of ultraviolet light. Due to higher quality, respectively less pollution, ground water requires less treatment steps – in some cases even no treatment. Usually spring water is of highest quality and requires lowest treatment – both, marginal and fixed costs are very low. In Switzerland for instance, more than 50 percent of the used spring water does not need any treatment, 42 percent needs only one stage of treatment such as ozonisation or addition of chlorine (see Kilchenmann and Kamm, 1997, p. 386). Hence, due to lower costs, water utilities tend to use raw water resources of higher quality such as spring or ground water first. Utilities extend their capacities by using surface waters such as rivers or lakes that require more complex and therefore more expensive treatment. As a result, water utilities marginal costs can be assumed to be increasing with higher production volume.

Production steps such as storage, water transportation, water allocation and retailing activities mainly affect fixed costs. These fixed costs arise due to investment and maintenance, related to the storage facilities and the pipe network. The share of costs related to the pipe network often ranges from 70 to 90 percent of total utilities' costs. Variable costs related to storage, transportation and allocation may arise due to pumping requirements. However, such requirements can be minimised by using the topography (storage facilities at higher levels) or building water towers in order to keep water pressure in the pipe network.

Due to the extensive part of fixed costs caused by the water network water utilities are assumed to be natural monopolies. As a result, water supply in most industrialised countries is mainly provided by public water utilities. There is a wide range of existing organisational structures, for instance local municipality departments, municipally (or partially) owned companies, inter-municipality associations or companies, or private companies that undertake operations through the signing of concessions contracts (see Gordon-Walker and Marr 2002, p. 93). We forbear from analysing organisational issues in this chapter, since we discuss it more detailed later in this book.

2 Introducing Product-Market Competition in the Water Industry

2.1 Introduction

Traditionally, network industries such as electricity, telecommunications, railways or water supply are regarded as natural monopolies. The duplication of the networks (railroad system, water pipes etc.) would not be efficient and therefore undesirable. Hence, there is no reason to have several firms engaged in the market, because total output could be produced cheaper within a single firm. For a long time, the existence of natural monopolies and quality concerns among other issues served to justify the absence of direct competition. For that reason in many European countries network services were provided by public enterprises or strongly regulated private firms. However, in the course of privatisation and liberalisation, governments and regulators tried to expand the role of competition. Two main possibilities exist in order to implement effective rivalry into network industries: franchise bidding, called competition *for* the market, and product-market competition, known as competition *in* the market. In the piped water industry, there is far more experience with the former approach. However, due to the capital intensity of water supply competition for the market has severe drawbacks. Hence, the introduction of product-market competition may be a valuable alternative. However, both practical experience and theoretical research about the effects and the efficiency of product-market competition are still very limited in the piped water industry. This Chapter analyses product-market competition within a simple model of interconnection where competition is introduced between vertically integrated neighbouring water suppliers.[2]

Franchise bidding was proposed by Harold Demsetz (1968). The governmental authorities auction off the monopoly; bidders are required to specify the tariffs they would charge for the supplied product – for a given set of performance parameters. The company promising the lowest tariffs gets the exclusive right to serve customers in the defined area. With enough bidders it is expected that a bidder reveals his minimum costs: He offers the price, which corresponds to the level of his effective average costs. In the piped water industry, franchise bidding has already been applied – for instance for many local systems in France or for the Buenos Aires water and sewerage system in 1993 (see also Klein, 1996). Theory suggests that franchise bidding is a reasonable way to implement competition in the water market. However, such auctions have different drawbacks, particularly in the capital-intensive water industry. Since parameters as technology, water quality, demand or legal aspects alter over time, the setting of prices in advance is dominated by uncertainty. Average

[2] The model outlined in this Chapter basically refers to Foellmi and Meister (2005).

costs are affected by modified circumstances, unwanted gains or losses in the long-term could be the consequences. To handle this problem, the governmental authorities could regulate the industry or repeat the auction frequently. However, carrying out new rounds of bidding is very costly. Furthermore Armstrong, Cowan and Vickers (1994, p. 129) indicate that a shorter holding period of the monopoly right undermine the incentives to invest into the network infrastructure. To prevent underinvestment, the incumbent should be compensated for his effort in case of a defeat in the latest auction. If however, as Williamson (1976) argues, the regulator cannot seriously determine the actual worth of the realised investments and therefore the compensation sum, there is a serious danger of ineffective competition or underinvestment.[3] Armstrong, Cowan and Vickers conclude that franchise bidding is unlikely to be very useful for capital-intensive elements of natural monopolies, such as water supply networks, where capital costs are usually 70 to 90 percent of total costs. In fact, the success of franchise bidding in the French water sector must be assessed ambivalent. In its 1997 report, the French national audit court (Cour des Comptes, 1997) identified a lack of competition, frequent re-negotiations of initial contractual terms, a tendency to extend existing contracts without subjecting them to tender and the existence of bribery and corruption.

Basically, such problems can be avoided by introducing product-market competition, known as common carriage in the water sector. 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 and allow each other access to their distribution pipes in exchange to an access fee – similar to interconnection in telecommunications or electricity. So far common carriage in the water industry has only been introduced in England and Wales. However, in practice common carriage still plays a minor role.[4] In this paper we present a model of product-market competition that takes the water sector's specific technical aspects into consideration. The model is based on a simple structure that allows an easy and practically feasible implementation of direct competition. Additionally the model counts for regulatory difficulties in fragmented water markets. Cowan (1997) indicates that the regulatory burden of assessing access prices for a great number of water networks would be large. He mentions that common carriage is *not* likely to be a major feature of the British water industry in the future. In fact the English regulator Ofwat does not regulate access prices ex ante.[5] We take Cowan's concern into account by assuming a worst case, where regulation does not exist and the incumbents are fully free to set their own access fees. Nevertheless, the model shows that even without regulation, competition arises and

[3] Harstad and Crew (1999) propose a franchise-bidding-model, which addresses the mentioned valuation problem of transferred assets. However, it is necessary to assume that the entrants are informed as good as the incumbent about the value of the assets to be transferred.
[4] See Correia and Kraemer (1997) or Cowan (1993) and Cowan (1997) for a survey of the reform in the water industry in England and Wales.
[5] It rather defines general terms for the calculation of access prices. On the basis of the guidance companies have to publish their specific access codes including indicative or standard prices for access (see Ofwat 2002, p. 20-22).

significant efficiency gains can be realised. However, the result describes a lower bound benchmark where the intensity of competition tends to be low, since the incumbent has significant market power due to its freedom to set the access fee. Obviously introducing common carriage does not remove the entire monopoly problem, but it reduces average production costs and retail price compared to a monopoly case. However, we show that extending the model by regulation would enhance competition and production efficiency.

Other network industries such as telecommunications, electricity or railways already gained some experience with product-market competition. To prevent inefficient network duplication, operators are forced by law to give competitors access to their networks. To secure non-discriminating access, governments either define ex ante the access prices or separate the network vertically from the operating company. The experience gained in these industries may provide useful information for the liberalisation process in the water industry. However, due to technical issues, product-market competition in the water sector differs substantially from other sectors, such as telecommunications. Our model takes these aspects, which will be described more detailed in section 1.1, into account and explores the effects of direct competition on tariff, supply and investment behaviour. As mentioned above, we assume a baseline case where regulation – especially the regulation of access prices – does not exist. Furthermore, the incumbents stay vertically integrated, i.e. they own their (inherited) network *and* they sell water to final customers. Vertical integration is justified by the existence of economies of scope: both distribution systems and water treatment facilities require sanitary know how. Actually, in the liberalisation process in UK, water suppliers remained vertically integrated. Although the firms remain vertically integrated and access price regulation is absent, our model shows that – under linear *and* non-linear access pricing – the former monopoly situation will not persist and that prices will decrease in the home market of the high-cost monopolist.[6]

A second issue of the liberalisation debate concerns the investment behaviour of the incumbents. Due to the long-term character of investments in the water pipe network, there is a serious danger of insufficient investment expenses. Depending on their material, water pipes have an operating life from 20 to 200 years (see Skarda 1998, p. 874). According to a far-reaching prejudice, incumbents neglect long-term network investments in order to improve market position and to maximise short-run profit if competition were introduced. As a result of competition, network quality would deteriorate and a considerable share of the produced drinking water would escape from the leaky water pipes. Nevertheless, despite of the absence of direct competition water today, leakage in European networks is estimated from 15 to 50 percent! European water suppliers replace on average 0,6 percent of their pipe networks yearly, while the International Water Service Association (IWSA) recommends to replace 1,5 percent (see Skarda 1998, p. 874). This underinvestment will be one of the main future issues in the water sector and justifies the model's additional focus on the investment behaviour. The model does not support the prejudice mentioned above. With only weak assumptions, the model predicts increased investment incentives of the low-cost monopolist, caused by the implementation of product market competition – remember that it is difficult for a regulator to verify the incumbents' actual investment volume.

There is a wide range of literature about liberalisation of network industries. Newbery (1997) gives a broad overview about theory and practice, in particular related to the electricity industry. He argues that the regulation of monopolised network industries is inevitably inefficient and that competition is the key to achieve the full benefits of privatisation. There is only little theoretic literature concerning the issue of competition *in* the market, applied to the piped water sector. The introduction of competition by common carriage in the water sector is for instance discussed by Cowan (1993 and 1997), Webb and Erhardt (1998), Grout (2002) or Scheele (2000).

Section 1.1 points out the specific structural aspects of the water sector and the corresponding implications for a competitive market. Based on these aspects, we present in section 1.1 a realistic model of product-market competition in the water industry. The model assumes a two-stage game, where firms set investments in the first period and both, output and access prices in the second period. After the determination of the cost and income structure of involved water suppliers, we solve the model in section 1.1 by backwards induction and analyse the incumbents' behaviour regarding output, access prices and investment. For both stages, we analyse the case of linear and the case of non-linear access prices, since in practice both tariff systems are common. In section 2.4.3, we analyse monopoly power and welfare gains in an unregulated regime. Section 1.1 considers the introduction of regulation. Investment for the physical connection of neighbouring water utilities and quality obligations related to the connection are analysed in section 1.1. The conclusions in section 1.1 discuss the relevant policy implications.

2.2 Structural Issues in the Water Sector

In contrast to railways or telecommunications water pipe network's extension is rather local or regional than national. In most European countries, communal authorities operate the water supply and the water pipe network. Since neighbouring networks are usually not connected, the utilities act as monopolists in often small local markets. In Switzerland for example there are 2'995 utilities serving 3'023 communities. More than 90 percent of the Swiss water suppliers serve an area with less than 5'000 inhabitants (see Klein and Manser 1998, p. 448).

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[6] Such result basically corresponds to the rather more general findings of Spulber and Sidak (1997). They analyse optimal access pricing in network industries and conditions for voluntary access.

Another impressive example is Italy, where 6'600 communities are served by 13'500 utilities. However, in West Germany, the number of suppliers has fallen dramatically after World War II. 1957 existed more than 15'000 utilities, 1990 less than 7'000 (see Correia and Kraemer 1997, p. 86 - 87).

The number of suppliers in an area and the network's extension are both based both on the production process in the water sector and political issues. The former is mainly influenced by the quality of used raw water resources. Drinking water can be produced in three different ways: exploiting surface waters such as lakes or rivers, pumping ground water to the surface or tapping spring water. Due to its high quality, spring water usually does not require any treatment as for instance screening, flocculation, clarification, filtration, the addition of chemicals or the use of ultraviolet light. Ground water usually requires a lower level of treatment than surface water, which mostly consists of poorer quality. Since treatment is a significant cost driver in water production, the use of spring water is very inexpensive, whereas the use of surface water is most costly (see Dwr Cymru Welsh Water 1999, p. 9). Depending on the existence of such raw water resources the water suppliers' cost and tariff structures are expected to vary significantly. 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).

Water treatment causes both, variable and fixed costs. Hence, economies of scale could be achieved through the centralisation of the drinking water production, especially when the share of used surface water is extensive. On the other hand, diseconomies of scale are related to the customer's distance from storage and treatment facilities. The increasing distance indicates higher water losses and greater pumping requirements (see Zarnikau 1994, p. 190 - 191). The pumping effort depends on distance and topography and causes fixed capital and variable energy costs. Another technical aspect that hinders the centralisation of drinking water production is the loss of water quality in the pipe network. The quality loss is positively correlated with transport distance: The longer water remains in the pipes, the larger gets the quality decrease. Furthermore, the capacity of several groundwater or spring water resources is very limited. The use of such relative inexpensive raw water resources indicates a decentralised water production.

Due to the existence of both economies and diseconomies of scale, different degrees of centralisation could be advantageous. In hilly or mountainous countries as there are Italy or Switzerland one expects water supply to be more decentralised than in others, since far-reaching networks would require a high pumping effort and the topography indicates the existence of spring water resources.[7] On the other hand, the increasing use of surface water

[7] In Italy the share of used spring water resources in the drinking water production amounts to 39 percent, in Switzerland 42 percent and in Germany 8 percent. The United Kingdom and the Netherlands use just ground and surface water, which require a higher level of treatment (see SVGW 1999, p. 9).

and the higher water contamination, raise treatment requirements and therefore the economic need for a stronger centralisation. This kind of consolidation and centralisation process was observed in countries such as Germany, Netherlands or England and Wales. In most European countries a further consolidation process is expected. Small utilities in local markets are often unable to meet growing demand or to keep raised quality standards, since the construction of new treatment facilities causes high fixed costs.[8] One possibility to raise economic efficiency in water markets is to merge neighbouring utilities and to connect their networks. Utilities facing poor raw water resources could overcome capacity lacks, while other suppliers could raise their treatment facilities' rate of capacity utilisation. Hence, the merger should implement a cost efficient production structure. Cost minimum would be arrived when all involved utilities face identical marginal costs. The potential efficiency gains could be substantial, since today – as mentioned above – water suppliers' marginal costs vary significantly. Despite such potential efficiency gains caused by the merger of neighbouring utilities, it seems not to be desirable to create bigger and therefore more powerful monopolists, which may exert political pressure e.g. to ask for exaggerated subsidies. Furthermore, the existence of such big and powerful monopolies is often impossible due to institutional or political grounds. More importantly, the fact that there are many water networks is to be looked as an efficient answer to technological constraints, i.e. the diseconomies of scale mentioned above.

2.3 A Simple Model

Several Swiss communities near Zurich have chosen a different way. Economically and legally independent neighbouring water suppliers connected their networks and made the commercial exchange of drinking water possible. Utilities facing poor resources purchase drinking water from better suppliers nearby, in order to overcome capacity problems. In 1997 about 13 percent of produced drinking water in Switzerland was delivered to neighbouring distribution systems (see SVGW 1999, p. 7). Since the waters of the buyer and the supplier mix within the buyer's distribution system, both have the same quality obligations. However, the quality coordination effort and diseconomies of scale caused by the above mentioned technical aspects prevent a comprehensive connection of different networks. The commercial exchange of water is therefore limited to a small number of neighbouring utilities that connected their networks physically.

[8] According to Dutch studies the utility's minimal production volume should vary between 10 and 20 million cubic metre drinking water per year in order to cover the extensive share of fixed costs (see Klein and Manser 1998, p. 448). Less than one percent of Swiss utilities would meet this requirement.

The connection of neighbouring networks could alternatively be used for product-market competition in the water sector. In such a competition approach, called common carriage, water suppliers allow each other access to their networks. Common carriage allows neighbouring water utilities to compete for customers in the same area, using a single set of pipes. Common carriage describes an ordinary interconnection competition as already applied in other network industries namely telecommunications, electricity or gas. It is important to note that interconnection competition does not solve the monopoly problem in the network. Due to the extensive share of fixed costs in investment it would be socially unwanted to duplicate networks. Hence, the pipe networks are essential facilities that are required by competitors e.g. interconnecting operators in order to compete. Common carriage therefore focuses on treatment activities in the value chain of water supply; the networks remain uncompetitive due to their natural monopoly character (see Webb and Erhardt 1998, p. 5).[9] However, even without competition in the network stage, effective interconnection competition takes place as long as the incumbent offers non-discriminatory network access to competitors. By means of regulation, governments can enforce access and ensure fair competition between producers – as applied in other sectors such as telecommunication or electricity. We consider regulation in section 1.1. However, as outlined in the introduction, regulation of access fees in the water industry is complex and costly. In a worst case, the incumbent is fully free in setting access fees. Obviously, such worst case leaves the incumbent with significant market power. Nonetheless, the incumbent voluntarily offers access to the competitor, as shown in section 1.1. Hence, the monopoly's negative consequences, i.e. the inefficiency of production and the existence of positive markups are attenuated.

In our model, every water utility owns an inherited, exogenously given network whose width may differ. Based on the mentioned technical issues in the water sector, competition between utilities takes place at a regional or local level, so that only a few networks can be connected. Since favourable raw water resources such as spring and groundwater are limited and the construction of new treatment facilities causes high sunk costs, the entrance of new market participants seems to be unlikely. For this reason the model's focus on already existing water suppliers, which remain vertically integrated due to economies of scope, seems to be realistic. In contrast to the telecommunication sector, where the former public utility owns the main share of the distribution system, the model implements a different structure, where the suppliers all own their own small network. To keep the analysis simple, we assume that only two former monopolists (denoted by A and B) connect their corresponding networks

[9] It is important to note that competition at the network stage also tends to be inexistent under alternative approaches: in France most water supply licences that are auctioned off in a franchise bidding procedure are designed as Leasing contracts, where the private utility is a monopolist that is a pure network operator. Furthermore it is *not* required to invest into the network.

(described as 1 and 2) and enter into direct competition.[10] Since drinking water mix in the connected networks, both firms supply a homogenous good. The model abstracts from additional product differentiation such as service or image. In the capital-intensive water industry, it is natural to assume that utilities choose their quantities or capacities rather than prices (with exception of access prices).

Using the competitor's network, each supplier is able to serve customers in the entire connected area. The corresponding grid owners charge an access fee. Incumbents could now defend their monopoly position by quoting extensive access prices. Importantly, we assume that a regulator *cannot* set the access price. 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.), access fees would have to be set in an individual manner. Thus, heterogeneous cost structures and asymmetric information prevent the regulator from verifying real marginal costs and therefore from assessing adequate charges.

The two firms A and B face heterogeneous cost functions with variable treatment costs $C_j(\bullet), j \in \{A, B\}$, with increasing marginal costs: $\partial C_j(\cdot)/\partial q_j > 0$ and $\partial^2 C_j(\cdot)/\partial q_j^2 > 0$. In order to minimise treatment costs, utilities firstly use raw water resources of high quality such as spring water. To overcome the relevant capacity constraints, firms 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 increasing in output. In addition, utilities face network investment costs $K_j(I_j)$ with $\partial K_i / \partial I_i > 0$. Higher network investment reduces water leakage L_i in the network i, $i \in \{1, 2\}$. It is important to note that water leakage does not depend on the sold quantity, since water pressure in the network has to be held constant anyway. Total production quantity consists of sold water and water leakage due to leaky pipes. A's relevant total cost function TC_A reads therefore

$$TC_A = C_A(q_{1A} + q_{2A} + L_1(I_A)) + K_A(I_A) \qquad (2.1),$$

where q_{1A} stands for the quantity of sold water to customers in A's own network 1, q_{2A} denotes the volume of A's delivered water to customers in network 2, and $L_1(I_A)$ stands for water losses in A's own network 1. B's relevant cost function can be written simultaneously by reversing the indices.

[10] There is a huge literature concerning network competition with "two-way interconnection" in telecommunications, e.g. Laffont et al. (1998) or Armstrong (1998). However, as Buehler (2000) notes, this literature deals mainly with the analysis of competition between symmetric firms or uses specific functional forms. Instead, our model works with general demand and cost functions and heterogeneous networks. Even more importantly, this literature has to deal with the problem that the two monopolists *have to* give access to each other such that consumer 1 reaches consumer 2 by telephone, this problem does not exist in the water market. Obviously, customers do not care who else is connected at the water-network.

In general, the utilities' revenues consist of three components. Firms deliver drinking water to customers connected to their own and their competitor's network and they generate income by charging an access fee, which can consist of a variable fee a and a fixed fee F, to their competitor. A's earnings can therefore determined as follows (B's earnings are of course defined analogously):

$$E_A = p_1(q_{1A} + q_{1B})q_{1A} + [p_2(q_{2A} + q_{2B}) - a_2]q_{2A} - F_2 + a_1 q_{1B} + F_1 \qquad (2.2),$$

where $p_1(q_{1A} + q_{1B})$ denotes the inverse demand function in the market/network 1. $q_{1A} + q_{1B}$ is the total quantity of sold drinking water in market 1.[11] Firm A's gross revenues in the market 2 are $p_2(q_{2A} + q_{2B})q_{2A}$. However, these revenues are reduced by the variable access price payment $a_2 q_{2A}$ and the fixed access payment F_2. Finally, firm A generates earnings by charging an access fee $a_1 q_{1B} + F_1$ to its competitor B, which uses A's network to deliver customers in the market 1. Putting costs and earnings together, we define firm A's profit as

$$\Pi_A = E_A - TC_A \qquad (2.3)$$

Firm A maximizes its profit by choosing q_{1A} and q_{2A}, the access price a_1, which is restricted to be quantity-independent, F_1 and the investment I_A. The quality of the produced drinking water, however, is not a choice variable of the utilities. We rather assume that a health authority sets a minimum quality standard, which can be verified by a laboratory. Profit maximizing firms will exactly meet this obligation.

The model is structured as a two-stage game. Long-term decisions are made in the first, short-term decisions in the second period. Due to the long-term character of network investments, firms set I_A and I_B simultaneously in the first stage. In the second period, the players simultaneously set the flexible choice variables, i.e. production quantities q_{ij}, access prices a_i and F_i. Both, output and access fees are assumed to be sufficient flexible and therefore set in the short-term. Firms set the quantities for both markets, given the quantities chosen by the other utility. This procedure meets the traditional Cournot analysis. However, such analysis cannot be applied for the setting of access fees. The determination of access fees is a price decision. If A raises access price a_1, B reduces its engagement in the foreign market 1, because the increased variable access price raises B's marginal costs. In order to maximize

[11] The model abstracts from two part tariffs in the retail market. This assumption is reasonable, because variable fees actually dominate tariff structures. In Germany e.g., more than 90 percent of the water suppliers' earnings are generated by variable fees. (Correia and Kraemer, 1997, p. 146).

profits, A must take B's behaviour into consideration.[12] This suggests q_{1B} and q_{2A} to be a decreasing function of a_1 and a_2, respectively.

2.4 Solving the model

2.4.1 Second Stage

2.4.1.1 Linear Access Pricing

We first focus the case of pure linear access pricing, where $F_1 = F_2 = 0$. Firms simultaneously set quantities in their own and foreign market and the access prices. We assume that each competitor will supply a positive quantity in its home-market but it may be unwilling to supply on the foreign market. The first order conditions of A's profit function (2.3) read therefore, where $\partial C_A(\cdot)/\partial q_{1A} = \partial C_A(\cdot)/\partial q_{2A} \equiv C_A'$ and $\partial p_1(\cdot)/\partial q_{1A} \equiv p_1'$:

$$\frac{\partial \Pi_A}{\partial q_{1A}} = p_1' q_{1A} + p_1 - C_A' = 0 \qquad (2.4)$$

$$\frac{\partial \Pi_A}{\partial q_{2A}} = p_2' q_{2A} + p_2 - a_2 - C_A' \leq 0 \text{ and } q_{2A} \frac{\partial \Pi_A}{\partial q_{2A}} = 0 \qquad (2.5)$$

$$\frac{\partial \Pi_A}{\partial a_1} = q_{1B} + \frac{dq_{1B}}{da_1}\left(p_1' q_{1A} + a_1\right) + \frac{dq_{2B}}{da_1} p_2' q_{2A} = 0 \qquad (2.6)$$

Due to symmetry B's first-order conditions can be written using the analogous notation

$$\frac{\partial \Pi_B}{\partial q_{2B}} = p_2' q_{2B} + p_2 - C_B' = 0 \qquad (2.4')$$

$$\frac{\partial \Pi_B}{\partial q_{1B}} = p_1' q_{1B} + p_1 - a_1 - C_B' \leq 0 \text{ and } q_{1B} \frac{\partial \Pi_B}{\partial q_{1B}} = 0 \qquad (2.5')$$

[12] In order to simplify the model's structure, we assume that access prices and quantities are set simultaneously in the same stage. Alternatively one could assume that at a second stage firms would set access prices and in a third stage the quantities. Such a structure would not change the model's results fundamentally.

$$\frac{\partial \Pi_B}{\partial a_2} = q_{2A} + \frac{dq_{2A}}{da_2}(p_2' q_{2B} + a_2) + \frac{dq_{1A}}{da_2} p_1' q_{1B} = 0 \qquad (2.6')$$

We want to determine how A will set its access price (for B the discussion would read analogously). We assume that each firm's payoff function and rationality (as reflected in the first order condition) is common knowledge. We focus on the case where $\partial \Pi_B / \partial q_{1B} = 0$[13] Solving equation (2.5') for a_1 then yields $a_1 = p_1' q_{1B} + p_1 - C_B'$. Using this expression and (2.4), we rewrite A's first order condition (2.6) regarding the access price a_1:

$$\left.\frac{\partial \Pi_A}{\partial a_1}\right|_{\frac{\partial \Pi_A}{\partial q_{1A}}=0,\ \frac{\partial \Pi_B}{\partial q_{1B}}=0} = q_{1B} + \frac{dq_{1B}}{da_1}\left[p_1' q_{1B} + (C_A' - C_B')\right] + \frac{dq_{2B}}{da_1} p_2' q_{2A} = 0 \qquad (2.7).$$

Total differentiation of (2.4') – (2.6') shows that $dq_{1B}(a_1)/da_1 < 0$ and $dq_{2A}(a_2)/da_2 < 0$.[14] Due to the non-existence of an access price regulation, each firm could easily defend its monopoly position in its origin market. If firm A charged a very high access fee a_1, firm B would not be interested to engage in market 1, since its marginal costs $C_B' + a_1$ would then be too large to serve customers in network 1. For that reason, B would confine its engagement to the own network 2 and firm A could exclusively serve customers in market 1. If A and B charged each another extensive access prices, competition would not take place at all, two independent monopolies would result, despite the connection of the networks. However, charging high access prices considerably restricts the two firms' opportunities to overcome capacity restraints or to generate additional earnings by charging access fees. Due to this trade-off, incumbents may set moderate access prices, which make interconnection and direct competition possible. To prove this statement, we analyse A's behaviour regarding the setting of a_1 in an autarky case, where $q_{1B} = q_{2A} = 0$. In such a case, the access price is so high that B abandons its engagement in market 1. Since $a_1 = p_1' q_{1B} + p_1 - C_B'$ holds, q_{1B} is zero when $a_1 = p_1 - C_B'$. Equation (2.7) takes the following value:

$$\left.\frac{\partial \Pi_A}{\partial a_1}\right|_{\frac{\partial \Pi_A}{\partial q_{1A}}=0;\ \frac{\partial \Pi_B}{\partial q_{1B}}=0,\ q_{1B}=0,\ q_{2A}=0} = \frac{dq_{1B}}{da_1}(C_A' - C_B') \qquad (2.8).$$

[13] Obviously, the case $\partial \Pi_B / \partial q_{1B} < 0$ is uninteresting, since then $q_{1B} = 0$. Access would not occur.

[14] Total differentiation of (4'), (5'), and (6') yields, applying Cramer's rule:

$$\frac{dq_{1B}}{da_1} = \frac{1}{H}\left[\frac{\partial^2 \Pi_B}{\partial a_2^{\,2}} \frac{\partial^2 \Pi_B}{\partial q_{2B}^{\,2}} - \left(\frac{\partial^2 \Pi_B}{\partial a_2 \partial q_{2B}}\right)^2\right] < 0 \quad \text{and} \quad \frac{dq_{2B}}{da_1} = \frac{1}{H} C''_B \frac{\partial^2 \Pi_B}{\partial a_2^{\,2}} > 0$$

Note that the term in brackets has to be positive due to the 2nd order conditions. H stands for the Hessian determinant, which is negative in the optimum. Interestingly, the quantity in its "home" market q_{2B} reacts to an access price increase of A: Since B reduces its engagement in market 1, marginal production costs decrease, and this leads B to increase the quantity in its own network 2.

Equation (2.8) is the central result of our model. If the left side of the equation is negative, it is profitable to reduce the access price a_1 below $p_1 - C_B'$ and therefore to promote *B*'s engagement in the market 1. Then, to maximise its own profit, *A* should give up its monopoly position by cutting a_1 and setting a non-discriminatory access price. Equation (2.8) shows that such a scenario happens, if *A* faces higher marginal treatment costs than *B* ($C_A' > C_B'$). Relevant are the marginal costs in the status quo (autarky), where both firms operate in separated markets. Because of the problem's symmetry, this statement is also valid for firm *B*. If *B* faces higher marginal treatment costs, it opens its network to competitor *A* by setting the access price a_2 below $p_2 - C_A'$, where *A* gets profit trough market entry. We summarise this in the following proposition.

Proposition I: *A vertically integrated water supplier opens its network to the competitor that produces with lower marginal costs.*

An analogous result could be achieved, using access price regulation by the Efficient Component Pricing Rule (ECPR).[15] According to this rule market entry is only profitable for firms that are more efficient than the incumbent. As in our model, market entry only happens, if the incumbent's competitor faces lower marginal costs. However, there is no voluntary motivation to open the network, since ECPR indicates revenue neutrality for the incumbent. In this respect, our model has stronger results: incumbents facing high marginal treatment costs are able to increase profit by opening networks to more efficient competitors, since access fees are not limited by any regulator. Therefore, incumbents can profit from their competitor's higher efficiency by leaving market shares to them. Decreasing sales are more than compensated by both, access charges that exceed original contribution margin and reduced marginal production costs.

Different marginal treatment costs are the main condition for the existence of interconnection and therefore direct competition. In what follows, we consider a situation where *A* faces higher marginal treatment costs than *B*. Due to proposition I firm *A* allows competitor *B* to serve customers connected to *A*'s distribution system. Hence, in the market 1, a duopoly competition arises. On the other hand *A* is not engaged in the market 2, since *B* has lower marginal costs. For that reason *B* maintains its monopoly position in market 2. Based on the additional engagement in the market 1 (denoted by q_{1B}), firm *B*'s marginal costs increase (or at least do not decrease). However, the high-cost-firm *A* reduces output q_{1A} and therefore its marginal costs. Thus, marginal costs of both firms approach each other. In contrast to the actual situation, where utilities act de facto as monopolists in separated

[15] See Laffont and Tirole (1996) for a detailed survey of access price regulation and critical assessment of the ECPR rule.

markets, drinking water production is now more efficient in the total of both markets. Highest efficiency would be achieved, if both firms faced identical marginal costs. However, such scenario cannot arise, since the model's equilibrium requires a difference in the firms' marginal costs. Equation (2.7) implies that C_A' must exceed C_B', if $q_{1B} > 0$.

Proposition II: *The introduction of competition in the water market increases efficiency of production, if utilities' marginal costs differ before liberalisation. Marginal cost differences decrease in the new equilibrium. Nevertheless, the equilibrium requires a minimal marginal cost differential. Therefore, highest possible efficiency is not achieved.*

It is straightforward to see that the introduction of such a duopoly competition raises the volume of sold water in the competitive market 1. Therefore, in equilibrium, price p_1 is lower as in the original monopoly situation.

Proposition III: *The introduction of competition reduces retail price and raises sold water volume in the network of the high-cost incumbent.*

A different effect arises in the market 2. As mentioned above, firm B may face increased marginal costs due to its additional engagement in the market 1. But higher marginal costs indicate a reduced monopoly output. Hence, retail price p_2 would rise and sold water volume q_{2B} in the market 2 would fall. However, aggregate welfare increases with certainty due to higher efficiency of production, as stated in proposition II.

2.4.1.2 Non-linear Access Pricing

Again, we consider the situation, where the less efficient monopolist A allows competitor B to serve customers connected to A's distribution system. In the above mentioned case of pure linear access pricing, monopolist A tends to set a positive access fee a_1 above its own marginal network costs (which are zero by assumption). For this reason, utility B's relevant marginal costs, which consist of marginal treatment costs and access price a_1, are higher than total marginal production costs. Hence B will limit its engagement q_{1B} in market 1 below the socially optimal amount, which would guarantee efficiency of production. As stated in proposition II, highest possible efficiency can not be achieved. However, instead of charging a pure linear access price a_1, monopolist A can implement a two part access tariff by combining a fixed fee F_1 with a variable price a_1.

Reducing the variable tariff a_1 increases B's incentives to engage in market 1, whereas monopolist A decreases its own production amount q_{1A}. Since we assumed that B faces lower marginal production costs than A, overall efficiency and therefore aggregate profit can be improved. However, according to equations (2.2) and (2.3) reducing q_{1A} and a_1 lowers A's revenues and therefore earnings. Only B would profit from the above mentioned efficiency gain. By charging an additional fixed access fee F_1, the incumbent A can compensate such loss. Since the fixed fee F_1 does not affect B's profit maximising behaviour at the margin, A can claim the entire additional aggregated profit. Charging F_1 shifts the profit, which results from the reduction of a_1, from B to A. Of course, A can not charge an infinite fee F_1, he has to meet B's participation constraint, which reads $\Pi_B^{Access} - \Pi_B^{Autarky} \geq 0$. Denoting the optimal quantities in the autarky case by q^*_{2B}, we can write

$$\Pi_B^{Autarky} = p_2(q^*_{2B})q^*_{2B} - TC_B(q^*_{2B}) \qquad (2.9) \quad \text{and}$$

$$\Pi_B^{Access} = p_2(q_{2A} + q_{2B})q_{2B} + p_1(q_{1A} + q_{1B})q_{1B} - TC_B(q_{1B} + q_{2B}) - F_1 - a_1 q_{1B} \qquad (2.10),$$

where equation (2.10) denotes gross profit minus access fees. We calculate the optimal access fees a_1 and F_1. A maximises its profit analogous to equation (2.3) by choosing the own production amount q_{1A} and the access fee, which consists of a_1 and F_1, given the above mentioned participation constraint. We set up the relevant Lagrangian:

$$\begin{aligned} L &= p_1(q_{1A} + q_{1B})q_{1A} - C_A(q_{1A}) + F_1 + a_1 q_{1B} \\ &+ \lambda\left[\left(p_2(q_{2A} + q_{2B})q_{2B} + p_1(q_{1A} + q_{1B})q_{1B} - TC_B(q_{1B} + q_{2B}) - F_1 - a_1 q_{1B}\right) - \Pi_B^{Autarky}\right] \end{aligned} \qquad (2.11)$$

In this case the first-order conditions for the profit maximisation problem are

$$\frac{\partial L}{\partial q_{1A}} = p'_1 q_{1A} + p_1 - C'_A + \lambda p'_1 q_{1B} = 0 \qquad (2.12)$$

$$\frac{\partial L}{\partial F_1} = 1 - \lambda = 0 \qquad (2.13)$$

$$\begin{aligned} \frac{\partial L}{\partial a_1} &= q_{1B} + \frac{dq_{1B}}{da_1}(p'_1 q_{1A} + a_1) \\ &+ \lambda\left((p_2 + p'_2 q_{2B} - C'_B)\frac{dq_{2B}}{da_1} + (p_1 + p'_1 q_{1B} - C'_B)\frac{dq_{1B}}{da_1} - \left[q_{1B} + \frac{dq_{1B}}{da_1}a_1\right]\right) = 0 \end{aligned} \qquad (2.14)$$

Equation (2.13) implies that $\lambda = 1$, so the last expression simplifies dramatically. We can rewrite equation (2.14) as follows:

$$\frac{\partial L}{\partial a_1} = \left(p_2 + p'_2 q_{2B} - C'_B\right)\frac{dq_{2B}}{da_1} + \left(p'_1 q_{1A} + p_1 + p'_1 q_{1B} - C'_B\right)\frac{dq_{1B}}{da_1} = 0 \qquad (2.14')$$

Using (2.4') and (2.5') we can simplify the above expression again. Inserting these two equations into equation (2.14') yields

$$\frac{\partial L}{\partial a_1} = \left(p'_1 q_{1A} + a_1\right)\frac{dq_{1B}}{da_1} = 0 \qquad (2.15),$$

which implies that a_1 is equal to $-p'_1 q_{1A}$. Interestingly, we do not get the well known result that the variable part of a non-linear price is set equal to the marginal cost that are zero. Instead it is positive, the reason is imperfect competition on market 1. The variable part of a non-linear price is set such that *B* gets the right incentives to increase its engagement in the foreign market 1 until C_A' is equal to C_B'. In addition, *A* maximises own profit by setting the fixed access fee F_1 in the way that the participation constraint holds with equality. Thus he extracts the full additional rent of monopolist *B*. Then the access fee F_1 is the difference between *B*'s gross profit (before paying access fees) in case of access and *B*'s profit in case of autarky.

Proposition IV: *With a non-linear tariff A extracts the full rent of an additional efficiency gain. He will set the variable access price a_1 to $-p'_1 q_{1A}$ and the fixed access fee F_1 such that the participation constraint of B holds with equality. Therefore B increases q_{1B} while A reduces q_{1A} until C_A' is equal to C_B'. The equalization of marginal costs guarantees highest efficiency and therefore maximum aggregated profits.*

In case of charging non-linear access tariffs, highest possible production efficiency will be achieved. This efficiency corresponds to the case, where only one monopolist serves both markets. Of course, this is rarely possible since there are institutional restrictions which forbid that. Big monopolies may also lead to higher x-inefficiency and to more severe informational problems of the public, which enhances, for example, rent seeking activities of the merged monopoly.

2.4.2 First Stage

2.4.2.1 *Investment Incentives and Linear Access Pricing*

In the first period the firms take their investment decisions. The central question to answer is how the introduction of competition changes the investment incentives in comparison to the case with two autonomous monopolists. Taking into account the optimal decisions of the second stage, we can solve the model by backward induction. We firstly discuss the case of pure linear access prising. Using the Envelope theorem, the derivative of the profit function (2.3) with respect to investment I_A reads

$$\frac{d\Pi_A}{dI_A} = \underbrace{(p_1' q_{1A} + a_1)\frac{\partial q_{1B}}{\partial I_A}}_{1.\ effect} + \underbrace{\left(p_2'\frac{\partial q_{2B}}{\partial I_A} - \frac{\partial a_2}{\partial I_A}\right)q_{2A}}_{2.\ effect} \underbrace{- C_A'\frac{\partial L_1(I_A)}{\partial I_A} - \frac{\partial K_A(I_A)}{\partial I_A}}_{3.\ effect} \qquad (2.16)$$

The derivative's sign and hence the investment decision is influenced by three effects. In equilibrium, the first effect only arises within the high-cost firm, whereas the second effect is only relevant in the low-cost firm. The third effect can be observed in both firms. The first effect is negative. Higher investment reduces water losses, thus for given amounts of sold water, the marginal costs of A are reduced. Lower marginal costs induce A to produce more and to push B out of the market.[16] On one hand A looses revenues of $(\partial q_{1B}/\partial I_A)a_1$. On the other hand the price in A's home market increases, which induces a gain of $(\partial q_{1B}/\partial I_A)(p_1' q_{1A})$. Equation (2.6) tells us that, in equilibrium, the former effect dominates.

The second effect, which occurs only when A is the low-cost firm, is ambiguous. We can identify two partial effects. By investing, firm A improves its position in the foreign market and induces B to reduce its quantity since marginal costs of A have decreased. This argument is reflected in the term $(p_2' \partial q_{2B}/\partial I_A) q_{2A}$, which is positive. The other partial effect, $(-\partial a_2/\partial I_A) q_{2A}$, is negative. B knows that A will stay in the foreign market even with a slightly higher access charge, because marginal costs of A have fallen. This induces B to get its part from the increased efficiency of A and to increase the access price. Obviously, this has a negative influence on A's profits. Which partial effect dominates in total cannot be determined generally.

The third effect denotes the direct effect and appears in the case with separated networks too. It relates marginal cost of investment $\partial K_A(I_A)/\partial I_A$ to their marginal revenues,

[16] We assume reaction curves to be falling.

the lower cost of production $-(\partial L_1(I_A)/\partial I_A)C_A'$. Since marginal cost of production is increasing, the firm, which increases production due to liberalisation, will face higher investment incentives, because with higher marginal production costs marginal revenues of investment are higher. The opposite holds for the firm that lowers production. Recall that in equilibrium, the low-cost firm will increase production whereas the output of the high-cost firm decreases. Liberalisation now decreases unambiguously their investment incentives through the first and the third effect. For the low-cost firm, investment incentives increase due to the third effect, whereas the second effect is ambiguous. We conclude that the introduction of competition has an asymmetric impact on investment incentives in the sense that efficient firms want to invest even more compared to high-cost firms.

2.4.2.2 *Investment Incentives and Non-linear Access Pricing*

We turn now to the case of non-linear access pricing. Taking the derivatives of A's profit function[17] with respect to I_A and using again the Envelope Theorem, we get

$$\frac{d\Pi_A}{dI_A} = \underbrace{q_{1B}\frac{\partial a_1}{\partial I_A} + \frac{\partial F_1}{\partial I_A}}_{1.\ effect} + \underbrace{p_2'\frac{\partial q_{2B}}{\partial I_A}q_{2A} - q_{2A}\frac{\partial a_2}{\partial I_A} - \frac{\partial F_2}{\partial I_A}}_{2.\ effect} \underbrace{- C_A'\frac{\partial L_1(I_A)}{\partial I_A} - \frac{\partial K_A(I_A)}{\partial I_A}}_{3.\ effect} \qquad (2.17),$$

where $\frac{\partial F_1}{\partial I_A} = p_1' q_{1B}\frac{\partial q_{1A}}{\partial I_A}$ and $\frac{\partial F_2}{\partial I_A} = p_2' q_{2A}\frac{\partial q_{2B}}{\partial I_A}$.

Again, we can distinguish three effects. The first effect captures the changes in investment incentives of- the high-cost firm due to market interaction. Its sign is negative. By investing, firm A reduces its marginal costs and improves its market position. This reduces B's profit. The participation constraint directly implies that A must charge a lower access fee F_1.

The second effect matters only when A is the low-cost firm. A priori, the effect is ambiguous as well. The reasons are exactly the same as in the first effect: On the one hand, $(p_2'\partial q_{2B}/\partial I_A)q_{2A}$ is positive. Due to higher investment I_A, B reduces its quantity q_{2B}, which increases price in market 2 and A's incentives to engage in market 2. On the other hand, B will increase the access fee when A increases its investment. With non-linear access fees, however, both channels exactly cancel. So the second effect sums up to zero.

[17] A's profit function can be defined analogous to B's profit function, which is described in equation (10). Reversing all indices in equation (10) yields A's profit function.

The third effect is the positive direct effect of a cost reduction. We conclude that the same effects occur in both access price schemes.

2.4.3 Does Unregulated Competition Solve the Monopoly Problem?

We showed that the introduction of product-market competition has positive welfare effects, even in a worst case where regulation does not exist. Nevertheless, unregulated competition does only partially solve the monopoly problem of too high mark-ups. The determination of the access prices gives significant market power to the incumbent, independent from the chosen access regime: setting the access price allows *A* to decide about its competitor's engagement in market 1 and therefore about the degree of competition. However, it is important to emphasize the central result of our analysis: due to the trade-off between income from the own engagement and access price income, *A* will not deter *B* completely from market entrance (see proposition I). The result would be much worse in a standard Cournot duopoly model without the specificities of network competition: *A* would raise its competitor's cost in order to deter market entry and to defend the monopoly position. The nature of the network competition reduces this problem of "vertical foreclosure". Allowing *B* to enter the market not only increases *A*'s profit, but additionally, it increases overall efficiency (see proposition II and IV) and *reduces* the equilibrium retail price compared to the separated monopoly (see proposition III). Resulting welfare must be higher than in a monopoly – where the inefficient *A* is the only supplier.

Hence, the introduction of competition without regulating access prices at least softens the monopoly power, although *A increases* its profit. The reason for this puzzling result is obvious. As mentioned in section 1.1, the water pipe network, which is the essential facility, remains uncompetitive due to its natural monopoly character. Since *A* is free to set the access price, its profits cannot be lower than before. Setting the access price allows *A* to decide about its competitor's engagement in market 1 and gives *A* the power to skim the main part of *B*'s profit in market 1. However, such result describes a lower bound benchmark, since we ignored any kind of regulation. *A*'s monopoly power can be reduced by introducing access price or retail price regulation (see section 1.1).

2.5 Introducing Price Regulation

Access and retail price regulation tend to be complex and costly in the piped water industry, due to the decentralised character of the market and the variance of network costs.[18] Asymmetric information about true costs and costs of regulation guarantee water utilities a significant freedom to determine prices. Up to this point the model describes a lower bound benchmark: regulation does not take place. In practice, some degree of regulation may be introduced, for instance by ex-ante regulation. In this section, we analyse the effects of introducing i) access price regulation and ii) retail price regulation.

The regulation of access prices in network industries is usually based on the relevant network costs. The welfare maximizing first best solution is to set access prices equal to marginal costs. Since there are no marginal costs of water transport in our model, the regulator optimally sets $a_1 = 0$. Hence, this regulation regime is the same as a fully unbundled water market, where two suppliers *A* and *B* are connected to *one* merged network consisting of network 1 and 2. Since water supply networks are one-way networks that ignore any network externalities occurring from an increasing amount of users, the market outcome is a standard Cournot duopoly with heterogeneous suppliers. The result in equilibrium is well-known: only the more efficient utility is able to extend its market share; when the efficiency differential is sufficiently high, *B* may even put *A* out of business. Compared to the unregulated regime with linear access prices, the more efficient utility *B* increases its quantity q_{1B} even stronger while the less efficient *A* tends to reduce q_{1A}. Due to the higher production efficiency total water supply q_1 is higher and the retail price p_1 is lower under the regulated regime. Additionally, the regulation changes the distribution of profits: *B* can increase its profit compared to the unregulated regime, *A* has a lower profit – even lower than under the monopoly. Obviously, under such regulation regime *A* would not have incentives to connect its network voluntary with its neighbour.

Unfortunately, marginal cost pricing does not allow the incumbent to cover fixed network costs. The incumbent must either be compensated by subsidies or positive access charges. In practice, the latter alternative is usually applied.[19] Of course, welfare will be lower than with marginal cost pricing. However, welfare is higher than under the unregulated regime when the regulator sets the access price below the level of *A*'s profit maximising access price charge ($\bar{a}_1 < \hat{a}_1$). The reason for the welfare gain lies in the reduced problem of double marginalisation. Obviously *A*'s incentives to connect its network voluntary with its

[18] Such variance occurs due to different pumping requirements, different leakage rates and the variance of the pipes' technological life-time that depends on several factors such as material of pipes, soil conditions, parasitic current or other external impacts (see Skarda 1998, p. 871).

[19] 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).

neighbour are increasing in the regulated access charge. A is indifferent when the access price income exactly compensates for the reduced income due to the lower market share.

Finally, retail prices can be regulated directly – for instance by using a price cap as applied in England and Wales. When the price cap in market 1, denoted by $\bar{p}_1$, is binding, i.e. lower than the equilibrium retail price in an unregulated regime, the introduction of a price cap leads to an increased water supply in market 1. The firms always have an incentive to fulfil market demand as long as the price cap is above marginal cost of the most efficient competitor. It is easy to show that A sets the access charge equal to $a_1 = \bar{p}_1 - c_B$. Hence, when the price cap decreases, A must lower its access charge such that it remains profitable for B to accommodate the risen demand on market 1. This induces the inefficient utility A to produce less for two reasons: (i) the market price is lower and (ii) the cost differential (due to lower access price) to B has risen. Most importantly, the incentives for A to allow for interconnection have even risen. Imagine an extreme case where the price cap is set equal to A's marginal costs: Without the more efficient firm B, utility A would not make any positive profits. This reasoning demonstrates that the retail price regulation turns out to be especially effective in such access networks. The lower retail price directly induces an inefficient firm to produce less and in addition it forces the firm to set lower access prices.

2.6 Interconnection Investment

Our model of common carriage requires the physical connection of the neighbouring water pipe networks in order to exchange treated water. Up to this point, the model assumed investment related to the connection facilities to be zero. Such assumption might be appropriate for water utilities that already have connected their networks with their neighbour's. As mentioned in section 1.1, several Swiss communities near Zurich already connected their networks with the Zurich water utility (WVZ) in order to buy water resources in case of capacity constraints.

However, some existing networks are not connected with their neighbours. In order to take the relevant connection investment into account, consider the following model extension. In stage 0, utilities A and B decide about investment into the physical pipe connection. If they invest, common carriage can occur. Otherwise the monopolists stay independent. The network connection physically consists of one or several pipes that have to be dug into the ground. Hence, the investment costs related to the interconnection basically consist of pipe asset costs and the costs due to digging activities. In case of unfavourable topographic circumstances the connection additionally requires pumping and/or storage facilities. Such costs tend to be higher at higher network distance.

For simplicity, assume that the Coase theorem holds. *A* and *B* connect their networks only if the additional profits due to the efficiency improvement are higher than the initial interconnection investment: $\Delta\Pi_A + \Delta\Pi_B > I_{Con}$, where $\Delta\Pi_A$ and $\Delta\Pi_B$ denote the firms' additional profits to the connection investment I_{Con}. From proposition II we know that the efficiency gains and therefore the additional profits (and the additional consumer surplus) are higher at higher levels of the initial efficiency differential. Hence, we note that the incentives to interconnect are higher at higher levels of the productivity differential. On the other side, $\Delta\Pi_A$ and $\Delta\Pi_B$ may be smaller due to recurring costs related to the interconnection. Such costs mainly arise from water quality issues. Mixing the incumbent's water with an entrant's different water, quality may negatively affect demand and/or cause faster corrosion of the pipes or increase build-up of residue inside the pipe. The problems tend to be more severe at higher network distances, since the transport of water causes quality losses. Incumbent and market entrant therefore have to coordinate their water qualities and their treatment procedures in order to prevent any harmful effects related to chemical and microbiological consistence, water hardness or water pressure in the pipe network (see DVGW 2001, p. 12 ff and Webb and Erhardt 1998, p. 3). However, it is important to note that quality coordination effort is also necessary in other network industries with interconnection. In electricity, for instance, detailed quality obligations related to voltage and frequency limits are necessary. Additional costs may arise from pumping requirements. Pumping costs are higher at higher network distance.

Will the utilities always choose to connect their networks when it is socially optimal? The answer is no. The interconnection also leads to a higher consumer surplus (as analysed in our model), this effect is not taken into account by the monopolists. This argument may justify public participation in the interconnection investment.

2.7 Conclusions

The non-existence of a national water grid restricts geographical extension of product market competition in the water sector to a regional or even local level. Although only few water suppliers are expected to participate in such a local competitive market, we showed that efficiency and welfare gains can be achieved by introducing competition *in* the market – even in a worst case where regulation is not applied. The connection of neighbouring networks and the implementation of direct competition allow some suppliers to overcome their capacity constraints while others are able to raise their treatment facilities' rate of capacity utilisation. To maximise profits, utilities facing high marginal costs *voluntary* open their networks to competitors and reduce own production volume, suppliers facing small marginal costs expand their production. In contrast to the former situation, where utilities act de facto as monopolists, direct competition arises and the relevant retail price in the competitive market declines. If non-linear access tariffs are allowed, we get the even stronger result, that by introducing competition *in* the market, highest production efficiency is achieved. Since interconnection competition focuses on the production stage, common carriage induces potentially higher efficiency and therefore welfare gains in areas where treatment is difficult and more costly. In the long-term, treatment effort is expected to increase due to increasing demand, capacity constraints and higher contamination of raw water.

It is important to note that the improvement of production efficiency and the reduced retail price level are achieved by the implementation of competition although the two market players are not able to negotiate efficiently. Furthermore, it is crucial to note, that the model in section 1.1 describes a worst case without any degree of regulation. Competition itself leads to higher production efficiency in the market. One may object that the water suppliers still have some degree of market power, despite the implementation of competition *in* the market. To address this problem, competition *in* the market can be combined with access or retail price regulation or additional elements of competition, for example yardstick competition. In section 1.1 we showed that retail price regulation proves to be especially effective. Additionally, we showed in section 2.4.2 that there are only weak reasons for reduced investment incentives caused by the introduction of competition. The effects are in both access pricing systems similar: on the one hand the less efficient firm reduces network investment; on the other hand the more efficient one tends to increase investments.

Our analysis was designed to capture an – in our view – important issue in the piped water industry. Nevertheless, the basic design of the model may also apply to other industries which are characterized by geographically separated natural monopolies. Relevant examples are local network based services. However, our model cannot be applied for two-way networks such as railroad and for industries where customers' utility depends on how many customers are connected to this network, as for example in the telecommunications industry.

The simple structure of the competition model and the non-existence of any regulation suggest an easier implementation of a direct competition than other approaches. In practice, just a few structural and legal changes and the physical connection of the neighbouring networks would be needed. Beside that, the relevant utilities have to coordinate their water qualities. Both utilities and consumers could profit from fast efficiency gains.

3 Do Welfare Maximising Water Utilities Maximise Welfare under Common Carriage?

3.1 Introduction

Privatisation and liberalisation in the piped water industry are not very popular. Opponents of such processes fear that private companies rather optimise short term profits instead of long-term welfare (see WWF 2003 or BMWi 2001). According to a poll, almost the entire Austrian population defeats any privatisation steps in the piped water sector. The German city of Potsdam retracted the water utility privatisation in 2000 since it feared increasing water and waste water fees (see Schoenbaeck et al. 2003, p. 1 and 391). Also in several Swiss municipalities the public voted against formal privatisation which intended to adjust the water utilities' legal constitution. The concerns about privatisation and liberalisation might root in the fact that water supply is widely seen as a natural monopoly. Hence, it tends be socially optimal to run a water monopoly as public welfare maximising utility instead of a private profit maximising company. In fact, private participation in Europe is not very developed, water supply is usually provided by municipal authorities (see Schoenbaeck et. al., 2003 or EEB, 2002). Extended subsidies from local governments indicate rather welfare than profit maximisation in the piped water sector (see Gordon-Walker and Marr 2002, p. 31).[20] However, due to recent changes in the European legislation, one can expect an increasing discussion about liberalisation. Before 2000 the European Community (EC) excluded the water industry from its competition law – in contrast to other network utilities such as postal services, gas or electricity. Today, water services are neither explicitly included nor excluded in the EC competition law. Nevertheless, in their report for the attention of the European Commission Gordon-Walker and Marr (2002) argue, "there is considerable scope of application of the EC competition rules to increase competition in the water sector".

Considering the *introduction of competition,* it might be useful to re-evaluate water utilities' objectives. In a competitive environment it could be appropriate to change the utility's legal structure, for instance into to a public limited company and/or to enhance private participation. Obviously, such steps tend to change the utility's objective from a welfare to a rather profit maximising approach. The purpose of this chapter is to evaluate the extent to which it is *socially optimal* to compose water utilities as *welfare or profit maximising* when considering the introduction of competition. Such competition can be introduced in two ways: competition *for* the market and competition *in* the market.[21] We focus the latter, which corresponds to the common carriage approach that is used in the water market in England and Wales. Common carriage is basically equivalent to interconnection, which has already been applied in several other network industries such as telecommunication, gas or electricity (see also chapter 2). Using a game theoretic model of mixed oligopolies that contains water markets specificities, this chapter reveals the surprising result that welfare tends to be higher in a regime, where the utilities are instructed to maximise profits rather than welfare.

There is a broad literature about mixed oligopolies, which describes the effects of different governance structures in oligopoly competition. Early literature assumes competition between a public welfare maximising company and private profit maximising companies, where the public company acts as a Stackelberg leader – see Bös (1986), Rees (1984) or Hagen (1979). The authors of this so called "second best analysis literature" investigate how the public firm should deviate from marginal cost pricing in order to maximise welfare. Harris and Wiens (1980) assume a dominant public firm that is able to announce its output policy to the private firms that react to this policy. With such setting, they show how the dominant government firm can impose a first-best allocation of resources within the industry. The public firm announces that it will make up any quantity difference between the competitive output and the private firms output. As a result, the private firms face a given market price – now it is optimal to equalise marginal costs and price. However, there is no serious justification for a public Stackelberg leadership. Beato and Mas-Colell (1984) changed the roles of the firms. In their duopoly model they assume a reverse model structure, where the public firm takes as given the private company's output. They show that welfare may be higher than under the assumptions made in the second best literature. De Fraja and Delbono (1989) extend the analysis by assuming different settings, where the public and the private firms play simultaneously or not. They show that welfare is higher in a pure oligopoly where the public firm acts as profit maximising company, as if the public firm is welfare maximising. If the public firm has the Stackelberg leadership it is always optimal to set the price above marginal costs. Cremer et al. (1989) extend this analysis and ask whether it is socially optimal to have a public welfare maximising company in a Cournot oligopoly, and if so, how many public firms are socially wanted. Their analysis contains several different assumptions, such as increasing returns to scale (based on fixed and variable costs), public firms' budget constraints or wage differences between public and private firms. However, from their analysis no clear answer emerges. De Fraja (1991) introduced a model that

[20] However, the new European Water Framework Directive requires full cost recovery when calculating water fees. But the directive leaves significant room for its application in practice since municipalities are free to account for additional aspects such as social, ecological or political issues (see Schoenbaeck et al. 2003, p. 457).
[21] For an overview about common carriage implemented in England and Wales see for instance Cowan (1997), Cowan (1993) or Webb and Erhardt (1998). For an overview about franchise bidding in France see for instance Clark and Mondello (2000) or Elnaboulsi (2001) or Furrer (2004).

contains competition between a less efficient public firm and more efficient private firms. He shows that the presence of the relatively inefficient public firm with no budget constraint may enhance the overall efficiency, since the lower market price stimulates the private producers to improve their efficiency. Fjell and Pal (1996) examine mixed oligopolies in the context of international competition. In their model, a state-owned public firm competes with both domestic and foreign private firms. They show that the public firm reduces its market engagement in case of the entrance of a domestic private firm. They show also that the entrance of the domestic private firm will enhance welfare, whereas entrance of foreign firms may enhance or reduce (domestic) welfare.

The model outlined in this chapter[22] is based on the mixed oligopoly literature, where the public and the private firm simultaneously decide about production quantities in a Cournot oligopoly. We extend the existing settings by taking the specificities of a network competition in the piped water industry into account. The applied common carriage model basically corresponds to the model designed in chapter 2. The potential market entrant can be assumed as a neighbouring water utility that connects its own with the incumbent's network physically. The incumbent applies an access fee for the use of its infrastructure – similar to the interconnection price in the telecommunication industry. The model is basically designed as a three stage game. At the first stage, an incumbent A in market 1 and the potential market entrant B decide about their objective function: welfare or profit maximisation. In a second stage, the incumbent *or* a regulator decides about the access fee – depending on the applied regulation regime. In the third stage, the incumbent and the market entrant decide about production quantities. The model shows, that welfare tends to be higher in a profit maximisation regime, in particular when assuming significant efficiency differentials between the incumbent A and the entering water supplier B. The reason is obvious: welfare maximisation enhances A's output but reduces B's engagement incentives in market 1. Hence, welfare maximisation increases consumer surplus compared to the profit maximisation regime but reduces A's profit due to a lower retail price, reduced access income and reduced overall production efficiency. The net effect on welfare in market 1 tends to be negative. By the introduction of access price regulation, the degree of competition in market 1 can be enhanced. However, the model shows that welfare in the incumbent's municipality does not necessarily benefit from regulation.

First, we explain the water market's specificities that have to be considered when designing a model of common carriage. Section 1.1 examines the model's basic settings and the players' objective functions. In section 3.2.3 we analyse the players' interactions based on a general demand function. Section 3.3 introduces a linear model that allows to calculate and to compare welfare in the different regimes explicitly.

[22] See also Meister (2005).

3.2 The model

3.2.1 Considering Water Market Specificities

When designing a competition model based on common carriage, one has to consider several technical aspects concerning the piped water industry. First, water networks are not expected to generate any network externalities: consumer *X* does not profit directly from the existence of any additional consumer *Y* connected to the same network.[23] Secondly, water networks are assumed to be one-way networks, since water suppliers do not receive any direct and network based feedback from their customers (see Economides 2000, p. 4). Thirdly, the geographical extension of water networks is expected to be regional or even local due to transport costs arising from pumping requirements and water quality losses that increase with the transport distance (see BMWi 2001, p. 24). Additionally, there are limitations of mixing different water qualities in one network, since it raises the possibility of leaching and corrosion of pipes, sedimentation and suspension of particles and it affects microbial quality (see Kurukulasauiya 2001, p. 24). Obviously, these specificities hinder the geographical extension of a common carriage competition in the water industry: transport costs on the one side and the limitations of mixing different water qualities on the other side significantly limit the opportunity of connecting neighbouring water networks. It can be followed that competition is expected to occur only between a restricted number of neighbouring water suppliers. The geographic extension of a competition based on common carriage in the piped water industry tends to be regional or even local and not very intense.

The basic setting follows Foellmi and Meister (2005 and 2005b) and is based on the model outlined in chapter 2, which considers the above described aspects. We therefore assume that only two neighbouring water utilities *A* and *B* connect their pipe networks 1 and 2. The physical connection allows *A* and *B* to exchange treated water resources within their networks. As a result, the connection allows *A* to serve customers connected to *B*'s network 2 and it allows *B* to serve customers connected to *A*'s network 1. Obviously, the introduction of such competition requires an access regime that allows the utilities to use their competitor's pipe network to supply customers with treated water. The model in chapter 2 foregoes designing an explicit access regime with regulated access prices, since in practice the regulation of access prices in the water sector tends to be difficult due to the high number of different water networks and the variance of networks costs. The argumentation is based on Cowan's (1997, p. 91) critique, that the regulatory burden of assessing access prices for

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

different companies' networks would be large. In fact, the regulator Ofwat in England and Wales does not explicitly regulate access charges ex ante. Obviously, such lack of regulation causes the danger of inexistent competition. Without any ex ante regulation A can charge a sufficient high access price in order to prevent the more efficient B's access and to defend its monopoly position. Nevertheless, in chapter 2 we show that under certain circumstances, voluntary access can occur even in an unregulated regime. Such voluntary access requires differentials in marginal treatment costs. A less efficient utility A with higher marginal treatment costs than its competitor B has incentives to allow third party access and therefore to admit competition. By allowing access, A is able to reduce own production quantity and therefore production costs. The reduced income can be compensated by charging an access fee. In fact, marginal treatment costs differ significantly between water suppliers – even between neighbouring water utilities.

In chapter 2, we assumed that the involved water utilities A and B are both profit maximising private companies. However, in practice it is rather assumable, that water utilities are owned by the public – usually by the municipalities. Utilities are therefore not assumed to be exclusively profit maximising. They rather face an objective function that maximises the relevant community's welfare. The following model considers this issue by changing the utilities' objective functions. We compare two different regimes: the incumbent is profit maximising or welfare maximising. Additionally, the model accounts for two different access price regulation systems: unregulated and regulated access.

3.2.2 The General Setting

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

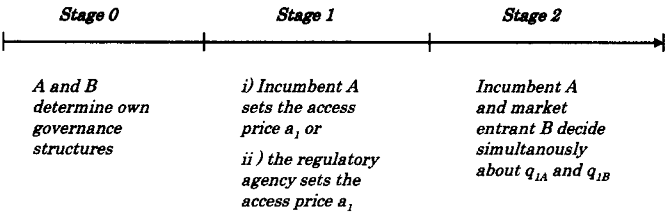

Figure 3: Time frame of the model

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

After determining the time frame and the model's variables, we can define the suppliers' objective functions. First let us determine *A*'s objective function under the assumption of profit maximisation. Such objective function basically corresponds to the one in chapter 2:

$$\Pi_A = p_1(q_1)q_{1A} + a_1 q_{1B} - C_A(q_{1A}) \qquad (3.1),$$

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

$$\Pi_B = p_2(q_{2B})q_{2B} + p_1(q_1)q_{1B} - a_1 q_{1B} - c_B(q_{2B} + q_{1B}) \qquad (3.2),$$

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

$$\frac{\partial \Pi_A}{\partial q_{1A}} = p_1'(q_1)q_{1A} + p_1(q_1) - C_A' = 0 \qquad (3.3)$$

$$\frac{\partial \Pi_B}{\partial q_{1B}} = p_1'(q_1)q_{1B} + p_1(q_1) - a_1 - c_B = 0 \qquad (3.4),$$

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

$$\frac{\partial \Pi_A}{\partial a_1} = q_{1B} + \frac{dq_{1B}}{da_1}\left[p_1'(q_1)q_{1A} + a_1\right] = 0 \qquad (3.5),$$

where the quantity reaction of B, dq_{1B}/da_1, can be determined by the total differentiation of equations (3.3) and (3.4), whereas the former only has to taken into consideration if $q_{1A} > 0$.[24] We get

$$\frac{dq_{1B}}{da_1} = \left[q_{1B}p_1'' + 2p_1' - \frac{(q_{1A}p_1'' + p_1')(q_{1B}p_1'' + p_1')}{q_{1A}p_1'' + 2p_1' - C_A''}\right]^{-1} \qquad (3.6) \qquad \text{if } q_{1A} > 0$$

and

$$\frac{dq_{1B}}{da_1} = \left[q_{1B}p_1'' + 2p_1'\right]^{-1} \qquad (3.7) \qquad \text{if } q_{1A} = 0$$

We assume that the reaction curves (in quantities) are falling, so $q_{1j}p_1'' + p_1' < 0$. Obviously, the quantity reaction of B is stronger when A produces. The reason is the strategic complementarity of quantities. An increase in the access fee leads to a reduction of q_{1B} (direct effect). This leads in turn to an increase in the quantity of the competitor q_{1A}, which induces B

[24] As usual the optimal access price depends on the quantity reaction of B, captured by the term dq_{1B}/da_1. In addition, by the $p_1'q_{1A}$ term A perceives that a decrease in quantity of B increases prices in the retail market. Note that the quantity reaction of A does not affect marginal profits, because of the Envelope theorem.

to produce even less (strategic effect). Note that in a regime, where the access price a_1 is determined by a public regulatory agency, the access price in equation (3.4) would be exogenously given at $\overline{a_1}$.

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

$$W_1 = \int_0^{q_1} p_1(q_1)\, dq_1 - p_1(q_1)q_1 + q_{1A}p_1(q_1) + a_1 q_{1B} - C_A(q_{1A}) \qquad (3.8)$$

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

$$W_2 = \int_0^{q_{2B}} p_2(q_{2B})\, dq_{2B} - p_2(q_{2B})q_{2B} + q_{2B}p_2(q_{2B}) + p_1(q_1)q_{1B} - a_1 q_{1B} - c_B(q_{1B} + q_{2B}) \qquad (3.9),$$

where q_{2B} denotes B's production quantity for customers connected to network 2. A's engagement in market 2 must be zero in equilibrium, therefore $q_2 = q_{2B}$. Note, from A's perspective nothing changes compared to a regime where B faces a profit maximisation objective function. Since B maximises domestic welfare in market (or municipality) 2, it maximises the sum of domestic consumer surplus, the profit from market 2 and additionally its profit from market 1. Obviously, from A's perspective B acts as a profit maximisation company in market 1. As a result equation (3.4) which describes B's first order condition regarding its engagement in market 1 is still relevant in the welfare maximisation regime. However, we have to redefine A's first order condition in such regime. Using the rule of Leibnitz we get:

$$\frac{\partial W_1}{\partial q_{1A}} = -p_1'(q_1)q_1 + p_1(q_1) + q_{1A}p_1'(q_1) - C_A'(q_{1A}) = 0 \qquad (3.10)$$

Since A still has incentives to maximise access income and since B still maximise income from its engagement in market 1 the equations (3.5) (3.6) and (3.7) still hold in a regime of welfare maximisation. However, in a system of access price regulation the access price would be exogenously given at $\overline{a_1}$ in equation (3.4).

3.2.3 Strategic Interactions

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

We firstly analyse A's reaction function on an exogenous change of B's engagement in market 1. For this reason, we consider the profit maximisation regime. We can derive dq_{1A} / dq_{1B} by using the total differentiation of A's first order condition, equation (3.3):

$$\frac{dq_{1A}}{dq_{1B}} = \frac{-\frac{\partial^2 \Pi_A}{\partial q_{1A} \partial q_{1B}}}{\frac{\partial^2 \Pi_A}{\partial q_{1A}^2}} = -\frac{p_1''(q_1)q_{1A} + p_1'(q_1)}{p_1''(q_1)q_{1A} + 2p_1'(q_1) - C_A''(q_{1A})} \qquad (3.11)$$

The right hand side of equation (3.11) tends to be negative. It is negative in case of a concave, linear or minor convex demand. It is only positive in case of a strong convex demand, where $p_1''(q_1) > 0$ and $p_1''(q_1)\, q_{1A} > -p_1'(q_1)$. We can derive A's reaction to an exogenous change in B's engagement analogously in a regime of welfare maximisation:

$$\frac{dq_{1A}}{dq_{1B}} = -\frac{\frac{\partial^2 W_1}{\partial q_{1A} \partial q_{1B}}}{\frac{\partial^2 W_1}{\partial q_{1A}^2}} = \frac{q_{1B}p_1''(q_1)}{p_1'(q_1) - q_{1B}p_1''(q_1) - C_A''(q_{1A})} \qquad (3.12)$$

Now, the right hand side of equation (3.12) can be zero, positive or negative. It is zero in case of a linear demand. It is negative in case of a convex demand and it is positive in case of concave demand. Note that the linear case is of high interest in the welfare maximisation regime, since it is exactly the border between a positive and a negative reaction on *B*'s reduced engagement.

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

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

$$\frac{dq_{1B}}{dq_{1A}} = \frac{-\dfrac{\partial^2 \Pi_B}{\partial q_{1B} \partial q_{1A}}}{\dfrac{\partial^2 \Pi_B}{\partial q_{1B}^2}} = -\frac{q_{1B} p_1''(q_1) + p_1'(q_1)}{q_{1B} p_1''(q_1) + 2 p_1'(q_1)} \qquad (3.13)$$

The right hand side of equation (3.13) tends to be negative. It is negative in case of a concave, linear or minor convex demand. It is only positive in case of a strong convex demand, where $p_1''(q_1) > 0$ and $p_1''(q_1)\, q_{1A} > -p_1'(q_1)$. Not surprisingly, the result corresponds to *A*'s reaction function in the regime of profit maximisation.

We turn to the analysis regarding the player's reactions on exogenous changes of the access price. Obviously, such analysis is of higher relevance when the access price is determined by a separate regulation agency. In such case the access price is in fact exogenous from *A*'s and *B*'s point of view. *B*'s reaction on exogenous shifts in a_1 is already determined by equation (3.6), respectively (3.7). The analysis can be focused on *A*'s reaction on an exogenous change of a_1. Since a_1 is set before *A* determines its production quantity q_{1A}, we analyse the change of *A*'s optimal quantity setting given an exogenous change of a_1. This is the evaluation of the second order partial derivative of A's objective function at $q_{1A} = q_{1A}^*$ and $q_{1B} = q_{1B}^*$. Again, we firstly evaluate the profit maximising regime:[25]

$$\frac{\partial}{\partial a_1}\left(\frac{\partial \Pi_A}{\partial q_{1A}}\right)\Big|_{q_{1A}=q_{1A}^*, q_{1B}=q_{1B}^*} = \frac{\partial q_{1A}}{\partial a_1}\left[p''(q_1)q_{1A} + 2p'(q_1) - C''(q_{1A})\right] + \frac{\partial q_{1B}}{\partial a_1}\left(q_{1A}p''(q_1) + p'(q_1)\right) \qquad (3.14)$$

In order to determine if the right hand side of equation (3.14) is positive or negative, we evaluate $\partial q_{1A}/\partial a_1$. However, this relation must be zero, since for a given q_{1B} A would not change its own q_{1A} when a_1 is increased or decreased exogenously.[26] We can rewrite (3.14) as follows:

$$\frac{\partial}{\partial a_1}\left(\frac{\partial \Pi_A}{\partial q_{1A}}\right)\Big|_{q_{1A}=q_{1A}^*, q_{1B}=q_{1B}^*} = \left(q_{1A}p''(q_1) + p'(q_1)\right)\frac{\partial q_{1B}}{\partial a_1} \qquad (3.15)$$

According to equation (3.6), respectively (3.7) we can assume that $\partial q_{1B}/\partial a_1 < 0$. As a result, the right hand side of (3.14) is positive in case of a linear or minor convex demand. Therefore, A's optimal quantity tends to increase with an exogenously increased a_1. A's reaction is only negative in case of a strong convex demand, where $p_1''(q_1) > 0$ and $p_1''(q_1)\, q_{1A} > -p_1'(q_1)$. The result corresponds to the findings above: in case of a linear or minor convex demand A would increase q_{1A} when B reduces its own production quantity. Since $\partial q_{1B}/\partial a_1 < 0$ A can expect that B reduces its engagement q_{1B} (for a given q_{1A}), when a_1 is exogenously increased. Similar to our analysis above, we evaluate A's reaction on an exogenous change of a_1 in the welfare maximisation regime. For this reason we can rewrite equation (3.15) as follows:

$$\frac{\partial}{\partial a_1}\left(\frac{\partial W_1}{\partial q_{1A}}\right)\Big|_{q_{1A}=q_{1A}^*, q_{1B}=q_{1B}^*} = -p''(q_1)q_{1B}\frac{\partial q_{1B}}{\partial a_1} \qquad (3.16)$$

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

[25] Equation (3.14) shows, how the optimal choice q_{1A}^* changes when assuming an exogenous change of a_1 at a given level of q_{1B}. For this reason we differentiate A's first order condition regarding q_{1A} at q_{1A}^* with respect to a_1. If the result is positive, one can follow that the peak of a function $\Pi_A(q_{1A}(a_1), q_{1B})$ shifts to the right, to higher levels of q_{1A}.

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

reduce q_{1B}, A does not change its optimal q_{1A}. According to equation (3.11), A would not answer the reduced q_{1B}.

3.3 Linear Analysis

3.3.1 Overview

In section 3.2.3, we analysed the strategic interactions between the incumbent A and the market entrant B for given governance structures. We used a general demand function that allows us to evaluate these interactions in detail. We can show that varying the governance structure significantly changes the strategic interaction between A and B. However, up to now A did not choose its governance structure strategically. Obviously, such decision requires more detailed information about the effects on profit and welfare. In this section, we extend the analysis to stage 0 of our model, where the incumbent chooses its governance structure strategically. Since the general demand function does not allow us to evaluate and to compare profits and welfare in the two regimes, we use a simple linear demand function. The use of linearity is very common in the literature of mixed oligopolies, since it allows an explicit evaluation of A's profit and welfare in market 1 in different regimes. We follow de Fraja and Delbono (1989, p. 304) or Pal and White (1998, p. 266) and define the inverse demand as follows:

$$p_1 = 1 - bq_1 = 1 - bq_{1A} - bq_{1B} \qquad (3.17),$$

where 1 is the reservation price and b determines the demand elasticity. Similar to the general analysis we assume a more efficient supplier B. To ease the analysis we assume linear cost functions for both utilities, whereby $1 > c_A > c_B$. In the following sections, we determine short run variables such as production quantities q_{1A} and q_{1B}, retail price p_1 and access price a_1 under the assumption of profit or welfare maximisation. Using these variables allows the calculation of A's profit and welfare in market 1. The comparison of welfare in profit in the two regimes allows A to decide about its governance structure in period 0. As showed above, at stage 0 there is no strategic interaction with player B, since from A's point of view B always acts profit maximising. The proposed procedure implies that profit maximisation not necessarily maximises A's profit and welfare maximisation not necessarily welfare in market 1.

3.3.2 Unregulated Access

In order to analyse and compare the two different regimes, we calculate the quantities, prices, profit, consumer surplus and welfare explicitly. To compare the regimes explicitly for all parameter values, it turns useful to separate the cases – for both regimes – where the players are engaged or *not* engaged in market 1. To differentiate the regimes, we add the index π in case of profit maximisation and the index θ in case of welfare maximisation. $\hat{p}_1^\pi$ and $\hat{p}_1^\theta$ denote the relevant equilibrium retail prices in market 1 under the two regimes.

	Case 1a $c_A > \hat{p}_1^\pi$	*Case 1b* $c_A = \hat{p}_1^\pi$	*Case 2* $c_A < \hat{p}_1^\pi$	*Case 3* $c_B + a_1^\theta > \hat{p}_1^\theta$
Profit maximisation regime	$q_{1A} = 0; q_{1B} > 0$	$q_{1A} = 0; q_{1B} > 0$	$q_{1A} > 0; q_{1B} > 0$	$q_{1A} > 0; q_{1B} > 0$
Welfare maximisation regime	$q_{1A} > 0; q_{1B} > 0$	$q_{1A} > 0; q_{1B} > 0$	$q_{1A} > 0; q_{1B} > 0$	$q_{1A} > 0; q_{1B} = 0$

Table 1: Cases to compare

From case 1a to case 3 we reduce A's marginal costs. In case 3 the low c_A induces a very strong engagement of A in its own market 1. Such engagement tends to be stronger under welfare maximisation. Due to the low resulting retail price $\hat{p}_1^\theta$, B may skip its engagement in market 1. Using the equations (3.15) in (3.3), (3.4), (3.5), (3.6), (3.7) and (3.10), allows us do determine the players production quantities, the relevant retail prices and access prices in both regimes. The results, which are illustrated in Table 2, allow us to define the borders of the above described cases. Under profit maximisation the entrant always faces incentives to engage in market 1, since A charges in equilibrium a sufficiently low access price. However, the incumbent A voluntarily stops its own water production when its marginal cost c_A exceeds the resulting retail price:

$$q_{1A}^\pi = 0 \quad \text{if} \quad \frac{5 + 2c_B}{7} < c_A$$

Such term above defines the border between cases 1 and 2. In case 1 the incumbent turns to be a pure network operator, since in equilibrium it is not profit-maximising to produce itself. However, we need to differentiate case 1a and 1b due to a bend in the access price function occurring from the equations (3.6) and (3.7). Case 1b describes such bend and applies where: $(3+c_B)/4 > c_A > (5+2c_B)/7$.

From equation (3.12), we know that under welfare maximisation A always faces the same (positive) production incentives when assuming a linear demand. Reducing c_A, increases its production volume and therefore reduces the retail price. In case 3, the retail price is sufficiently low, so that B does not enter the market 1.

$$q_{1B}^{\pi} = 0 \quad \text{if} \quad \frac{1+c_B}{2} \geq c_A$$

The term above therefore describes the border between the cases 2 and 3. After defining the relevant cases to compare, we can turn to the welfare analysis.

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

$$\Pi_1^{\theta} - \Pi_1^{\pi} = \frac{2 - 7c_A + 3c_B - 3c_A c_B + 5c_A^2}{8b} \qquad (3.18)$$

One can show for any relevant values of c_A and c_B and b that the right hand side of equation (3.22) is negative. A's profit in case 1 is higher in the profit maximisation regime. From Table 3 we know, that consumer surplus is higher in the welfare maximisation regime, since $1 < 3 - 2c_A$. The welfare difference is defined as follows:

$$W_1^{\theta} - W_1^{\pi} = \frac{-4c_A + 4c_B - 4c_A c_B + 4c_A^2 - c_B^2}{32b} \qquad (3.19)$$

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

$$\Pi_1^\theta - \Pi_1^\pi = \frac{9 - 28c_A + 10c_B + 20c_A^2 - 12c_A c_B + c_B^2}{8b} \qquad (3.20)$$

Considering $(3 + c_B)/4 > c_A > (5 + 2c_B)/7$ for case 1b we can show that such difference is negative for any relevant values of c_A and c_B and b. Profit is always higher under profit maximisation. The welfare difference is:

$$W_1^\theta - W_1^\pi = \frac{-1 + 4c_A - 2c_B - 3c_A^2 + 2c_A c_B}{2b} \qquad (3.21)$$

Again, it is straightforward to show that welfare in case 1b, is higher in the profit maximising regime.

Case 2 compares profit and welfare maximisation when both utilities are engaged in market 1. We know that A's engagement in the regime of welfare maximisation is higher than under profit maximisation: $q_{1A}^\pi < q_{1A}^\theta$. However, B's engagement is lower in case of welfare maximisation. Such result is not very surprising, since we know from equation (3.12) that B reduces its own engagement at higher levels of q_{1A}. Nevertheless, the net effect regarding the total amount of sold water in market 1 is still positive. In the welfare maximisation regime total quantity q_1 is higher than in the profit maximisation regime. Hence, the resulting retail price in market 1 is lower in the welfare maximisation regime. Again, up to this point, the result is not surprising, since welfare maximisation increases the amount of sold quantity and it reduces prices. Consumer surplus must be higher in the welfare maximisation regime. In fact, Table 3 shows that $CS_1^\pi < CS_1^\theta$. Introducing welfare maximisation into the model increases consumer surplus in market 1. However, as stated above the increased engagement of A in a welfare maximisation regime reduces the engagement of B in market 1. Such crowding out effect directly affects A's profit, since it reduces A's income from the access business. Again, we compare profit:

$$\Pi_1^\theta - \Pi_1^\pi = \frac{-5 + 10c_B + 2c_A^2 - 4c_A c_B + c_B^2}{40b} \qquad (3.22)$$

A's profit in the welfare maximisation regime is lower than under profit maximisation for any values of c_A and c_B and b. However, we should determine the net effect regarding social welfare. Welfare in the regime of welfare maximisation profits from a higher consumer surplus due to a higher production volume. However, welfare in the regime of profit maximisation profits from a higher domestic profit. Equation (3.23) compares:

$$W_1^{\theta} - W_1^{\pi} = \frac{6.25 - 45c_A + 32.5c_B - 7c_A c_B + 26c_A^2 - 12.75c_B^2}{200b} \qquad (3.23)$$

Under the restriction $(1+c_B)/2 < c_A < (5+2c_B)/7$ we can show that the right hand side of equation (3.23) is always negative. Welfare is higher in a regime of profit maximisation. The welfare difference is higher at lower cost differentials. Lower levels of c_B at unchanged levels of c_A reduce welfare in the welfare maximisation regime relatively. We can illustrate this issue by reducing the level of c_B. In the welfare maximisation regime, A does not change its own production volume. Due to this strong commitment, B increases its own engagement less significant than in a profit maximisation regime, where A reduces its own production quantity at lower levels of c_B. As a result, the additional consumer surplus in the welfare maximisation regime is only of second order. However, the effect regarding access price income is of first order: in the profit maximisation regime access price income can be increased stronger. We can summarise that welfare is higher in a profit maximisation regime since A's higher profit overcompensates for lower consumer surplus.

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

$$W_1^{\theta} - W_1^{\pi} = \frac{25 - 70c_A + 20c_B + 68c_A c_B + c_A^2 - 44c_B^2}{200b} \qquad (3.24)$$

Again, we consider $c_A < (1+c_B)/2$. The right hand side of equation (3.24) can be positive or negative. It tends to be positive at higher levels of k and/or lower levels of c_A. Obviously in such case A produces relatively more efficient, the resulting consumer surplus tends to be higher and can overcompensate for non-profit. Such result basically corresponds to a result derived by de Fraja and Delbono (1989). They show that *nationalisation* (a public monopoly that maximises welfare) is socially always better than Stackelberg leadership of the public company in a competitive environment under profit maximisation. In their model, additional profit can not compensate for lower consumer surplus. However, they assume that the players face similar costs. In our model the player face different marginal treatment costs. At higher levels of c_A, but still $c_A \leq (k+c_B)/2$, the profit maximisation gets relatively more attractive regarding social welfare. Obviously, overall production efficiency is higher in the profit maximisation regime. Profit compensates now for a lower consumer surplus.

The resulting welfare in the different cases and regimes can be illustrated graphically (see Figure 4). We assume $b = 1$ and and $c_B = 0.01$. As mentioned above, in cases 1a and 1b welfare is always higher under profit maximisation than under welfare maximisation. In case 1a the difference is lower at higher levels of c_A. Obviously W^π is unaffected from c_A since $\partial W^\pi / \partial c_A = 0$. However, $\partial W^\theta / \partial c_A$ is positive at higher levels of c_A. The gap between W^π and W^θ is increasing in case 1b. Due to a lower equilibrium access price in the profit maximisation regime, the relative performance of the profit maximisation can be enhanced. Similar to cases 1a and 1b, the welfare in the profit maximisation regime is higher than under welfare maximisation. However, the result may change in case 3, where A's efficiency is increased.

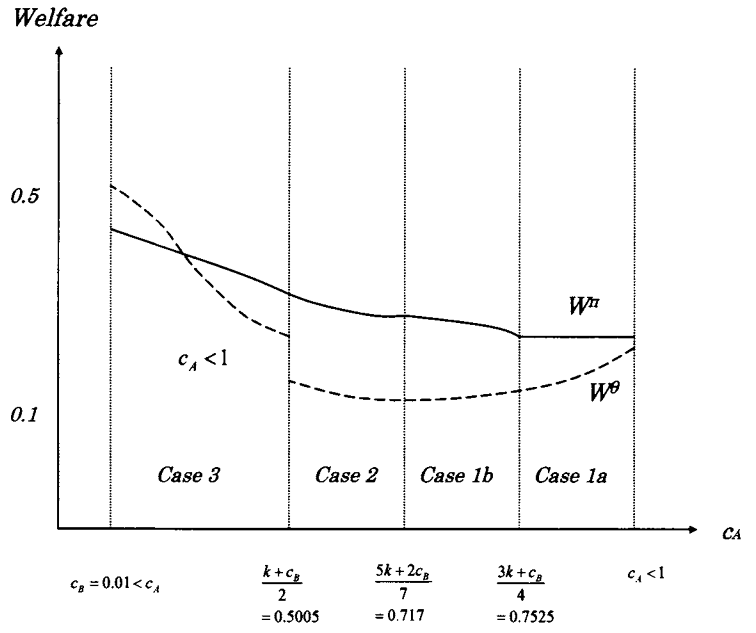

Figure 4: Welfare comparison

In case 3, both, $\partial W^{\theta} / \partial c_A$ and $\partial W^{\pi} / \partial c_A$ are negative. Note that the absolute value of the welfare in the welfare maximisation regime is not continuous. In case 3, the incumbent does not care about *B*, since *B* does not have any incentives to enter the market. In cases 2 and 1, *A* takes *B*'s behaviour into account. We can show that the absolute gap between welfare in the profit and the welfare maximisation regime is decreasing in *b*. From equations (3.19), (3.21) and (3.23), we know that the gap is lower at higher levels of *b*. The reason for this is obvious, since higher levels of *b* reduce consumer surplus and profit. At very high levels of *b*, welfare converges to zero in both regimes. However, it is easily to show that the relative gap (welfare in the welfare maximisation regime as a percentage of the welfare in the profit maximisation regime) does not change with an increased or reduced level of *b*.

	A's engagement	*B's engagement*	*Total quantity*	*Retail price*	*Access price*
Profit maximisation: Case 1a	$q_{1A}^{\pi}=0$	$q_{1B}^{\pi}=\frac{k-c_B}{4b}$	$q_1^{\pi}=\frac{k-c_B}{4b}$	$p_1^{\pi}=\frac{3k+c_B}{4}$	$a_1^{\pi}=\frac{k-c_B}{2}$
Profit maximisation: Case 1b	$q_{1A}^{\pi}=0$	$q_{1B}^{\pi}=\frac{k-c_A}{b}$	$q_1^{\pi}=\frac{k-c_A}{b}$	$p_1^{\pi}=c_A$	$a_1^{\pi}=2c_A-k-c_B$
Profit maximisation: Cases 2 and 3	$q_{1A}^{\pi}=\frac{5k-7c_A+2c_B}{10b}$	$q_{1B}^{\pi}=\frac{2(c_A-c_B)}{5b}$	$q_1^{\pi}=\frac{5k-3c_A-2c_B}{10b}$	$p_1^{\pi}=\frac{5k+3c_A+2c_B}{10}$	$a_1^{\pi}=\frac{5k-c_A-4c_B}{10}$
Welfare maximisation: Cases 1 and 2	$q_{1A}^{\theta}=\frac{k-c_A}{b}$	$q_{1B}^{\theta}=\frac{2c_A-k-c_B}{4b}$	$q_1^{\theta}=\frac{3k-2c_A-c_B}{4b}$	$p_1^{\theta}=\frac{k+2c_A+c_B)}{4}$	$a_1^{\theta}=\frac{k-c_B}{2}$
Welfare maximisation: Case 3	$q_{1A}^{\theta}=\frac{k-c_A}{b}$	$q_{1B}^{\theta}=0$	$q_1^{\theta}=\frac{k-c_A}{b}$	$p_1^{\theta}=c_A$	

Table 2: Quantities, retail price and access price

	A's profit	*Consumer surplus in market 1*
Profit maximisation: Case 1a	$\Pi_A^{\pi}=a_1^{\pi}q_{1B}^{\pi}=\frac{(k-c_B)^2}{8b}$	$CS_1^{\pi}=\frac{(k-c_B)^2}{32b}$
Profit maximisation: Case 1b	$\Pi_A^{\pi}=a_1^{\pi}q_{1B}^{\pi}=\frac{(k-c_A)}{b}(2c_A-k-c_B)$	$CS_1^{\pi}=\frac{(k-c_A)^2}{2b}$
Profit maximisation: Cases 2 and 3	$\Pi_A^{\pi}=\frac{5k^2-10kc_A+9c_A^2-8c_Ac_B+4c_B^2}{20b}$	$CS_1^{\pi}=0.5(k-p_1^{\pi})q_1^{\pi}=\frac{1}{2b}\left(\frac{5k-3c_A-2c_B}{10b}\right)^2$
Welfare maximisation: Cases 1 and 2	$\Pi_A^{\theta}=\frac{k^2-4kc_A+2kc_B+4c_A^2-4c_Ac_B+c_B^2}{8b}$	$CS_1^{\theta}=\frac{(3k-2c_A-c_B)^2}{32b}$
Welfare maximisation: Case 3	$\Pi_A^{\theta}=0$	$CS_1^{\theta}=\frac{(k-c_A)^2}{2b}$

Table 3: Profit and consumer surplus

3.3.3 Regulated Access – an Extension

The section above assumed the absence of any access price regulation. A is fully free to set any level of a_1. But the introduction of competition by third party access in network industries such as telecommunications, railways, gas or electricity usually assumes some kind of access price regulation. However, the relevant network costs in local and decentralised water networks vary significantly (see section 3.2.1), an effective access price regulation tends to be difficult and expensive. Nevertheless, in this section we extend the model by the introduction of effective regulation. Traditional regulation theory suggests marginal cost pricing for access in order to maximise welfare. Since such a pricing regime describes a first best solution we use it as a benchmark. In our model, we assumed no marginal costs of water transport and allocation. The regulator should therefore set $a_1 = 0$. Again, we analyse the effects of 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. In order to keep this analysis simple, we assume $b = 1$. Now, we can easily derive quantities and retail price in the profit maximisation regime. Again, we have to consider that in the regulated profit maximisation regime A stops the own production when $c_A \geq (1+c_B)/2$. Again, we differentiate two different cases in order to compare the two regimes (see Table 4). As to differentiate the cases from above, we call them *case R.1* and *R.2*.

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

Table 4: Relevant cases

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

$$W_1^{\pi} = \frac{(1-c_B)^2}{8} \qquad (3.25)$$

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

$$W_1^{\theta} = \frac{4(1-c_A)(c_B-c_A)+(2-c_B-c_A)^2}{8} \qquad (3.26)$$

Now, welfare can be higher or lower in both regimes. At a sufficient high level of c_A, welfare is higher in the profit maximisation regime. The reason is obvious. As mentioned above, in the regulated welfare maximisation regime A suffers a loss. The loss is increasing in c_A. Now, the relatively higher consumer surplus in the regulated welfare maximisation regime can not compensate for A's loss. Of course, higher welfare in the profit maximisation regime is basically a result of the higher production efficiency – similar to the findings in 3.3.2. However, at lower levels of c_A such loss can be overcompensated by the additional consumer surplus: at lower levels of c_A welfare tends to be higher in the regulated welfare maximisation regime. Obviously, the efficiency effect gets less relevant at lower levels of c_A.

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

Table 5: Quantities and retail price

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

Table 6: Profit and consumer surplus

In *case R.2* both utilities produce a positive amount of water, since *A*'s marginal costs are lower than $(1+c_B)/2$. Again, the total amount of water sold in market 1 is higher in the regime of *regulated welfare maximisation.* As a result the retail price in market 1 is lower in the welfare maximisation regime. And again, it can be followed that consumer surplus must be higher under welfare maximisation. Similar to case R.1, *A* always suffers a loss in the regulated welfare maximisation regime. Social welfare in the regulated welfare maximisation regime is defined by equation (3.26). However, welfare in the regulated profit maximisation regime is now defined as follows:

$$W_1^{\pi} = \frac{2(1+c_B-2c_A)^2+(2-c_B-c_A)^2}{18} \qquad (3.27)$$

We can easily show that the difference between equations (3.26) and (3.27) defined as $W_1^{\theta} - W_1^{\pi}$ is always positive when assuming $c_B < c_A < 1$. As a result, in case R.2, welfare is always higher in the welfare maximisation regime. Again, the effect of a higher consumer surplus is stronger than the negative impact of *A*'s loss. The higher production efficiency in the profit maximisation regime can not compensate for lower prices. Additionally, in contrast to the unregulated regimes, welfare in market 1 does not directly profit from *B*'s engagement through the access price income. As a result, the effect of a higher consumer surplus is even more dominant.

3.3.4 Comparing the Regimes – a Simulation

One may ask, if from a welfare maximisation point of view it is useful to introduce any kind of access price regulation. For this reason, we compare the regulated regimes with the unregulated regimes by using a simple simulation of the linear model. Again, we consider the different cases when varying c_A. To ease the analysis, we compare the regimes by defining $b = 1$, $c_B < c_A < 1$ and $c_B = 0.01$.

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

Table 7: Simulation

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

3.4 Conclusions

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

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

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

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

4 Enhancing efficiency of Water Supply – Product Market Competition versus Trade

4.1 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.[27] Such local operators often face very different marginal production costs due to differences in production scales and the use of different raw water resources, as for instance 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. Countries 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.[28] 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 chapter 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 may be higher in case of unregulated competition when assuming high efficiency differentials between water utilities. England and Wales introduced a model of product market competition based on competition *in* the market. One main element of this competition is common

[27] 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).

[28] 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).

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, competition is expected to be weak and very local.[29] A second way to enhance efficiency might be increasing cooperation between neighbouring utilities. A 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 clearly 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 cause 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 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. There is a wide range of literature related to the trade of *water rights*.[30] However, there are few authors analysing spot water markets: Howitt (1998) shows that spot markets stabilise water availability better than water rights markets; 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

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[29] 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.

[30] 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.

into irrigation technology under uncertainty and conclude that, contrary to common belief, water markets may delay investment. 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 1.1 provides evidence on competition and trade in the European water market. In section 1.1, 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 1.1, we consider an example with linear demand and constant marginal costs. 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 4.5, 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.

4.2 Competition and Trade in the Water Industry

4.2.1 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.[31] Border line competition allows customers who 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 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.

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[31] 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).

Moreover, 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) argue that the regulatory burden of assessing access prices for different companies' networks is large.[32] 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.

4.2.2 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 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.

[32] 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).

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.[33] 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.

4.3 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 5 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 may differ significantly – even between neighbouring water suppliers. Using spring water usually needs no treatment and is therefore less expensive 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,

[33] 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.

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). 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.

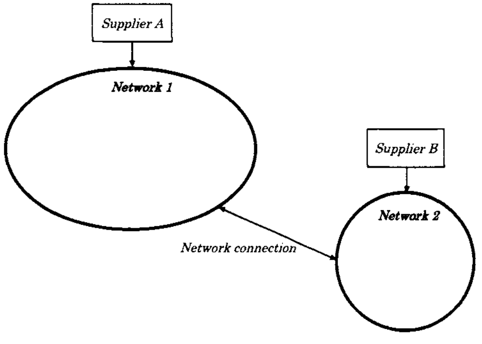

Figure 5: Connection of two neighbouring water networks

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 $C_A'' \geq 0$.[34] 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

[34] 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.

analysis would be more complex since we would have to consider price and quantity changes in both networks 1 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 chapter 1).

4.3.1 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 (see chapter 1) 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:

$$\Pi_A = p_1(q_{1A} + q_{1B})q_{1A} + a_1 q_{1B} - C_A(q_{1A}) \qquad (4.1)$$

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 profit from market 1. Such profit is given as follows:

$$\Pi_B = p_1(q_{1A} + q_{1B})q_{1B} - a_1 q_{1B} - c_B q_{1B} \qquad (4.2)$$

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.[35] 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}.:

$$\frac{\partial \Pi_A}{\partial q_{1A}} = p_1' q_{1A} + p_1 - C_A' = 0 \qquad (4.3)$$

[35] 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 chapter 2), that the inefficient utility A voluntarily opens its network to the low-cost competitor B.

$$\frac{\partial \Pi_B}{\partial q_{1B}} = p_1' q_{1B} + p_1 - a_1 - c_B = 0 \qquad (4.4),$$

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:

$$\frac{\partial \Pi_A}{\partial a_1} = q_{1B} + \frac{dq_{1B}}{da_1}(p_1' q_{1A} + a_1) = 0 \ . \qquad (4.5)$$

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 (4.3) and (4.4), whereas the former only has to taken into consideration if $q_{1A} > 0$. We get

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

$$\frac{dq_{1B}}{da_1} = [q_{1B} p_1'' + 2p_1']^{-1} \qquad \text{if} \quad q_{1A} = 0 \qquad (4.6).$$

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 (4.6) in (4.5), solving it for a_1 and inserting the result into (4.4), we derive the relevant retail price in market 1.

$$p_1 = -q_1(q_1 p_1'' + 3p_1') + q_{1A}[2p_1' + (q_1 + q_{1B})p_1''] + q_{1B} \frac{(q_{1A} p_1'' + p_1')(q_{1B} p_1'' + p_1')}{q_{1A} p_1'' + 2p_1' - C_A''} + c_B \qquad (4.7),$$

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

Equation (4.7) 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 (4.3), 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[36] 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 (4.4), (4.5) and (4.6):

$$p_1 = \min\left\{C_A'(0),\ -q_{1B}(q_{1B}p_1''+3p_1')+c_B\right\} \text{ if } \quad q_{1A} = 0 \qquad (4.8)$$

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 B's 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 (4.8) since $-p_1'q_{1B} + c_B = p_1 - a_1 < C_A'(0)$ according to equation (4.4) 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 (4.6).

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.

4.3.2 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 incentives to buy treated water from the more efficient utility B that faces lower marginal

[36] 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 severe.

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:

$$\Pi_B = q_T(p_T)p_T - c_B q_T(p_T) \quad (4.9),$$

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:

$$\Pi_A = p_1(q_1)(q_A + q_T) - C_A(q_A) - p_T q_T \quad (4.10),$$

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, 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.

4.3.2.1 *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 profit from trading activities described by equation (4.9). Maximization of *B*'s trade profit with respect to p_T yields to the following first order condition:

$$\frac{\partial \Pi_B}{\partial p_T} = q_T + (p_T - c_B)\frac{\partial q_T}{\partial p_T} = 0 \qquad (4.11).$$

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 (4.10). Maximization of *A*'s profit with respect to q_A and q_T yields the following first order conditions:

$$\frac{\partial \Pi_A}{\partial q_A} = q_1 p_1' + p_1 - C_A' \leq 0 \qquad (4.12) \quad \text{and}$$

$$\frac{\partial \Pi_A}{\partial q_T} = q_1 p_1' + p_1 - p_T = 0 \qquad (4.13).$$

In case of utility *A* decides to produce itself a positive amount of water ($q_A > 0$), inequation (4.12) turns into an equation. Total differentiation of (4.12) and (4.13) and applying Cramer's rule, we derive the slope of the demand schedule, dq_T / dp_T.

$$\frac{\partial q_T}{\partial p_T} = \frac{q_1 p_1'' + 2p_1' - C_A''}{(q_1 p_1'' + 2p_1')(-C_A'')} = \frac{1 - \left[\frac{\partial MR_A}{\partial q_1} \Big/ C_A''\right]}{\frac{\partial MR_A}{\partial q_1}} \qquad (4.14) \quad \text{if} \quad q_A > 0$$

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 equation (4.12), since $q_A = 0$. Total differentiation of (4.13) and solving for dq_T / dp_T yields

$$\frac{\partial q_T}{\partial p_T} = \frac{1}{q_1 p_1'' + 2p_1'} = \frac{1}{\frac{\partial MR_A}{\partial q_1}} \qquad (4.15) \quad \text{if} \quad q_A = 0\,.$$

The demand curve is less elastic after utility A decides to stop own production ($q_A = 0$), since the right hand side of equation (4.15) is less negative than the right hand side of (4.15). 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.

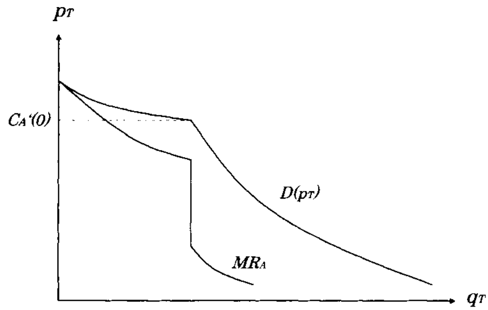

Figure 6: Demand for traded water

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 or not A produces a positive amount of water (see Figure 6). The relevant bend in the demand curve for traded water must therefore be at a trade price $p_T = C_A'(0)$.

4.3.2.2 *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.

	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 8: Cases to compare

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 (4.6)). 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. 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.[37] According to equation (4.3) 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 (4.13) and (4.12) 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 (4.8) we know that the retail price is given by:

$$p_1 = -q_{1B}(q_{1B}p_1''+3p_1')+c_B \qquad (4.16)$$

In the trade regime, we apply equations (4.14) and (4.15) in (4.11) to get

$$p_1 = -q_T(q_T p_1''+3p_1')+c_B \qquad (4.17).$$

[37] 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 (4.16) and (4.17) 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 (4.16), we enter case 1b. Now, the retail price is given by $C_A'(0)$ (see equation (4.8)). 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 (4.17) still holds. However, in the competition regime, the retail price is given by equation (4.7). 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 4.5 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_l 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 (4.7) is strictly lower than that of (4.17), since* $q_{1j}p_1''+p_1'<0$.

Obviously, from a consumer's point of view 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 6). 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:

$$p_1 = C_A'(0) - q_T p_1' \quad (4.18)$$

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 (4.14). Using equations (4.11), (4.13) and (4.14), we derive price p_1 in the trade regime

$$p_1 = -q_1(q_1p_1''+3p_1') + (\mu q_A + (1-\mu)q_1)(q_1p_1''+2p_1') + c_B \quad (4.19),$$

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 by both, 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, 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.

4.3.2.3 *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 (4.9) 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 4.3.2.1, 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 generally not clear, whether p_1 is lower than in the competition regime as under trade *A* acts as a monopolist on its home market.

4.4 Linear Analysis

In order to illustrate the results derived for general demand functions in section 4.3.2.1 (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:

$$p_1 = k - bq_1 \qquad (4.20)$$

Using equations (4.3), (4.4), (4.5), (4.13), (4.15), (4.17) and (4.20), 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 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 *B*'s marginal cost curve cuts its marginal profit curve from trading activities in its vertical range.

	p_I	q_I	q_{IA}	q_{IB}	a_I 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 9: Retail prices, quantities and access respectively trade prices.

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 (4.15) and (4.20), we get $\partial q_T / \partial p_T = -1/(2b)$. Table 9 illustrates the relevant equilibrium values for both regimes. Additionally it shows the equilibrium values for a monopoly regime in order to create a benchmark case.

Figure 7 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.

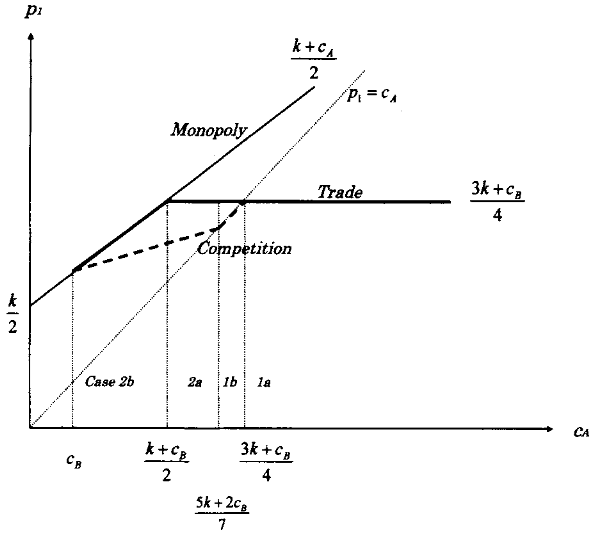

Figure 7: Retail price in market 1: monopoly, trade and competition

4.4.1 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 8 illustrates this fact.

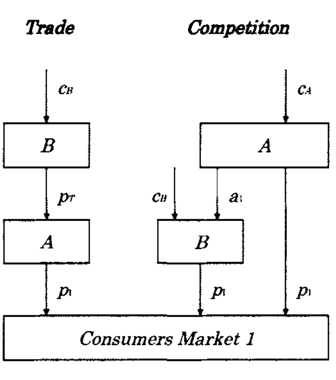

Figure 8: Market structure: trade versus competition

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 $p_T = a_1 + c_B$. As 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, it can be followed 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 5). 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 7). Our simulations in section 4.5 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.

4.4.2 Shifting the Bargaining Power

The linear analysis can easily be extended to the trade regime, where the entire bargaining power is shifted to the less efficient utility A (see section 4.3.2.3). 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 9 illustrates the relevant retail prices.

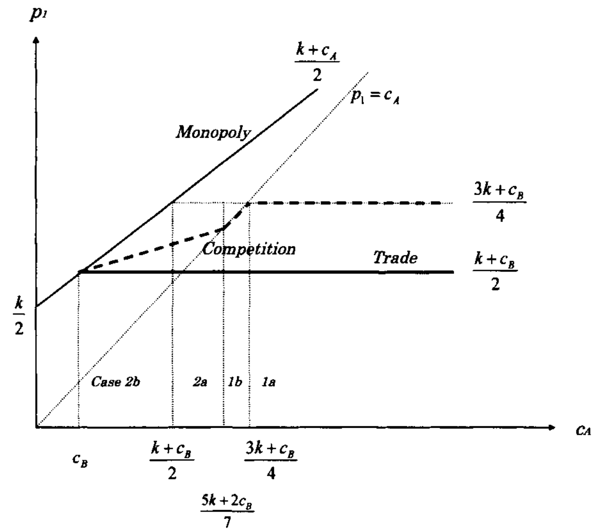

Figure 9: Retail price in market 1 (*A* has the entire bargaining power)

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.

4.4.3 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 *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. The relevant retail price is illustrated in the following figure:

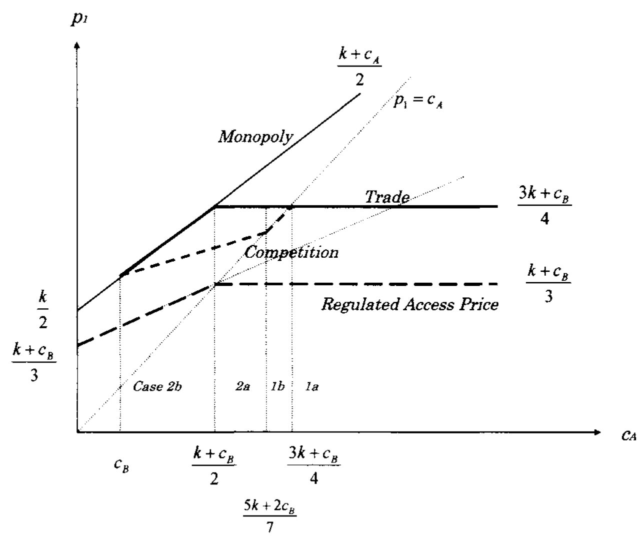

Figure 10: Retail price in market 1 (with 1st best regulated access price)

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[38]. However, marginal cost pricing does not allow the incumbent to cover fixed network costs (e.g. related to 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.[39] However, introducing a mark up over short run marginal costs reduces the relative performance of the regulated access price regime. When $a_l > 0$, B faces marginal costs of access and reduces its engagement in market 1. The resulting retail price p_1 would be higher than illustrated above. 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. 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.[40] 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 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.

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[38] 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 $c_B > c_A$.

[39] 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).

[40] 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.

4.5 Simulation

In section 4.4.1, 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 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 $C_A'(q_A) = c_0 + c_1 q_A$. B's 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 10). 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 10: 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.

Table 11 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.

	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 11: Varying the curvature of the demand curve

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 11 shows, this holds true in the numerical simulation. For elastic demand, competition works better whereas in the inelastic case trade prevails.

4.6 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 4.4.3). 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. 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 as Germany or Switzerland, the principle of territorial exclusivity (Oertlichkeitsprinzip or 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. It can be followed 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 as they are part of the public authority. Also, common carriage is not applied due to the legal framework.

5 Franchise Bidding in the Water Industry – Auction Schemes and Investment Incentives

5.1 Introduction

Due to extensive shares of fixed costs, network industries such as electricity, gas, railways or water are widely seen as natural monopolies. In such case, it is cost minimising and therefore socially wanted when only one single firm serves the entire market. Usually these services are rendered by public enterprises or strongly regulated private companies. Harold Demsetz (1968) proposed franchise bidding as an alternative to regulation. He argued that auctioning the rights to a natural monopoly would lead to a similar outcome as regulation, but at lower costs. In fact, franchise bidding has often been used in practice. Even though, there is only some experience in the water sector – mainly from France. The success of the auctioning model in the French water sector is assessed ambivalent since competition at the re-auctioning stage is only minor intensive. However, in theory the main criticism of Demsetz' proposal rather concerns investment incentives than competition intensity. It was Oliver Williamson (1976), who pointed out the problem of long-term specific investments. If the life-time of specific assets exceeds the contract length and transferring the ownership of assets is difficult, the franchisee faces a serious hold-up problem. As a result, re-auctioning a natural monopoly undermines investment incentives. The hold-up problem tends to be stronger in sectors where investment is very specific, long term oriented and hardly to evaluate by a third party. One can assume that investment in the capital-intensive water sector exactly corresponds to these characteristics. Water pipes have technological lifetimes up to 100 or more years and they can not be dug out and used elsewhere. Additionally, investment into the underground network can hardly be monitored by a third party. However, if an incumbent franchisee is able to pretend higher investment and to receive higher compensation in case of loosing the re-auction process, he has an advantage in the re-auctioning stage. Armstrong et al. (1994, p, 129) mention: "If Investment in specific assets is important, as in major parts of the utilities there is a serious danger either of underinvestment or of ineffective competition for franchise". They conclude that franchise bidding is not useful for capital-intensive natural monopolies. One should have in mind that investment into the pipe network plays an important role in the capital-intensive water industry. Up to 90 percent of total costs in the piped water industry concerns investment into the network. However, in many European countries, investment has been widely neglected due to the municipality's financial restrictions. As a result, water losses in different networks amount up to 50 percent of total water production.

Chapter 5 of this book basically refers to the model outlined by Meister (2005). After discussing the background of specific investment in procurement auctions and some auction theory in section 5.3, we introduce a simple model which examines investment incentives in an auctioned water monopoly. The model presented in this chapter basically examines an incumbent franchisee's investment incentives. The model assumes that investment into the pipe network reduces water losses in a pipe network and therefore total costs of water production. Additionally, investment is *i)* long term oriented, *ii)* very specific and *iii)* not verifiable. Section 5.4.2 varies the duration of the concession contract. Obviously investment incentives are stronger in a long term contract, since the hold-up problem tends to be less intensive. Section 5.4.3 introduces a re-auctioning procedure and investigates investment depending on different auction schemes such as a first-price sealed bid auction, second-price sealed bid auction and the English auction. Such analysis uses a game theoretic approach. On a first stage of the model, the incumbent player decides about the amount of investment, on the second stage the incumbent competes with a potential market entrant in the auctioning procedure. The model can be solved by backwards induction. Using a common value auction scheme, where the incumbent has superior information about its past investment and therefore future production cost, one can show that investment incentives differ in these auction schemes. However, investment tends to be the lowest in the English auction scheme, where the concurrent bidder is able to observe the incumbents bidding behaviour. In section 5.4.6, the model is extended by assuming vertical separation. And section 5.5 investigates additional aspects which are relevant in different auction schemes. Such aspects concern political sustainability, the hazard of the winner's curse and opportunities of collusion amongst bidding firms.

Some literature examines investment incentives in procurement auctions. One main paper was written by Tan (1992), who analysed R&D investment. He showed that in case of simultaneous investment and ex-ante symmetric firms, investment incentives are equal for all participants. Furthermore, firms' investment incentives do not differ in first and second price auctions. Laffont and Tirole (1993) analyse investment in repeated auctions and show that investment can be improved by giving preference to the incumbent in the re-auction. The case of heterogeneous firms was investigated by Arozamena and Cantillon (2000). In their model, firms invest in pre-auction investment in order to improve their relative position in the procurement auction. They show that in the first price sealed bid auction firms tend to underinvest since they anticipate stronger competition afterwards. Tolga Yuret (2004) examines the auction design problem when bidders invest before the auctioning process in order to increase the expected valuation. He shows that in equilibrium, none of the bidders invests when the auctioneer is not able to commit to an auction scheme before the bidders invest. However, our model applies basic auction theory to the water sector's specific problems. In contrast to most papers above, there is only one bidder – the incumbent – investing before the auction takes place.

5.2 Theoretical Background

5.2.1 Franchise Bidding and Specific Investment

According to Demsetz's proposal in his famous article "Why Regulate Utilities" (1968), firms bidding for a natural monopoly do not specify the purchase price they are willing to pay. Instead, they are required to define the per-unit price they would charge for the relevant product or service at given performance parameters. The company promising the lowest price gets the exclusive right to serve customers in the defined area. With enough bidders, it is expected that a bidder reveals his minimum costs and offers a price, which "differs insignificantly from the per-unit cost" (Demsetz 1968, p. 64). Such average cost price is expected to be lower than the profit-maximising monopoly price.[41] Demsetz pointed out that the resulting prices from the auction procedure are a result of the competition at the auctioning stage instead of regulation. In a world of perfect information and efficient contracts, the role of the government can be reduced to the organisation of the auction – ex post price regulation would not be necessary. However, in practice, both, information and contracts are fairly incomplete. One might conclude that franchise bidding is expected to be less efficient than predicted by Demsetz. It was in particular Oliver E. Williamson (1976), who pointed out the problem of specific investments in long term franchising contracts. It is supposable that the actual terms of a franchising contract do not count for all possible states in the future. Contractors are not able to anticipate all circumstances that require a modification of the original terms, such as the relevant per unit price. In order to prevent unwanted welfare impairments the governmental authorities can re-auction the monopoly periodically[42]. However, Williamson indicates that re-auctions combined with shorter holding periods undermine the incumbent's incentives to invest in durable specific assets. Due to their specificity assets cannot be used elsewhere and are hardly tradable. Williamson argues that in order to maintain investment incentives "some method of transferring assets from existing

[41] Lester Telser (1969) objected that the maximisation of social welfare requires marginal cost pricing. Average cost pricing induces only a second-best solution. However, such solution assures that the winning firm does not need subsidies to cover entire costs. In order to enforce a first-best solution, bidders could alternatively be required to offer a two-part tariff. The regulator chooses the firm which maximises social welfare. However, to choose such first-best solution the regulator would need exact information about demand (see Viscusi et al. 1998, p. 418).

franchisees to successor firms plainly needs to be worked out" (Williamson 1976, p 85). A basic rule was already proposed by Richard A. Posner (1972, p. 116): An incumbent franchisee is required "to sell his plant (included improvements) to the latter at its original costs as depreciated". Williamson argued that Posner declines to supply the "troublesome details" of such rule. As to use such rule 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 the franchisee itself is able to evaluate its assets accurately, outsiders such as competitors or regulators can not observe and verify past investment behaviour properly. Furthermore, Williamson remarks the hazard of inflated equipment prices when a franchisee is integrated backwards into equipment supply or when kickbacks are paid. The more informed incumbent firm may successfully pretend an oversized investment level and obtain a significant advantage at the contract renewal interval. Re-auctioning the monopoly therefore causes not only the danger of underinvestment but also the hazard of lacking competition at the auctioning stage.

Based on Williamson's critique, Jean-Jacques Laffont and Jean Tirole (1993) developed a theory regarding optimal re-auctions in case of specific but transferable assets. They assume that the incumbent's specific investments can not be observed and verified by a regulator. In order to maintain the incumbent's investment incentives, Laffont and Tirole recommend a re-bidding scheme that gives preference to the incumbent. However, such rule implies a break with the principle of bidders' parity in auctions. One might concern about the practical implementation of such rule, since a regulator should assess the relevant "preference for the incumbent". Michael Klein (1998/b, p. 3) recommends an auction scheme that restricts the regulators' discretion. The regulator should define *before* the auction that another bidder wins only if it underbids the incumbent's offered per-unit price by – for example – more than 10 percent. Yet, in practice, such discount-rule has been used in several auctions – in particular in water concession auctions in France. Klein (1998/b, p. 4) complains that such rules usually meant that water concessions are just re-awarded to the incumbent.

5.2.2 Auction Schemes

Before examining the relation between auction schemes and investment incentives in the water industry in section 1.1, it is useful to give a brief survey of auction schemes that can be used for franchise bidding procedures. Such survey is given by several authors such as McAfee and McMillan (1987), Milgrom and Weber (1982), Engelbrecht-Wiggans (1980), Milgrom (1989), Rothkopf and Harstad (1994) or Becker (2001). Auction theory suggests

[42] Of course, such problem could basically be solved by the renegotiation of the contractual terms. However, Richard A. Posner (1972, p. 115) argues that a regulator is not expected to represent consumers' interest in such renegotiations adequately. He rather recommends re-auctioning the monopoly periodically.

four basic schemes[43]: The English auction, the Dutch auction, the first-price sealed-bid auction and the second-price sealed bid auction. Both, the English and the Dutch auction are open auctions. Bidders traditionally gather at one place to bid, whereby they are able to observe other's bidding behaviour. In the English auction scheme the auctioneer raises the price incrementally. Bidders decide if they are still willing to pay the actual price and continue participating in the auction. The auctioneer stops raising the price when only one bidder remains. The winner has just to outbid the second highest bid. In case of infinite small incremental price steps, the price to be paid equals the second highest valuation. The Dutch auction is organised reverse: The auctioneer reduces an initially defined price incrementally. The first bidder who signals willingness to pay receives the auctioned good – the price equals its own bid. Sealed bid auctions do not offer participants to observe their concurrent bidders. In the first-price sealed bid auction, bidders submit sealed bids. The highest bidder is awarded the item for the price he bid. The second-price sealed bid auction is basically organised similar. But the price to be paid equals the second highest bid. Such rule was proposed by William Vickrey (1961).

	First-price	*Second-price*
Open	Dutch	English
Sealed	First-price sealed bid	Second-pricesealed bid

Table 12: Auction rules

The bidder's strategies may differ depending on the available information about the value of an auctioned good and on the information about other bidder's valuation of the good. Standard models in auction theory assume independent private values where each bidder knows exclusively his own value for the good and the bidders' valuations are statistically independent. In such setting, the bidders' strategies in the English and the second-price sealed bid auction are equivalent: competing up to the maximum valuation is a dominant strategy for all bidders. Furthermore, bidder's strategies in the Dutch and the first-price sealed bid auction are equivalent: bidders face a trade off between losing the auction against the profitability of

[43] All of these auction schemes give preference to the bidder with the highest willingness to pay, e.g. the one who offers the highest price for a good. Of course, these schemes can easily be transformed into an auction scheme that gives preference to the bidder that offers the lowest per-unit price.

winning. Bidders will therefore not reveal their maximum valuation (see Rothkopf and Harstad 1994).

In real auctions, it might be necessary to weaken the assumptions regarding independent valuation. Common value models assume one "true value" of a good. Bidders estimate this value based on similar common random factors they observe. One can therefore assume that valuations must be positively correlated. Milgrom (1989, p. 13) points out, that such setting is applicable especially in auction models for oil and gas drilling rights or for wine and art. In these cases, bidders face a common uncertainty about the value. Milgrom and Weber (1982) introduced a model with *affiliated values*. Their model has independent private values as one polar case and common values as another. They showed that open auctions offer bidders to gather more information about the value, since they allow to observe others bidding behaviour. As a result, the English and second-price auctions are not equivalent. Due to the additional information, bidders tend to be more aggressive in the English auction. However, the Dutch and the first-price auctions are still strategically equivalent.

5.3 The Piped Water Industry

5.3.1 The Role of Investment

The distribution network is the main cost driver in the piped water industry. Up to 90 percent of water utility's total costs are related to network investment and maintenance (see Skarda 1998, p. 867). Water pipes have a technological life-time that ranges from 50 to 100 years – depending on their material. Main pipe damages are caused by corrosion since the largest part of the network consists of cast iron pipes. In order to maintain the network and to minimise water leakage, utilities are required to renew their network continuously. The International Water Service Association (IWSA) recommends a yearly turnover rate of 1.5 percent – which means utilities are required to replace 1.5 percent of their network. In fact turnover rates are far lower and amount to an international average of about 0.6 percent (see Skarda 1998, p. 867). As a result, water leakage rates in the network systems are significant and amount up to 50 percent of total water production in some areas. In Spain the average leakage rate amounts to 30 percent, in England and Wales to 29 percent, in France to 25 percent, in Germany to 9 percent and in the Netherlands to 3 percent (see EEB 2002, p. 29). The cost of water leakage equals the relevant water production costs, since water has to be treated *before* introducing it into the pipe network. Costs therefore depend on the quality of used raw waters and the relevant treatment requirements. Hence, water leakage tends to be less expensive in regions with high quality raw water resources such for instance spring or ground water. It is more expensive in regions where surface water is used, which has to be treated more extensive and therefore costly (see Dwr Cymru Welsh Water 1999, p. 9). On a quantitative basis, the extent of water leakage for a given pipe length and time period is determined by two factors: the consistency of the pipe network on the one side and water pressure in the pipe network on the other side. Water utilities can influence the pipe consistency by network investment. A higher renewal rate increases network consistency and reduces water leakage. Water pressure in the pipe network is given by factors such as topography, network extension or the location of water treatment and storage facilities. Utilities have to ensure a permanent minimal operating pressure in order to satisfy customer needs.

A further role for investment is the extension of supply capacities. Such investment may concern treatment and storage facilities on the one hand and pipe networks on the other hand. However, in practice capacity extensions today play a minor role in many developed countries since per capita water consumption significantly declined during the last 15 years – mainly due to technical inventions and changed industrial structures. In Germany for instance, per capita consumption declined about 13 percent between 1990 and 2001. At the same time, water utilities extended their capacities significantly during the seventies and eighties in exception of an increasing demand. Prognoses assumed a daily per capita household consumption of 219 litres in 2000. In fact, consumption amounts to 136 litres (see BGW 2004). Similar trend occurred in other European countries, e.g. Switzerland. Daily household consumption amounted to 162 litres in 2003 – in 1982 it was 182 litres. Within the same period, total per capita consumption declined from 500 to 391 litres (see SVGW 2003, p. 1).

Investment into the water pipe network is assumed to be very specific. Michael Klein (1998/b, p. 1) emphasises that "water pipes normally cannot be dug out and used elsewhere economically". Since water pipes can not be used alternatively, the relevant costs can be assumed to be sunk (see Furrer 2004, p. 24). Furthermore it is obvious that a fair and true evaluation of a water utility's network assets must be difficult. Since pipelines are in the ground, it is not possible to assess the quality of the water pipelines (see Klein 1998/b, p. 2). Even when exact data about the age and the structures of the network are available, it would be difficult to assess the consistency and therefore the value of the network assets. The technological life-times of pipes vary significantly and depend on several factors such as material of pipes, soil conditions, parasitic current or other external impacts (see Skarda 1998, p. 871).

5.3.2 Franchise Bidding in the Water Industry – Evidence from France

Obviously, network investment in the piped water industry is highly specific and very long term oriented. In a re-bidding procedure for a franchised water monopoly one can expect a serious hold-up problem as described in section 5.2.1. Since investment into underground assets can not be observed and verified exactly by a third party, there is a serious danger of underinvestment or ineffective competition. Michael Klein (1998/b, p. 3) argues, that re-bidding for a water concession "will remain the toughest challenge" since underground pipes are the hardest to inspect. Nevertheless, many water sector reforms in practice used franchise bidding as a way of introducing privatisation and competition into the piped water industry. Major experience in auctioning water monopolies has been made in France. At the beginning of the 19th century, large cities such as Paris, Marseille or Lyon already called private companies to make infrastructure investments in exchange for the right to manage them. The process of delegation and privatisation strongly continued in the second half of the 20th century. Today, more than 75 percent of total population in France is served by private water companies (see Clark and Mondello 2000, p. 326 and Hemmer et. al. 2002, p. 12).[44]

The extent of private involvement in water supply varies significantly between municipalities. Elnaboulsi (2001) differentiates four basic types of delegation: Management Contracts (Gérance), Régie Interessé, Leasing (Affermage) and Franchise (Concession). This paper focuses Leasing and Franchise where the entire water supply is delegated to one company[45]. Under the Leasing contract, the private company is responsible at its own risk for provision of the water service, including operating and maintaining the infrastructure and charging water fees to customers. But investments into pipe network and treatment facilities are rendered and financed exclusively by the municipality; the private company pays a fee for using the infrastructure. Under the Franchise contract, the private company is additionally responsible for financing and carrying out the investments that are required to meet the relevant obligations fixed in the contract or defined by a regulator. At the end of the contract period, the incumbent can be compensated if investment is not fully amortised.

In both delegation models, the municipality auctions the right to serve water supply to a private company. Usually, the auction procedure contains two major steps. In a first step the auctioneer evaluates financial and technical capabilities of potential bidders. Firms that meet the auctioneer's requirements are allowed to make concrete tenders in the second step, where the main evaluation criterion is the offered per-unit price. The second step basically refers to a first price sealed bid auction. However, municipal authorities are free to negotiate with bidders and to choose the preferred company – based on several criteria beside per-unit price (see Furrer 2003, p. 216).

[44] Since recent years franchise bidding has also been applied in other countries such as Italy, Hungary, Argentina, Bolivia, Manila, Morocco, Colombia, or Senegal.

[45] Both Management Contracts and Régie Interessé use a relative low level of private sector involvement, where a private company operates only specified parts of the water supply system. Under the Management Contract the company charges a fixed fee for its service, under the Régie Interessé the relevant fees depend on efficiency.

	Leasing	*Franchise*
Financing operations	Private	Private
Financing investment	Public	Private
Duration of concession	20 years	10 – 12 years

Table 13: Delegation contracts (see Elnaboulsi 2001, p. 536)

The success of franchise bidding in the French water sector is assessed ambivalent. One main criticism is the lack of competition at the auctioning, respectively the re-auctioning stage. In its 1997 report the French national audit court (Cour des Comptes 1997) identified a lack of competition, a lack of transparency and excess pricing. The report emphasised in particular the repeated use of the negotiated procedure, nearly always with the same companies and a tendency to extend existing contracts without subjecting them to tender. Additionally, cases of bribery and corruption occurred. Municipalities awarded concessions to companies that paid *entry fees*. Municipal authorities used these payments to improve their budget situation.[46] Moreover, the audit court stated the widespread renegotiation of original contract terms. Incumbent firms often renegotiate franchising contracts ex post in their favour. Asymmetric information and costs of re-awarding the monopoly to another firm give the incumbents significant bargaining power in this process (Cour Des Comptes, 1997, p 125). Water tariffs vary significantly between French municipalities. On average, prices are 30 percent higher in case of private supply. However, higher prices are not only a result of lacking competition. Private companies tend to supply more problematic and therefore costly areas. Additionally investment into infrastructure tends to be more continuous than in public served areas (see BMWi 2000, p. 16).

Recently, the French government tried to improve the degree of competition in the water industry. As major steps, it limited the duration of franchising contracts and forbid the practice of entry fees (see Furrer 2003, p. 208). Obviously, such measures tend to limit the market power of incumbent franchisees. However, increased competition undermines the incumbent's incentives to invest in specific assets. One can expect that in the near future the French water industry will increasingly face the trade off between competition and investment incentives.

[46] One main example is Grenoble, where the private company Cogese paid entry fees worth FF 226 millions. Cogese recovered these costs through charging higher tariffs to water users (see Hall and Lobina 2001, p. 6).

5.4 A Simple Model

5.4.1 The Model's Design

Since investment into the pipe network can not be observed and verified properly by third parties, contracts between the public body and a private franchisee concerning the amount of investment are expected to fail. Sufficient investment can not be guaranteed by a contract or regulation. In this case, the public body has to consider a franchisee's investment *incentives* when arranging a franchise bidding procedure and writing the relevant franchise contract. The following model basically assumes a Franchise contract between a private franchisee and the public body, where the private firm is responsible for carrying out and financing the investment. We extend the model in section 5.4.6 by introducing vertical separation of infrastructure investment and infrastructure operations. The time frame of the model consists of two periods. In the first period, water supply and network investment is carried out by an incumbent firm A. The chosen investment determines the consistency of the pipe network and therefore water leakage in the first *and* the second period – since investment is assumed to be long-term oriented. In the second period water supply is provided by the incumbent firm A again, or by an entrant B. In our analysis, we focus the incumbent's investment behaviour in the first period – investment in the second period is not of interest and can be ignored. Figure 11 outlines the basic design of the model:

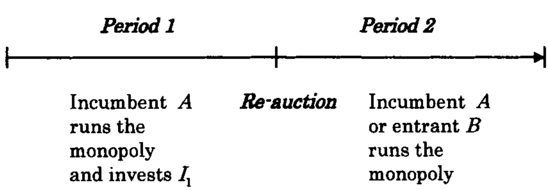

Figure 11 : Time frame of the model

In order to keep the analysis simple, the model assumes a fixed demand for treated water in both periods. Elasticity of demand is therefore assumed to be zero in the relevant range. Such assumption might be appropriate, since effective demand elasticity in the urban piped water sector tends to be very inelastic.[47] There is a common knowledge about market demand q_1, respectively q_2. The quantities q_1 and q_2 can be different.

A water supplier's costs consist of treatment costs C on the one hand and investment costs K on the other hand. We omit further administrative costs since they are not relevant in our analysis. Water treatment costs are increasing in the production quantity, which is determined by sold water and water leakage. As explained in section 0, the amount of water leakage for a given pipe length and time period depends on the consistency of the pipe network on the one side and water pressure in the pipe system on the other side. In this model water pressure is exogenous. The consistency of the pipe network depends on the extent of investment. Water treatment costs in period one can be defined as follows:

$$C_1 = C_1(q_1 + L_1(I_1)) \qquad (5.1)$$

C_1 stands for total treatment costs in period one, q_1 for the quantity of billed water, L_1 for the amount of water losses in period one and I_1 for investment in period one. Since investment into the pipe network can not be observed and verified by a third party, the franchisee can not expect to be compensated adequately in case of loosing the re-bedding procedure. Costs of investment are therefore sunk.[48] It is reasonable to assume, that the life time of network assets exceed the Franchise contract length.[49] One can therefore assume that water leakage and therefore treatment costs in the second period are as well affected by first-period investment:

$$C_2 = C_2(q_2 + L_2(I_1)) \qquad (5.2)$$

Since any supplier would use the same infrastructure in the second period, both suppliers A and B would face similar treatment costs C_2. Water treatment costs increase in production quantity. Since both billed water and water losses have to be treated before introduced into the pipe network, we can define $\partial C_i / \partial q_i = \partial C_i / \partial L_i > 0$ where $i \in \{1, 2\}$. Obviously, the investment tends to reduce water leakage stronger in the first period than in the second period – the older the assets, the higher the leakage. Therefore: $\partial L_1 / \partial I_1 < \partial L_2 / \partial I_1 < 0$. As a result, water treatment costs are decreasing in investment, $\partial C_i / \partial I_1 < 0$. Additionally, we can assume

[47] Dalhuisen et. al. (2000) analysed 70 studies, which contain 241 estimates on water demand. According to their meta-analysis the distribution of estimated price elasticities has a mean of -0.51 and a median of -0,41. About 15 percent of the estimates have a price elasticity of about 0.

[48] One could alternatively assume that the incumbent and a regulator negotiate about the compensation. However, in such case the resulting compensation would rather reflect bargaining power than actual worth of investment. The compensation is then assumed to be exogenous since it is not explained by the model. Such assumption would not change any results.

[49] In France the duration of Franchise contracts amounts to a maximum of 30 years. The technical lifetime of network assets varies between 50 and 100 years.

that $\partial^2 C_i(I_1)/\partial I_1^2 < 0$. Beside treatment costs the water supplier A faces costs of investment in the first period. We define such costs as follows:

$$K_1 = K_1(I_1) \qquad (5.3)$$

Costs of investment are increasing in the amount of Investment, $\partial K_1/\partial I_1 > 0$. Furthermore, we assume that investment costs increase at an increasing rate, $\partial^2 K_1/\partial I_1^2 > 0$. In the following sections, we examine A's investment incentives in the first period. In section 5.4.2, we analyse the influence of the contract length. In 5.4.3, we introduce a re-auction procedure after the first period and compare investment incentives in different auction schemes. In section 5.4.4, we analyse the player's participation incentives in the auctioning stage and in 5.4.5, we extend the model by allowing for firm specific efficiency differentials. Section 5.4.6 extends the model by assuming vertical separation of operations and investment according to a Leasing contract.

5.4.2 Long-term versus Short-term Contracts

Investing into the pipe network allows the incumbent A to reduce the extent of water leakage and therefore production costs in the first *and* the second period, since investment into the pipe network can be assumed to be long-term oriented. A therefore faces a hold-up problem when the relevant contract period is short term. A's profit maximising problem from running the water monopoly only in the first period can be defined as follows:

$$\max_{I_1} p_{1A} q_1 - C_1(q_1 + L_1(I_1)) - K_1(I_1) \qquad (5.4)$$

where p_{1A} denotes A's per-unit price in period one. The price can be seen as exogenous, because it results from the initial franchise bidding procedure at the beginning of period one. Since we assumed that costs of investment $K_1(I_1)$ are sunk, A is not compensated for its past investment at the end of the contract period. One can easily derive the optimal investment level by using the first order condition:

$$\frac{\partial K_1}{\partial I_1} = -\left(\frac{\partial C_1(\cdot)}{\partial L_1}\frac{\partial L_1}{\partial I_1}\right) \qquad (5.5)$$

A equals marginal costs and marginal benefits from investment. Such benefits arise due to a reduction in total treatment costs in period one. Benefits of the investment are denoted by the left hand side of equation (5.4). However, the incumbent A does not take into account any positive effects from cost-reducing investment in period two. A welfare-maximising regulator would rather require the equalisation of marginal costs and total marginal benefits from both periods. A profit maximising firm that runs the monopoly in both periods would meet such requirement:

$$\max_{I_1} p_{1A}q_1 - C_1(q_1 + L_1(I_1)) - K_1(I_1) + \delta[p_{2A}q_2 - C_2(q_2 + L_2(I_1))] \qquad (5.6)$$

where δ denotes the discount factor. Again, one can derive the optimal investment level by using the first order condition:

$$\frac{\partial K_1}{\partial I_1} = -\left(\frac{\partial C_1(\cdot)}{\partial L_1}\frac{\partial L_1}{\partial I_1} + \delta\frac{\partial C_2(\cdot)}{\partial L_2}\frac{\partial L_2}{\partial I_1}\right) \qquad (5.7)$$

It is easy to show that direct investment incentives are higher in the two-period monopoly, since the right hand side of equation (5.7) exceeds the right hand side of equation (5.5). Obviously, the hold-up problem can be removed by exceeding the contract period. However, as mentioned in section 5.2.1, the regulator faces a trade off between keeping direct investment incentives and degree of competition. Exceeding the contract period and leaving the re-auctioning stage remove competition and therefore the potential for price reductions. Net-welfare effects of a longer contract period can be negative if technical progress or other external effects reduce production cost. Nevertheless, since demand is assumed not to be varying in retail prices, the amount of investment always corresponds to the social optimum. Since we focus investment behaviour, we can use the resulting investment incentives given by equation (5.7) as a benchmark in the following.

5.4.3 Re-auctioning the Monopoly

In order to limit the incumbent's potential market power, the regulator can re-auction the monopoly after the first period. The re-auction of the concession can basically be designed as a two stage game. In a first stage, an incumbent franchisee chooses the amount of investment which determines actual and future water leakage. In the second stage, a regulator re-auctions the water monopoly. The model assumes two risk-neutral bidders, the incumbent company A and a potential market entrant B. In order to define their bidding strategies in the re-auction process, both, the incumbent A and the entrant B need to forecast average treatment cost C_2/q_2

= c_2 in the second period.[50] As mentioned above, both water suppliers *A* and *B* would use the same pipe network in the second period. As a result, they would face similar treatment cost c_2 after winning the re-auction – if we abstract from firm specific efficiency differentials. However, the model assumes asymmetric information about the investment level and therefore about water leakage and treatment costs in the second period. Obviously the incumbent firm *A* faces an information advantage, since it knows the extent of its past investment exactly. In our model, we assume a perfectly informed incumbent *A* that assesses average production cost in period two exactly at c_2. However, the less informed player *B* can not observe c_2. Therefore *B* is not aware of true costs. In order to prepare its price bid in the auction process, *B* makes a cost estimate c_{2B}. From the incumbent's perspective, *B*'s cost estimation is a random variable c_{2B} with a uniform distribution on $[0, \bar{c}]$ as presented in Figure 12. We assume that actual costs c_2 in the second period are in the range of 0 and $\bar{c}$. The cost maximum $\bar{c}$ would result at zero investments in period one. The distribution is *not* assumed to be common knowledge among both bidders.

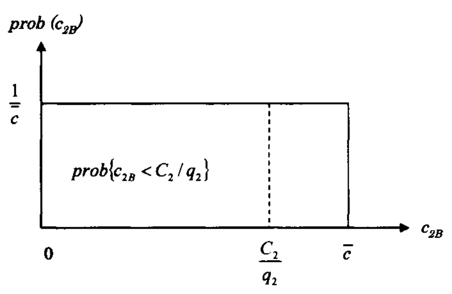

Figure 12 : The distribution of *B*'s average cost estimation

One might complain that using a backwards induction could allow *B* to anticipate *A*'s optimal investment level I_1^* and therefore actual average production costs. However, we assume that *B* does not have any information about the relevant starting point: *B* does not know about the pipe network's initial consistence and therefore about *A*'s true treatment costs at the beginning of period one. In such case, *B* is not able to anticipate *A*'s investment behaviour and therefore the average production cost in period two. In addition, there might be other sources of uncertainty: Costs may differ between *A* and *B* due to different labour productivity.

[50] In their tenders bidders have to define the per-unit price they would charge to customers. Since bidders do not want to generate losses, they compare the per-unit price with average costs. An optimal bidding strategy requires a per-unit price which is increasing in average costs.

However, the model represents a reduced form and abstracts from such additional sources of uncertainty. We summarise that *A* does expect that *B* is not able to observe or to anticipate I^*.

In the following sections, we analyse *A*'s auctioning and investment behaviour under different auction regimes. For this purpose we assume *A's* and *B*'s *participation* in the auctioning procedure as exogenously given. Such assumption is useful, since up to this point we did not allow for firm specific efficiency differentials. However, we extend the analysis in section 5.4.4, where we make the participation decision endogenous and when we allow for firm specific efficiency differentials.

5.4.3.1 First-Price Sealed Bid Auction

For concessions it is the standard to use a first-price sealed bid auction (see Klein 1998/a, p. 1). Bidders submit a sealed envelope to the regulator. The monopoly is awarded to the bidder with the lowest per-unit price. In order to examine the incumbent's investment incentives we solve the model by backwards induction. In the second stage of the model, *A* and *B* compete in the re-auctioning process. Therefore we firstly analyse their competitive behaviour which determines the relevant per-unit price in the second period on the one side and the probability of winning the auction on the other side. Afterwards, we analyse the first stage of the model where the incumbent decides about its investment into the pipe network.

The incumbent *A* wins the first-price sealed bid auction when the offered price p_{2A} is lower than p_{2B} offered by entrant *B* et vice versa. In a first-price sealed bid auction, both bidders face a trade off between maximising the probability of winning the auction and maximising the relevant profit margin (see Becker 2001, p. 6). Obviously, the bidders' lowest possible bids equal forecasted average costs c_2, respectively c_{2B} – otherwise the outside option is more attractive. Bidding a price equal to average costs maximises the bidder's probability of winning the auction. However, a price above average costs increases the payoff when winning. Since the offered price is expected to increases in average costs, we can define the bidder's price strategies as $p_{2A} = p_{2A}(c_2)$, $p_{2B} = p_{2B}(c_{2B})$. We follow Rothkopf (1969) and simplify the exposition by assuming that players only choose multiplicative strategies. Such strategies are defined as follows: $p_{2A} = \alpha_A c_2$ and $p_{2B} = \alpha_B c_{2B}$, where $\alpha_i \geq 1$ is the "mark-up multiplier". Now we can write the necessary condition for winning the auction. The incumbent firm *A* wins the auction when $p_{2A} < \alpha_A c_{2B}$ or

$$\frac{p_{2A}}{\alpha_B} = \frac{\alpha_A c_2}{\alpha_B} < c_{2B} \qquad (5.8)$$

Firm *A* therefore faces the following maximisation problem:

$$\max_{\alpha_A} E\left[(\alpha_A c_2 - c_2)\, prob\left(\frac{\alpha_A c_2}{\alpha_B} < c_{2B}\right)\right] \quad (5.9)$$

When maximising the expected profit, bidder A not only takes its own costs into account. Obviously, A considers B's mark-up multiplier and therefore B's cost forecast. From equation (5.9) we know that the rival's cost forecast c_{2B} affects the probability of winning the auction. A believes that c_{2B} *is* uniformly distributed on $[0, \bar{c}\,]$. The incumbent A faces therefore the following maximisation problem for a given mark-up multiplier α_B^* in B's strategy.

$$\max_{\alpha_A} E\left[(\alpha_A c_2 - c_2)\left(1-\left(\frac{\alpha_A c_2}{\alpha_B^* \bar{c}}\right)\right)\right] \quad (5.10),$$

Using the first order condition for A's maximisation problem we can define A's optimal strategy.

$$p_{2A}^* = \alpha_A^* c_2 = \frac{1}{2}\left(c_2 + \alpha_B^* \bar{c}\right) \quad (5.11)$$

From equations (5.11) it can be followed that A offers a higher price when B's mark-up multiplier α_B^* increases. In addition A offers a higher per-unit price when B's uncertainty about true costs increases. Such uncertainty increases when $\bar{c}$ increases. Due to the trade off between mark-up and probability of winning the minimum offered price amounts to $1/2\alpha_B^* \bar{c}$. And we know $1/2\alpha_B^* \bar{c} \geq 1/2\bar{c} > 0$. In order to derive an explicit Nash equilibrium in the first stage of the game, we would have to consider B's optimal price strategy in equation (5.11). However, due to the assumed information asymmetry defining an explicit Nash equilibrium in the second stage of our model is not only expected to be complex, in addition it requires extended rationality from A. In order to ease our analysis, we omit defining such equilibrium. Instead, we analyse A's investment behaviour given B's strategy α_B^*. Such procedure corresponds to a decision theoretic approach, where the case of only *one strategic bidder* is analysed (see Engelbrecht-Wiggans, p. 124).[51] Since our analysis is focused on A's investment behaviour, it is appropriate to use such approach. Using α_B^* and A's price strategy from (5.11), we can define A's maximisation problem at the first stage of the game as follows:

[51] Other bidders are assumed to be non-strategic. In such setting the strategic bidder defines its optimal bidding strategy *given* the other's bidding behaviour. Such behaviour can be assumed to be random. In our model the strategic bidder has believes about the other bidder's cost forecasts c_{2B}. Therefore B's offered per-unit price $p_{2B} = \alpha_{2B}\, c_{2B}$ is random from A's point of view. Of course, one could extend the model by introducing an additional distribution function $F(\cdot)$ from which A derives its estimation of B's mark-up multiplier α_{2B}. In order to ease the analysis we assume that A assesses α_{2B} at α_{2B}^*.

$$\max_{I_1} p_{1A}q_1 - C_1(q_1 + L_1(I_1)) - K(I_1) + \delta\left[\frac{1}{2}\alpha_B^* \bar{c} q_2 - \frac{1}{2}C_2(q_2 + L_2(I_1))\right]\left[\frac{1}{2} - \frac{C_2(q_2 + L_2(I_1))}{2\alpha_B^* \bar{c} q_2}\right] \tag{5.12}$$

Since we assumed B's strategy as given, and since B can not observe or anticipate A's investment behaviour in the first stage, the actual amount of investment is not expected to have an impact on B's mark-up strategy: $\partial\alpha_B^* / \partial I_1 = 0$. In addition, we know that $\alpha_B^* \geq 1$. Using the first order condition regarding I_1 allows us to derive the optimal level of investment into the pipe network in the first period.

$$\frac{\partial K(I_1)}{\partial I_1} = -\left[\left(\frac{\partial C_1}{\partial(\cdot)}\frac{\partial L_1}{\partial I_1}\right) + \left(\delta\frac{\partial C_{2A}}{\partial(\cdot)}\frac{\partial L_2}{\partial I_1}\right)\left(\frac{1}{2} - \frac{C_2(q_2 + L_2(I_1))}{2\alpha_B^* \bar{c} q_2}\right)\right] \tag{5.13}$$

The first term of the right hand side of equation (5.13) denotes A's direct investment incentives from period one. Higher investment reduces water leakage and therefore costs in the first period. Investment increases profit in the first period directly. The second term is related to the second period. The marginal benefit of additional investment amounts to the marginal cost reduction multiplied with the probability of winning the auction. Such result is not surprising and follows from two effects. On the one side, investment reduces treatment costs and increases the probability of winning the auction. On the other side the cost reduction directly increase profit in the second period. One can easily show that in our model both effects have the same size. Adding the effects leads to the second term in equation (5.13). Such result is intuitive: basically the marginal benefit of an investment amounts to the marginal cost reduction in the second period. However, the incumbent profits from such cost reduction only with a certain probability. Such probability is higher at higher levels of I_1, since lower per-unit costs would cause a lower offered per-unit price in equilibrium.

From equation (5.13), we know that A's investment incentives are increasing in α_B^*. A higher α_B^* increases A's probability of winning the auction on the one side, and it allows A to increase the own offered per-unit price p_{2A} on the other side. Investment into the pipe network gets more attractive, since the hazard of the hold-up decreases. In addition investment increases when B's uncertainty about the true costs increases. Again, the increased uncertainty increases the probability of winning the re-auction and allows A to bid a higher per-unit price. Additionally, investment increases in the discount factor δ.

5.4.3.2 Second-price Sealed Bid Auction

A regulator could alternatively use a second price sealed bid auction. Such rule was proposed by William Vickrey (1961). In practice such auction scheme is less common for concessions than first-price auctions. However, second-price auctions have been used as well. New Zealand, for example, applied second-price sealed bids to auction licenses for radio spectrum (see Klein 1998/a, p. 1). In a second-price sealed bid auction, the bidder with the lowest per-unit price bid wins the auction. The actual price that the winner can charge to customers equals the second lowest bid. Again, we solve our model by backwards induction. At the second stage of the game, the participants of the auction define their per-unit price offers. Obviously, we can define the player's strategies more easily than in the first price auction. In the second-price auction, both bidders *A* and *B* have strong incentives to bid a per-unit price that equals the own average treatment costs in period two. Since the actual price is independent of the own bid, the bidder maximise expected profit only by maximising the probability of winning the auction. Obviously, bidding average costs is a dominant strategy for both. Such result is not surprising and is very well known in auction theory (see Becker 2001, p. 8). In our model, we assumed a common value auction, where winning the auction has the same value for both bidders. However, such assumption does not change their strategies, since the second-price sealed bid auction with only two bidders does not allow any bidder to gather any information about the other's cost forecast.

Since both players have a dominant strategy that is independent from the other's strategy, we can easily define a Nash Equilibrium in the first stage of the game. *A*'s equilibrium strategy is defined as $p^*_{2A}(c_2) = c_2$, the entrant *B*'s strategy as $p^*_{2B}(c_2) = c_{2B}$.[52] However, *A* can not observe c_{2B}. Instead, *A* has a believe about it which is based on the uniform distribution $[0, \bar{c}]$. Since *A* wins the auction when $p^*_{2A} < p^*_{2B}$, respectively when $c_2 < c_{2B}$, we can define *A*'s perceived probability of winning the auction as follows:

$$prob(winning) = \left(1 - \frac{C_2(q_2 + L_2(I_1))}{q_2 \bar{c}}\right) \qquad (5.14)$$

And the estimated price given *A* wins the auction can be written as follows:

[52] One may concern that it is rather optimal for *B* to make a price bid equal to zero. In such case *B* would win the auction with certainty, the actual retail price would equal c_2, the relevant margin is zero. Then, *A* would lose the auction with certainty and, hence, *A* would not have incentives to take part in the auction. However, if *B* considers the possibility that *A* foregoes to file an offer in the sealed-bid auction, it can not be optimal to make a bid equal to zero, since it would result in a loss in the second period. Additionally, assuming that *B* does not know about the actual number of bidders, it can not be optimal for *B* to choose $p_{2B} = 0$, otherwise it faces the danger of a loss in period 2. We summarise that it must be optimal for both parties to make a bid which is equal to their cost estimation.

$$E\left(p_2 \middle| c_2 < c_{2B}\right) = \frac{1}{2}\left(\bar{c} + \frac{C_2(q_2 + L_2(I_1))}{q_2}\right) \qquad (5.15)$$

We can use (5.14) and (5.15) in A's maximisation problem in the first stage of the game:

$$\max_{I_1} \; p_{1A}q_1 - C_1(q_1 + L_1(I_1)) - K(I_1) + \delta\left[\frac{1}{2}\bar{c}q_2 - \frac{1}{2}C_2(q_2 + L_2(I_1))\right]\left[1 - \frac{C_2(q_2 + L_2(I_1))}{q_2\bar{c}}\right] \qquad (5.16)$$

Using the first order condition regarding I_1 allows us to derive the optimal level of investment into the pipe network in the first period.

$$\frac{\partial K(I_1)}{\partial I_1} = -\left[\left(\frac{\partial C_1}{\partial(\cdot)}\frac{\partial L_1}{\partial I_1}\right) + \left(\delta\frac{\partial C_2}{\partial(\cdot)}\frac{\partial L_2}{\partial I_1}\right)\left(1 - \frac{C_2(q_2 + L_2(I_1))}{q_2\bar{c}}\right)\right] \qquad (5.17)$$

The result is not very surprising. Again, the first term of the right hand side of equation (5.17) denotes A's direct investment incentives from period one. Investment increases profit in the first period directly. The second term is related to the second period. The marginal benefit of additional investment amounts to the marginal cost reduction multiplied with the probability of winning the auction. Such result exactly corresponds to the one in the first price sealed-bid auction in section 5.4.3.1. However, the relevant probability of winning the auction is defined different since A's bidding strategy in the two auction schemes varies.

5.4.3.3 *English Auction*

In open auctions such as Dutch or English auctions, bidders gather at one place. Such schemes allow bidders to observe others' bidding behaviour. Open auctions are less common for concessions than sealed bid auctions. Dutch auctions are often used for selling fast perishable goods, such as flowers or food. English auctions are very common for selling unique goods such as art or antiques (see Becker 2001, p. 3). Traditional auction theory predicts similar bidding strategies in first-price sealed bid and Dutch auctions, respectively second-price sealed bid and English auctions. However, such result requires independent private values: each bidder knows its valuation for a good exactly and knows that such value is statistically independent from others' valuations. Bidding strategies are expected to be different in models assuming statistical dependence among bidders' value estimates. Milgrom and Weber (1982) analysed bidding behaviour in a general auction model with independent private values and common values as polar cases. They show that in contrast to the model with independent private values, the second-price sealed bid auction and the English auction are not equivalent. Instead, the English auction leads to larger expected prices (respectively to lower expected per-unit retail prices in our auction scheme) than the second price auction. The English auction therefore influences the degree of competition positively, since bidders tend to bid more aggressively. However, they show that bidding strategies in the Dutch and the first-price sealed bid auction are still equivalent – just as they are in private value models (see Milgrom and Weber 1982, p. 1095).

Our model is based on statistical dependence amongst the value estimates of different bidders. We assume a polar case with only one common value for the concession. Such value is determined by true average costs c_B. Bidders have different estimates about costs in the second period and therefore about the common value. Due to the assumed asymmetry, the incumbent A has superior information about true costs: A's cost estimate equals c_2. B only has an estimate c_{2B} about it. Since B knows about A's information advantage, B's estimate must be perfectly correlated with A's cost forecast. In the following, we focus the English auction scheme, since bidding strategies in Dutch and first-price sealed-bid auction are expected to be equivalent. Again, we solve our model by backwards induction.

First, we analyse the player's bidding strategies in the auction stage. In the English auction scheme, the auctioneer reduces the per-unit price p_2 incrementally. Bidders decide if they are still willing to participate in the auction at the actual price level or if they want to leave the auction. The auctioneer stops reducing the per-unit price when only one bidder remains. One can easily derive the bidders' strategies. The incumbent A is willing to participate in the auction as long as the auction price p_2 exceeds c_2. At a level of $p_2 = c_2$ A is indifferent, since profit would be zero in the second period. A therefore signals to leave the auction exactly when $p_2 = c_2$ since a lower per-unit price would cause a negative profit. Hence, A has a dominant bidding strategy: participating in the auction as long as $p_2 > c_2$, leaving the auction at $p_2 = c_2$. Now we can define B's strategy as a best response to A's dominant strategy. The English auction scheme allows B to observe A's bidding behaviour and therefore to gather information about true costs c_2: as long as A decides to participate in the auction, p_2 exceeds c_2. Obviously, it would not be rational for B to leave the auction procedure before A, since treatment costs are the same for both utilities in the second period. The rational player B knows about A's dominant strategy to leave the auction at $p_2 = c_2$. There is only one best response: waiting until A stops bidding and gathering the concession at $p_2 = c_2$ – since the auctioneer stops reducing the price when the other bidder signals to leave the auction. Considering both players' strategies, we can derive the Nash equilibrium. The resulting price level amounts to $p_2 = c_2$, the expected profit from period two amounts to zero. Additionally the entrant B can expect to win the auction definitely. One can easily define A's maximisation problem at the first stage of the game, where it decides about optimal investment:

$$\max_{I_1} \; p_{1A}q_1 - C_1(q_1 + L_1(I_1)) - K(I_1) \qquad (5.18)$$

Using the first order condition regarding I_1 allows us to derive the optimal level of investment into the pipe network in the first period.

$$\frac{\partial K_1}{\partial I_1} = -\left(\frac{\partial C_1(\cdot)}{\partial L_1}\frac{\partial L_1}{\partial I_1}\right) \qquad (5.19)$$

Equation (5.19) exactly corresponds to equation (5.5). A's investment incentives in the English auction equal the investment incentives of a one-period monopoly. Obviously, there is no marginal benefit of the investment related to the second period. Every cost reduction caused by investment would only reduce the second period per-unit price to the same extension. The result basically corresponds to Milgrom's and Weber's findings. They show that players tend to bid more aggressively in the English auction than in a second-price sealed bid auction. As a result, competition at the re-auctioning stage is higher and the expected per-unit price tends to be lower. Since we assumed a polar case where B's cost estimation is perfectly correlated with A's cost forecast, the resulting per-unit price equals c_2.

5.4.3.4 Evaluating the Auction Schemes

In sections 5.4.3.1 to 5.4.3.3 we applied different schemes for the re-auction of a water monopoly considering the information asymmetries in a piped water market. In this chapter, we evaluate and compare these schemes regarding the incumbent's incentives to invest in the first period of our model. It is obvious that the introduction of any auction scheme lowers A's investment incentives compared to the benchmark case, where the incumbent runs the monopoly both periods with certainty. Increasing competition lowers A's probability to win the auction and therefore increases the hold-up problem. However, an incumbent still has positive investment incentives which are related to the second period, since investment can influence the probability of winning the re-auction on the one side, and the profit margin in the second period on the other side. In order to compare the above described auction schemes regarding the incumbent's investment incentives, we have to analyse the impact of investment on profit margin and probability of winning.

It is easy to show that based on our model, the hold-up problem is the strongest in the English auction. From equation (5.18) we know that A can not expect a marginal benefit in the second period from investing in the first period, since the probability of winning the re-auction amounts to zero at any investment level. Comparing equation (5.19) with equations (5.13) and (5.17), one can easily show that equilibrium investment in the English auction is lower than in sealed bid auctions. However, the English auction assures the highest degree of competition, since the expected per-unit price equals true average treatment costs in the second period. The high degree of competition is a result of the open auction scheme, which offers *B* to observe *A*'s bidding behaviour and therefore to anticipate true average treatment costs c_2. Since *A* loses its information advantage, competition basically refers to a situation with two players facing similar costs. Such strong competition in the re-auctioning stage undermines investment incentives.

Sealed bid auctions in contrast, offer the incumbent *A* to use its information advantage since *B* has no opportunity to observe or anticipate true average treatment costs. Obviously, such information advantage lowers *A*'s perceived degree of competition at the re-auctioning stage and increases the probability to win. *A* can use such advantage by defining its bidding strategy in a way that maximises expected profit in the second period. Since bidding strategies in the first- and the second-price sealed bid auction schemes vary, one can expect different investment incentives in these two auction schemes. Using equations (5.12) and (5.16), one can easily show that the impact of an additional amount of investment on the profit margin in period two is equal in both schemes. Higher investment causes lower treatment costs on the one side but a lower (expected) per-unit price on the other side. Potential differences in investment incentives are therefore caused by the impact on the probability of winning the re-auction. In fact, we know from equations (5.13) and (5.17) that in equilibrium investment incentives in these two auction schemes vary with the probability of winning. In both schemes, the marginal costs of investment equal the marginal cost reduction in the first period plus marginal cost reduction in the second period multiplied with the probability of winning the re-auction. Since the probability of winning the re-auction is defined different, the equilibrium investment may differ in the two schemes. In order to derive the equilibrium investment incentives in the first- and the second-price auction graphically, we define $\Omega(I_1)$ as the probability of winning in the first price auction, $\Phi(I_1)$ as the probability in the second price auction. Since demand is assumed to be constant we can use $q_2 = 1$ and therefore $C_2 = c_2$. $\Omega(I_1)$ and $\Phi(I_1)$ are defined as follows:

$$\Omega(I_1) = \left(\frac{1}{2} - \frac{C_2(q_2 + L_2(I_1))}{2\alpha_B^{*}\bar{c}} \right) \quad \text{and} \quad \Phi(I_1) = \left(1 - \frac{C_2(q_2 + L_2(I_1))}{\bar{c}} \right).$$

Both functions are increasing in $\bar{c}$ and increasing in I_1, since a higher I_1 lowers average costs c_2 in the second period. However, a higher I_1 raises the probability of winning in the second price auction stronger than in the first price auction, since the marginal effect of an additional investment tends to be stronger in the second price auction:

$$0<\frac{\partial\Omega(I_1)}{\partial I_1}<\frac{\partial\Phi(I_1)}{\partial I_1}$$

Additionally, we know that $\partial^2\Omega(I_1)/\partial I_1^2<0$ and $\partial^2\Phi(I_1)/\partial I_1^2<0$ since $\partial^2 C(I_1)/\partial I_1^2>0$. In the second price auction, the probability of winning amounts to a maximum of 1 in case of very high investment, respectively very low costs C_2. In the first-price auction, the probability of winning amounts to a maximum level of only 1/2. Such result is not surprising: since A faces a trade off between maximising the probability of winning and maximising the profit margin the offered per-unit price amounts to a minimum of $1/2\bar{c}$. However, one can not conclude that the probability of winning is always higher in the second-price auction. At very low equilibrium levels of I_1, respectively at very high cost levels where c_2 converges to $\bar{c}$, the value of $\Omega(I_1)$ may exceed $\Phi(I_1)$. Such case requires

$$c_2>\frac{\alpha_B^*\bar{c}}{2\alpha_B^*-1} \qquad (5.20)$$

Obviously this condition is only fulfilled for a sufficient high level of α_B^*. In case of very intensive competition where $\alpha_B^*=1$, the values of both $\Omega(I_1)$ and $\Phi(I_1)$ amount to zero at $I_1=0$, respectively at $c_2=\bar{c}$; $\Phi(I_1)$ always exceeds $\Omega(I_1)$ at positive investment levels. In order to derive the equilibrium investment we have to consider the additional terms in equations (5.13) and (5.17).[53] We define:

$$\Psi(I_1)=\frac{\frac{\partial K(I_1)}{\partial I_1}}{-\delta\frac{\partial C_{2A}}{\partial(\cdot)}\frac{\partial L_2}{\partial I_1}}>0$$

where $\Psi(I_1)$ is positive since $-\partial C_{2A}/\partial I_1>0$ and $\partial K_1/\partial I_1>0$. Additionally $\partial\Psi(I_1)/\partial I_1>0$ since $-\partial^2 C(I_1)/\partial I_1^2>0$ and $\partial^2 K_1/\partial I_1^2>0$.[54] Figure 13 shows $\Omega(I_1)$, $\Phi(I_1)$ and $\Psi''(I_1)>\Psi'(I_1)$. In both auction schemes equilibrium investment tends to be higher at a lower levels of $\Psi(I_1)$, where $\Psi(I_1)=\Psi'(I_1)$. Lower levels of $\Psi(I_1)$ are caused by a lower value of $\partial K_1/\partial I_1$ or an increased value of $(-\partial C_2/\partial I_1)$. Obviously, investment gets less expensive and therefore more attractive. From Figure 13 we know that investment in second-price auctions tends to be relatively higher at lower levels of $\Psi(I_1)$ where marginal costs of investment are low or the

53 Since investment incentives related to the first period are similar in both schemes, we can ignore them. Therefore we set the first terms of the equations (13) and (17) equal to zero.

54 The second deviation of $\Psi(I_1)$ can be assumed to be positive when assuming all third deviations as zero.

impact of additional investment on treatment costs is high. At very low levels of $\Psi(I_1)$ investment incentives in the second price auction scheme converge to the investment level in our benchmark case, where the incumbent runs the monopoly in both periods with certainty. Increasing marginal costs of investment weakens the second-price auction's relative performance. The first-price auction gets relatively more attractive. At a sufficient low level of $\Psi(I_1)$, equilibrium investment $I''_{1\Omega}$ in the first-price auction may even exceed investment $I''_{1\Phi}$ in the second price auction – provided $\Omega(I_1)$ exceeds $\Phi(I_1)$ at very low levels of I_1. Since the resulting I_1 in equilibrium tends to be very low in *both* auction schemes, *A* expects high average costs in the second period. In this case, the probability of winning the re-auction tends to be higher in the first-price auction: since *A* expects *B* charging a positive mark-up as well, *A* perceives a positive probability of winning the re-auction even when its investment is very low and costs in period two are high.[55] As a result, investment incentives are higher in the first-price auction, where the hazard of hold-up is lower.

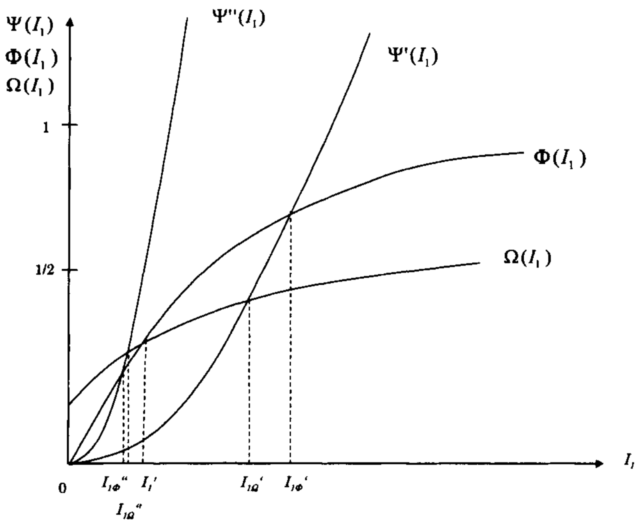

Figure 13 : Investment incentives in the first- and the second-price auction schemes

[55] Obviously *A* can expect a (small) positive probability of winning the re-auction even when actual marginal cost in the second period are close to $\bar{c}$ since *B* might offer a price that exceeds $\bar{c}$ as well. However, in the second-price auction scheme the probability of winning amounts to zero when $c_2 = \bar{c}$.

Additionally, the relative performance of the first-price auction can be altered by varying the perceived degree of competition. Competition is basically determined by α_B^* – A's assessment of B's mark-up multiplier. A higher level of competition is associated with a lower level of α_B^*, since player B bids more aggressively. Obviously, a lower value of α_B^* reduces the value of $\Omega(I_1)$, but increases the slope of $\Omega(I_1)$. In Figure 14 the mark-up multiplier α_B^* is lower in $\Omega''(I_1)$ than in $\Omega'(I_1)$.

At a given level of $\Psi(I_1)$ the equilibrium investment I_1 in a first-price sealed bid auction scheme is higher at lower levels of competition. Such result is not surprising, since the higher α_B^* increases A's probability of winning the auction on the one side, and allows to increase the own offered per-unit price p_{2A} on the other side. Investment into the pipe network gets more attractive, since the hazard of the hold-up decreases.

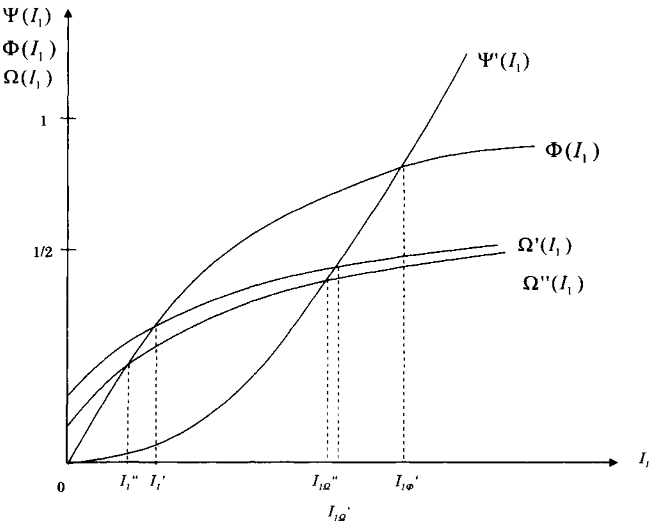

Figure 14 : Varying the degree of competition in the first-price sealed bid auction

From Figures 13 and 14 we can conclude that *both* auction schemes may be superior regarding investment incentives. One can summarise that investment in the second price auction tends to be relatively higher than in the first-price auction, when marginal costs of investment are lower or the impact of investment on water losses is higher.[56] However,

[56] One can assume that costs and effectiveness of network investment vary with the consistency of the pipe network at the beginning of the two periods on the one side and the local circumstances on the other side. Such local circumstances depend on the character of underground material or on the situation at the surface. Obviously

investment under the first-price auction scheme becomes relatively more attractive, when investment into the pipe network is very costly and less efficient and competition is assumed to be weak. Therefore a regulator would need extensive information about costs and productivity of investment and therefore about the actual and future consistence of the pipe network and also about the expected degree of competition in order to choose the sealed bid auction scheme that maximises the incumbent's investment incentives. However, it is assumable that the regulator's information about all these aspects is rather imperfect. The optimal decision is therefore expected to be very complex in practice. Additionally, the regulator needs to be credible in order to achieve the desired investment behaviour of the incumbent. Obviously, a regulator could have incentives for opportunistic behaviour. After announcing a sealed bid auction scheme at the beginning of period one he could rather use an English auction in order to maximise competition at the re-auctioning stage while keeping investment incentives. Of course, the hazard of opportunistic behaviour increases the incumbent's hold-up problem and undermines its investment incentives.

5.4.4 Endogenous Participation

So far the model assumed that each player A and B takes part with certainty in the auction procedure. We ignored their *incentives to participate* in the auction procedure and assumed the inexistence of any participation costs. In this section, we extend the model by making the participation decision endogenous. Any potential market entrant faces a significant risk due to lacking information about the network's consistence and therefore about actual future treatment costs. Making an obligatory per-unit price offer, which does not cover average costs could end up in losses and finally in bankruptcy. As a result, the participation in the re-auctioning procedure of a water monopoly concession tends not to be very attractive for any third party that has less information than the incumbent. To some extend, this finding may explain the low degree of competition in the French water sector, where re-auctions are usually won by the incumbent or where re-auctions do not take place, since the concession is just re-awarded to the incumbent *without* any auctioning procedure.

Considering the model above, participation of the two parties is not for sure, since winning the auction does not necessarily brings a positive profit. In the second-price sealed bid auction, only the incumbent may have a positive profit when winning the auction, since the relevant retail price amounts to B's price offer. If B wins the auction, the relevant retail price amounts to c_2, which is not profitable. Hence, B may forego to participate in the auction. In such case, A wins the re-auction with certainty, the relevant investment incentives increase. Obviously, in the first-price sealed bid auction the result is different. Now, both parties have

investment tends to be more expensive in urban than in rural areas, since construction works tend to be more complex and therefore costly.

positive probabilities to win the auction with profit. Hence, both have incentives to take part in the procedure. Figure 15 compares the relevant investment incentives in a first- and a second-price sealed bid auction.

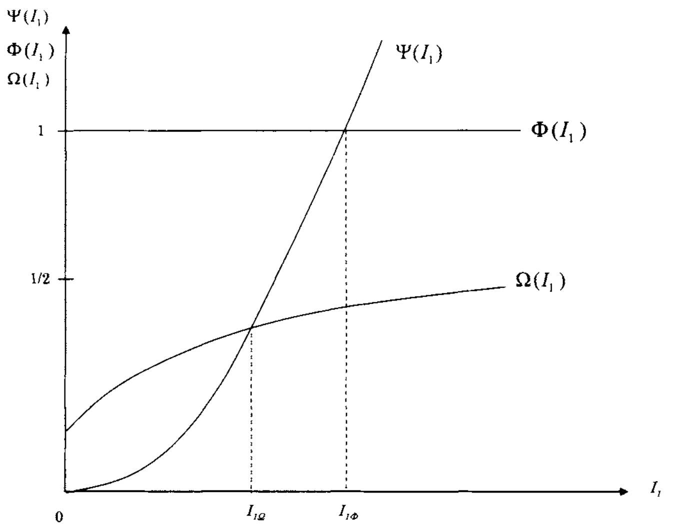

Figure 15 : Considering participation incentives

In the English auction, participation is not very attractive for both parties. *A* expects to loose the auction, *B* expects to win the auction, but with zero profit. Actually, both would forego to take part in the auction process. However, considering such idea, it would be optimal for a party to take part – hoping that the other party foregoes to participate in the English Auction. To overcome such puzzling results, we should allow for firm-specific efficiency differentials. Such differentials support the assumption above, that each party has incentives to take part in the auction process.

5.4.5 Firm Specific Efficiency Differentials

Water utilities costs are mainly determined by factors such as quality of used raw waters, pipe network's consistence or production capacity. These parameters are not firm specific and can be seen as exogenously given for any market entrant *B*. Nevertheless, there is some minor potential for firm specific efficiency differentials, mainly related to operational activities. Cost differentials between *A* and *B* are, for instance, caused by differences in organisational terms, employment contracts or technical skills. However, it is straightforward to show that allowing for efficiency differentials does not change the results from section 5.4.3 fundamentally.

The model can be extended by introducing a firm specific efficiency parameter θ_i into the cost function: $C_j = C_j(q_j + L_j(I_1), \theta_i)$, where j denotes the relevant period, $j \in \{1, 2\}$, i denotes the firm, $i \in \{A, B\}$ and $\partial C_j / \partial \theta_i > 0$. One can assume that each player knows his own θ_i, but not the other's. The introduction of θ_i increases *A*'s uncertainty about *B*'s cost estimation – from *A*'s point of view the range of potential c_{2B} values increases depending on the assumed distribution of θ_B. We forbear to model this extension explicitly. However, we know that θ_B increases the values of c_{2B} at the upper end, when *A*'s assumes that θ_B tends to be higher than θ_A. *A* fears less competition at the re-auctioning stage, investment increases in the first- and the second-price sealed bid auction schemes. Additionally, investment increases in both schemes at relatively lower levels of θ_A, since *A*'s perceived probability to win the re-auction increases. As a result, the introduction of θ_i may change the level of investment in both schemes, but it does not change their relative investment performance. We gain additional information about *B*'s participation in the second-price sealed bid and the English auction: *B* does only participate when expecting $\theta_B \leq \theta_A$.

5.4.6 Vertical Separation

Investment incentives may be different in a franchising model that assumes the vertical separation of operations from investment. In fact, the Leasing contract is the most common used delegation contract in the French water industry (see Furrer 2004, p. 212)[57]. Under a Leasing contract (see Table 13), the franchisee is only responsible for operating the infrastructure including treatment of raw water and charging water fees to customers. Investment into pipes and treatment facilities is excluded from the (re-) auctioning procedure. The municipal body or a strongly regulated infrastructure company owns the pipe and treatment facilities and is responsible for the entire investment. Financing the investment can

[57] Full vertical separation has applied used as well in several other liberalisation processes, for example in the U.S. telecommunications industry or the British railway industry.

be assured by charging utilization fees to the operating company that uses the infrastructure. In such Leasing approach, only the *operation* of network and treatment facilities can be (re-) auctioned, the investment is excluded from the re-auctioning process. As a result, the franchisee's hold-up problem is expected to be removed. However, vertical separation does not necessarily guarantee an optimal investment level. Obviously one has to consider investment incentives of the infrastructure company.

In this section, we investigate investment incentives of a separated infrastructure company. For this reason, we assume an independent upstream company *U* that owns the network infrastructure in both periods. Similar to the analysis above, we focus network investment and do not consider additional infrastructure such as treatment and storage facilities. One can assume *U* as a strongly regulated but profit-maximising private company.[58] *U*'s revenues consist of utilization fees charged to a downstream company *D* which uses the network to render its water services. *U* charges a fee that depends on the amount of water transported through its network. Such fee is assumed to be linear and similar in both periods. In order to restrict *U*'s monopoly power, a public regulator is required to restrict *U*'s freedom to determine the utilization fee by defining a price cap a_U. In our model, a_U can be seen as exogenous. *U*'s costs are determined by investment costs $K(I_1)$ in period one. Since not relevant in our analysis, we omit from further administrative costs. The upstream company's profit maximisation problem can therefore be defined as follows:

$$\max_{I_1} a_U q_1 - K(I_1) + \delta a_U q_2 \qquad (5.21)$$

One can easily show that the infrastructure company *U* does not face any incentives to invest into the pipe network since additional investment only causes higher costs at constant revenues. Obviously, *U* does not face any voluntary investment incentives since the resulting costs caused by water losses are not relevant in its income statement. As a result, the regulator should not only regulate the utilization fee, in addition he is required to regulate and monitor *U*'s investment behaviour in order to ensure welfare maximisation. But as stated in section 5.3.1, the regulation and monitoring of investment into underground pipes is expected to be difficult since it can not be observed and verified exactly by a third party.

However, a downstream company *D* that renders water services may complain that the upstream company *U*, which fails to invest into the infrastructure, is responsible for any water losses in its network. A regulator therefore may force *U* to compensate *D* for costs that arise from water losses. From section 5.3.1 we know that these costs equal treatment costs for water losses. In order to calculate the compensation fee, one has to measure water losses L_1

[58] Alternatively one can assume *U* as a publicly owned company. As stated in public choice theories public companies tend to follow other objects than maximising social welfare. One of these objects may be profit maximising. In fact some French municipal authorities used their water companies in order to improve their budget situation (see Furrer 2004, p. 214).

and L_2 in period one and two. In practice, it is possible to measure the extension of water losses since they amount to the difference between sold water quantity and water quantity inserted into the pipe network. However, it requires metering of water consumption on the one side and metering of total production quantity on the other side. In order to determine the relevant compensation fee, the regulator may multiply the fraction of water losses from total water production by the total of *D*'s treatment costs. Obviously, such computation tends to be feasible in practice, since water losses can be measured and total treatment costs can be extracted from *D*'s income statement. Using the compensation fee in *U*'s profit maximisation problem, one can rewrite equation (5.21) as follows:

$$\max_{I_1} a_U q_1 - K(I_1) - \lambda_1(I_1) C_1\left(\frac{L_1(I_1)}{\lambda_1(I_1)}\right) + \delta\left(a_U q_2 - \lambda_2(I_1) C_2\left(\frac{L_2(I_1)}{\lambda_2(I_1)}\right)\right) \quad (5.22),$$

where

$$\lambda_1 = \frac{L_1(I_1)}{q_1 + L_1(I_1)} \quad \text{and} \quad \lambda_2 = \frac{L_2(I_1)}{q_2 + L_2(I_1)}$$

We can derive *U*'s optimal investment level by using the first-order condition regarding investment:

$$\frac{\partial K_1}{\partial I_1} = -\left[\frac{\partial \lambda_1(I_1)}{\partial I_1} C_1\left(\frac{L_1(I_1)}{\lambda_1(I_1)}\right) + \lambda_1(I_1)\frac{\partial C_1}{\partial(\cdot)}\frac{\partial L_1(I_1)}{\partial I_1} - \frac{\frac{\partial C_1}{\partial(\cdot)}\frac{\partial \lambda_1}{\partial I_1}L_1(I_1)}{\lambda_1(I_1)}\right]$$
$$-\delta\left[\frac{\partial \lambda_2(I_1)}{\partial I_1} C_2\left(\frac{L_2(I_1)}{\lambda_2(I_1)}\right) + \lambda_2\frac{\partial C_2}{\partial(\cdot)}\frac{\partial L_2(I_1)}{\partial I_1} - \frac{\frac{\partial C_2}{\partial(\cdot)}\frac{\partial \lambda_2}{\partial I_1}L_2(I_1)}{\lambda_2(I_1)}\right] \quad (5.23)$$

Obviously, the introduction of a compensation fee in a model of vertical separation increases *U*'s investment incentives compared to the case without compensation fee, since the right hand side of equation (5.23) is positive. Again, we compare investment incentives given by equation (5.23) with investment incentives in the benchmark case given by equation (5.7). One can easily show that the right hand side of equation (5.7) is higher than the right hand side of (5.23) when

$$\frac{C_1(q_1 + L_1(I_1))}{q_1 + L_1(I_1)} + \frac{C_2(q_2 + L_2(I_1))}{q_2 + L_2(I_1)} < \frac{\partial C_1}{\partial(\cdot)} + \frac{\partial C_2}{\partial(\cdot)} \quad (5.24)$$

Assuming increasing marginal costs the right hand side of inequation (5.24) exceeds the left hand side. As a result, investment incentives are always higher in the benchmark case where the vertically integrated utility runs the monopoly for two periods. The gap between actual investment in a model with vertical separation and the benchmark case is increasing in the second deviation of the cost function. At lower levels of $\partial C^2 / \partial(\cdot)^2$, the relative performance of the vertical separation with compensation fee is increasing. In case of linear treatment costs, investment incentives are equal in both approaches. Such result is not surprising, since in the model of vertical separation the compensation fee is computed based on average costs. *U*'s marginal cost savings arising from a lower compensation fee tend to be lower than marginal cost savings in an integrated water utility. However, optimal investment can be implemented by adjusting the computation of the compensation fee. Obviously, the fee would have to be based on the additional treatment costs that occur due to water losses. The compensation fee in period $i \in \{1, 2\}$ can be defined as follows: $C_i(q_i + L_i(I_1)) - C_i(q_i)$. One can rearrange *U*'s maximisation problem as follows:

$$\max_{I_1} a_U q_1 - K(I_1) - C_1(q_1 + L_1(I_1) - C_1(q_1) + \delta\big(a_U q_2 - C_2(q_2 + L_2(I_1)) - C_2(q_2)\big) \qquad (5.25)$$

However, such approach requires not only information about *D*'s total treatment costs. In addition, the regulator needs exact know-how about the curvature of *D*'s cost function. In practice it is rather assumable that a regulator is not able to compute the "right" compensation fee, since *D*'s has private knowledge about its true cost function. Obviously, *D* tries to overstate additional treatment costs due to water losses. As a result, actual investment may exceed optimal investment. One can expect that such approach may be less applicable in practice, since the definition of "additional costs" tends to be problematic.

One can conclude that inducing a first-best solution in a vertical separated structure seems to be unrealistic. However, in practice one could implement a second-best solution, where the relevant compensation fee is determined by multiplying the fraction of water losses from total water production by the total of *D*'s treatment costs. Our model did not count for potential economies of scope between rendering water services and carrying out network investment. In fact, one can assume the existence of economies of scope. Both, operating and maintenance of network and treatment facilities require extended sanitary know how. Obviously increasing economies of scope worsen the relative performance of a model that assumes vertical separation.

5.5 Evaluating Additional Aspects

Up to this point, we analysed the different auction schemes only regarding investment incentives. However, auction schemes can be evaluated from additional perspectives. According to Klein (1998/a, p. 1), the choice of an auction method for concessions is affected by three arguments: *i)* political sustainability of the outcome, *ii)* robustness of firms bidding strategies and *iii)* opportunities for collusion amongst firms. We follow Klein and evaluate auction schemes in the water industry according to these arguments. First we focus *i)*. Klein (1998/a, p. 2) claims that sealed bid second-price auctions are "clearly dangerous for political sustainability when there are only a few bidders". Obviously, the winner of a second-price auction may offer a per-unit price that is significantly lower than the second highest bid. However, the winner is allowed to charge a retail price that equals the second lowest bid. Of course, welfare maximisation in a static model would require charging the lowest possible price.[59] Milgrom (1989, p. 18) claims that a regulator faces incentives to manipulate the outcome of an auction procedure. Opening the bids allows the regulator to learn about the bidders valuations. What would prevent the regulator from inserting a false bid in order to lower the per-unit price? Milgrom adds that a second-bid auction, in which the auctioneer inserts extra bids after opening the sealed-bids, is virtually identical to a first-bid auction. Political sustainability tends to be higher when more bidders participate in the auction procedure since the probability of large and therefore unsustainable differences between their bids tends to be lower.[60] Additionally, sustainability tends to be higher in an open auction scheme as for instance the English auction. Since the auctioneer stops reducing the price when the second-lowest bidder leaves the auction, nobody knows about the winner's potential lowest per-unit price. Klein mentions that first-price and sealed bid auctions can both yield reasonable sustainability.

In addition the sustainability of the auction's outcome may differ in *ii)*, the robustness of the bidder's strategies. Common value auction schemes complicate the player's strategy definition: the value of a concession not only depends on the bidder's personal valuation, in addition it depends on factors that affect all bidders. However, in a franchising procedure in the water sector one can assume that different bidders have different information – as assumed in the model above. Such setting holds a serous danger of the winner's curse (see Klein 1998/a, p. 3 or Wolfstetter 1994, p. 5). One can expect that the most optimistic bidder who assesses the relevant costs at the lowest level wins the auction – instead of the most

[59] The auction of a radio spectrum in New Zealand created political problems, since the first bid was NZ$ 100,000, the second bid only NZ$ 6. Obviously authorities had significant problems to explain such outcome to the public (see McMillan 1994).

[60] However, experience from franchise bidding in the French water industry rather indicates that only a few bidders take part in the auction procedures.

efficient bidder. Obviously, an overoptimistic bidder will suffer a loss during the following contract period. When the franchisee becomes aware of true costs, he tries to re-negotiate the contractual terms ex-post. Such behaviour undermines the benefit of competition at the re-auctioning stage. Anticipating the opportunity for re-negotiation allows bidders to bid more aggressively. However, the result of the auction is *not robust*, since one can expect that it will be changed ex-post. In fact, re-negotiations in franchised water monopolies are fairly common. For example in the Buenos Aires water concession, the winning company Aguas Argentinas was able to achieve 13.5 percent higher water tariffs than agreed in the original concession contract.[61] Klein (1998/a, p. 3) mentions that the hazard of the winner's curse and contract re-negotiations can be avoided by using an English auction. Such open auction scheme allows less informed bidders to gather information about true costs during the auction procedure. As a result, the hazard of overoptimistic bidding tends to be lower. Such finding corresponds with the result of our model. Only the potential market entrant *B* can suffer a loss due to overoptimistic bidding, since the incumbent *A* has perfect information about costs in period two. Obviously, the hazard of the winner's curse tends to be the highest in the first-price sealed bid auction. Since we assumed only two bidders in our model, there is no danger in the second-price sealed bid auction. The problem would occur when assuming more than two bidders. Similar to Klein's findings, the hazard of the winner's curse is the lowest in the English auction scheme, where the offered per-unit price never falls below true costs – independent of the number of bidders. However, there may be a trade off between minimising the danger of the winner's curse on the one side, and maximising investment incentives on the other side.

A further argument concerns *iii)*, the opportunities for collusion amongst bidding firms. The degree of competition at the (re-) auctioning stage tends to be lower at higher levels of collusion. Hence, the per-unit price tends to be higher and social welfare lower. Bidding cartels are expected to be more stable in open auctions, since they allow firms to observe each other's bidding behaviour and they allow retaliation of other's defection immediately. However, Klein (1998/a, p. 3) argues that collusive behaviour may occur in sealed bid auctions as well, if there is repeated bidding for concessions involving similar players. In fact, collusion amongst bidders frequently happened in France, where the first-price sealed bid auction scheme predominates and where basically three main companies dominate the entire water market. In its critical report, the French national audit court (Cour Des Comptes, 1997, p 125) stated the high degree of concentration resulted from "organised competition".

[61] In addition the minimum water connection fee was increased by 84 percent, the water infrastructure fee by 38 percent, the minimum sewerage connection fee by 42 percent and the sewerage infrastructure fee by 46 percent (see Alcázar et. al., 1999, p. 35).

5.6 Conclusions

Investment into underground water pipes tends to be very long-term oriented, specific and hardly to verify by a third party. Following Armstrong et al. (1994, p, 129), one should conclude that the capital intensive water industry is not really well suited for franchise bidding. Obviously, short term contracts undermine long-term investment incentives. The resulting hold-up problem causes a serious danger of underinvestment in franchised water monopolies. The model above, which assumes that an incumbent firm can invest into long-term underground pipes in order to reduce water leakage and therefore (future) production costs, strongly supports such conjecture. One can easily show that investment tends to be lower in a short term franchising contract. However, one can not conclude that very long-term franchising contracts that exclude the opportunity of periodical re-auctions are superior in the water industry. Using a re-auctioning process is the only way to ensure competition. If a regulator decides to auction of a water monopoly, he has to consider periodical re-auction procedures. As a result, he faces a trade off between introducing competition on the one side, and keeping investment incentives on the other side.

However, the regulator should consider that the incumbent's investment incentives may be different when using different (re-) auction procedures. In fact the model above shows that investment incentives may vary in different auction schemes. One main result of the paper is that investment incentives tend to be the lowest in an English auction. Such open auction scheme allows potential market entrants to observe the incumbent's bidding behaviour and gather information about true production costs. Loosing such information advantage weakens the incumbent's position in the re-auctioning process. The hold-up problem increases and undermines incentives to invest. Using a closed auction such as first- or second-price sealed bid auction allows the incumbent to benefit from its information advantage. Investing into underground pipes not only reduces future production costs. Additionally, it strengthens the incumbent's position in the re-auctioning process. Investment incentives in closed auctions tend to be higher than in an English auction. However, as shown in section 5.4.3.4, investment incentives may be different in a first- and a second-price auction scheme. Depending on several conditions, investment may be superior in one of these schemes. The model shows that investment in the second price auction tends to be relatively higher than in the first-price auction when marginal costs of investment are lower or the impact of investment on water losses is higher.

When deciding about the applicable auction scheme, the regulator may take additional aspects into account. As showed in section 5.5, political sustainability of the auction outcome tends to be higher in a first-price sealed bid and in an English auction since the regulator can not identify the bidder's minimum average costs. In a second-price sealed bid auction, where the bidder's reveal their minimum costs, the regulator has incentives to manipulate the outcome ex-post in order to minimise the per-unit price. In addition, the English auction tends to be most favourable when evaluating auction schemes regarding the hazard of the winner's curse. However, the English auction allows bidders to observe each other, which supports stability of potential bidding cartels.

In order to decide about the applicable auction scheme, the regulator needs to evaluate and to assess all the arguments above. If investment is a very important issue in its evaluation, he should use a sealed bid auction scheme. Based on additional information about the specific market the regulator then has to decide about a first- or a second-price auction scheme. However, such decision tends to be complex in practice, since one can assume that the regulator's information is rather imperfect.

The regulator can eliminate the incumbent's hold-up problem by implementing vertical separation. Investment into the pipe network is excluded from the franchise bidding procedure, and is carried out by a separated infrastructure company. Still, in order to optimise investment incentives, the regulator has to implement a complex compensation system. The infrastructure company compensates the operator for costs arising from water losses. Again, information asymmetries complicate the computation of the relevant compensation fee. However, when evaluating vertical separation more detailed, one has to consider potential economies of scope between carrying out investment and operating the network.

Obviously, one can not expect to implement a first-best solution when using a franchise bidding procedure in the piped water industry. Using any kind of auction design induces the hazard of underinvestment. One may ask the question, if franchise bidding is a valuable alternative in the piped water sector. However, in practice, several municipal authorities, for example in France, used franchise bidding due to a lack of financial resources and technical know-how. Investment into the pipe network under a franchising regime may be suboptimal, but still higher than under a public ownership.

6 Summary and Conclusions

In practice, introducing competition in the piped water sector tends to be difficult. Both, competition *in* and competition *for* the market have several drawbacks due to the water market's specificities. Nevertheless, we can *not* conclude that competition in the water industry is not useful or not possible to apply. The non-existence of competition tends to be an inferior situation – even when the monopoly is driven by public authorities. Experience in practice shows that public water supply does not necessarily secures efficient and high-quality water supply. In both, developed and less-developed countries many governments started to introduce privatisation due to a lack of financial resources or due to a lack of know-how. Privatisation is therefore widely seen as a way to overcome the *failure* of public services. However, it is important to note that privatisation itself is not expected to be a superior alternative. For good reasons, one might be even more concerned about private monopolies. Privatisation has to be accompanied by the introduction of competition. In any sector, competition tends to foster technical progress, to increase efficiency and to lower retail prices. Even when water market's specificities make competition less intense or more complex to apply, it may be useful to introduce at least some degree of competition. However, it is necessary to count for these specificities when applying a competition scheme and when defining the relevant regulatory framework. Regulation has to ensure high quality of supply, high connection rates, efficiency by the use of economies of scale and affordable retail tariffs.

As shown in Chapter 2, competition in the market by common carriage is not expected to be very intense. First, due to technical difficulties related to the mixing different of water qualities in one pipe network the geographical extension and the amount of connected networks are very limited. Second, the fragmented and decentralised water market makes it very difficult to regulate access prices that ensure non-discriminatory access to an incumbent's pipe network. Taking this points together, we can conclude that competition by common carriage induces rather a low degree of competition between neighbouring suppliers that are able (and willing) to connect their pipe networks. Nevertheless, the analysis showed that competition by common carriage may induce positive welfare gains – even in a situation with only two involved parties and without any kind of regulation. In such worst-case scenario, a less efficient incumbent voluntarily opens its network to a more efficient utility, since it allows to reduce the own costly production. In order to compensate the relevant losses, the incumbent charges an access fee. Such mechanism increases the overall efficiency of production and reduces the relevant retail price. Both, suppliers and customers profit from competition. Of course, the performance of such competition model can be enhanced by introducing regulation, for instance the regulation of access or retail prices.

In chapter 3 we showed that the relevant welfare gains from introducing common carriage may vary when applying different governance structures. According to the model's results, welfare gains vary when composing water utilities as profit-maximising or welfare-maximising companies. Welfare tends to be higher in a profit maximisation regime when assuming higher efficiency differentials between an incumbent and an entering supplier. Only at very low efficiency differentials, welfare maximisation may generate a higher level of welfare. In a welfare maximisation regime, the incumbent acts like a Stackelberg leader and announces a hard commitment about its production quantity due to its objective function. Under profit maximisation, the incumbent tends to produce less, the retail price is higher. However, lower consumer surplus in the profit maximisation regime can be overcompensated by the incumbent's higher profit. Additionally, production efficiency is higher under profit maximisation, since the more efficient market entrant's engagement is higher.

The low degree of competition under common carriage indicates that welfare gains may be similar or even higher, when allowing the neighbouring water utilities to trade treated water resources voluntarily. In fact, in chapter 4 we showed that both, common carriage and cross border trade enhance the efficiency of water supply. However, such gains may vary. In a competition regime, a less efficient incumbent faces higher production incentives. As a result the retail price tends to be higher under competition than under trade. Production efficiency is higher under trade, since the high-cost incumbent is less engaged. At low cost differentials between the neighbouring water utilities the efficiency effect dominates: welfare is higher under a trade regime. The optimal choice of the institutional framework therefore depends on the initial efficiency differential between neighbouring utilities.

In practice, competition by franchise bidding is more relevant than common carriage. In particular France gained extended experience with competition *for* the market. However, such experience was not only positive. Ineffective competition (in particular at the re-auctioning stage), bribery and corruption and a lack of long-term investment are main problems occurring from tendering water utilities. Chapter 5 dealt with only one issue, the investment problem. Investment into underground water pipes tends to be very long-term oriented, specific and hardly to verify by a third party. One can conclude that the capital intensive water industry is not really well suited for franchise bidding: the resulting hold-up problem causes a danger of underinvestment. Nevertheless, franchise bidding is applied. Chapter 5 analyses re-auctioning designs and their impact on long-term investment. The result is not surprising. Re-auctioning schemes that give an information advantage to an incumbent enhances its investment incentives. Such advantage increases the probability of winning the re-auction and therefore the probability of enjoying the fruits of the own long-term investment. The model above shows that investment incentives vary in different auction schemes. Investment incentives tend to be the lowest in an English auction, where potential market entrants can observe the incumbent's bidding behaviour and gather information about the consistence of the pipe network and therefore about production costs. Closed auction schemes such as first- or second-price sealed bid auction allow the incumbent to benefit from its information advantage. Investing into underground pipes not only reduces future production costs. Additionally, it strengthens the incumbent's position in the re-auctioning process. However, it is important to note that a regulator, respectively an auctioneer should consider additional aspects when designing the auction scheme: political sustainability of the auction outcome tends to be higher in a first-price sealed bid and in an English auction. Additionally, the English auction tends to be most favourable regarding the hazard of the winner's curse. However, the English auction allows bidders to observe each other, which supports stability of potential bidding cartels. Chapter 5 shows that it is important to evaluate and analyse the structural conditions – such as the need for investment, costs and effectiveness of investment or the number of bidders – very detailed before applying an auction design.

The results derived in this book may not be a sufficient base for deciding about the introduction of competition in a particular market. Such a decision requires detailed and numerical information about the impacts of the above described structural conditions. This book contains only a formal analysis of the main issues that are related to competition in the piped water industry. It is therefore useful and necessary to enhance this analysis by empirical research. Using the results derived in this book, it is appropriate to analyse the effects of different competition approaches more detailed. Further research should therefore address the empirical analysis of competition. Obviously, such analysis requires extended data. There may be some data in the field of franchise bidding. However, the collection of data regarding common carriage is difficult, since some additional years of experience are needed.

Beside empirical research, it is useful to analyse the impact of regulation more detailed. The models described in this book deal in a very global way with regulation issues. In practice, there are many different ways to regulate access prices or retail prices. Of course, varying the regulation scheme could change the efficiency of the chosen competition approach. Additionally, the book neglected regulation of investment into underground pipes since they tend to be hard to inspect and to verify by a third party. However, in practice there may be some opportunities to solve – at least to some extend – the problem of information asymmetry between regulator and utility. Additional research should deal with the problem of information asymmetry and the relevance for regulation. Such additional research may be motivated by technical progress that allows a more sophisticated monitoring of an incumbent's investment.

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