Université De Paris XI – Paris Sud
Faculté Jean Monnet
Droit—Économie—Gestion

Competitive Solutions for Managing Local Public Services

An Economic Analysis of Water Supply in France

Thèse Pour Obtenir le Doctorat en Sciences Économiques

présentée et soutenue par

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le 8 Novembre, 2006

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ACKNOWLEDGEMENT

The preparation of a Ph.D. dissertation is an arduous task. Without the help and encouragement of numerous people around me, it would have been impossible for me to accomplish this work. My utmost gratitude goes to them.

First and foremost, I am tremendously indebted to my supervisor, Professor Stéphane Saussier. Without his patience, guidance and support, none of this would have been possible. His careful readings, discussions, criticisms and encouragements have been most precious in widening my perspective, and have contributed substantially to the work done in this dissertation. He has also greatly helped me by being my co–author in two papers that have served as a basis for my discussion in this dissertation. I am fortunate to have a supervisor such as him.

I am also very grateful to Didier Chabaud, Professor Pierre Garrouste, Professor Jean–Michel Glachant, Professor Claude Ménard, Professor Thierry Pénard, Yannick Perez, Emmanuel Raynaud, Carine Staropoli, Professor Steven Tadelis and Anne Yvrande–Billon for generously sharing valuable comments, knowledge and experience with me. Other colleagues and fellow students at the ADIS and ATOM research centre have also offered many enlightening thoughts and discussions that have proved to be highly useful to my work. They include Laure Athias, David Cayla, Marc–Kevin Codognet, Claudine Desrieux, Céline Hiroux, Sébastien Lécou, Florent Maupas, Matthieu Mollard, Jean–Michel Oudot, Annie Royer, Roxana Saplacan and Marcelo Saguan. I would like to thank them for their time and effort, and for the moral support that they have provided to me throughout the years. It has been a great pleasure to work with them. I would also like to mention a special thanks to Fréddy Huet and Faye Steiner, who have collaborated with me on various papers. They have also allowed me to learn a lot, making my experience as a Ph.D. student an enriching one.

My gratitude goes to the *Conseil National de l'Information Statistiques* (CNIS) and the *Service Central des Enquêtes et Études Statistiques* (SCEES) of the Ministry of Agriculture for allowing me to use the data from the survey that they have conducted on local territories and the environment (*Enquête sur les collectivités térritoriales et l'environnement - volet eau et assainissement*) in 2003.

Last, but not least, I would like to thank my family and my friends, especially Thierry Cosio, Ming Xin Lin, Aude Mazeron and Wee Pin Ng, for their unconditional support.

Abstract

This Ph.D. dissertation seeks to study the use and the limits of competitive solutions, namely franchise bidding (Demsetz [1968]) and yardstick competition (Shleifer [1985]), for managing local public service provision. We also account for informal mechanism such as *ex post* competition and intermodal competition when we study franchise bidding mechanisms. The efficiency of franchise bidding is examined through the Transaction Costs Economics approach. Using an original dataset on the French water sector and switching regression models, we show that franchise bidding contributes to lower observed water prices for consumers. Nevertheless, some inefficiencies may still prevail in the French water sector, as services run by private operators exhibit higher water prices on average. This leads us to consider the use of yardstick competition to enhance efficiency for such services. Through a review of the theoretical literature on this subject, it is found that, in general, yardstick competition performs better than individual incentive regulations due to competitive pressures. Costs of informational rents are reduced because of informational externalities. These competitive solutions can therefore be beneficial when used to manage local public services. However, an important danger that underlies the use of such mechanisms is collusion. Consequently, we study the plausibility of collusion among operators. More precisely, we consider how operators may sustain collusion through repeated interactions, and how their capacity to do this is altered by franchise bidding or yardstick competition, or when both mechanisms are used together. We show that collusion is harder to sustain when contractual length is long enough. Surprisingly, the use of franchise bidding together with yardstick competition may in fact help operators to sustain collusion. Our empirical study of the French water sector shows partial evidence that contractual length tends to be shorter when threats to revert to public provision are credible.

Keywords: Local public services, auctions, franchise bidding, yardstick competition, collusion, water sector.

Résumé

L'objectif de cette thèse est d'étudier l'utilisation et les limites des solutions concurrentielles dans la gestion des services publics locaux, à savoir les mécanismes d'enchères (*franchise bidding*) et la concurrence par comparaison. Nous prenons aussi en compte des mécanismes informels tels que la concurrence *ex post* et la concurrence entre modes de gestion lors de l'analyse des mécanismes d'enchère. L'efficacité de ces derniers est examinée à l'aune de l'approche transactionnelle. En mobilisant une base de données provenant du secteur de la production et de la distribution de l'eau en France, et en prenant en compte au niveau économétrique la possibilité d'endogenéité du choix du mode de gestion par la commune, nous trouvons que les mécanismes d'enchères favorisent une réduction du prix de l'eau versé par les consommateurs. Néanmoins, des inefficacités sont susceptibles de perdurer dans ce secteur dans la mesure où les services gerés par les opérateurs privés présentent en moyenne des prix plus élevés qu'en cas de gestion publique. Cela nous amène à considérer le recours à la concurrence par comparaison en vue d'améliorer l'efficacité de ces services. Une revue de la littérature théorique sur ce sujet nous montre que la concurrence par comparaison peut, en général, donner lieu à une meilleure performance qu'une réglementation incitative individuelle sous l'effet de pressions concurrentielles. Celles–ci créent des externalités informationnelles qui allègent les coûts des rentes informationnelles. Ces solutions concurrentielles peuvent en conséquence être bénéfiques à la gestion des services publics locaux. Cependant, un danger important sous–jacent à l'utilisation de ces mécanismes concurrentiels est le risque de collusion. Plus précisément, nous considérons la façon dont les opérateurs peuvent soutenir la collusion à travers des interactions répétées. En particulier, nous examinons les déterminants de cette capacité en cas d'utilisation de l'enchère, ou de la concurrence par comparaison, ou des deux en même temps. Nous montrons que la collusion est plus difficilement soutenable lorsque la durée du contrat est suffisamment longue. Il s'avère que l'utilisation à la fois des mécanismes d'enchère et de la concurrence par comparaison est susceptible d'aider les opérateurs à soutenir la collusion. Notre étude empirique du secteur de l'eau en France révèle que la durée du contrat tend à être plus courte quand la menace d'un rétour au régie est crédible.

Mots clés : Services publics locaux, enchères, concurrence par comparaison, collusion, secteur de l'eau.

Contents

Introduction and Overview

While local public services such as water distribution or public transportation are traditionally provided in–house by local public authorities (municipalities, associations of municipalities, regions and likewise), there has been in recent years a growing trend towards outsourcing such services to the private sector. Part of this trend may be explained by increasingly tight budget constraints on the local public authorities, and by the supposedly higher efficiency gains that could be expected from a private firm due to the difference in incentive structure between a private firm and a public organization (Vickers and Yarrow [1991], Dixit [1997]). Whatever the true reasons for bringing in (or not) the private sector into such public services, there will be efficiency consequences at stake for such a decision.

One important dimension of most of these services concerns their monopolistic nature. Indeed, when one looks at industries like the water sector or the public urban transport, one can easily see the need for heavy infrastructure in order for such services to be functional. As a consequence, market competition may not be viable (Baumol, Panzar, and Willig [1988]). In other words, in such industries, it is more efficient to have a unique firm providing the services to satisfied the demand rather than have several competing firms. Hence, a problem that could arise when participation of private firms in such industries is desired is that of monopoly power. As Klein and Gray [1997] pointed out, reforms seeking to privatize network industries may not be able to bring about long lasting public benefits if govern-

ments do not account for problems that are linked to the monopoly segment of the privatized industry. A major question is therefore the following one: how can the public authority pass benefits expected from greater productive efficiency of private provision on to consumers and/or taxpayers?

Even if competition in the market is precluded due this natural monopolistic characteristic, competitive solutions may still exist when it comes to managing the provision of such local public services. Arguably, competition could help in promoting efficiency on how these services are run, and allow consumers to benefit from associated efficiency gains. Two such solutions are franchise bidding mechanisms and yardstick competition.

Franchise bidding mechanisms as a way to introduce competition into industries where market competition is precluded was suggested by Chadwick [1859] and popularized later on by Demsetz [1968]. Under such a mechanism, auctions can be organized by a public authority to attribute temporary monopolistic market rights to private firms, *via* a contractual arrangement between the public entity and a private firm. Such competition should therefore be beneficial in terms of limiting market power conferred by such contracts unto the chosen private operator. The authors show that the absence of competition *in* the market can be replaced by competition *for* the market when such a mechanism is used.

Yardstick competition is another way by which competition may be introduced. This mechanism, first proposed by Shleifer [1985], is actually a regulatory tool under which a private operator's financial outcome depends on its relative performance *vis-à-vis* that of its reference group. This is especially relevant for local public services. Indeed, where such services are concerned, several local monopolies should be available at the national level, thus providing a basis on which relative performance comparisons can be made. Yardstick competition has been implemented for instance in the British water industry (Sawkins [1995]; Cowan [1997]), in the Norwegian bus industry (Dalen and Gómez-Lobo [2003] and in the Japanese passenger railway (Mizutani [1997], Okabe [2004]).

However, we should mention that both solutions are subjected to some limits.

While the limits of franchise bidding have been well studied in the literature, yardstick competition receives to this day relatively little attention from economists. In particular, it is well known by now that *ex ante* competition is unable to deal with *all* the problems associated with contracts attributed by local authorities to private operators for the provision of a public service. Transaction Costs Economics pointed out that potential problems may arise due to the very long–term dimension of such contracts and the fact that these services often require some (specific) investments (Williamson [1976], Goldberg [1976], Goldberg [1977]).[1] Basically, this line of analysis points out the fact that a contract established between the public sector and a private operator inevitably creates the need for adaptation to the original contractual terms. Indeed, contracts are inevitably incomplete, and unforeseeable events may arise during the execution of a contract. This is especially true for contracts on local public services, as such contracts generally have a long duration. Such *ex post* adaptation leaves room for eventual opportunistic behaviour, both from the public and the private partner. *Ex ante* competition may not suffice to solve for such problems. As an illustration of this point, Guasch [2004] observes that *ex post* renegotiation occurs more frequently in Latin American infrastructure concession contracts when these are attributed through auction mechanisms. This can be taken to show that contracting parties do adapt their initial contracts *ex post*. While such renegotiations can be *Pareto* efficient, there may also provide room for *ex post* opportunism. In particular, the author shows that renegotiations of concession contracts in Latin American countries typically lead to better terms for the operators. For instance, operators may be able to secure tariff increases, or lessen their investment burden. We believe therefore that the criticisms raised by Transaction Cost Economics on the difficulty of auctions are relevant.[2]

Yardstick competition may be used as a substitute, or a complementary device to enhance efficiency in local public services provision. Indeed, the need for *ex post* intervention to adapt an initial contract creates room for opportunistic behaviour,

[1] Transaction Costs Economists also pointed out that problems may occur during the *ex ante* contracting stage as well as during a contract renewal stage. We will further develop on these arguments in Chapter 1

[2] Note however that empirical studies such as Zupan [1989b], Zupan [1989a] find no supporting evidences for these criticisms.

and hence inefficiency. Regulation is therefore a possible means to achieve better efficiency for the provision of local public services. Yardstick competition is particularly interesting in this respect, since a regulator may create artificially competition through such a regulatory policy.

Another important limit to franchise bidding in particular, and competitive solutions discussed above in general, is the possibility that collusion will occur. Indeed, recent studies have shown that collusion may be a pervasive problem in auctions concerning public contracts in general. For instance, Porter and Zona [1993], Porter and Zona [1999], Pesendorfer [2000] have econometrically established bid rigging in auctions of public procurement contract in sectors such as highway construction and school milk. Competition authorities in both side of the Atlantic have also detected several cases of cartel behaviour in auctions for public contracts. In the European Union, for instance, the Swedish Competition Authority exposed a cartel in procurement contracts of road-surfacing (Swedish Competition Authority [2003], Swedish Competition Authority [2005]). Likewise, the French Competition Authority recently convicted three firms in the public urban transportation sector for market sharing between 1996 and 1998 (Conseil de la Concurrence [2005b]) and five firms for collusion in road construction markets between 1991 and 1998 (Conseil de la Concurrence [2005a]). Needless to say, collusion undermines the efficiency of the auction mechanism. Likely, the theoretical literature has also shown that yardstick competition could be vulnerable to collusion (Laffont and Martimort [2000], Tangerås [2002]). In particular, the authors show that when the benefit from using yardstick competition is the highest, the private operators, or firms, are the most likely to collude. Needless to say, this would undermine any efficiency gains that one may expect from yardstick competition.

The present dissertation seeks to study the efficacy and the limits of these competitive solutions for local public service provision. In particular, we are interested in knowing whether such solutions may be adapted for managing the provision of local public services. To this end, we will consider franchise bidding mechanisms and yardstick competition in turn. To this end, it seems natural to us to consider

first the competitive solutions before looking into problems raised by collusion.

More specifically, we will start by considering franchise bidding mechanisms. This is motivated by the observation that franchise bidding mechanisms are increasingly being advocated by economists to attribute public contracts[3], both limits that have been raised above should be taken into careful consideration. Indeed, both dimensions contain strong implications on whether franchise bidding mechanisms are sufficiently reliable to pass on the efficiency gains that could be expected from using the private sector to provide for such services to consumers/taxpayers. Moreover, franchise bidding presents a more simple and direct way by which benefits from competitive forces may be harnessed: such mechanisms may be implemented directly by local public authorities, on whom the task of organizing local public services usually falls. As such, this solution could be readily implemented at a decentralized level, while yardstick competition would certainly be feasible through a centralized and more coordinated body.

To explore the role that such competitive forces may play to address the problems that arise from the use of auctions in attributing contract for local public services, we intend to adopt both a theoretical and an empirical approach. A theoretical study into the effects of competitive pressures on problems due to opportunism and/or collusion in public contracting through auctions and yardstick competition can have implications for our understanding on how best to organize public service provision. With respect to opportunism in long term contracts attributed through auctions, previous literature has largely focused on competitive forces in place during auctions. We intend to complement on these studies by taking into account other possibly existing competitive forces. Indeed, in addition to competitive pressures of an auction for these contracts, there could be a variety of other naturally existing competitive forces at work: first of all, as we have briefly

[3]In developed countries like the United States and the European Union, for instance, there has been a trend towards institutionalizing the use of auctions for public procurement contracts. For instance, Bajari, McMillan, and Tadelis [2003] noted that the US Federal Acquisitions Regulations (FAR) "*... strongly favor the use of auctions in public sector procurement ...*". Likewise, there has been a recent directive from the European Union that attempts to make auctions compulsory for public procurement contracts over a threshold value. In his book, Guasch [2004] has also advocated the use of auctions in attributing infrastructure concession contracts in the public sector in Latin American countries.

mentioned, local public services are traditionally provided in house by local pubic authorities. This suggests the possibility of *intermodal competition*: a local public authority may revert back to providing a service inhouse if he should be unsatisfied with his private partner. Therefore, there should be some competition between public provision and private provision of a good. Competition may also prevail between an incumbent and future candidates where the incumbent's monopoly rights for a service come to its term. This *ex post competition* may well work as a disciplinary device on the incumbent when the contract is being executed. Besides, Public Private Partnerships (PPPs), which constitute a hybrid organizational form for local public service provision between a local public authority and a private partner, may be an adequate instrument to harness both public benefit and private expertise. Such contracts may be sufficient to overcome the limits of more traditional franchise bidding contracts *à la* Demsetz [1968]. Under this latter configuration, a private operator is left entirely in charge of the service provision, while in PPPs, public authorities can be more or less involved. To our knowledge, there have been relatively few studies that try to identify effects of *ex post* competition and intermodal competition. We believe that these competitive forces may serve to restrain *ex post* opportunisms of contracting parties. We use an argument from the relational contracting literature to justify this. While we are principally interested in the contractual relation between a public partner and a private partner for services that exhibits a locally monopolistic dimension, we believe our study could be useful to understand how these extra-contractual "devices" may be used in complement to other existing institutional and contractual solutions to curb opportunistic behavior.

To understand the benefits and identify the possible limits of yardstick competition, we will conduct a review into the theoretical literature on this subject. While it is beyond the scope of our dissertation to determine whether this latter type of regulation could be used as a complementary device to, or a substitution for, PPPs and/or auctions, we intend to study how such a regulatory policy can perform when compared to more individualistic type of regulation such as cost of service regulation or price cap regulation. Such a comparison may allow us to shed some light on the benefits and limits of using yardstick competition as a

means to regulate local public services.

As we have mentioned, collusion is a potentially serious and common limit to both competitive solutions. This leads us to consider how collusion could be overcome when such competitive solutions are used. In particular, the operators' ability to collude is considered from the aspect of the sustainability of their collusive agreement. Indeed, in order to collude, operators must ensure that all members participating in the cartel abide by their collusive agreement. Given that collusion is illegal, this collusive agreement must be self–sustainable. In this aspect, we use repeated game theory to help us consider the capacity of operators to collude when competitive solutions are used to provide local public services. More specifically, in our study, collusion is more plausible the easier operators may sustain their collusive agreement. Using this theoretical framework, we study whether contractual length may be used as a way to discourage operators' bid rotation initiative during an auction. We find that a longer contract may make collusion harder to sustain. This shows more generally that contractual provisions may be used directly by local public authorities to discourage collusion during auctions.

However, contractual variables may not be the only way to discourage collusion. Collusion could also be made more difficult through the institutional framework. In particular, how would operators' ability to collude change when yardstick competition is used instead of auctions? There has been relatively little literature on the subject. To our knowledge, there were only two important contributions to this issue, namely Laffont and Martimort [2000] and Tangerås [2002]. Both contributions build on the methodology proposed by Laffont and Martimort [1997], and use a static mechanism design approach to study firms' incentives to collude under yardstick competition. In the authors' settings, collusion is seen as a side agreement coordinated and enforced by a benevolent third party. This modelling, as Laffont and Martimort [2000] argued, can be seen as a short cut to a more dynamic setting where collusion is self-enforced, and allows the authors to focus on the trade off between rent extraction and productive efficiency distorsion when a regulator has to account for firms' incentives to collude. We provide a complementary analysis to the literature by considering a setting where collusion is

explicitly self enforceable through an infinitely repeated game. We attempt further to contribute to the literature by studying how firms' capacity to collude is affected when a combination of yardstick competition and franchise bidding is used. As far as we know, this dimension has yet to be rigorously addressed in the literature, apart from some allusions to using such a mixture when collusion is a problem in transport economics (see, for instance, Bouf and Péguy [2001]).

For our empirical work, we will focus on the French water sector using a representative database that comes from the French Institut of Environment (IFEN, for *Institute Français de l'Environnement*). We believe that the water sector in France is particularly adapted for the issues that we want to study. Indeed, water services are local natural monopolies *par excellence*. Furthermore, the French case is particularly interesting for two main reasons: first of all, in France, water services are provided by municipalities, and secondly, the French institutional framework grants great liberty to local municipalities on the way such services can be managed. In terms of analysis, the variety of arrangements that results from such liberty provides a fertile arena to study the efficiency of PPPs and the effects of using auctions.

The French water sector also provides an interesting ground for our empirical work because there has been an increasing dissatisfaction on how water services are being managed in recent years. In 2006, a French consumer association, *Union Fédérale des Consommateurs*, has published a study on high water prices in France in its magazine *Que Choisir* (Union Fédérale des Consommateurs [2006]). The association pointed out that this could be due to inefficiencies stemming from lack of competition when contracts for water services are attributed through auctions[4], and called for the establishment of a national regulator who will perform comparative studies on water prices in France. In other words, this ongoing debate to adopt yardstick competition in the French water sector strengthens the relevance of the choice of this sector in this dissertation. Hopefully, our results and discussion in this dissertation would be useful to the ongoing debate.

[4]There are three major players in the water sector in France.

Our work in this dissertation is, however, limited in several ways. Firstly, we feel that we have not completely explored the links between franchise bidding and yardstick competition. In particular, we are aware that the present dissertation does not offer enough insights into when one scheme, or the other, or both schemes should be used for managing local public services. Although this question is important and has strong policy implications, we believe that to address this question in a satisfactory manner, one should take into account the political as well as institutional factors. Clearly, such an analysis would be very complex. A related limit concerns our assumption on the benevolence of public authorities adopted throughout this dissertation. One should note that public authorities, just as any economic agents, react to incentives and may pursue their own agenda. A realistic approach in our study would have been to account for this possibility. Other limits will be discussed within the dissertation.

Nevertheless, we believe that our dissertation shows that competitive solutions may be used when it comes to managing local public services. An important issue to bear in mind in this case is that agents may react strategically to these solutions. The general efficiency of such solutions will therefore depend on how agents may strategically react to them.

The present dissertation will be divided into two parts: in the first part, we will focus only on the effects that various types of competition may have on the efficiency of local public service provision, while our second part proposes a study into private operators' incentives to collude when auctions and/or yardstick competition is used to organize local public service provision. We briefly discuss how each part of our dissertation is organized in the following.

The first part of our dissertation, dedicated to examine various potential competitive pressures that might be beneficial to the efficiency of local public services provision, consists of the two following chapters:

In our first chapter, we start by considering the impact of auctions on the efficiency of public service provision. More specifically, we argue that auctions may not entirely solve for problems related to franchise bidding mechanisms *à la*

Demsetz [1968] identified by Transaction Cost Economics. We then turn to study how *ex post* competition and intermodal competition can actually help to reduce possible opportunism using arguments developed by the literature on relational contracting (Baker, Gibbons, and Murphy [2006]). We then empirically explore the efficiency of using PPP, and the impact of various competitive pressures on the efficiency of water prices in France. Our empirical results show that PPPs *per se* do not have a direct significant impact on observed water prices. However, water prices are indirectly influenced by PPP through variables such as the amount of time left until a contract expires, and the identity of the private partners.

Chapter 2 then turns towards studying the effects of yardstick competition as opposed to more individualistic incentive regulation through a review of the theoretical literature on regulation. Our objective in this chapter is to evaluate the relative performance of such a regulatory policy that allows a regulator to virtually introduce competitive pressures, as compared to more individualistic and traditional forms of regulation. This chapter is a first step towards understanding what are the benefits of using yardstick competition, as well as limits inherent with such an instrument. Arguably, this is a first step towards understanding whether yardstick competition may be adapted to be applied where local public services are concerned. Our goal here is to identify possible benefits of yardstick competition, due to the competitive pressure that it generates. In this sense, this chapter is complementary to the previous one.

The second part of our dissertation intends to study the question of collusion in more depth. As seen from the discussion above, collusion seems to be a pervasive problem when auctions are used to attribute contracts for local public services. This part will also be divided into the two following chapters.

Chapter 3 explores the relationship between collusion and auctions. In particular, we are interested in studying whether contractual length in a contract can be used by a local public authority to discourage collusion when this latter is a concern. To the best of our knowledge, while there are studies on how auction

mechanisms could be modified to discourage collusion during an auction[5], we are aware of few studies that study how contractual variables may be used in this respect. Using a repeated game formulation and a symmetric independent private value (IPV) model, we show that firms may find it harder to collude when contractual length increases. This shows that contractual length may be used to deter collusive initiative. We then check whether this instrument is used in the French water sector, by empirically exploring the determinants of contractual length. We find no supporting evidence that this is the case.

Finally, chapter 4 considers firms' incentives to collude under yardstick competition. As mentioned above, yardstick competition may be a substitute for franchise bidding mechanisms if collusion is a concern in the latter case. Yardstick competition may also create competitive pressures among regulated firms. However, firms may also have incentives to collude when such a scheme is used. To shed light on this issue, we use a repeated game framework again to study firms' incentives to collude under yardstick competition. We find that firms' incentives to collude will depend on the form of yardstick competition being used. In particular, when a relatively more efficient firm (as identified by the yardstick mechanism) is rewarded for its superior efficiency, collusion under yardstick competition is harder to sustain. We will also consider firms' incentives to collude when both yardstick competition and franchise bidding are used together. Interestingly, we show that collusion may be facilitated by the supplementary franchise bidding mechanism. However, when contractual length is high, collusion will be harder to sustain when firms are patient and when both schemes are used together.

A general conclusion resumes our work and discusses some limits and possible extension for future research.

[5]Thomas [2005] for instance studies the role of reserve prices, while Fabra [2003] considers collusion under a uniform auction mechanism and a discriminatory auction.

Part I

COMPETITIVE FORCES AND THEIR LIMITS IN THE PROVISION OF LOCAL PUBLIC SERVICES

Chapter 1

Auctions, ex post competition and Public Private Partnerships: The case of the French water sector*

1.1 Introduction

Local public services, such as water distribution, public transportation or garbage collection, often exhibit general public interest attributes, and sometimes, natural monopoly characteristic, that prevent their provision to be entirely left to private operators through a full privatization. Nevertheless, ever since the privatization program initiated by the Thatcher administration in the United Kingdom during the 1980s, there has been an increasing interest to bring in private expertise into the production and provision of these goods and services. A well–known economic rationale behind such an initiative for the public sector is to enhance

*This chapter is based on two joint works with Fréddy Huet, Stéphane Saussier and Faye Steiner: Chong, Huet, and Saussier [2006a] and Chong, Huet, Saussier, and Steiner [2006b]. The author gratefully acknowledges help from his coauthors. Both papers have greatly benefited from comments and suggestion by Christian Bontemps, Eduardo Engel, Antonio Estache, Elisabetta Iossa, Paul Joskow, John Kwoka, Ricco Maggi, Yannick Perez, Chris Rueback, Emmanuel Raynaud, Antoine Terracol, Vincent Thouvenin, Anne Yvrande-Billon, two anonymous referees and participants at the ATOM and ADIS Research seminars, French Conseil d'Etat Conference, the 2004 Western Economic Association Conference in Vancouver, the 2005 ISNIE conference held in Barcelona and the IDEI–Institut Veolia Environnement Conference on Public Services and Management: Designs, Issues and Implications for Local Governance in Toulouse. We gratefully acknowledge their help. The author is solely responsible for errors or omissions.

productive efficiency of these goods and/or services. Where local public services are concerned, private participation in the provision of such services can globally be apprehended through the form of Public-Private Partnerships (PPPs). A PPP is a contract established between a public entity and a private firm for the provision of a public good or a service to end users. A PPP contract generally confers on the private firm or partner a temporary monopoly right to serve the market in question throughout the contract's lifetime. PPPs include in fact a wide range of contractual arrangements that differ in terms of allocation of decision prerogatives, investment obligations, risks, and revenues across the public and private partner (Grout and Stevens [2003]).

While ownership structure matters when it comes to performance[1], an incontestable advantage to allowing private participation in the provision public goods and/or services is the possibility for the public authority to benefit from competitive pressures when choosing his private partner. As Vickers and Yarrow [1991] pointed out, "[c]*ompetition, which is conceptually distinct from ownership, can greatly improve monitoring possibilities, and hence incentives for productive efficiency...*", and that, "*...it may be difficult to introduce rivalry without some private ownership ...*".

A major source of competition may stem from auctions or competitive tendering procedures: a public authority outsourcing the provision of a certain good or service may use such mechanisms to choose his private partner.[2] In this case, competition during an auction *for* the market may substitute for the absence of competition in the market. The outcome of an auction can then be enforced through a contract that the public authority establishes with the winner. The

[1] Vickers and Yarrow [1991] offer a general discussion on the effects of ownership on performance. The authors point out that private ownership results in better performance mainly because, *inter alia*, management are provided with better incentives to this end under private ownership. Boycko, Shleifer, and Vishny [1996] develop the argument that private management is shielded from vagaries of political interference, and therefore may lead to management practices that are more market-oriented, and thus enhances efficiency. On the empirical side, Megginson and Netter [2001] provide an extensive survey on empirical studies on the effects of ownership on performance. They found that private ownership does generally lead to better performance.

[2] Competition through negotiation is another possibility, as pointed out by Bajari, McMillan, and Tadelis [2003].

winner is then left to provide the service in question, and is compensated according to the contractual terms based on its (winning) bid. This allows the public authority to reap the benefits of competition and avoid the inefficiencies of public production and provision. This idea has been developed as early as 1859 by Chadwick [1859], and has been popularized in later years by Demsetz [1968].

However, as pointed out by Goldberg [1976], Goldberg [1977] and Williamson [1976], among others, franchise bidding would provide an efficient framework if the only important aspect of the contracting process were to determine prices. When other contractual dimension matters, franchise bidding may in fact lead to an inefficient outcome. This is could be the case in network industries, where provision of the services requires complex mixes of service quality, investments in (specific) assets, *ex post* adjustments to adapt to realized condition etc. (Glachant [2002]). In such cases, public management may yield greater efficiency, due to lower transaction costs associated with this form of governance when other factors need to be accounted for.

Being a hybrid arrangement, PPPs might in fact dominate both fully public and private provision by inducing cost minimization behaviour by the chosen private operator while reducing potential market failures (e.g. supra-competitive prices) that could occur under complete privatization through an auction mechanism. While PPP may harness the benefits of both the fully public and private solutions, they may still be sub-optimal due to the long–term dimension that these contracts often imply. Such a characteristic may therefore subject PPPs to important contractual hazards, making PPP a costly solution. This aspect of PPPs is illustrated in the now old debate on "franchise bidding" as a solution to the local monopoly problems mentioned above (Demsetz [1968], Goldberg [1976], Williamson [1976], Goldberg [1977] etc.). Individual heterogeneity may thus be expected to drive the optimality of alternative governance structure, contractual arrangements and institutional environments in providing public services.

There could be two other sources of competitive pressures, which we will term for convenience as *intermodal competition* and *ex post competition*. The first

refers to the competition that may exist between public in–house provision and the contracting out solution for local public services. This captures the idea of competition between organizational choices: private operators would be subjected to higher competitive pressures the easier local public authorities can operate a service in–house. *Ex post* competition is another potential source of competition that private operators may face. By *ex post* competition, we mean the pool of potential firms available that are interested in taking over an incumbent's operations once the incumbent's contract with a local public authority has expired. We argue that *ex post* competition may play a role in restricting costs due to contractual hazards present in long–term PPP contracts if the incumbent wishes to enhance the probability that its contract be renewed. It seems natural that such an effect is determined by the time left until an incumbent's contract expires. This lead us to formulate the hypothesis that the shorter the length of time left until a contract expires, and the higher the level of *ex post* competition and intermodal competition, the better PPPs will perform. Understandably, lower contractual costs allowed by such possible competitive pressures could lead to a greater efficiency of PPPs.

While the literature has greatly advanced on the theoretical state of the art in identifying the parameters that drive the (in)efficiency of PPPs (Hart, Shleifer, and Vishny [1997], Williamson [1999], Guasch, Laffont, and Straub [2003], Hart [2003]), we are aware of no empirical studies that quantify the efficiency PPPs for local public service provision and take into account the possible types of competitive pressures mentioned above. The objective of this chapter is therefore to *empirically explore the link between auctions, organizational choice and performance*. More precisely, we intend to account for intermodal competition and *ex post* competition effects, and examine empirically the role that they may play in determining the efficiency of how local public services are being organized.

We believe that the French water sector provides a fertile ground to explore the issues raised above for several reasons: first of all, water production and distribution involves extensive sunk investments at a local level that usually rep-

resent a substantial part of the cost in the sector.[3] On top of this, technological progress does not seem to leave ground to believe in any near future dissipation of economies of scale in this sector, contrary to what happened for some other network industries such as telecommunications industry. As such, the water industry is widely perceived as a local natural monopoly *par excellence*. Secondly, the French case is particularly interesting because the decision on how water services are to be organized is made entirely by local public authorities. As a consequence, a large variety of organizational structure for water services can be observed in France, ranging from in–house provision or direct public management to concession contracts. This makes the French water sector particularly relevant for our empirical study on the efficiency of PPPs. We also intend to exploit an institutional change in the French legislation to crudely approximate and isolate the effect of auctions on performance from the impact of organizational choices. The institutional change in question is a reform introduced in 1993 known as the Sapin Law, which makes competitive tendering compulsory for any municipalities that seek to outsource their water services. Therefore, PPP contracts signed after this reform would been systematically subjected to some competitive pressures stemming from a competitive tendering procedure. The final reason why the French water industry is interesting in order to address the issues that we intend to study is due to the fact that organization of local public services is subjected to what is known as the "*intuitu personae*" principle. This principle enables local public authorities to choose his private partner for the provision of water services according to some intrinsic unobservable characteristics over efficiency (price or cost) considerations. In other words, even when an auction is used, a local public authority is not obliged to choose the candidate with the best offer. It follows that non parity during auctions may be credible, and it suggests a greater role for *ex post* competition and intermodal competition. As such, we believe that the French water sector provides an adequate framework for us to empirically explore the effects of such implicit dimensions.

[3]For instance, Armstrong, Cowan, and Vickers [1994] estimated that sunk costs made up of about 80% of total costs in the water industry in England and Wales. A recent report (Stone & Webster Consultants Ltd. [2004]) for the British water sector regulator, OFWAT, provides econometric evidence on the existence of economies of scale in the UK water sector. Shih, Harrington, Pizer, and Gillingham [2006] also found evidence of economies of scale in the US water industry.

We study the case of water supply in France using an original database of about 5000 observations on organizational choices, water retail prices and water network characteristics that stems from a survey conducted by the French Institute of Environment (IFEN, for *Institut Français de l'Environnement*) and the Service of Survey and Statistical Studies (SCEES, for *Service Central des Enquêtes et des Études Statistiques*) in 2001, completed with data from the French Health Ministry (DGS) in 2001. The database allows us to explore the link between performance, organizational choices and the role of auctions. To further examine the possible effects of *ex post* competition, we merge this database with another one coming from various French regional Water Agencies, which contain data on the identity of operators who have been chosen in 2001 to operate water services. The effects of *ex post* competition are studied through a Herfindahl index that indicates the degree of concentration of the water industry at the local area. We will use a variety of econometric techniques, including a switching regression model, to assess the impact of various variable discussed above on performance in the French water sector. We find that consumers *indirectly* pay more when local public authorities uses PPPs for water services, after controlling for other factors that might have an impact on water prices: PPPs *per se* do not have a direct effect on prices that consumers pay. However, variables related to PPPs such as operators fixed effects and time left until a PPP contract expires do have a significant effect on water prices. We also find supporting evidence that water prices decreases with the level of intermodal competition. Finally, our estimates also show that water prices decreases as the contract draws nearer to its end. We believe that this reflects the value of future transactions for the incumbent private operator.

In a study similar to ours, Carpentier, Nauges, Reynaud, and Thomas [2005] also use data observed in 1998 from IFEN–SCEES–DGS to study the effects of PPP on water prices. They found that water prices are slightly but not significantly higher when water services are run through a PPP.[4] Similarly, they also provide evidence that governance choices are not randomly chosen by local public authorities. However, in their study, they do not account for competitive pressures due to auctions, nor *ex post* competition as in our case. In contrast with their

[4]They argue that this effect is not statistically significant at a threshold of 5%. However, we note that this effect could be significant at a threshold of 10%.

study, we also attempt to account for some simple political variables when we study a local public authority's choice to use PPP or direct public management. We are able to do so, however, at the price of a smaller sample.

The present chapter is organized as follows: we start by providing an overview on the French water sector in the following section (section 1.2). The third section (section 1.3) then looks into recent theoretical developments and presents some testable propositions. In particular, we will briefly remind the readers of the old debate on "franchise bidding" and discuss how intermodal competition and *ex post* competition may be expected to influence performance of local public services. The fourth section (section 1.4) then presents our data in further details and discusses our empirical strategy. Estimation results and discussion follows next (section 1.5). Concluding remarks close this chapter.

1.2 The French water sector: An overview

In France, as in most European countries, local public authorities[5] are in charge of the organization of local public services. More precisely, they are responsible for the existence and the operation of these services. The reason for this is that these activities have general public interest attributes. By law, provision of these services cannot be left entirely to the private sector in the sense that any private firm(s) may only be granted monopoly rights over these services for a limited period of time at best. To fulfill their responsibilities, local public authorities must define the general principles governing the service. There is generally no national regulator for these services.[6] In the following, we look at further length how local public authorities are able to do this (subsection 1.2.1) and what their legal constraints are (subsection 1.2.2). A brief discussion on the industrial structure of the market for water contracts follows (subsection 1.2.3).

[5]The authorities are essentially municipalities or associations formed by several municipalities.

[6]An exception to this is the UK case, where water services are economically regulated by the Office of Water Services (OFWAT).

1.2.1 A wide range of contractual arrangements

There is a wide range of instruments available to local public authorities to help them organize the provision of a given local public service. Some of these arrangements allow local public authorities to benefit from expertise of the private sector in providing such services. In France for instance, local public authorities may decide to transfer some of their decision rights and revenue rights to an external operator (Desrieux [2006]). In other words, a local public authority can choose either to manage directly himself (direct public management or in–house provision), or to initiate a PPP that leaves a private operator in charge of managing the service. In the latter case, there is a variety of contractual instruments at a local public authority's disposal to serve as a basis for forming such partnerships.

Briefly, these contracts differ with respect to two major dimensions: first of all, the degree of a firm's involvement in the service (who makes the investments); and secondly, the risks that the private operator bears (how is the operator paid). In this sense, a "*gérance*" contract is the closest to direct public management: the operator is only responsible for the management of the service and is paid a fixed amount by the public authority. The operator is free of all investment obligations. The "*intermediary management*" contract has similar contractual arrangements, with an exception concerning the private operator's compensation for managing the service: instead of a fixed compensation, part of the operator's revenues will depend on his performance.

A public authority can also choose to use a "*lease*" contract or a "*concession*" contract. These contractual forms leave more responsibility to the private operator in terms of investments. Under a lease contract, the private operator is in charge of some investments, even if the most important investments remain public. In contrast, a concession contract leaves a substantial part of investments to the private operator. Under a lease or concession contract, the operator is paid through receipts from end users rather than by the public authority himself, which increases the proportion of risk they bear as compared to "*gérance*" and intermediary management. In particular, water prices in France is adjusted over

time by weighting the initial price in the contract with a coefficient that accounts for variations in the costs of production factors over time.[7] It should be noted that cost differences are measured at the national level, and therefore do not account for local conditions. In terms of risks, concessions are even riskier than lease contracts because of the higher proportion of investments the operator must realize. Investments made by the private operator under both types of contracts automatically revert back to the public authority once the contract terminates. Generally, operators do not receive any supplementary financial compensation when this happens.

The various differences between the contract types that a local public authority may use to organize the provision of a local public service are summarized in figure 1.1. Huet and Saussier [2003] provide a more in depth description of these organizational modes.

1.2.2 A specific institutional framework

As we have already noted, local public authorities in France enjoy a great degree of flexibility in organizing the provision of local public services. It should also be noted that the institutional framework in which this freedom of choice is embedded amplifies the discretionary power of local public authorities. Indeed, the *"intuitu personae"* principle[8] governs how local public authorities organize a

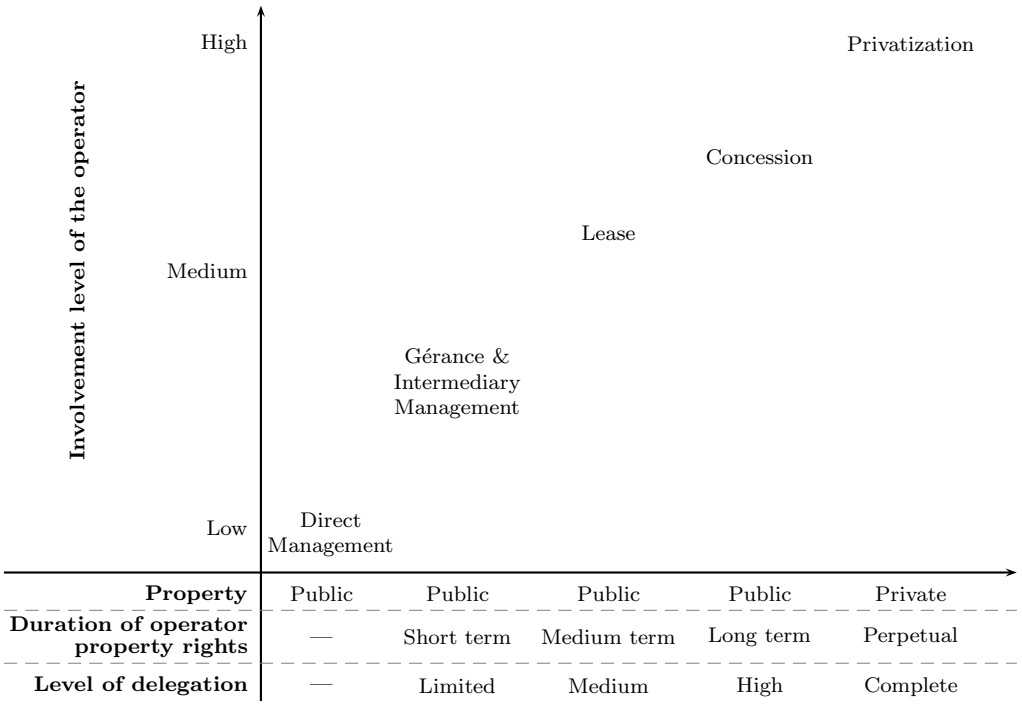
[7] More precisely, water prices P evolves according to the following formula:

$$P = kP_0$$

where P_0 is the initial price in the contract and k is an affine function of indices that capture the variations in costs of production factors such as energy and labour.

[8] A contract concluded *"intuitu personae"* is a contract involving a customized relationship between the buyer and the seller. Employment contracts and mandates are examples of *"intuitu personae"* contracts. For instance, an employer is not obliged to engage the candidate with the highest qualifications who is willing to accept a job at the lowest wage, but may also consider intrinsic characteristics of the candidates themselves (dynamism, kindness, ability to communicate with colleagues and/or customers, ...) before deciding whether or not to employ a candidate. These features cannot be incorporated into a contract and are not verifiable by a court. The

Figure 1.1: Contractual options for local public services in France



Source: Huet and Saussier [2003].

service. Furthermore, the fact that such contracts are considered to be "administrative contracts" also gives great power to the public contracting party as we explain below.

1.2.2.1 Negotiations and competition for the field: the intuitu personae principle

If the public authority chooses a lease or a concession contract, the selection mechanism of his partner consists in a two–step procedure:

(i) In the first step, the public authority chooses a number of potential candidates using a classical competitive tendering process.

(ii) In the second step, there is a phase of negotiation between the public authority and the potential providers. At the end of the negotiation, the public authority chooses its final partner for the duration of the contract.

same reasoning applies to a local public authority choosing a firm within the framework of an intermediary management, a lease or a concession contract.

What matters here is that the municipality is not obliged to select its partner by complying with any objective criteria defined by law, as would be the case in a strict competitive tendering process. The use of such a two–step procedure gives the public authority latitude to select its partner freely, using not only objective but also subjective criteria that are not necessarily specified by law. Furthermore, the local public authority does not need to justify his decision to organize the service through a PPP or through direct public management.[9]

1.2.2.2 PPP and the rules on administrative contracts

In France, contracts signed between local authorities and private operators are considered as "administrative contracts". Such contracts are characterized by an asymmetric position between the public and the private contracting parties in that the local authority may unilaterally change the terms of the contract after it is signed. Of course, such changes must be justified (through reasons of general public interests) and the private operator may claim for a fair compensation.[10] Nevertheless, in case of conflict, the private operator must first conform to the wish of the local authority before bringing the conflict to court. In practice, local authorities do not use this power often. Nevertheless, it provides a credible threat that helps to prevent the private operator from acting opportunistically, because it generates fear of the contract being terminated prematurely or changed unilaterally.

[9]Flexibility is not necessarily less efficient. It may help to overcome many of the problems identified concerning the choice of the operator in a more rigid franchise bidding process (Bajari, McMillan, and Tadelis [2003], Athias and Saussier [2005]).

[10]The legal right of a local public authority to unilaterally change the terms of a contract are confer by the French jurisprudence. This right is affirmed in a series of judgement by the French "Council of the State" (*Conseil d'État*): *l'arrêt CE 10 janvier 1902 Gaz de Deville–les–Rouen, l'arrêt CE 21 mars 1910 Compagnie générale des tramways,* and *l'arrêt CE 2 février 1983 Unions des transports publics*. In the second case, it was decided that the local public authority in question had the right to oblige the private operator to increase the number of streetcar services (with respect to the number agreed upon in the initial contract) that it ran. This judgement was motivated by the fact that such an increase is necessary to ensure that the streetcar service would "function normally" (in the original text of *l'arrêt CE 21 mars 1910 Compagnie générale des tramways*, page 216, "*..., pour assurer, dans l'intérêt du public, la marche normale du service ...*").

1.2.2.3 Evolution towards anti-corruption laws

As of 1993, under the Anti-Corruption Law (Loi Sapin), local authorities have been required to advertise their willingness to contract out the provision of local public services and to organize an auction for interested candidates. Nevertheless, as we argued earlier, the *"intuitu personae"* rule implies that local authorities are not obliged to choose the best offer. Thus prices might be lower for contracts signed after 1993, compared to those signed before, to the extent that anti-corruption laws should lead to increased *ex ante* competition (*i.e.* reduced discretion for local authorities in so much as they are politically constrained by the publication of the auction's results).

The benefits of using an auction, however, also depend on the number of potential operators that are capable of running the service. It is well–known that the higher the number of bidders, the more efficient an auction mechanism can be (Demsetz [1968], McAfee and MacMillan [1987]). Therefore, we will offer a brief overview of the industrial structure of the French water sector in the following.

1.2.3 The industrial structure of the French water sector

The water industry in France is a highly concentrated one, and the industry is dominated by three major players who form an oligopoly. Together, they provide water services to about 75% of the French population.[11] In 2000, according to the French Competition Authority (*Conseil de la Concurrence*), as much as 98% of the contracts outsourced in the water sector goes to one of these three operators. More specifically, the French Competition Authority also observed in 2001 that these three operators, and their joint–ventures, detain 56%, 29% and 13% of market shares in the sector, the remaining 2% are detained by independent and small local water companies.[12] This leads to a Herfindahl index of 4250, indicating that the French water sector has a particularly concentrated structure. Furthermore,

[11] The remaining population are served through direct public management.

[12] See *Bulletin officiel de la Concurrence, de la Consommation et de la Répression des fraudes*, http://www.minefi.gouv.fr/dgccrf/boccrf/01_01/a0010006.htm.

the High Council for Public Service (*Haut Conseil du Service Public*) observed in a report in 1999 (Haut Conseil du Service Public [1999]) that only about 5% of the contracts changed hands after expiry. This indicates a certain stability on the market shares of these operators over time. As a result, *ex ante* and *ex post* competition may potentially be weak at the national level.

However, given the local characteristics of water services, one could expect that the relevant measure of competition may be at a local level. Indeed, local conditions play an important role in how water services are run: raw water used in the production are found at a local area, exploitation of water services depend on local conditions, raw water supply are influenced by local climate conditions etc.. Furthermore, in the water industry, there are also some small firms not affiliated with any of the three major players. These small firms are usually active at a local level, operating in certain regions and relatively absent at the nationals. A look at figure 1.2 illustrate our point: figure 1.2 shows that competition is much more vibrant at the local level: in some *Départements*[13], the market is dominated by a single firm, while in others, many firms, including small ones not affiliated with the three major players, are active. One may also see that certain *Départements* extensively use direct public management to provide water services, while other *Départements* rely more on private operators to provide water services. It would seem that the high level of concentration at the national level does not automatically lead to a high concentration at the local level. Competition could therefore potentially be stronger at a local level. We are also able to compute the market shares of firms in the water industry using our data. This is shown in table 1.1. Again, we see that market shares for small firms are much higher at a local level.

In a nutshell, water sector in France is highly concentrated, but due to the important role that local conditions play when water services are run, competition may not be potentially weak at a local level.

[13]A *Département* is a French geographical administrative division. The 26 French regions are subdivided into 100 *Départements*, which are subdivided in turn into municipalities.

Figure 1.2: Geographical repartition of firms in 25 French *Départements*

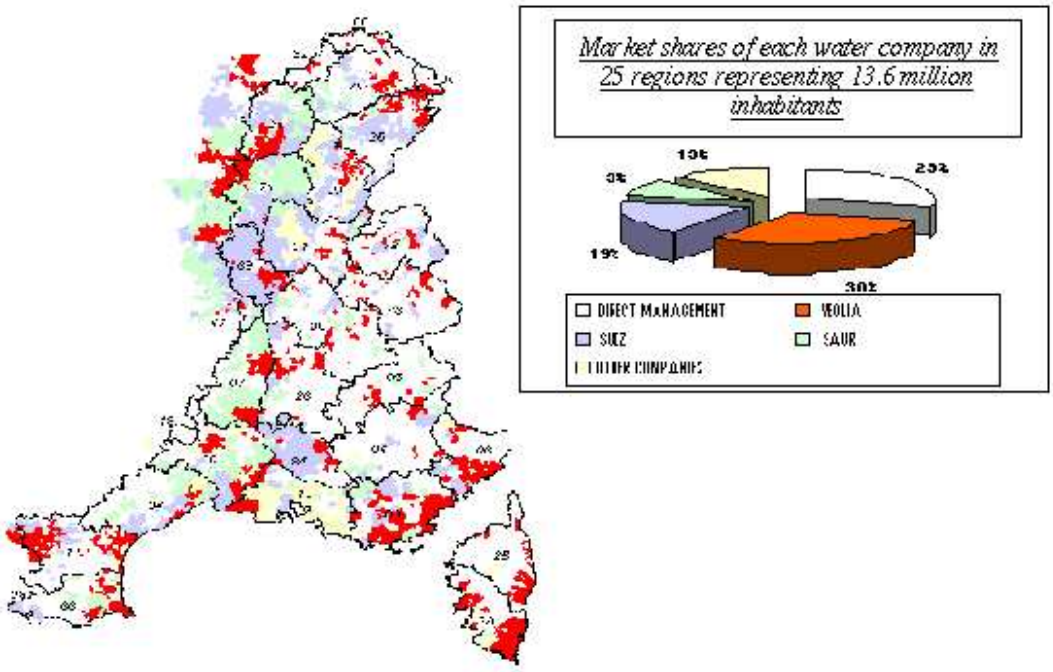


Table 1.1: Market shares of water operators in *Rhône—Meditérranée–Corse* and *Adour–Garonne*

Operators	Market Share (Local Level)	Market Share (National level)
Operator 1	33.00%	29%
Operator 2	41.50%	56%
Operator 3	15.30%	13%
"Independent" firms	10.20%	2%
Total	100%	100%

Note: Market shares are computed at the local level using share of population served by an operator with respect of total population served through a PPP in 2001. The market shares are computed for regions corresponding to water bassin Rhône–Méditérranée–Corse *and* Adour–Garonne *using our data set from IFEN–SCEES–DGS and the regional Water Agencies. Market shares at the national level are taken from the French Competition Authority as mentioned in the text.*

The French system, due to its great variety of contractual and governance arrangements, provides an exciting laboratory in which to analyze the links between organizational choices made by local public authorities providing public services and performance. The following section develops on the possible economic rationale behind contractual choices and performances.

1.3 Some theoretical perspectives on the role of competition and the efficiency of PPPs

In order to empirically explore the link between the efficiency of PPPs and the effect of competition on the performance of water services, we will first briefly summarize the debate on "franchise bidding" as a solution to the natural monopoly problem before studying what role intermodal competition and *ex post* competition could play in influencing performance. The first part of our discussion aims at identifying potential limits to PPPs that are attributed through a competitive tendering process (which we will refer to as *ex ante* competition), while the second part aims at examining how these limits can be altered by more informal types of competition, such as intermodal competition and *ex post* competition. We intend to derive testable propositions applicable to the water sector by going through these arguments. Although political considerations may partially explain in part the performances of various organizational choices made for the provision of local public services (Boycko, Shleifer, and Vishny [1996], Spiller and Tommasi [2003], Levin and Tadelis [2005]), we limit our analysis to economic considerations. More precisely, we are limited in our capability to account for the impact of political cycles or other factors (due to institutional settings and otherwise) that could drive local public authorities to behave opportunistically: our data do not enable us to account for such factors, interesting and essential as they are.[14] Therefore, in what follows, we will assume that local public authorities are benevolent.

[14]We do, however, control for the political fraction of local public authorities in our empirical work.

1.3.1 Ex ante competition and the efficiency of PPPs in the French water sector

PPPs are generally long–term contracts that confer a temporary monopoly right on a market to a private firm, due to production technologies that often characterize the concerned activities. This is the case in the water sector. A legitimate concern that arises in this case is a possible exercise of monopoly power by the chosen private operator. As the literature on economic regulation has shown, regulatory intervention as a response to this problem may well lead to "regulation failures".[15] One could then easily understand why Demsetz [1968]'s idea of "franchise bidding" became so popular among economists and policy-makers alike: *ex ante* competition during an auction would well then curb potential monopoly power by the chosen private operator, provided that outcome of the competitive auction can be implemented and enforced *via* a contractual arrangement throughout the duration of monopoly right that is conferred. In other words, competition *for* the market would lead to an efficient allocation of resources even if competition within a market were absent.

However, as prominent critics have already pointed out, such a solution hinges on the fact that the initial contractual arrangement is completely specified and entirely enforceable. More specifically, Williamson [1976] has highlighted the following fundamental problems with Demsetz [1968]'s monopoly franchise bidding solution: organizing competition for the market is not easy, the world is not static, transaction costs may make contracts incomplete, and switching costs make public authorities who enter such contracts vulnerable to *ex post* contractual opportunism. We will briefly go through each of these points in the following.

A first difficulty as pointed out by critics of Demsetz [1968]'s approach concerns the organization of an auction to select the most efficient partner for the provision of a service. Such a task can be challenging because the selection process

[15] A now classical example of regulation failure is Averch-Johnson effect related to Rate of Return regulation which was historically widely used to regulate industry when market failures occur (Averch and Johnson [1962]). The authors showed that such a regulatory scheme leads to overcapitalization of the regulated industry. This study has also prompted a series of later research into regulation failures.

itself may be complex, requiring the specification of a vector of prices for different types of consumers, consuming at different times, and for different levels of quality. Moreover, if operators are selected according to price bids, public authorities may be vulnerable to "winner's curse", since the best offer may come from the most "optimistic" operator who unintentionally underestimates production costs or overestimates future revenues (Bulow and Klemperer [2002], Hong and Shum [2002]). Alternatively, public authorities may also be victims of aggressive bids when prospective operators strategically underestimate costs or overestimate future revenues in order to win the deal and provoke later renegotiations with a "captive" local public authority in the future. In particularly, Bajari, Houghton, and Tadelis [2006] show empirically that bidders incorporate in their bids anticipated costs that may arise due to the incompleteness of the contract signed.

Once the contract is attributed, PPPs, being long–term contracts, are known to be prone to *ex post* adaptation problems due to unforeseeable events that may arise. This gives rise to *ex post* renegotiations between the contracting parties, and paves the way for opportunistic behaviour[16] by the contracting parties. Obviously, *ex post* (re)negotiation may arise only if a PPP contract that is signed in incomplete to some extent, or when agents are not able to completely enforce the initial contractual provisions. However, PPPs, being long–term contracts, are unavoidably incomplete due to agents' bounded rationality (Williamson [1985], Williamson [2002]), and/or high costs in identifying and specifying all future contingencies (Segal [1999], Bajari and Tadelis [2001]). Deciding *ex ante* what has to be done *ex post* is a way to stabilize the contract by avoiding (as much as possible) renegotiations during which opportunistic behaviour may appeared. In this case, however, stability is obtained at the cost of making the contract maladapted to unanticipated circumstances (Crocker and Masten [1991], Crocker and Reynolds [1993], Saussier [2000], Athias and Saussier [2005]).

[16] Williamson [1985] defines opportunism as "*self-interest seeking with guile*" that "*often involving subtle forms of deceit*", especially under the form of "*calculated efforts to mislead, distort, disguise, obfuscate, or otherwise confuse ...*" (Williamson [1985], page 47). Opportunism is the direct consequence of contractual incompleteness. It can be viewed as actions undertaken by a contracting party to strategically use the contract's imperfections in order to obtain a higher proportion of the value generated by the contract at the expense of its contracting partner.

Ex post renegotiations to adapt to circumstances not specified in a contract is a recurrent economic phenomenon where public services are concerned. Ample empirical evidence was provided by Guasch [2004] concerning infrastructure concession contracts in Latin American countries. A particularly spectacular finding from this study is that water concession contracts are renegotiated for the first time on average 1.6 years after the concession was granted. This is particularly impressive, given that water contracts are typically long–term (in our sample for instance, average contractual length is about 13 years). The author also shows that there are about 30% of Latin American infrastructure concession contracts in his sample which were subjected to *ex post* renegotiations in general. In contrast, about 74% of contracts in the water sector which was renegotiated. Outcome of such processes tend to favor the private operator.[17]

Lastly, at the contract renewal stage, the winner of the original competition retains an advantage because of the "fundamental transformation"[18] that gives rise to specific human assets for the winner *versus* other potential bidders. Furthermore, there is a greater likelihood that the incumbent is better informed with regards to the cost of service provision and the amount of investments needed in the future to operate the service. In such a context, the incumbent, who operated the service in a monopoly situation for an extended period of time, clearly has an informational advantage.

While subsequent literature has not found any empirical evidence to sustain these shortcomings concerning the use of auctions in outsourcing public services (Zupan [1989b], Zupan [1989a]), these criticisms advanced by Transaction Cost Economics still prevail largely in the economic literature (Littlechild [2002]). Littlechild [2002] suggested that institutional and contractual solutions may exist and could reduce problems stemming from transaction costs. In the French water

[17]For instance, the author observes from his sample that renegotiations lead to an increase in tariffs for the private operator in 62% of cases, delays and decrease in terms of investment obligations in 69% of cases, and decrease in annual fee paid by an operator to the government in 31% of cases.

[18]Williamson [1985], Willamson [1988] noted that when specific assets are involved, bidding parity will not hold during the contract renewal stage because the incumbent inevitably holds an advantage over other potential candidates: the *ex ante* competitive market is therefore "transformed" *ex post* into a bilateral monopoly.

sector, the rules of administrative contracts as well as *intuitu personae* principle may well be such solutions.

In France, since PPPs are considered as administrative contracts, local public authorities are empowered by the French legislation with the possibility to unilaterally modify contractual terms after signing a contract, provided that they justify the changes (*e.g.* for safety reasons). Private operators may claim fair compensation, but in the event of a conflict, it must first comply with the changes before bringing suit. Arguably, even if local public authorities do not often exercise this power, this could prevent a private operator from acting opportunistically by providing a credible threat of modification. Moreover, *ex post* opportunism is also constrained by the rule that obliges a public authority to re-initiate a bidding procedure to select a new operator when renegotiation that leads to change of value by more than 5% of the initial value of the contract. Furthermore, where the water sector is concerned, European water distribution norms specify more than 60 verifiable quality parameters that are monitored by public agencies. All these legal aspects may help to restrain *ex post* opportunism.

The *intuitu personae* principle at work may also help to mitigate *ex post* contracting problems. According to this principle, local public authorities are not legally constrained in setting the criteria according to which they short–list and ultimately choose an operator. They do not even need to publicize their subjective criteria. This may create an informational asymmetry between the public authorities and prospective operators and gives local public authorities greater latitude to choose a partner. While such a principle could lead to a reduction of competition for the field and facilitate collusion among operators and/or between (some) operators and the public authorities, it could also give incentives to prospective operators who lack information on the subjective selection criteria to submit bids which could correspond better to their "true" values. Negotiations allow by this principle may also contribute to reduce *ex post* transaction costs in the case of complicated contracts where renegotiations will be required, as shown by Bajari and Tadelis [2001]. In what follows, we argue that the *intuitu personae* principle also provides a channel for *ex post* competition as a device to restrain possible *ex*

post operator opportunism.

To conclude briefly on this subsection, auctions may have a positive impact on the efficiency of PPPs. However, from a Transaction Cost Economics perspective, PPP contracts are inevitably prone to some potential *ex post* problems that are unlikely to be solved entirely by auctions. It should nevertheless be noted that these problems are not necessarily important enough to disqualify PPP for public services. Institutional and contractual solutions may reduce the severity of these problems identified by Transaction Cost Economics. In this respect, the theoretical debate remains unresolved on whether or under what circumstances PPPs will lead to more or less efficient water distribution. We will examine this question empirically by looking at how consumer prices differ across fully public versus PPP water distribution municipalities in France. Before that, we try to identify whether *ex post* competition and intermodal competition may also act as a complementary device to mitigate transaction costs in PPPs in what follows.

1.3.2 Ex post competition and the efficiency of PPPs in the French water sector

As we have already mentioned, PPP contracts confer on a selected operator temporary monopoly rights for the operation of a public service. During this period, no effective competition is available, and PPP contracts, being long–term contracts, are prone to *ex post* opportunistic behaviour. However, when a PPP contract expires, a local public authority will have to re-organize the provision of the same public service. At this moment, the local public authority may choose to switch from the incumbent operator to a new one, or to revert back to public provision. The level of *ex post* competition and intermodal competition provides potential competitive forces when a PPP contract is in force, in the sense that when both types of competition are high during the execution stage of a PPP contract, a local public authority's threat to switch either to a different operator or to another organizational mode is more credible. Such credibility to switch may exercise a disciplinary effect on potential *ex post* incumbent opportunism. To show this, we use an argument based on dynamic interactions between a local public authority

and an incumbent operator.

The importance of a PPP contract for a private operator may help reduce the incentive for the private operator to behave opportunistically during the execution stage. Indeed, as pointed out by Baker, Gibbons, and Murphy [2006], Baker, Gibbons, and Murphy [2004] and Poppo and Zenger [2002], a repeated relationship may serve as a governance structure and helps constraining potential *ex post* opportunistic behaviour. Using an infinitely repeated game framework, the authors argue that when the value of an ongoing contractual relationship is important enough for the contracting parties, parties will refrain from behaving opportunistically as long as the discounted long–term benefits from an ongoing relationship outweigh the short term gains from opportunism. In other words, a private operator may be tempted by the perspective of repeated transactions with a public partner, and such a perspective may make it refrain from behaving opportunistically. From an economic point of view, relational contracting is sustained through repeated interactions between contracting parties.

Where public service provision is concerned, the effectiveness of such a relational governance structure obviously hinges on the following question: to what extent can a local public authority credibly commit to continue his contractual relation with the incumbent operator? As a necessary condition, a local public authority should be able to freely choose either a new private operator or the incumbent, and/or can freely revert back to public provision. It seems that the *intuitu personae* principle at work in the French water sector allows such a freedom of choice. Remember that under this principle, a local public authority does not need to justify his choice of private operators, even if the given operator has not submitted the best offer during an auction stage. Consequently, a local public authority is able to freely renew his contractual relationship with an incumbent operator if he wishes to do so when their contract expires. This provides the ground for a relational governance structure, in the sense that an incumbent's probability of renewing its contract does not rely entirely on the outcome of an auction used to re-attribute a PPP. In the French water sector, it has been observed that only 5% of the contracts changed hand at expiry (Haut Conseil du

Service Public [1999]). This could be seen as a sign that relational governance as we have discussed is at work.[19]

Nevertheless, it should be noted that freedom of choice under a legislative framework is not equivalent to freedom of choice when it comes to the real workings of organizing public service provision. We believe that it is here that *ex post* competition and intermodal competition may play a role. When *ex post* competition is high, or intermodal competition is high, a local public authority may more credibly choose to switch to a new operator and/or revert back to public provision when his contract with an incumbent operator expires. In the former case, there is a pool of private operators that are interested in substituting for an incumbent available; and in the latter case, expertise and experience from surrounding areas may make the cost of switching back to the public solution lower for a local public authority. In both cases, a local public authority obviously has a better outside option when a contract draws to its end, either duly or prematurely.[20] In turn, an incumbent who values sufficiently opportunities of future transactions with the same public partner may be expected to behave less opportunistically. In doing so, the incumbent may enhance its probability of having its contract renewed. In addition to this, incumbent operators may also wish to build up or maintain their reputation capital in areas where direct public management are dominant: by refraining from opportunism, incumbent operators may be able to "persuade" other neighbouring local authorities to outsource their water services to them. Such potential gains may reinforce an incumbent operator's motivation to refrain from opportunism.

Furthermore, one may expect such effects due to *ex post* competition and intermodal competition to intensify as the contract of the incumbent operator draws nearer to its end. Using a repeated game framework, whether a relational governance structure is effective in discouraging incumbent opportunism depends on

[19]This could only be one interpretation of the phenomenon. The existence of a market–sharing cartel could also be expected to lead to such an observation.

[20]Premature termination of contracts can be costly, and is rarely observed in our case. This is why we will rather focus on the case when PPP duly arrives to its term. However, we note that the higher *ex post* competition and intermodal competition, the more credible the threat by a local public authority to prematurely terminate a contract in case of incumbent misbehaviour.

the net present value of a renewed and repeated transaction and of opportunism for the incumbent. All else equal, one may easily see that for any discount factor in the open interval between 0 and 1,

(i) the present value of a renewed transaction with the local public authority is higher when the contract draws closer to its term; and

(ii) the present value of gains from behaving opportunistically is lower when the contracts draw closer to its term if these gains are distributed over the entire remaining lifespan of the contract.

Although whether such relational governance may succeed in constraining *ex post* opportunism by an incumbent will depend on the importance of both types of gains for the latter, it seems that when a contract draws closer to its term, gains from the perspective of a renewed transaction will be more likely to dominate gains from *ex post* opportunism. We could expect the same when gains from *ex post* opportunism are punctual or distributed over a short lapse of time when the contract is in effect due to the fact that the present value of a renewed transaction is increasing with the time left until a contract expires. Hence, the higher the level of *ex post* competition and/or intermodal competition and the nearer an incumbent is to the end of its contract, the more likely will the incumbent want to refrain from behaving opportunistically in order to enhance its probability of having its contract renewed. Consequently, the length of time left until a contract expires may be expected to play an important role in enforcing or dampening the effect of *ex post* competition and intermodal competition on an incumbent operator's incentive to behave opportunistically.[21] For convenience, we will term

[21]Another potential channel through which *ex post* competition, intermodal competition and the "termination effect" may impact on the efficiency of PPPs could be that the incumbent operator wishes to signal some hidden information concerning its ability to run the service in question to the local public authority in order to enhance its probability of having its contract renewed. One may therefore think that when *ex post* competition and/or intermodal competition is fierce, and when a contract draws nearer to its end, the incumbent operator has a higher incentive to adopt such a signalling strategy. However, we are not convinced that this is the main channel in our case since the local public authorities are obliged to organize an auction when the contract draws to its end. One may assume that information are screened during this process. Therefore, we do not see any benefits for a local public authority to disregard bidding parity in response to such signals. Moreover, such a strategy would erode (remaining) informational rents for the incumbent operator: it could be more advantageous for an incumbent operator to wait until the auction to signal any hidden information in its favor, when its competitors are better

this effect as "termination effect".

Note that this "termination effect" relies on the strong assumption that local public authorities cannot perfectly recall past actions of the incumbent operator, nor can they infer past opportunistic behaviour of the incumbent from current observed variables (when the incumbent has curbed its opportunistic behaviour to enhance its probability of having its contract renewed). Otherwise, only *ex post* competition and/or intermodal competition may play a role.

An important dimension of our argument above depends on the value for an incumbent of renewing its contract once it expires. We believe that where water services are concerned, the value of these contracts is important. According to the French Ministry of Environment, the total revenue generated by the 12,000 contracts in 2003 in the French water sector amounts to approximately 4.57 billions of euros.[22] This would yield a crude average of about 381,097€ per contract in 2003. Moreover, PPP contracts are generally long–term contracts, and therefore entitle an operator to stable flux of revenue throughout the contract's lifespan. These lead us to believe that an incumbent generally should have high enough stakes in getting their contracts renewed. *Ex post* competition, intermodal competition and the "termination effect" could therefore be expected to play a role in the French water sector. We resume our propositions on these competitive pressures in the following propositions:

Proposition 1. *Prices should be lower for contracts when* ex post *competition and/or intermodal competition are high. We globally term this as "potential competition" effect.*

Proposition 2. *The "potential competition" effect should increase with the proximity of the renewal of a contract. This is the "termination effect".*

These propositions highlight the fact that *ex post* competition and intermodal competition may constrain the behaviour of an incumbent operator especially in

known at the time of the auction. Nevertheless, it would be interesting to test or discriminate between both channels. Unfortunately, our data do not allow us to do this.

[22]See http://www2.environnement.gouv.fr/dossiers/eau/pages/politique/gouvernance/gestion-eau.htm.

the dynamic perspective of winning future contracts to be awarded.[23]

In the following section, we will put both Proposition 1 and Proposition 2 to test and explore the empirical link between the efficiency of PPP and auctions in the French Water sector.

1.4 Empirical methodology and data description

In the present section, we will first address our empirical strategy to study the link between the role of competition and the efficiency of PPPs in the French water sector. We will also briefly present the sample that we will use for our empirical analysis and discuss some of the more important variables used in our empirical work.

1.4.1 Data and Description

For our empirical study into the impact of organizational choice and the role of competition on the efficiency of PPPs, we use an original dataset obtained by merging three sets of data: the first set of data comes from a survey conducted in 2001 by the French Institute of Environment (IFEN, for *Institut Français de l'Environnement*) and the Service of Survey and Statistical Studies (SCEES, for *Service Central des Enquêtes et des Études Statistiques*) on the French water sector; the second set of data contains information from the French Ministry of Health (DGS, for *Direction Générale de la Santé*); and the third set of data stems from two regional French Water Agencies[24] (the Water Agency of *Adour–Garonne*

[23] One may say that contracts are awarded through competitive auctions and that past observed prices should not have an impact on the probability of being retained at the renewal stage. Nevertheless, such a remark omits the "fundamental transformation" highlighted by Transaction Cost Economics (Williamson [1985]) and the "*intuitu personae*" principle that makes future competitive auctions dependent on past observed behaviours. In the same spirit, Laffont and Tirole [1988] show that a principal may commit optimally to favor an incumbent operator during an auction in order to incite the incumbent operator to invest in specific assets.

[24] A Water Agency (*Agence de l'Eau*) is a State establishment that is in charge of coordinating the development and management of water resources in France. There are altogether 6 Water Agencies in France, corresponding to the 6 water bassins.

and *Rhône–Méditerranée–Corse*).

The first set of data is a representative sample of the total population of French municipalities (all sizes of local authorities are proportionally represented in the sample, with the exception of large local public authorities who are all included in the sample). This sample consists of 5000 observations and contains information on various aspects of water service in France, including technical variables such as network characteristics, water prices and organizational choices. From the original dataset, only 3650 observations are usable: 557 observations (about 11.14% of the original sample) are eliminated because of different organizational choices that have been adopted for water production and water distribution, and 1350 observations are eliminated because of missing data on at least one of the variables that we need for our estimations purposes. We have chosen not to account for observations that have adopted different organizational choices for water production and water distribution because the observed price of water in our dataset is jointly determined by both functions. We are thus unable to disentangle from our observed price the "price" that consumers are charged for each service. Supplementary information from DGS with respect to water treatment technologies and water sources is used to complete this dataset.

The third set of data from the French Water Agencies contains observations for about 16000 municipalities representing about 20 million or one third of the French population. This dataset allows us to identify the water company in charge of providing water services in a given municipality across 43 *Départements*. Using this data set, we are able to compute market shares at the *Département* level for each water company that offers its services in a given *Département*. Such an indicator is useful for constructing variables that approximate the level of competitive pressures at the *Département* level, and allows us to explore the effects of *ex post* competition.

A total of 1129 observations are obtained when we merged both sample. For our empirical study, we will only use 1102 observations from this sample, eliminating observations using a "*gérance*" contract or an intermediary management contract

since there are few observations on these two organizational modes available in our merged sample. For convenience, we will refer to this latter as the "Merged Sample", and to the original and usable dataset containing 3650 observations from IFEN–SCEES–DGS as "Whole Sample". In the following, we statistically explore the characteristics of the French Water sector and our sample with respect to organizational choices, water prices and potential competitive pressures. Definition and characteristics of the other variables that we will use in our empirical analysis are resumed in table 1.5 and table 1.6, at the end of this section.

1.4.1.1 Organizational choices

The following table (table 1.2) provides a view on the distribution of organizational choices in the French water sector.

Table 1.2: Distribution of organizational choices

Governance Structure	*Whole Sample*		*Reduced Sample*	
	Freq.	Percent	Freq.	Percent
Direct Public Management	1132	31.01%	394	34.90%
Gérance	128	3.51%	10	0.89%
Intermediary Management	152	4.16%	1	0.09%
Lease	2074	56.82%	683	60.50%
Concession	164	4.49%	41	3.63%
Total	3650	100.00%	1129	100.00%

Source: IFEN & SCEES.

We see from table 1.2 that a large proportion of municipalities organize their water provision services either through direct public management or through a lease contract. We could also see that there is not much difference in the distribution of both the representation whole sample and our reduced sample where major governance structures are concerned. "*Gérance*" and intermediary management are under-represented in our reduced sample (a total of 11 observations only and about 1% of total observations in our reduced sample). We have decided to drop these observations in regressions done on our reduced sample, since these organizational choices are under–represented.

1.4.1.2 A diversity of organizational choices resulting in a diversity of prices

In our empirical work, we have chosen to use water prices paid by consumers as a measure of efficiency. Water prices paid by consumers are an essential indicator of consumer surplus, and hence we evaluate the efficiency of PPPs from the perspective of consumer welfare. Water prices in our samples are measured in euros per 120m^3 in 2001.[25] A glance into the link between water prices and various organizational choices is offered in table 1.3.

Table 1.3: Prices and organizational choice

Governance Structure	Observed water prices in 2001 (€ per 120m^3)					
	Whole Sample			*Reduced Sample*		
	Freq	Mean	Std. Dev.	Freq	Mean	Std. Dev.
Direct Public Management	1132	125.09	33.76	394	121.60	35.24
Gérance	128	201.35	48.05	10	185.86	23.96
Intermediary Management	152	170.99	12.06	1	108.00	—
Lease	2074	156.86	46.14	683	161.54	49.64
Concession	164	160.50	30.03	41	162.61	36.94
PPP	2518	160.50	45.55	735	161.86	48.82
Total	3650	149.52	45.31	1129	147.81	46.49

Source: IFEN & SCEES.

One could see from table 1.3 that the prices that consumers pay in France per 120m^3 of water vary according to how water services are being organized. One may easily notice that water prices are lower for consumers who live in municipalities that organize their water services under direct public management. When water services are organized under a lease contract or a concession contract, consumers pay on average about 30€ to 40€ more per 120m^3 of water in comparison with consumers who live in areas where water services are managed directly under public provision. However, one may not directly infer from this that direct public management can achieve higher efficiency. Indeed, governance structures are not chosen randomly: in particular, a local public authority may tend to choose a PPP for water provision services if operating conditions are harsh (Ménard and Saussier [2002]). This may lead to higher observed prices for these contracts, and

[25] 120m^3 is approximately the average annual volume of water consumed by a family comprising of 4 members.

may not be attributed to organizational forms. Consequently, in order to assess the impact of organization forms on the efficiency of PPP, one must account for such exogenous factors.

Local public authorities may subsidize water services in various ways when they run the service themselves. This may also explain why consumers pay less for water prices when water services are run through direct public management. However, it seems to us that such an explanation is not plausible in our case for the following reason: *de jure*, these services have to be financed only through receipts from users of the services, and financial equilibrium has to be respected (*Code Général des Collectivités Territoriales*, articles L.2224-1 and L.2224-2). The application of this law implies that budget for these services are kept independent from a local public authority's general budget.[26] Therefore, it seems unlikely that lower water prices paid by consumers under direct public management are a result of subsidies.

1.4.1.3 Competitive pressures

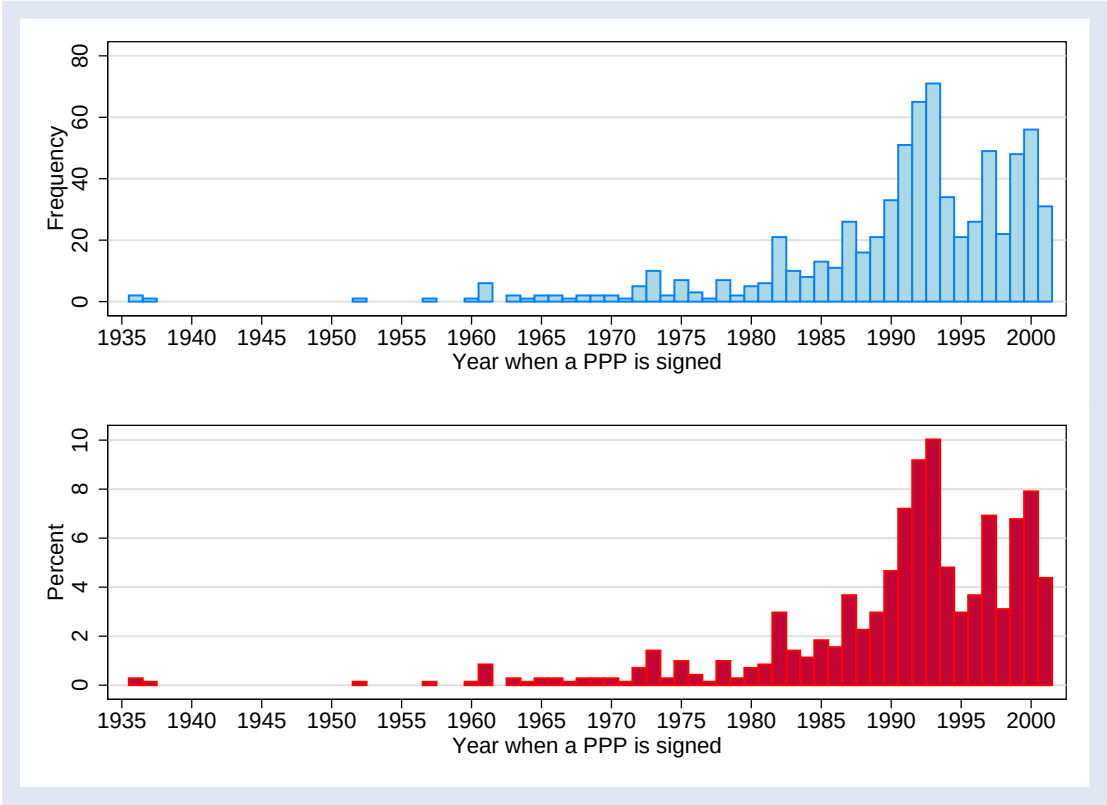
Recall from our previous discussion that we are interested in the effects of three types of competition: competition that arises from using auctions, *ex post* competition and intermodal competition.

In order to evaluate the incidence of auctions on efficiency of PPPs, we intend to use the change in the French legislation introduced in 1993 by the Sapin Law. This law, taking effect as of 1993, obliges local public authorities to organize an auction to attribute temporary monopoly rights for water services if local public authorities intend to outsource the provision of water services to an external operator. Our dataset contains observations spanning from 1936 to 2001, allowing us to determine whether such a law could have an impact on the efficiency of PPPs. The distributions of the year when a contract is signed and the year when contracts

[26] See http://www.colloc.minefi.gouv.fr/colo_struct_fina_loca/comp_loca/fich_tech/mine.html.

are to end in our reduced sample are shown in figure 1.3 and figure 1.4.[27] From figure 1.3, we could see that a majority of PPP contracts in our reduced sample has been signed between 1983 and 2001.

Figure 1.3: Distribution of the year of signature of PPPs in reduced sample

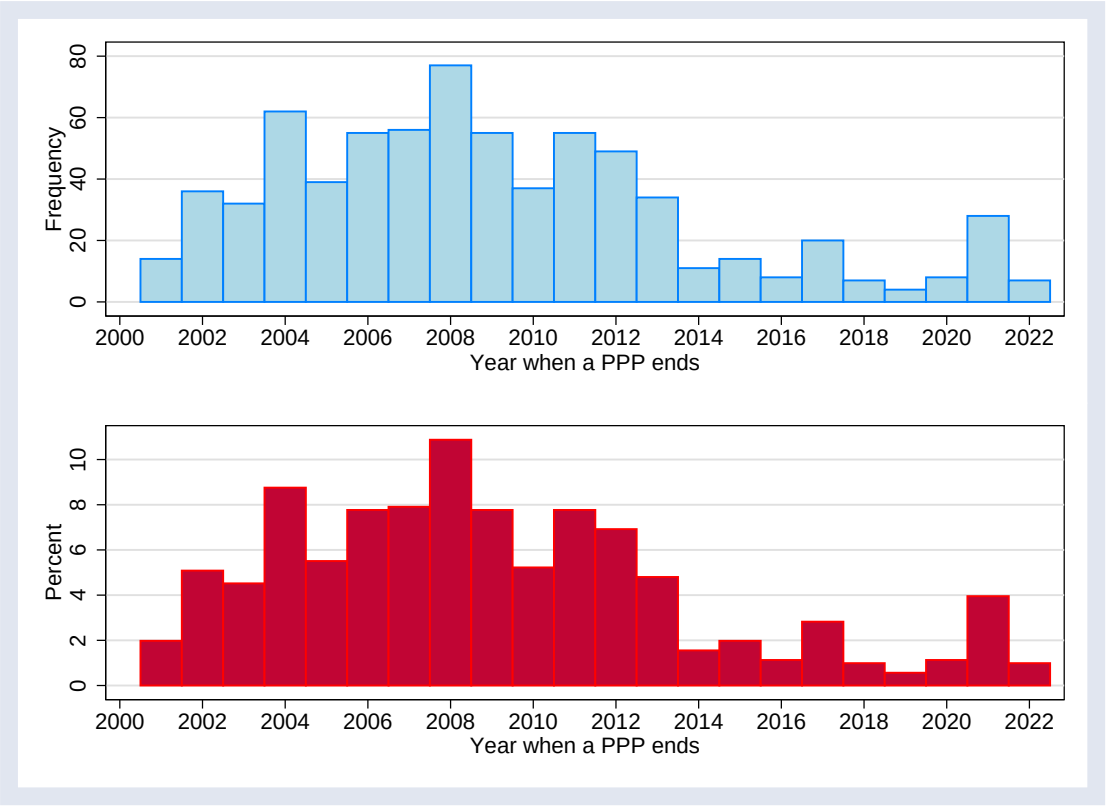


*Note: Relative frequency (in percentage) is computed relatively to the total number of outsourced contracts in our reduced sample (*i.e. *724 observations).*

We use the variable dummy variable After 93 to crudely measure the effects of competition from using auction mechanisms on the efficiency of PPPs. Note that an important shortcoming to this approach is that we do not directly measure the impact of auctions, but the impact of using auctions together with subjective awarding criteria that result from the exercise of the "*intuitu personae*" principle. Some statistics on water prices according to whether the corresponding contract is signed before or after the Sapin Law is given in table 1.4.

[27]The distribution of contractual length is provided in Chapter 4, figure 3.1.

Figure 1.4: Distribution of the year when PPPs end in reduced sample



*Note: Relative frequency (in percentage) is computed relatively to the total number of outsourced contracts in our reduced sample (*i.e. *724 observations).*

We see from table 1.4 that water prices are indeed higher for contracts that are signed before 1993, *i.e.* before the coming into effect of the Sapin Law. There seems to be about 10€ of difference on the average in water prices between contracts that are signed before 1993 and those that are signed after 1993. A t–test on equality of mean confirms that mean water prices for contracts that are signed before 1993 is significantly different from water prices for contracts that are signed after 1993.[28] In particular, the t–tests also indicate that water prices are higher on the average in municipalities who have signed their PPP contracts before 1993. We believe thus that the dummy variable After93 may allow us to crudely measure the effects of competitive pressure that stems from a compulsory use of a competitive tendering procedure, once other exogenous factors affecting water prices are accounted for.

[28]We have conducted the t–tests under the assumption of equal variance in both sub-samples. We are unable to reject the nul hypothesis that variance of water prices are the same for contracts signed before 1993 and after 1993 using a Bartlett's test for equality of variance.

Table 1.4: Prices and the Sapin Law

	Observed water prices in 2001 (€ per $120m^3$)					
	Whole Sample			*Reduced Sample*		
	N	Mean	Std Dev	N	Mean	Std Dev
Contracts signed before 1993	1089	165.84	46.59	365	167.21	49.88
Contracts signed after 1993	997	157.12	45.87	370	156.57	47.22
Direct Public Management	1132	125.09	33.76	394	121.6	35.24
Total	3218	148.8	45.87	1129	147.81	48.50
t Test for equality of mean water prices of contracts signed before and after 1993	Δ: 8.72 t–Statistics: 4.2998 p–value: 0.0000			Δ: 10.64 t–Statistics: 2.9690 p–value: 0.0031		

Source: IFEN & SCEES. t-Test on mean price comparisons conducted under the assumption of equal variance. Δ measures the difference in mean observed water prices for contracts signed before 1993 or after 1993.

Another measure of the level of competition that we use is the Herfindahl index, Herf, of the concentration of firms at the *Département* level. The Herfindal index is constructed using market shares of each water company present in a given *Département*. To approximate market shares for a given water company, we use the percentage of the population in a given *Département* served by the company. The Herfindahl index is then computed as follows

$$\text{Herf} = \sum_{i=1}^{n} \text{market shares}_i^2, \quad \text{with} \sum_{i=1}^{n} \text{market shares}_i = 1$$

A high index value indicates high concentration of water companies in a *Département*, and hence potentially low competition. The Herfindahl index is used as an indicator of *ex post* competition. We are able to compute the Herfindahl index in 43 *Départements*.

In the same way, intermodal competition is measured as the percentage of the population in a given *Département* whose water services is directly run by a local public authority (*i.e.* organized through direct public management). A higher value of this variable, which we denote ShareDM, can be taken to indicate a higher level of competition between public provision and private provision. Indeed, as we have mentioned above, two reasons may be advanced to support this: firstly, areas in which public management is dominant may provide a less costly transition back to public management for local public authorities in a private management structure. Secondly, operators in an area may want to appear efficient in order to build up a reputation capital that could be used to convince other nearby

local public authorities to opt for PPPs. As such, we believe that the level of intermodal competition may be approximated by the percentage of population served in water services through direct public management and we expect water prices to be negatively correlated with ShareDM.

It should be noted that both Herf and ShareDM measures competitive pressure at the local level, or more precisely, they measure competitive pressures in a *Département*. As we have argued above (in section 1.2.3), this could be a relevant scale to measure competition, given the importance of local conditions when running water services.

Nevertheless, we should note that a shortcoming of Herf and ShareDM is that they do not distinguish between municipalities that are situated at the "frontier" of a *Département* from municipalities that are located in the middle of a *Département*. One may legitimately suspect that municipalities that are located at the "frontier" of a *Département* are more prone to competitive pressures from bordering municipalities, even if these municipalities are located in another *Département*. Unfortunately, we have no means to correct for this shortcoming.

1.4.2 Empirical model

We seek to estimate the impact of organizational choices and the role of competition on performance, as measured by consumer prices, across a cross-section of municipalities. We begin by estimating a least squares regression (OLS) of price on a set of indicator variables for organization choices, a set of variables for competition levels, and a set of exogenous factors that should shift the supply and demand, and thus the retail price of distributed water:

$$\mathsf{Price}_i = \boldsymbol{O}_i'\omega + \boldsymbol{C}_i'\gamma + \boldsymbol{X}_i'\beta + u_i, \tag{1.1}$$

where Price_i is observation i's price in Euros per 120m^3 of water distributed, $\boldsymbol{O}_i$ contains indicator for observation i's chosen organizational choice, $\boldsymbol{C}_i$ is a set of variables that approximates level of competition related to observation i, $\boldsymbol{X}_i$ is a set of exogenous control variables, and u_i is an error term. In our estimation,

$\mathbf{u}$[29], the vector of stochastic error terms, is assumed to be possibly heteroskedastic across observations:

$$\mathbf{u} \rightsquigarrow (0, \Sigma)$$

The coefficients of ω measure the average shift in price across different contract types ranging from direct public management to concessions.

An econometric problem arises, however, from the fact that a local public authority's choice of contract type is endogenous. In particular, there may be individual heterogeneity across local public authorities that is unobserved by the econometrician, but that is correlated with both organizational choice and performance. In this case, $\mathbb{E}[\mathbf{O}'\mathbf{u}|\mathbf{X}, \mathbf{C}] \neq 0$, and OLS estimates of equation 1.1 will be biased and inconsistent.

While a full structural model studying the determination of organizational choices is beyond the scope of this chapter, we attempt to account for the possible endogenous decision of a local public authority by considering his choice of using either PPP or direct public management. To this end, we estimate an endogenous switching regressions model and allow cross-equation correlation in errors in order to obtain unbiased estimates of the impact of (endogenous) organizational choice on performance. The basic switching regression model that we estimate is given by the following system:

$$\begin{cases} \mathsf{Price}_i &= \mathsf{PPP}_i\pi + \boldsymbol{X}_i'\beta + v_i \\ \mathsf{PPP}_i &= \mathbb{I}(\boldsymbol{X}_i'\alpha + \boldsymbol{Z}_i'\zeta \geq w_i) \end{cases} \tag{1.2}$$

$$\text{with} \qquad \begin{pmatrix} v_i \\ w_i \end{pmatrix} \Bigg| \mathbf{X}_i, \mathbf{Z}_i \rightsquigarrow \mathscr{N}\left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \sigma_v^2 & \sigma_{vw} \\ \sigma_{vw} & 1 \end{bmatrix} \right)$$

Here PPP_i is an indicator variable that takes value 1 when a local public authority uses a PPP contracts and zero if the local public authority chooses a direct public management. $\mathbb{I}(\cdot)$ is the indicator function that depends on the value of its argument. As one can see, we assume that a local public authority's decision to choose a PPP depends of the set of factor that influence price, $\boldsymbol{X}_i$, and a set

[29] We use subscripts, slanted and boldface characters to denote the vector of variables corresponding to observation i. Upright boldface characters without subscripts are used to denote corresponding matrix.

of variables which are assumed to have no impact of water prices. The selection equation is also normalized by the standard deviation of $\mathbf{v}$. The error terms v_i and w_i are assumed to be distributed according to a bivariate normal distribution with zero mean. σ_v^2 is the variance of $\mathbf{v}$ and σ_{vw} is the covariance between the two normally distributed error terms. This procedure should account for endogeneity in PPP_i and yields unbiased estimates of π, the unconditional mean premium or discount paid by consumers in a municipality that has chosen a PPP.[30] In order to study the effects of various types of competition, competition variables $\mathbf{C}$ will be added to the price equations in our estimations accordingly. In the following, we briefly offer some rationales on the choice of our $\mathbf{X}$ and $\mathbf{Z}$ variables used in our estimations.

1.4.2.1 Explanatory variables: $\mathbf{X}$

We include a set of variables that might shift costs of water production and distribution. These variables may therefore be expected to have an impact on observed water prices, as well as on a local public authority's decision to use PPP.

We include a set of variables that account for the complexity of raw water treatment that has to be performed before water is distributed. Complexity of raw water treatment technologies are classified in three categories in France:

(i) A1-type treatments are relatively simple treatments. They only involve some raw water filtering technology and light disinfection.

(ii) A2-type treatments involve some mechanical or chemical treatment before disinfection and distribution.

[30] Applying conditional normal theory and change of variable, we can write the individual contribution to the likelihood, $f(\mathsf{Price}_i, \mathsf{PPP}_i)$, as:

$$\frac{1}{\sqrt{\sigma_v^2}}\phi\left(\frac{v_i}{\sqrt{\sigma_v^2}}\right)\left[1-\Phi\left(\frac{(-\boldsymbol{X}_i'\beta-\boldsymbol{Z}_i'\zeta-v_i)}{\sqrt{\sigma_v^2}\sqrt{1-\rho^2}}\right)\right]^{\mathsf{PPP}_i}\left[\Phi\left(\frac{(-\boldsymbol{X}_i'\beta-\boldsymbol{Z}_i'\zeta-v_i)}{\sqrt{\sigma_v^2}\sqrt{1-\rho^2}}\right)\right]^{1-\mathsf{PPP}_i}$$

where $\phi(\cdot)$ and $\Phi(\cdot)$ denote respectively density function and cumulative function of standard normal random variable. In our switching model, the β are not separately identifiable because $\boldsymbol{X}_i$ enters both the price and PPP equations. However, our initial OLS estimates of equation 1.1 is sufficient for predictive purposes, and allows us to interpret the estimated β.

(iii) A3-type treatments involve previous treatments and a supplementary operation to "refine" water. Arguably, this type of treatment is the most complex in this classification.

The dummy variables Treat A2, Treat A3, Tr. Mix A1&2 and Tr. Mix A3 are therefore used to approximate technology complexity as well as the level of specific investments that are needed to operate water services in a local area. We expect water prices to increase with the complexity of raw water treatment technology needed to operate the service.

The variable Underground is used to control for the source of raw water (surface water or underground water). The quality of underground water is often more stable over time, and therefore uncertainty over the kind of treatment needed to be used on raw water is reduced over the lifetime of a contract. Water price may therefore be lower when raw water comes from (an) underground source(s).

The variable Indep Ratio, for independence ratio, measures the extent to which a municipality relies on imported water to satisfy its demand in water. This ratio is computed as the share of total volume of water distributed over the sum of total distributed water volume and imported water volume. Greater independence with respect to raw water supply may be expected to lead to lower prices. In the same spirit, we have included an indicator variable, Water Limit., that measures whether water use restrictions have been introduced in 2001 in a particular local area.[31]

Touristic, a dummy variable that indicates whether a municipality is touristic or not, is incorporated into our empirical estimations. This variable can be used to account for the volatility of water demand due to seasonal variations in the population. Over-capacity might be needed in order to satisfy peak-load demand, and might therefore leads to higher water prices.

We also included a set of variables that attempt to account for possible economies of scale in the water industry: Density which measures the size of water network

[31]Regulations to limit to use of water may be introduced for instance in the event of a dry spell.

per inhabitant in a local area, and Interauthority which indicates whether water services are organized jointly at the level of several local public authorities (through an association of these authorities). Such inter–authority organization is typically chosen when service is hard to provide. These variables should increase the price of water.[32] We also include the size of population, Pop, and its square, Pop^2 to account for the size of the market.

A set of variables that seek to capture heterogeneity in terms of infrastructure quality is also included: these include Extension, the length of network extension undertaken in 2001, Replacement, the length of network replaced in 2001, Invst Prg., whether an investment program is in place in 2001, and Leak Ratio, which measures the state of the water distribution network. These variables account for the nature of infrastructure and efforts to adequately maintain or even extend the infrastructure. However, quality and particularly the condition of a distribution network could be endogenous from the perspective of price and organizational choice: poor infrastructure could motivate a particular organizational choice and/or associated water prices, or *vice–versa*. We run several auxiliary regressions (including regressing Leak Ratio on observed water prices or PPP), and find no supporting evidence that these variables are endogenous.[33]

Finally, in order to account for unobserved heterogeneity, regional fixed effects are also included in both our price and PPP equations.

1.4.2.2 Explanatory variables: $\mathbf{Z}$

In our selection equation (organizational choice equation) of our switching model regressions, we have included all $\mathbf{X}$ variables. In addition to these, the two following variables are used only in our selection equation. Arguably, they could be expected to have an impact on a local public authority's choice of PPP, but

[32] As defined in table 1.5, larger values of the variable Density correspond to *less* dense networks. When there are economies of density, a more dense network should lead to lower prices, hence we expect prices to increase with Density.

[33] These variables are at best marginally significant in most regressions, but we retain them because we believe that they should be included from a theoretical perspective.

should not have any impact on water prices. These variables could therefore be seen legitimately as instruments in our switching regression model.

The first variable is Sanitation, a variable that indicates whether a local public authority has chosen to use PPP to manage his sanitation services. We can see no reason why using a PPP for sanitation services in a municipality could have an impact on observed water prices in the same municipality. However, if local public authorities have preferences over organizational modes, it is likely that their organizational choice for water provision is correlated with their organizational choice for sanitation services. In fact, a local public authority may have some preferences over certain organizational modes for ideological reasons and/or historical reasons. Hence, Sanitation could be used to approximate such effects on a local public authority's governance structure choice on organizing local public services.

The choice to use a PPP may also depend on the political affinity of the population in a municipality, and hence the political adherence of elected a local public authority. A stereotyped left–winger tends to prefer public provisions, while a stereotyped right–winger tends to favor an outsourced solution relying on a private operator. A majority of left–(or right–)wingers in the population makes it more likely that a local public authority elected at the municipality adheres to left (respectively right) wing ideologies. These local public authorities may therefore tend to prefer one organizational mode to another. It seems clear that while such political affinities within a municipality's population may have an impact on organizational choices, they could not be expected to have an impact on observed water prices. Hence, we believe that the share of left–wingers (or right–wingers for the matter) could be legitimately used as an instrument for organizational choices.

For our empirical study, we measure the share of left–wingers in the population in a local area using the variable Left Wing. This variable is actually the average share of left–wing voters (taken with respect to the population that could legitimately vote in an election) in a municipality during the 1995 and 2002 presidential elections in France.[34] This variable should therefore provide an approximation of

[34]We used the number of left–wing voters in the first round of the presidential election, without

the share of "core" left–wingers in the population of a municipality. While a more adapted measure for political affinities of a local public authority could be obtained from results of municipal elections, we are unable to find such variables. Nevertheless, we believe that our variable Left Wing is a sufficiently good measure of a local public authority's political tendency. We expect a negative effect from this variable on the probability that a local public authority chooses a PPP for his water services.[35]

We will now present and discuss the results of our estimation in the following section.

distinguishing among various left–wing ideologies.

[35]Although we do include political variables in our regressions, we remind the reader that we are unable to account for political cycles, which could influence on the efficiency of PPP.

Table 1.5: Definition of variables used in estimations on the water prices

Variable	Definition
Price	Observed consumer water price per $120m^3$ in 2001
Gérance	Takes value 1 if water service is organized as a *Gérance*
Inter. Mng.	Takes value 1 if water service is organized as a intermediary management
Lease	Takes value 1 if water service is organized as a lease contract
Concess	Takes value 1 if water service is organized as a concession contract
PPP	Takes value 1 if water service is managed through a PPP
After93	Takes value if contract is signed after 1993
Herf	Herfindahl index at the *Département* level
Share DM	Share of population in a *Département* served through direct public management
Expiry	Number of years left from 2001 until contract expires
TreatA2	Takes value 1 if raw water requires A2 type treatment
TreatA3	Takes value 1 if raw water requires A3 type treatment
Tr. Mix A1&2	Takes value 1 if raw water requires both A1 and A2 type treatments
Tr. Mix A3	Takes value 1 if raw water requires A3 type treatment and any of the both types (A1 and/or A2)
Density	Length of water network (in km) per inhabitants
Extension	Length of water network extended in 2001
Replacement	Length of water network replaced in 2001
Invst Prg	Takes value 1 if there is an investment program in 2001
Underground	Takes value 1 if water origin is underground
Indep Ratio	Total distributed water volume/(Total distributed water volume+ Total imported water volume)
Leak Ratio	Volume of water loss/Size of water network
Water Limit.	Takes value 1 if there are water use restrictions regulations in 2001
Touristic	Takes value 1 if municipality is touristic
Interauthority	Takes value 1 if the local public authority organizes water services in cooperation with other authorities
Pop	Number of inhabitants concerned by the contract/10000
Pop^2	Square of Pop
Op. 1	Takes value 1 if Operator 1 manages the contract
Op. 2	Takes value 1 if Operator 2 manages the contract
Op. 3	Takes value 1 if Operator 3 manages the contract
Op. 4	Takes value 1 if Operator 4 manages the contract
Sanitation	Takes value 1 if sanitation services is managed through PPP
Left Wing	Average share of left wing voters in a municipality during the 1995 and 2001 French presidential elections

Table 1.6: Statistics of variables used in estimations on water prices

Variable	*Whole Sample*			*Reduced Sample*		
	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.
Price	3650	146.515	45.309	1102	147.321	48.379
Gérance	3650	0.04	0.2	—	—	—
Inter. Mng.	3650	0.04	0.18	—	—	—
Lease	3650	0.57	0.5	1102	0.607	0.489
Concess	3650	0.45	0.21	1102	0.035	0.185
PPP	3650	0.690	0.46	1102	0.642	0.479
After93	3218	0.31	0.46	1102	0.325	0.469
Herf	—	—	—	1102	0.462	0.147
Share DM	—	—	—	1102	32.579	22.786
Expiry	3174	5	4.37	1102	5.164	5.555
TreatA2	3650	0.163	0.369	1102	0.198	0.399
TreatA3	3650	0.186	0.389	1102	0.118	0.323
Tr. Mix A1&2	3650	0.047	0.211	1102	0.027	0.163
Tr. Mix A3	3650	0.050	0.218	1102	0.068	0.252
Density	3650	22.523	36.477	1102	29.227	53.024
Extension	3650	0.464	1.722	1102	0.464	1.272
Replacement	3650	0.542	1.252	1102	0.474	0.953
Invst Prg	3650	0.660	0.474	1102	0.635	0.482
Underground	3650	0.650	0.477	1102	0.661	0.474
Indep Ratio	3650	0.902	0.203	1102	0.912	0.199
Leak Ratio	3650	0.259	0.139	1102	0.297	0.144
Water Limit.	3650	0.030	0.172	1102	0.018	0.134
Touristic	3650	0.879	0.326	1102	0.817	0.387
Interauthority	3650	0.675	0.468	1102	0.640	0.480
Pop	3650	9.376	42.161	1102	8.045	32.118
Pop^2	3650	1864.939	75606.550	1102	1095.368	20149.800
Op. 1	—	—	—	1102	0.160	0.367
Op. 2	—	—	—	1102	0.177	0.382
Op. 3	—	—	—	1102	0.180	0.384
Op. 4	—	—	—	1102	0.039	0.194
Sanitation	3650	0.42	0.49	1102	0.422	0.494
Left Wing	3618	0.3	0.07	1102	0.307	0.067

Source: IFEN, SCEES, DGS & French Water Agencies

1.5 Estimation results and discussion

In table 1.7 and table 1.8, we provide estimates obtained from regressions run respectively on the whole sample and on our reduced sample. In our reduced sample, we are able to account for operator fixed effects as well as various competition variables. We also provide heteroskedastic robust standard errors within parentheses for our estimations using OLS. We estimate our switching regression models using maximum likelihood methods. Different specifications in terms of explanatory variables are used in our estimations: in table 1.7, the first column (*OLS (1)*) show estimates when we account for different types of governance structure (intermediary management, lease, ...) , while in the second column (*OLS (2)*), estimates are obtained by aggregating all outsourced contracts under PPPs. *Switch (1)* provides estimates of an endogenous switching regression model on the whole sample. In the same way, in table 1.8, *OLS (3)* and *Switch (2)* (respectively *OLS (4)* and *Switch (3)*) show OLS and switching regression estimates on our reduced sample when operator fixed effects are excluded (respectively included). Finally, estimates when competition variables (**C** variables) are included are provided by *Switch (4)*.

From both tables, it seems that our estimates are globally consistent with respect to our explanatory variables **X**. A comparison across estimates produced by various specifications and sample shows some minor differences in scale. Globally, the estimated signs of our explanatory variables remain unchanged. We are therefore led to believe that our reduced sample is not biased as compared to the representative whole sample.

As one could see, Density has a positive impact on observed water prices. This confirms the existence of economies of scale from the density of a water distribution network: a less dense[36] network leads to a higher water price per 120m^3. In the same way, where raw water comes from underground, water prices are lower by

[36]We remind our readers that a higher value of Density implies a less dense network.

Table 1.7: Estimates for water prices (Whole Sample)

	OLS (1)	*OLS (2)*	*Switch (1)*	
Indep. Var.	Price	Price	PPP	Price
Gérance	47.639*** (3.397)	—	—	—
Inter. Mng.	35.546*** (2.990)	—	—	—
Lease	26.873*** (1.406)	—	—	—
Concess	40.159*** (2.483)	—	—	—
PPP	—	29.102*** (1.356)	—	15.690*** (3.691)
Treat A2	9.734*** (2.025)	10.544*** (2.013)	0.302*** (0.085)	12.174*** (2.086)
Treat A3	5.771* (2.401)	5.712* (2.440)	0.522*** (0.108)	8.306*** (2.517)
TreatMix A1&2	1.481 (3.712)	0.129 (3.782)	0.350* (0.151)	2.332 (3.419)
TreatMix A3	0.539 (3.481)	0.741 (3.469)	0.011 (0.128)	1.632 (3.167)
Density	0.197* (0.082)	0.196* (0.082)	0.001 (0.001)	0.188*** (0.018)
Extension	-0.213 (0.318)	-0.084 (0.343)	0.043+ (0.023)	0.172 (0.392)
Replacement	0.849 (0.746)	0.855 (0.758)	-0.090*** (0.027)	0.699 (0.643)
Invst. Prg	0.018 (1.573)	0.512 (1.576)	-0.132* (0.059)	0.445 (1.422)
Underground	-10.893*** (1.999)	-11.678*** (1.982)	0.164+ (0.087)	-10.047*** (2.054)
Indep. Ratio	-5.833+ (3.413)	-5.477 (3.435)	-0.354* (0.145)	-6.789* (3.258)
Leak Ratio	6.243 (5.338)	7.398 (5.407)	-0.226 (0.194)	7.560 (4.769)
Water Limitations	2.848 (4.994)	1.894 (5.056)	0.317+ (0.189)	3.062 (4.278)
Touristic	0.583 (2.211)	0.411 (2.236)	0.114 (0.089)	0.220 (2.041)
Interauthority	21.434*** (1.846)	21.685*** (1.818)	0.476*** (0.063)	22.760*** (1.544)
Population	-0.067 (0.078)	-0.051 (0.078)	-0.000 (0.002)	-0.051 (0.036)
Population^2	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Sanitation	—	—	1.424*** (0.063)	—
Left Wing	—	—	-1.362** (0.416)	—
Const.	139.442*** (7.280)	138.129*** (7.304)	0.867** (0.269)	148.720*** (6.554)
Region	Incl.	Incl.	Incl.	Incl.
ρ			0.284***	
R^2	0.366	0.356	—	
N	3650	3650	3618	

*Note: Levels of significance: +10% *5% **1% ***0.1%. Regional fixed effects are globally significant at 5%. Robust standard errors within parentheses.*

Table 1.8: Estimates for water prices (Reduced Sample)

	OLS (3)	*OLS (4)*	*Switch (2)*		*Switch (3)*		*Switch (4)*	
	Price	Price	PPP	Price	PPP	Price	PPP	Price
PPP	34.673***	23.535***	—	19.249***	—	5.861	—	-6.473
	(2.505)	(5.611)		(5.803)		(7.036)		(7.629)
After93	—	—	—	—	—	—	—	-10.610***
								(2.926)
Herf	—	—	—	—	—	—	—	-5.517
								(11.190)
Share DM	—	—	—	—	—	—	—	-0.673***
								(0.081)
Expiry	—	—	—	—	—	—	—	1.158***
								(0.305)
Treat A2	16.308***	14.177***	0.472**	18.664***	0.464**	16.488***	0.456**	13.095***
	(3.428)	(3.425)	(0.150)	(3.786)	(0.150)	(3.787)	(0.149)	(3.722)
Treat A3	1.694	2.469	0.484*	5.265	0.488*	6.152	0.479*	3.260
	(4.944)	(5.060)	(0.208)	(5.136)	(0.208)	(5.096)	(0.208)	(4.956)
Tr. Mix A1&2	33.648***	33.829***	0.649+	35.367***	0.658+	35.861***	0.662+	34.345***
	(8.434)	(8.613)	(0.352)	(8.171)	(0.353)	(8.117)	(0.351)	(7.903)
Tr. Mix A3	6.066	4.611	0.302	7.375	0.294	5.898	0.269	6.151
	(5.360)	(5.532)	(0.210)	(5.342)	(0.209)	(5.303)	(0.207)	(5.167)
Density	0.136+	0.134+	-0.000	0.131***	-0.000	0.129***	-0.000	0.127***
	(0.072)	(0.073)	(0.001)	(0.023)	(0.001)	(0.023)	(0.001)	(0.023)
Extension	0.518	0.365	0.126*	0.978	0.124*	0.908	0.120*	1.240
	(1.080)	(1.096)	(0.050)	(1.083)	(0.050)	(1.085)	(0.049)	(1.055)
Replacement	-2.874*	-2.789+	-0.127+	-3.511*	-0.125+	-3.505*	-0.121+	-2.748+
	(1.439)	(1.452)	(0.067)	(1.559)	(0.067)	(1.549)	(0.066)	(1.514)
Invst. Prg.	-7.416**	-6.602*	-0.060	-7.304**	-0.063	-6.441*	-0.072	-6.496*
	(2.755)	(2.756)	(0.106)	(2.648)	(0.105)	(2.633)	(0.105)	(2.562)
Underground	-16.119***	-15.659***	0.247	-14.606***	0.251+	-14.049***	0.245	-13.586***
	(3.500)	(3.577)	(0.152)	(3.788)	(0.152)	(3.762)	(0.151)	(3.662)
Indep. Ratio	2.702	1.654	0.044	1.482	0.042	0.096	0.043	-1.912
	(7.294)	(7.497)	(0.252)	(6.248)	(0.252)	(6.223)	(0.253)	(6.072)
Leak Ratio	5.992	7.003	-0.178	4.639	-0.178	5.761	-0.174	10.555
	(10.603)	(10.594)	(0.342)	(8.696)	(0.342)	(8.638)	(0.340)	(8.408)
Water Limit.	-4.539	-5.990	0.302	-2.385	0.301	-3.720	0.301	-4.099
	(6.852)	(6.389)	(0.317)	(8.936)	(0.316)	(8.864)	(0.315)	(8.612)
Touristic	-1.394	-2.212	0.247+	-1.078	0.248+	-1.968	0.253+	-2.684
	(3.663)	(3.661)	(0.139)	(3.294)	(0.138)	(3.280)	(0.138)	(3.192)
Inter-author	25.525***	26.405***	0.722***	28.309***	0.724***	29.513***	0.722***	30.332***
	(3.090)	(3.071)	(0.113)	(2.960)	(0.113)	(2.956)	(0.113)	(2.874)
Pop	-0.253**	-0.220**	-0.019*	-0.236**	-0.018*	-0.204*	-0.016+	-0.343***
	(0.081)	(0.083)	(0.009)	(0.091)	(0.009)	(0.090)	(0.009)	(0.091)
Pop^2	0.001***	0.001***	0.000	0.001***	0.000	0.001***	0.000	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Op. 1	—	2.456	—	—	—	4.562	—	2.674
		(5.827)				(4.926)		(4.835)
Op. 2	—	13.011*	—	—	—	14.370**	—	15.359**
		(6.230)				(4.999)		(4.987)
Op. 3	—	16.649**	—	—	—	17.462***	—	16.466***
		(5.960)				(4.888)		(4.846)
Op. 4	—	27.501*	—	—	—	31.754***	—	32.788***
		(11.532)				(8.228)		(7.984)
Sanitation	—	—	1.711***	—	1.711***	—	1.697***	—
			(0.124)		(0.124)		(0.125)	
Left Wing	—	—	-3.192***	—	-3.155***	—	-3.170***	—
			(0.784)		(0.783)		(0.774)	
Const.	132.789***	131.067***	0.305	139.315***	0.296	138.498***	0.328	165.621***
	(12.555)	(12.362)	(0.556)	(13.338)	(0.554)	(13.296)	(0.553)	(15.214)
Region	Incl.	Incl.	Incl.	Incl.	Incl.	Incl.	Incl.	Incl.
ρ	—	—	0.324**		0.349**		0.423***	
R^2	0.382	0.395	—		—		—	
N	1102	1102	1102		1102		1102	

*Note: Levels of significance: +10% *5% **1% ***0.1%. Regional fixed effects are globally significant at 5%. Robust standard errors within parentheses.*

about 10€ according to our estimates on the whole sample and to *Switch (4)*, all else being equal. On the average, consumers also pay more per $120m^3$ of water when the service is organized through an association of several local public authorities.

Complexity of raw water treatment technology also plays a role in determining water prices. As we have expected, complex raw water treatment leads to higher water prices when compared with the simplest technology. This effect can be observed for all estimates across our various specifications and on both of our samples. This is confirmed by the estimates of Treat A2, which is significant in all estimations across sample and specification. Note however that Tr Mix A1&2 is only significant for estimates on our reduced sample, while Treat A3 is significant only for estimates on the whole sample.

1.5.1 The choice of PPPs and its efficiency

Our estimations also indicate that PPPs are not randomly chosen by local public authorities. This can be seen from the estimate of the inter–equation correlation, $\hat{\rho}$, which is positive and significant in all our switching regression estimations. Furthermore, our estimations are globally significant. This suggests that there are unobservable factors (to the econometrician) that lead local public authorities to choose PPPs and which also impact on performance as measured by water prices: the municipalities with high water prices also have a propensity to choose PPPs.

Notice first that our instruments work quite well in explaining a local public authority's propensity to choice PPP instead of direct public management. Hence, a local public authority having chosen to use PPP for his sanitation services are more likely to choose PPP for his water provision services, *ceteris paribus*. In the same way, the higher the variable Left Wing, the less likely water services will be run through a PPP, *ceteris paribus*. Political considerations do seem to contribute to the decision of using PPPs for water services. Both variables are significant at

0.1% in all our switching regression estimates.

Nevertheless, there is also an underlying economic rationality in a local public authority's choice of using a PPP or a direct public management for his water services. This can be seen from estimations of economic variables in our switching regression specifications. As it turns out, complexity of raw water treatment technology(ies) required to run water services, as well as uncertainty of the quality of raw water, as measured by the variable Underground, make it more likely for a local public authority to choose a PPP instead of directly running the services himself, all else being equal. Estimates for these variables are consistent across sample and are significant.

A first look at our estimates seems to indicate that organizational choices do have an impact on water prices. As one can see from the estimations yielded by *OLS (1)*, *OLS (2)*, *OLS (3)*, *Switch (1)* and *Switch (2)* all show that water prices are significantly higher when PPPs are used. Consumers living in municipalities who have delegated their water services through a PPP pay higher prices compared to their counterparts living in areas where water services are organized through a direct public management. OLS estimates on the whole sample indicates that these consumers pay about 30€ more on the average, all else equal. In other words, using estimations from *OLS (2)*, when a local public uses a PPP instead of running the water services in–house, water prices jump from 138€ to about 168€ on the average. This is roughly 22% higher that what consumers pay under direct public management. Accounting for endogeneity of organizational choices, the PPP effect on water prices remains significant (*Switch (1)* and *Switch (2)*), albeit being smaller in magnitude. According to these two latter specifications, consumers pay about 16€ to 20€ more per 120m^3 of water consumed, *ceteris paribus*.

However, once accounting for operator fixed effects, we could see that PPP becomes non significant when we control for endogenous choice of PPP by local public municipalities (*Switch (3)*). According to estimates produced by this latter specification, consumers do not pay any higher premium on the average for their

water services when a PPP is used to run these services. Indeed, the estimated coefficient for PPP in this specification is not significant, even at a threshold of 10%. This result holds even if we account for competition effects (*Switch (4)*). The estimated average premium of PPP becomes negative in this case, *ceteris paribus*, albeit not being significant. Wald tests suggested that the operator dummies are jointly significant, and hence should be retained in our estimations.

We are therefore led by these observations to think that the efficiency of PPPs resides in fact of establishing partnerships with a *specific* private operator. In other words, it seems that there are no direct effects of PPP *per se* on water prices that consumers pay. However consumers pay a high price for water indirectly because of the chosen operator that runs the water services. This may be supported by the fact that consumers are found not to pay any higher premiums in areas where water services are run through PPP once we have controlled for exogenous factors and once operator fixed effects are accounted for. We had run a supplementary regression dropping the dummy variable Operator 1 which is not significant in *Switch (3)* and *Switch (4)*, and found that estimates do not change much. More specifically, estimate for PPP remains insignificant, while estimates of Operator 2, Operator 3 and Operator 4 remain significant and consistent with those produced by *Switch (3)* and *Switch (4)*. Therefore, we are quite confident that operator fixed effects (of operator 2, 3 and 4) account for the loss of significance for the variable PPP in our switching regression estimations, and that this result is not a consequence of possible bias due to the use of our reduced sample.

Estimates produced by *Switch (3)* and *Switch (4)* show in fact that consumers pay on the average a premium depending on the operator that has been chosen to run the water services. Premia may range from about 14€ to 32€ depending on the chosen operator. However, using a Wald test, we found that the average premium paid by consumers in areas where water services are run by operator 2 is not significantly different from the premium paid by consumers whose water services are run by operator 3. Conversely, Wald tests also indicate the average premium paid to operator 4 is significantly higher. Operator 4 is in fact a joint–venture between operator 1 and operator 2.

In a nutshell, it seems that PPP *per se* does not directly lead to higher or lower efficiency in the way water are being provided in a municipality. Nevertheless, there are still some *indirect positive* effects on water prices when a PPP is used to provide water services. Part of these effects can be attributed to the chosen private operator under a PPP.[37] Consumers are found to pay a premium for having their water services run by a given private operator under a PPP with respect to those whose water services are directly run by their local public authorities, all else being equal. This is the case when operator 2, operator 3 or operator 4 is chosen to run the water services.

1.5.2 The impact of ex post competition

Estimates for the effect of competitive variables on the efficiency of PPPs are provided by *Switch (4)*. We remind our readers that we use After93 to crudely estimate the impact of using competitive tendering procedures on observed water prices, Herf as a measure of concentration of private operators at a local level (the *Département* level) and Share DM as a proxy for intermodal competition.

We can see from our estimates that competitive pressures can indeed contribute to lower observed water prices: controlling for all other factors, water price are significantly lower by about 10€per 120m^3 of water for contracts that are signed after the Sapin law (which makes it compulsory to organize a competitive tendering procedure to attribute contracts to an external operator) was introduced. Note that this is a crude measure of the effect of using auctions to grant water contracts. Indeed, before the Sapin law, local public municipalities may also grant contracts through a tendering procedure: only that this is not compulsory. Nevertheless, our estimate shows that there could be a positive effect in using auctions, at least when it comes to prices per $120m^3$ of water that consumers pay.

The impact of *ex post* competition on observed water prices, as approximated by the estimate of Herf indicates a negative relationship between these two vari-

[37]PPP also leads indirectly to higher prices, through for instance the termination effect. We shall discuss further in the coming subsection (subsection 1.5.2)

ables. However, this estimated coefficient is not significant in *Switch (4)*. Our argument on the effect of *ex post* competition on the efficiency of PPPs is therefore rejected by empirical data. Note however that this may also be due to how our Herfindahl index was computed too. This may also reflect the absence of competition as a result of high industrial concentration.

Nevertheless, our data does corroborate on the "termination effect". This is shown by the estimate of the variable Expiry. This latter is in fact the number of years left (starting from 2001) until a PPP contract expires. The estimated coefficient of Expiry is positive and significant at 0.1%. This suggests that the further away in time a PPP contract is from its expiry date, the higher the observed water price is, *ceteris paribus*. The estimate shows that all else equal, water price will be about 1.16€ lower per 120m^3 of water when the contract is a year nearer to its term. This means that for a PPP with an average length of 13 years, water prices at the beginning of the contract could be about 13€ lower per $120m^3$, all else being equal.

Intermodal competition also contributes to a lower water prices, as the estimated coefficient of Share DM shows. Share DM is negative and highly significant: water prices are lower in *Départements* where the share of population being served in water services directly through their local public authorities is high, *ceteris paribus*. This is consistent with our vision according to which operators in areas where direct public management is dominant tend to curb their potential *ex post* opportunistic behaviour in order to enhance their probability of having their contract be renewed and/or to build up a good reputation in order to win contracts in the area. We have also run estimations on our switching regression model incorporating an interaction variable between Share DM and PPP, and we found that this interaction variable is significant, while estimates for other variables remains consistent with those we have provided here. This shows that intermodal competition does indeed have an impact on prices that consumers pay when their water services are run through a PPP. In other words, intermodal competition has a particular impact of water prices of PPPs. This observation corroborates our argument.

In general, competitive pressures do seem to contribute to greater efficiency, especially in terms of intermodal competition and competitive pressures generated in the process of an auction mechanism. Both types of competition contribute to lower observed water prices, as shown by our estimations. In addition to this, there seems to be a "termination effect" that contributes to lower water prices when a contract draws nearer to its term. Nevertheless, *ex post* competition, as we have discussed above, is not found to have a significant impact of observed water prices. These effects are robust and consistent: we have run estimations using operator price instead of total water price. We will not reproduce the resulting estimations here, but we observe that these variables are consistent with our estimates shown here. We are therefore confident on the robustness of our estimations.

To summarize, our estimates show that while PPP does not in itself directly lead to higher or lower efficiency, but consumers do pay higher water prices when their water services are run by certain operators (operator 2, 3 and 4) under a PPP, *ceteris paribus*. This is a first indirect effect of PPP on water prices. Another indirect effect of PPP on water prices paid by consumers is the "termination effect", reflecting the prices are lower when a contract is close to being renewed, and hence re–auctioned. As a result of such indirect effects, consumers pay on the average higher water prices when their water services are run under a PPP.

A priori, operators fixed premium are paid by consumers when a PPP is used can be due to several reasons: firstly, they could result from operator specific know–hows in running water services. When such knowledge is necessary to run water services in a local area, the local public authority establishes a contract with a given operator. This may explain why operator 2, 3 and 4 are compensated with a premium. However, this does not explain why premium paid to operator 2 and 3 are not significantly different, nor does it explains why operator 4, which is a joint–venture between operator 1 and 2, touches so high a premium. This last point is especially puzzling, since our estimate shows that operator 1 is not paid any premium for water services that it runs. Secondly, operator fixed premium may be necessary to incite operators to higher productive efficiency. When PPPs

are used, and when private operators have superior private information. In this case, to provide incentives to private operators to achieve higher productive efficiency, local public authorities will have to trade off allocative efficiency and productive efficiency even when auctions are used (Laffont and Tirole [1987], Laffont and Tirole [1993]). Operator premiums may therefore be a consequence of this. Finally, these premia could also be a consequence of collusion in the French water industry. As we have seen, the water industry is highly concentrated. This should facilitate collusion. However, we would like to stress that high concentration does not automatically lead to collusion, nor does the existence of operator fixed premia that we found. At this stage of our analysis, and given our data, we may only speculate on the sources of these premia. Nevertheless, we believe that these operators fixed premia is an indication of some inefficiencies in how water services are being organized.

PPPs also impact on water prices indirectly through the "termination effect". This effect is negative, indicating that when a PPP contract draws nearer to its end, water prices paid by consumers are lower. Symmetrically, this also indicate higher water prices are paid by consumers under a PPP when the PPP is just starting. These indirect effects of PPPs can be taken to indicate that some inefficiencies may still prevail in the French water sector, despite institutional and contractual arrangements used to organize the service, and competitive forces.

Both types of indirect effects discussed above may lead one to believe that certain productive efficiency gains from using private expertise in water production (through PPP) are not entirely passed down on consumers, or are passed on to them at a slow rhythm. Nevertheless, competitive pressures (auctions and intermodal competition) contribute to lower consumer prices in PPPs, and thus improve the efficiency of PPPs.

1.6 Conclusion

In recent years, there has been an increasing political demand to get the private sector involved in the operation and provision of services that are traditionally undertaken directly by public entities. One of the goals that underpin this trend is greater productive efficiency: private operators are widely perceived to be more efficient than their public counterparts. This trend can also be observed for local public services such as water services, garbage collection and public urban transportation. For such services, a way to benefit from private expertise is to use a PPP to form a partnership with a private operator. Indeed, full privatization of these services are often politically hard to achieve due to their inherent general public interest attributes.

An important advantage in using PPP resides in the fact that a local public authority using a PPP may use an auction mechanism to choose his private partner. Competitive pressures generated during the process may well substitute for the absence of market forces in the market that so often characterizes local public services. However, as Transaction Cost Economics pointed out, this could be true only if the contract auctioned off to a selected operator is fully specified and perfectly enforceable. Otherwise, *ex post* renegotiations may be needed to adapt the contract after the auction, leaving room for possible *ex post* opportunistic behaviour from both the operator and the local public authority. Even if PPPs are in fact partnerships between a public authority and a private operator, such contracts are not entirely exempt from the risks of *ex post* opportunism and other potential problems that could have plagued more traditional form of franchised contracts that leave an operator fully in charge of a service.

In this chapter, we argue that there are potentially two other types of competition that may exist where such contracts are concerned. Firstly, provision of a service can always be reverted back to public management. This is what we term intermodal competition. Secondly, other private operators may be interested in taking over an incumbent's contract when this latter draws to its term. This provides a source of potential competition during the contract renewal stage. We

called this *ex post* competition. We then argue that when the incumbent operator cares about renewing its transaction with a public authority, the former may want to curb *ex post* opportunism when the level of *ex post* competition and/or intermodal competition are high. Indeed, when both competitive forces are strong, a public authority may have better outside options, and an incumbent operator may have better incentive to avoid behaving too opportunistically. Consequently, efficiency should be enhanced with the presence of such competitive forces. Moreover, we expected that the effect of these forces could be stronger when an incumbent's contract draws nearer to its end.

We then empirically examine the efficiency of PPPs and the impact of competition from auction, *ex post* competition and intermodal competition using data on the French water sector. to the best of knowledge, ours is the only study to date that attempt to account for competitive forces in determining the efficiency of PPPs, while at the same time accounting for informal aspects of a PPP contract. We find that PPPs are endogenously chosen by local public authorities in France for their water services. In particular, political considerations, as well as economic rationality, underlie a local public authority's decision to use PPPs. More interestingly, we find that PPP *per se* does not directly lead to higher or lower water prices when compared to direct public management, once we account for the endogeneity of using PPP and for operator fixed effects. Our results stress that indirect effects are more important when using PPPs for water services. In particular, consumers could pay a positive operator premium when their water services are run through PPPs. More specifically, consumers whose water services are run by operator 1 are not subjected to a operator premium, whereas consumers whose water services are run by operator 2, 3 or 4 pays significantly higher operator premium. Another indirect effect of PPP is the "termination effect", according to which water prices in PPP contracts tend to decrease as contracts are closed to being renewed.

On the other hand, we also find that contracts signed after 1993 exhibit significantly lower prices than those signed before. 1993 is the year when competitive tendering procedures are made compulsory for local public authorities, and hence

we interpret our results as a crude average of effects stemming from competition in an auction. According to our estimates, observed water prices are about 10€ lower per 120m^3 for contracts signed after 1993, all else being equal. We are however, unable to find any evidence on the effects of *ex post* competition on water prices. This could be due to an inadequate measure of *ex post* competition effect: we have computed this variable to measure concentration in the water sector at a *Département* level. This is perhaps not the best measure of *ex post* competition, especially for municipalities located at the border of a *Département*. To the best of our knowledge, our study is the first to consider competitive effects and efficiency of PPPs in the French water sector, taking into account both *ex ante* and *ex post* dimensions of how water services are organized. We are neither aware of any previous study that disentangles direct and indirect effects of using PPPs.

We also believe that indirect effects of PPPs that we have found in our study highlight possible inefficiencies in using PPPs to provide water services in the French water sector. This raises the question of whether such possible inefficiencies may be further reduced, so that benefits from using private expertise for water provision in particular, and local public service provision in general, could be pass on better to consumers. One possible means to this end could be to introduce some regulations in this sector. A particular interesting regulatory instrument in this case is yardstick competition, through which competition may be artificially created. Moreover, such an instrument is being used in the UK to regulate the water sector. This indicates that it could be readily applied to regulate the French water sector too. This leads us to ponder on the use of regulations for local public services in the following chapter.

More generally, our results point to the fact that efficiency on how local public services are organized has to be analyzed as a whole, and one should not focus merely at the *ex ante* stage contracting stage and/or auctions stage. As we have seen, at the *ex post* stage, informal mechanism may affect efficiency and therefore, should be taken into consideration as well. However, our treatment on the effects of informal mechanisms on PPPs do not allow us to have a clearer picture of when these mechanisms may be important. While it seems that subjective awarding

criteria in auctions are necessary in order for such informal mechanisms to play a role, it is not unclear from our study if such a framework could do better than objective awarding criteria in auctions. This suggests that further research into the articulation of both *ex ante* and *ex post* dimensions of a contract auctioned is needed.

Chapter 2

Yardstick competition vs. individual incentive regulation: What has the theoretical literature to say?*

2.1 Introduction

Due to the natural monopolistic dimension inherent in most local public services, a way for a local public authority organizing the service to benefit from competitive pressures and private expertise is through using auction mechanisms to attribute a complete contract for such services. Demsetz [1968] was among the first economists to suggest that competition *for* the market may be a substitute for the absence of normal competition in a market. Such a solution is attractive, in that it may allow a local public authority to avoid substituting market failures with regulatory failures, as pointed out by Demsetz [1968].

Nevertheless, as we have mentioned in the previous chapter, Transaction Cost Economists pointed out that such an approach has its own limits during the three principal contracting stages when it is implemented: the *ex ante* auction and contracting stage, the execution stage of the contract and the renewal stage

*This chapter is adapted from a working paper with the same title (Chong [2006b]). We thank Emmanuel Reynaud, Steven Tadelis and participants of the ATOM seminar for their helpful comments and criticisms. The author bears all responsibility of errors and/or omissions.

of the contract. Various problems may involve the winner's curse during the bidding stage, *ex post* renegotiations and opportunisms during contract execution, and the fact that an incumbent operator may be advantaged during the contract renewal stage etc.. This latter aspect would dampen competitive benefits of future auctions. In practice, such a solution may well require a public authority to intervene *ex post* in place in order to adapt the initial contract to conditions during contract execution stage (Williamson [1976], Goldberg [1976], Goldberg [1977]). One may note here that in this case, the franchise bidding mechanism *à la* Demsetz [1968] would turn out in practice to resemble to some forms of regulation, the very situation that such a mechanism initially seeks to avoid (Yvrande-Billon [2004]).

In the previous chapter, we have argued that hybrid organizational forms such as Public Private Partnerships (PPP)s, and informal mechanisms such as *ex post* competition and/or intermodal competition may help to contain inefficiencies due to potential *ex post* opportunism from a private operator, and thus reduce *ex post* "regulatory" burden of a public authority. We then tried to empirically examine the efficiency of PPPs and the role that these competitive pressures may play on the French water sector. We found that while auctions contribute to significantly lower water prices, PPPs tend to lead to higher prices for consumers indirectly. More precisely, water prices paid by consumers under a PPP contract are found to be decreasing when the contract is closer to renewal, and consumers whose services are run by certain (not all) operators are subject to a positive premium. While we were unable to determine why these premia exist, we offer several possible reasons for their existence: operator–specific know–how in running a given service, asymmetric information to the benefit of private operators, or possible collusive behaviour. As we have argued, the first reason seems unlikely, as we have controlled for characteristics of water services run. In any case, these indirect effects leading to higher water prices paid by consumers whose water services are run through a PPP suggest possible prevailing inefficiencies in the way the French water sector is organized. More precisely, it seems that benefits from using private expertise to provide water services have not been passed on to consumers. A legitimate question that arises is therefore the following one: can the use of

some regulatory mechanism be able to enhance consumer welfare, in ensuring that consumers may better benefit from private expertise used to run local public services?

More particularly, given that some *ex post* intervention may already be practiced even when PPP contracts are attributed through an auction, leading to some "informal" regulation, a more relevant question would be: can formal regulations may be more beneficial, since *ex post* adaptations will be more organized? Indeed, there are some forms of "informal regulation" at play if local public authorities intervene *ex post* to adapt the initial PPP contracts to local realized conditions for the operation of associated services. An advantage in using more formal mechanisms can stem from a better coordination in efforts to make *ex post* adjustments on how local public services are provided.

Indeed, a major difficulty when one seeks to intervene *ex post* to adapt the provision of local public services to *ex post* conditions and environment stems from the access to operators' superior and private information. This is the issue of asymmetric information, and it has received widespread attention from the economic literature (Baron and Myerson [1982], Laffont and Tirole [1993], Armstrong and Sappington [2006] etc.). More specifically, even if observed costs are known, a public authority seeking to intervene lacks knowledge on how efficient an operator really is, or on how efficient can an operator possibly and reasonably become. Economic theory shows that this information can be solicited. To obtain this information, or consequently, to reduce inefficiencies due to a private operator's superior information on its own costs, this latter should be entitled to some rents. In other words, (costly) informational rents have to be given up in order to provide adequate incentives to operators to perform efficiently, or to have access to their private information.

Riordan and Sappington [1987] and Laffont and Tirole [1988] show that even when auctions are used, in presence of asymmetric information, a public authority must give up some informational rents to the selected private operator. However, the magnitude of such rents depends on the competitive pressure during the auc-

tion. In Laffont and Tirole [1988]'s setting, private operators may moreover endogenously bring down their costs. They find that an auction mechanism plays no role when a public authority seeks to incite a private operator to better productive efficiency. In other words, the resulting incentive contract does not depend on whether an operator is chosen through an auction or not.[1] Our observation on operator–specific premia obtained in the previous chapter is consistent with this theoretical perspective of regulation under asymmetric information.

In this perspective, an advantage of better coordination that may be achieve through more formal regulation mechanisms is the possibility for public authorities to benefit from positive informational externalities.[2] Indeed, local public services are often monopolistic only on a local scale. Consequently, at the national level, observations on a particular service run by different operators in different municipalities or regions are (or can be made) available. Such information can then be used to uncover, to a certain extent, an operator's hidden information and/or to provide incentives and enhance social efficiency when using private operators for local public services. Arguably, some coordination is needed in order to for public authorities to have access to better information in this way.

This suggestion was first advanced by Shleifer [1985], who argues that such observations on different operators or local markets could be used to deduce their private information, and to regulate them consequently. More specifically, Shleifer [1985] proposes that an operator's compensation should be made dependent on performances of other similar and comparable operators[3], and he term this type of regulation as "yardstick competition". Obviously, such a scheme may allow costly informational rents to be saved up, and provides incentives to operators

[1]This is termed as the "separation property" (Laffont and Tirole [1988], Laffont and Tirole [1993]).

[2]An interesting study into the benefits of informational externalities is Auriol and Laffont [1992] The authors show that in some cases, it is optimal to duplicate fixed costs in a monopolistic industry in order to create a duopolistic structure, and thereby benefit from informational externalities. Inefficiencies due to duplicated fixed costs may be outweighted by lower informational rents paid to a monopoly in presence of asymmetric information.

[3]By similar operators, we mean operators that are comparable among themselves. While operators do not need to be identical, the regulator using yardstick competition should be able to account for heterogeneous factors affecting the operators. Such factors may arise from the operators" production technologies or environments in which they operate.

in order to achieve better productive efficiency. Yardstick competition has been implemented for instance in the British water industry (Sawkins [1995] ,Cowan [1997]), in the Norwegian bus industry (Dalen and Gómez-Lobo [2003] and in the Japanese passenger railway (Mizutani [1997],Okabe [2004]).

A question that arises would be: would using yardstick competition to regulate local public service be desirable? This is the question we seek to reply through a review into the theoretical literature and by comparing results between yardstick competition (or more generally a relative performance mechanism) and individual incentive regulations. Here, we will define yardstick competition (or relative performance evaluation) as a scheme that makes an operator's financial outcome dependent on its relative performance *vis–à–vis* its peers, and individual incentive regulation as a scheme that makes an operator's financial outcome dependent only on its own observable performance. One may think that the current practice in France, where the local public authority is in charge of organizing local public services, is akin to a decentralized individualistic type of regulation, if they intervene *ex post* indeed to adapt their PPP contracts. In any case, as we have mentioned above, such a configuration may leave the operator with some rents. This may be manifested through the indirect inefficiencies of PPPs that we found in our empirical study. It follows naturally from our discussion from the previous chapter that we should consider the possibility of using regulatory tools here.

Obviously, in order to use yardstick competition, a national regulator will have to exist in the first place. To get clear picture on whether yardstick competition should be put in use for water services in France, one would also have to weight the pros and cons of the current situation which involves some decentralized "regulation" on an individualistic level, to the situation where a national regulator exists and administer a centralized regulatory policy. While this institutional aspect is essential to our question and interesting in itself, we will rather contained ourselves to comparing the relative performance of yardstick competition and an individualistic type of regulation.[4] By focusing on the hypothetical case that a

[4]Laffont and Sant-Zantman [2002] examine the difference in terms of efficiency when decision on policies on public good provision are made at a centralized level or when they are made at a more decentralized level. They show that the choice between a more or less centralized structure

national regulator exists and has to choose between yardstick competition or individual regulatory schemes, we hope to achieve greater compatibility in terms of our comparison between the two types of regulation. Nevertheless, the importance of a centralized versus decentralized way of organizing these services cannot be stressed enough. We leave such a question for future work.

The objective of this chapter is therefore to study the strengths and limits of both types of regulation *per se*. It seeks only to uncover some necessary conditions where yardstick competition would allow a regulator to achieve higher efficiency, and therefore provide a first step towards a thorough assessment on whether yardstick competition should be adopted for local public services in general, and water services in France in particular. We find that yardstick competition will generally performed better than individual incentive regulations (such as price cap regulation) both from a static perspective and from a dynamic perspective when there are some common factors that impacts on how operators run the local public services. These factors may be common uncertainty faced by operators when running the provision of a given service, and/or some similarities in the technologies that they use to run the service. In this case, informational costs to have access operators' private information are reduced under yardstick competition, and better incentives can be provided to operators to enhance their productive efficiency. Consequently, consumer welfare is enhanced. Nevertheless, a major difficulty that arises from using yardstick competition could reside in how relative performances of operators may be measured. While various empirical methods can be used to this end, measures yield by these methods may differ substantially. As a result, operators may bear unjustified risks that are artificially introduced only through the measure(s) chosen by a regulator. In this case, the efficiency of using yardstick competition is undermined.

This chapter is organized as follows: we start by considering presenting a static multiple agent setting to study yardstick competition and individual schemes (sec-

can be seen as a trade off between benefits from better information at the decentralized level (that a centralized authority may be unable to completely elicit from decentralized authority(ies)) and benefits from the internalization of external effects or political distortions if the decentralized authority is not benevolent.

tion 2.2). We briefly discuss some works on agency theory in a multiple agent setting first before discussing yardstick competition and individual regulation in a static framework. We show that yardstick competition can do better than an individual one when performances are correlated. This is followed by a discussion into the relative dynamic efficiency of both types of regulation, since regulation between operators and a regulator is often repeated in time (section 2.3). We distinguish two types of dynamic efficiency in our discussion. Firstly, we study how operators will strategically hold back their information from the regulator over time in order to maintain their rents through time. In other words, we study potential "ratchet effect" in this subsection (subsection 2.3.1). In a subsequent subsection (subsection 2.3.2), we study the case when operators may influence their productivity over time. Operators could enhance their productive efficiency over time by investing. Operators may decide to limit their investments if they anticipate that they would not be able to fully benefit from future improvements related to their investment decisions. This is the "hold–up" problem. In our discussion, we focus on both cases under the assumption that the regulator has limited commitment powers. Indeed, it is well known by now that commitment powers of a regulator play an important role in determining the dynamic efficiency of contracts. Finally, we examine some limits that could result from relative evaluation mechanisms, and we analyze if an individual incentive regulation could do better in these cases (section 2.4). A first danger resides in possible quality deterioration when yardstick competition is used, since operators may have a sharper incentive to reduce production costs. Then, we look into how yardstick competition may be implemented in practice. This leads to the question on how relative performance may be measured, and the consequences of measurement on regulated firms' behaviour. Lastly, firms may possibly collude under yardstick competition due to the competitive pressure inherent in this regulatory policy. We briefly review some existing work on this dimension in this chapter. Concluding remarks come after.

2.2 Relative performance evaluation in a multiple agents setting

The problem of regulatory policy under asymmetric information is analyzed in the economic literature using agency theory. This is why we start by looking into incentive contracts when the principal is confronted with either one agent, or multiple agents. We will first consider the case when a principal is only confronted with a moral hazard problem (subsection 2.2.1). We then turn towards the literature that also accounts for adverse selection problems faced by a principal (subsection 2.2.2). Finally, we discuss on how and when such relative performance evaluation tools may be used to regulate operators (subsection 2.2.3).

2.2.1 Multiple agents and the moral hazard problem

In a classical moral hazard problem, a principal is unable to observe or monitor an agent's actions or efforts that could have an impact on the agent's output.[5] As efforts could be costly in terms of disutilities for an agent, the agent will not assign appropriate level of effort or take adequate actions from the principal's point of view. To motivate the agent to take actions that is aligned with the principal's interests, the latter will have to provide incentives to the former.

It is now well known in the literature that the optimal contract under moral hazard when the principal is confronted with a single agent depends crucially on the agent's attitude towards risks. It can be shown[6] that when the agent is risk-averse, and assuming that the principal is risk-neutral, then the principal will have to trade off risk sharing and incentive provision. Indeed, the incapability of the principal to observe the agent's actions results in the fact that the principal will want to make the agent's payoff dependent on its own output, which is the only observable variable (and which is informative on the agent's action). As

[5]More precisely, an agent's action will have an impact on the likelihood of the outcome. For instance, an agent could increase the probability of having a higher output if it puts in more efforts.

[6]See for instance, Laffont and Martimort [2002] for an in-depth discussion.

the agent's output is random in nature, such a payment scheme will inevitably introduce some risks for the agent. As a result, there is a conflict between incentive provision and risk sharing in the contractual relationship. The full-information solution cannot be attained in this case, as the principal cannot fully insured the agent (by offering a fixed payment regardless of the agent's output, as would be the full information case) in order to provide incentives so that the agent will take actions that is aligned with the principal's interest.

However, when the agent is risk–neutral, the full information first–best contract can be achieved. Incentives are then provided by making the agent's payoff dependent on its output, without the need for the principal to insured it against the risk. There is no trade–off between insurance and incentives in this case.

Let us now suppose that besides an agent's output x, the principal can observe a verifiable supplementary signal z. From Holmström [1979], we know that if x is a sufficient statistic for $\{x, z\}$ with respect to the agent's actions, then the optimal contract will not depend on z . In other words, if a signal is completely uninformative (with respect to the agent's action), using it in the agent's contract will only add noise to its payment scheme, and adding noise to an agent's pay is almost never beneficial (Holmström [1979]). Another direct implication of this result is that when z is informative, the principal should make the agent's payoff dependent on the signal. Let us note that this result applies whether the agent is risk-averse or risk-neutral.

One could easily extend this to the multiple agents case, where the principal's problem is to determine the vector of each agent's actions and their respective payoffs. To this end, the principal is confronted with two problems: firstly, he has to ensure that an agent will participate in the transaction. In other words, the resulting contract must satisfy each agent' participation constraints or individual rationality constraints. Secondly, the principally has to account for the fact that that given a payment scheme, an agent's action will depend on other agents' actions. This leads to Baiman and Demski [1980] and Holmström [1982]'s result that relative performance evaluation is generally better off than an independent

one when the agents' (observable) output is not independently distributed. Indeed, when $T(x)$ is a vector of sufficient statistic based on x, the vector of all agents' outputs, for each agent i's action, the optimal payment scheme of each agent i should be based on $T_i(x)$. The reason for this is that $T_i(x)$, as a sufficient statistics, contains all relevant information on an agent i's action. In other words, relative performance evaluation would generally do better than an individual one when agents' outputs are not independent. This is the case because other agents' outputs become informative signals for the principal on a particular agent's hidden action.

In particular, as Nalebuff and Stiglitz [1983b] and Nalebuff and Stiglitz [1983a] show, incentive provision is enhanced under relative performance evaluation scheme because common uncertainties affecting the output of all agents are "filtered" out under such a scheme. As a consequence, a principal need not insure agents against such risks, which allow him to better provide incentives.

One direct implication of this result is that *it is valueless to reward agents according to their relative performance if there is no common underlying uncertainty.* Another implication is that rank-order tournaments (Lazear and Rosen [1981], and Green and Stokey [1983], which awards prizes based on ordinal rankings, is suboptimal. Indeed rank statistics, not being sufficient statistics, contain rarely all relevant information. As such, it is informationally wasteful to use such schemes. However, one should note that, as Green and Stokey [1983] show, when the number of agents is sufficiently large, rank statistics can be an accurate estimator of agents' actions.

In fact, relative performance evaluation is not only useful to the principal when there are common underlying uncertainties. Mookherjee [1984] shows that when there is no common underlying uncertainty, but "production externality", relative performance evaluation is also optimal. In other words, relative performance evaluation schemes may also allow the principal to achieve the first best outcome. By production externality, Mookherjee [1984] means the case where the output of an agent is dependent on the output of another agent. In other words, when

Table 2.1: Optimality of relative performance evaluation and individual scheme: moral hazard

	Agents' outputs correlated	Agents' output independent
Risk-averse	relative evaluation	individual
Risk neutral	relative evaluation	individual

output of agents is correlated in any manner, relative performance evaluation would generally be preferred over an individual payment scheme based solely on the particular agent's output. In Mookherjee [1984]'s case, the added value of a relative performance evaluation scheme resides in the fact that the principal is able to use one agent to "police" or monitor the other agent's outcome, and therefore allows the former to create better incentives. Ma [1988] pointed out however that this observation hinges on the assumption that agents are able to perfectly observe each other's actions. Otherwise, unique second best implementation can be more demanding than the simple optimal sharing rules found in previous studies.

Nalebuff and Stiglitz [1983b] and Nalebuff and Stiglitz [1983a] find another advantage to using relative performance evaluation mechanisms when the principal is confronted with several agents: they argue that such a mechanism is more flexible than an individual scheme in providing incentives, as individual incentive schemes tend to be tailor to specific situations. On the other hand, since agents' performances are evaluated comparatively under a relative performance evaluation scheme, common changes in the agents' operating environment are automatically accounted for. This makes it less necessary to change the incentive contract to adapt to changes in the agents' common environment. Hence, for the authors, when an environment is fast changing, the principal should prefer a contract based on relative performance evaluation because of its greater flexibility.

From this subsection, two conclusions can be derived: firstly, similarities in the firms' operating environment make their performances comparable; and secondly, using relative performance evaluation mechanisms allow the principal to do better than an individual scheme whenever agents' observed outputs are correlated in any way as a result of common uncertainties that affect the agents' outputs. From

our discussion above, we can reach the following proposition in terms of relative performance between yardstick competition and individualistic regulation:

Proposition 1 (Incentives provision and uncertainty)**.** *Yardstick competition allows a regulator to enhance incentives provision in comparison with individual incentive schemes whenever*

(i) there are underlying common uncertainties in firms' operating environment; or

(ii) firms' actions have an impact on the relative performances of their counterparts, and they are able to observe each other's actions hidden from the regulator.

The first part of the proposition is due to the fact that relative performance evaluation mechanisms allows the principal to better shelter the firms from common risks without diminishing incentives (even if the firms are risk-neutral), while the second part stems from the fact that the principal can create incentives by using agents to police against each other.

2.2.2 Adding adverse selection to the problem

In addition to moral hazard, a principal may be unable to observe some relevant private information on an agent. In this case, the principal will also be confronted with an adverse selection problem.

Demski and Sappington [1984] study this issue both in a single agent setting and in a multiple agents setting. In their study, they assumed two agents, each characterized by an adverse selection parameter that can take two different values with a certain probability. Output of an agent is a function of their respective adverse selection parameter and each agent's action or efforts. The two adverse selection parameters are positively correlated, which means that if one agent has a certain value (for instance, a high productivity), it is more likely that the other agent will have a similar value (that is high productivity) rather than another one (that is low productivity).

Under their assumptions, an individual scheme (for risk neutral agents) will lead to the second best: in this case, the regulator will have to distort the agent's efforts and will give up some rents. The reason is simple: since the agent has some private information that it could use to its advantage that the principal cannot foresee, the latter will have to make the agent reveal this information by giving it rents. Since rents are costly, the principal will have an interest to distort efforts in order to make a contract less interesting for a more advantaged agent to pretend to be a less advantaged agent. The resulting optimal contract thus trades off rents and efforts, *i.e.* allocative efficiency and productive efficiency.

However, making agents reveal their private information is easier when the principal is faced with two agents. The principal can then devise payment scheme for an agent based on its own output and on the other agent's output. By doing so, they show that there exists payoffs for the agents contingent on their output that could lead to the full information first–best outcome. In fact, the principal will specify four payoffs in this case, depending on whether an agent's output is high or low, and depending on its counterpart's output. They show that such a payment scheme satisfies both the agents' participation constraints at their reservation utility (allocative efficiency), and incentive constraints. There will neither be any productive inefficiencies that arise from such a scheme, allowing them to conclude that when output of the agents are correlated, and when the agents are risk-neutral, the principal can achieve the full information outcome even when agents detain private information.[7] More generally, Crémer and McLean [1985], Crémer and McLean [1988] and McAfee and Reny [1992] show full extraction of rents is possible when there exists the slightest correlation in agents' private information. In other words, the principal is able to achieve the full information outcome with even the smallest correlation in the agents' private information. They derive their results using an auction setting. Note however that this is an extremely strong result, and even Crémer and McLean [1988] pointed out

[7]In fact, they suggest treating the agents asymmetrically in order to achieve a better result: the principal would preferred an incentive scheme that constrained an agent to report truthfully as a dominant strategy and the other agent is constrained to report truthfully as an equilibrium response. The reason behind this is that we would have a subgame undominated strategy equilibrium here, while in the other scheme, we have not explicitly consider what other strategy the agents might adopt.

themselves that, "...[e]*conomic intuition and informal evidence ... suggest that this result is counterfactual...*".[8]

What is important is that when the firms' private information is correlated, the regulator can benefit from informational externalities. Private information therefore can be acquired more easily and costlessly.

2.2.3 Implications on regulation

Shleifer [1985] was among the first to apply relative performance evaluation mechanism to regulate local monopolies. He shows that by breaking up the dependency of a firm's[9] payoff on its own performance (which is basically cost of service regulation), and relating it to other firms' performances, the regulator could artificially create some competition among locally monopolistic firms. Concretely, he suggests that a regulator should construct benchmarks through statistical or econometric methods, and set his regulatory policy (price policy and transfers if desired) based on such benchmarks. This would make a firm's payoff dependent on the actions of its peers, and therefore instigating competition among them. He terms this regulatory policy *yardstick competition*. Such a scheme would, he shows, will allow the regulator to deliver the first–best equilibrium.

It should be noted that Shleifer [1985] considers the case where there is no adverse selection, and that the firm's performance depends deterministically on its efforts or cost reducing investments. As firms are further assumed to be risk-neutral and the regulator only cares about global social surplus, it is not clear why the regulator could not use an individual incentive scheme and make each firm residual claimant on its own cost-savings.

When we take adverse selection into account, Laffont and Tirole [1986], Laffont and Tirole [1993] show that an individual incentive contract will imply the same trade off as discussed previously. In the optimal contract that ensures that a

[8] See Crémer and McLean [1988], page 1254.

[9] We will use the terms "firm" and "operator" indifferently to refer to private operators.

firm truthfully reveals to the regulator its private information, the regulator will depress efforts in contracts intended for a less productive firm, with distortion at its maximum in the contract intended for the least productive firm. The reason is that rents can be socially costly. When rents are not costly, Sobel [1999] shows that an individual incentive regulation can deliver the first–best outcome just as yardstick competition. He concludes that *yardstick competition is thus better when there are shadow costs to social funds.*

Why is this so? The reason is that yardstick competition can help the regulator in compelling firms to reveal their private information: making comparisons across firms allows the regulator to avoid soliciting directly the firms' for their private information. As a result, yardstick competition reduces the informational costs that have to be incurred by the regulator in order to have access to this private information. Dalen [1998] and Tangerås [2002] both show clearly how this is done, by appealing to the Revelation Principle and by using a stochastic structure assumption on the firms' private information introduced by Auriol and Laffont [1992].

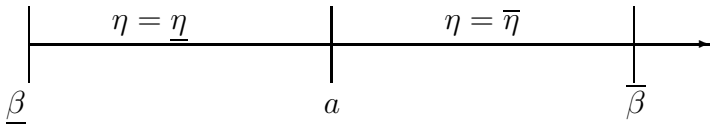
Auriol and Laffont [1992] study informational externalities brought about by a duopolistic market structure, assuming that a firm's adverse selection parameter is comprised of two parts. Let us note β_i the adverse selection parameter of firm i. Auriol and Laffont [1992] assume that firms' private information is a linear function of a common random variable and an idiosyncratic one:

$$\beta_i = \alpha\eta + (1-\alpha)\varepsilon_i, \quad i = 1, 2.$$

The authors assumed also that the common part of the parameter, η, can take on two values $\{\underline{\eta}, \overline{\eta}\}$, while the idiosyncratic part, ϵ_i, is identically and independently distributed on a continuous support. η can be seen as an industry–wide productivity parameter, while ε_i is a firm–specific productivity parameter. The correlation between firms can then be measured by α. They assume moreover that α will be such that the distribution of the adverse selection parameter can be "split up" into two distinctive intervals. Specifically, when there are two firms, both will either have their adverse selection parameter in the right side interval

or in the left side interval, as depicted in figure 2.1.[10]

Figure 2.1: Stochastic structure of β_i in Auriol and Laffont [1992]



The regulator can thus detect and punish incompatible reports made by firms. Indeed, as firms should both belong to the same interval, whenever reports made by the firms do not fall into the same interval, the regulator would know which firm is attempting to withhold information. Given this specific stochastic structure, the regulator now dispose of means through which he can compel firms to reveal their private information.[11]

Dalen [1998], Auriol [2000], Tangerås [2002] and Tangerås [2003] use the same stochastic assumption to show that yardstick competition reduces the regulator's informational costs. In Tangerås [2002] for instance, firms are first asked to summit a report on their common adverse selection parameter. Since the regulator can dissuade any untruthful reports, the regulator will be able to propose the optimal individual incentive contracts in each interval after receiving reports on firms' common adverse selection parameter, having only to induce the firms to reveal their idiosyncratic adverse selection parameter in this second step. As the common uncertainty is filtered out in the first step, adverse selection asymmetry is reduced, enabling the regulator to save up a part on costly informational rents. This in turn allows the regulator to impose less effort distortion on firms in their contracts. As a whole, yardstick competition delivers a better solution.

Principally, the analysis from this section allows us to shed some light on three questions: firstly, when can yardstick competition be used? Secondly, how can we define "comparable" firms? And thirdly, when is yardstick competition desirable?

[10]The assumption on α also makes it impossible for the regulator to extract all rents from regulated firms when there is the slightest correlation in firms' private information, as in the case of Crémer and McLean [1988] for instance. Auriol [1993] provides an in–depth discussion on this issue, and provides an analysis using a more relaxed stochastic structure for the firms' private information.

[11]The author suggest punishing lying firms to this end.

If a regulator wants to use yardstick competition, obviously he would need to have some comparable firms so that he could benefit from informational externalities from them. Firms are comparable relatively to two aspects: similarities in their operating environment, and/or similarities in their production technologies. What is more problematic is whether the regulator can use a comparable firm that is not directly under his own jurisdiction. The reason is that different regulatory constraints could introduce some heterogeneous factors, and comparing a national firm against a foreign one operating under another regulatory could yield undesirable results for the regulated national firm. Proposition 2 resumes this discussion:

Proposition 2. *Yardstick competition can deliver a better outcome from a static efficiency point of view whenever there are some shadow costs of public funds, and whenever firms' performances are correlated. Firms' performances are said to be correlated when*
(i) firms' performances are affected by common environmental variables; and/or
(ii) firms' production technologies are correlated.
In the case where there is no shadow costs to public funds, an individual scheme is as good as any scheme based on relative performance evaluation mechanism.

It is quite clear from this section that yardstick competition allows the regulator benefits from informational externalities. Information costs are reduced because the regulator can exploit the underlying correlation between agents' private information to compel the agents to reveal their private information. As a result, less information rents needed to be given up. This also allows the regulator to avoid depressing as much productive efficiency as he would have needed to under an individual incentive scheme. In other words, the regulator could provide better incentives under yardstick competition. This is because common part of firms' private information can be "filtered out" through yardstick competition, leaving the firms with "less" private information. For a regulator, informational costs can be high when there are some shadow costs to public funds, or when a regulator values more consumer surplus. In these cases, yardstick competition enhances welfare in comparison with individual regulatory schemes.

2.3 Dynamic efficiencies of yardstick competition and individual incentive regulation

In reality, the relationship between a regulator and the regulated firms are dynamic in nature. When this is true, a regulatory policy can produce effects over time. This in turn can have important implications on the behaviour of regulated firms. Moreover, firms' performances over time, and consequently social welfare, may depend on investments that firms undertake. This is especially true where local public services are concerned. For instance, where water services are concerned, heavy infrastructure are involved in the production and distribution of water. In order to run these services efficiently over time, a regulator needs to ensure that regulated firms invest adequately. As the economic literature has amply shown, dynamic efficiency of a regulatory policy, whether investments are involved or not, depends essentially on the power of the regulator to commit to his policy. More specifically, dynamic efficiency of a regulatory scheme depends on whether a regulator is able to commit to avoid exploiting information revealed by a regulated firm or to expropriate rents stemming from investments that have been undertaken previously by the regulated firm(s). If the regulator has limited (or no) commitment power to future policies, a "ratchet effect" may arise in the first case, while in the second case, there may be a "hold up" problem. In the following, we will briefly discuss dynamic efficiency of yardstick competition and individual incentive regulation with respect to these aspects.

2.3.1 The ratchet effect

It is well known by now that when an individual incentive regulation is used, the ability of a regulator to commit *ex ante* over time to his regulatory policy is crucial in determining the dynamic efficiency of the regulatory scheme (Laffont and Tirole [1993]). The authors show that if a regulator has full commitment powers, then the optimal dynamic policy will merely duplicate the optimal static policy in each period. However, when the regulator has limited commitment powers, he may be tempted to exploit the regulated firm's private information once this is

revealed to save up on informational rents. Anticipating this, the regulated firm will be reluctant to truthfully reveal its private information in this first place, thus compromising the efficiency of the regulatory policy. This is the ratchet effect.

The optimal individual incentive scheme in a dynamic setting depends therefore on the regulator's ability to commit himself to a scheme. In particular, Laffont and Tirole [1993] distinguishes three principal cases according to the regulator's commitment power:

- The case of perfect commitment powers: As mentioned above, the optimal scheme in this case is simply the optimal independent static policy for each period. A regulator would avoid the ratchet effect, but achieve a second best outcome during every period.

- The case of "moderate" commitment powers: This case corresponds to the situation where the regulator and the regulated firm may write binding long–term contracts, but are unable to commit to not renegotiate the initial contract when such renegotiations are *ex post* Pareto efficient (so that both parties will agree to renegotiate). The optimal policy then depends on the regulator's and the firm's discount factor. When this discount factor is high, the regulator may refrain from soliciting the firm's private information. He does this by proposing during the first period with some positive probability to offer one contract that does not allow him to learn the regulated firm's information (instead of the usual menu of contracts). In other words, he uses a pooling strategy. The higher the discount factor, the more likely the regulator will use a pooling strategy.

- The case of no commitment power: In this case, the regulator cannot specify the policy that he will implement in future periods until they start. The optimal individual regulatory policy again depends on the parties' discount factor. With small to moderate values of the discount factor, the regulator solicits the firm for its private information during the first period, at the price of costly information rents and distortions in productive efficiencies. The full information outcome in implemented in subsequent periods. When discount

factor have high values, partial pooling strategies is again implemented.

The above results are discussed in Laffont and Tirole [1993] or Armstrong and Sappington [2006] in further details. Partial pooling strategies[12] are a way for the regulator to increase his "commitment powers" by assuring firms that he will not extract their rents with a certain probability. Notice as well that when the regulator cannot commit himself, distortions that will be introduced can depress productive efficiency so much that it would be preferable that he does not have access to the firm's private information. The regulator uses the pooling scheme in this case. In a nutshell, in order for the regulator to achieve the *ex ante* optimal equilibrium, he has to consent to some productive inefficiencies. Inefficiencies that a regulator foregoes will be more important the more limited is his commitment powers. Moreover, social welfare is shown to decrease as the regulator's commitment powers deteriorate.

Meyer and Vickers [1997] and Faure-Grimaud and Reiche [2006] both study the ratchet effect under yardstick competition. In Meyer and Vickers [1997]'s setting, when the regulator cannot explicitly use relative performance evaluation mechanism, comparing agents' performance is beneficial when the correlation of agents' temp-invariant hidden characteristics is stronger than their time-dependent one. In fact, when the time-invariant characteristics is strongly correlated, the regulator could rely less on other agents' performance to infer its value for a certain agent. To the extent that an agent's second period payoff depends less on another agent's first period performance, the agent would be less constrained to restrain its first period efforts, thereby dampening the ratchet effect. They further argue that the British regulatory policy has such an "implicit" yardstick competition feature, as comparisons are only used during price cap reviews. When one consider explicitly an agent's pay on performance of its counterparts, they show that yardstick competition can have two effects: an insurance effect that is always positive, and the ratchet effect that is ambiguous. Note that Meyer and Vickers [1997] are not interested in extracting the agents' private information. They are only concerned

[12]That is the regulator induces with a certain positive probability to use a policy that does not allow him to know the firm's private information.

with how the principal may provide incentives to motivate agents' to take actions in the principal's interests.

However, Faure-Grimaud and Reiche [2006] show that the regulator is not subject to any ratcheting under yardstick competition even if he is not able of any commitment. More precisely, they show that if a regulator lacks commitment powers, it is not possible to implement the optimal correlated mechanism in each period. However, the regulator optimally solicits the firms' private information during the first period without giving up any informational rents, regardless of the discount factor.[13] This is achieved by the fact that even if regulated firms are tempted to ratchet the regulator individually, they are discouraged from doing so by the form of yardstick competition used. In particular, the regulated firm who ratchet the regulator will incur an important loss under the mechanism proposed by Faure-Grimaud and Reiche [2006], given that other firms do not and their private information are correlated.

As the literature stands currently, there seems to be a certain discontinuity when we go from individual incentive regulation to yardstick competition when firms' private information are correlated. In the former case, dynamic efficiency depends on commitment powers of a regulator, while in the latter case, the ability to commit seems to be irrelevant and does not induce any ratcheting in equilibrium. Based on these observations, we are led to the following proposition:

Proposition 3 (Dynamic efficiency)**.** *A regulator ability to commit is irrelevant under yardstick competition. Yardstick competition allows a regulator to achieve higher dynamic efficiency, except when there is no shadow costs to public funds (or when the regulator does not care more for consumer surplus) and the regulator has perfect commitment powers.*

Proposition 3 follows directly from Faure-Grimaud and Reiche [2006]. In particular, yardstick competition may be expected to yield a higher dynamic efficiency because, in the authors' case, regulated firms' private information can be costlessly solicited, while under an individual incentive regulation, information rents still ac-

[13]In other words, the regulator will never adopt any pooling strategies.

crue to firms even when a regulator has perfect commitment power. In this latter case, informational rents are costly only when there are some shadow costs of public funds (or when a regulator cares more for consumer surplus than producer surplus). Furthermore, given that efficiency of an individual regulation scheme decreases when a regulator lacks commitment powers, yardstick competition allows a regulator to achieve better dynamic efficiency.

However, we would like to note that caution should be exercised when it comes to Proposition 3. Indeed, that commitment capacity plays such an important role in the dynamic efficiency of individual incentive regulation and becomes irrelevant when it comes to yardstick competition is in itself an extremely strong result. So is the observation that no informational rents has to be given up by a regulator to solicit the firms' private information. This latter result is in fact a dynamic version of the result derived by Crémer and McLean [1988]. Moreover, one cannot be sure from the authors' setting that truthful revelation is indeed the *unique* equilibrium outcome. On top of this, we suspect that under such a setting, stakes for regulated firms to collude against the regulator are particularly high.

2.3.2 Investments incentives

Investments are often a means for a firm to improve its future productivity. In the same way as discussed above, firms' incentives to invest depends on the ability of a regulator to commit. Indeed, investments are undertaken in order to secure some future rents. When a regulator cannot commit to leave such future rents to regulated firms, a "hold up" problem occurs: anticipating that a regulator would expropriate rents from future productivity improvements, a regulated firm's investment incentives will be dampened in the first place, leading to an under–investment problem. This was initially analyzed by Williamson [1975]. Moreover, under non-commitment, investment could be socially sub–optimal, in the sense that the firm may not specialize its investment sufficiently: the firm can preserve "outside opportunities" by deliberately investing in more general technology rather than in specific technologies.

Sobel [1999] and Dalen [1998] both analyze how yardstick competition affects firms' investments incentives. Under non–commitment from the regulator, Sobel [1999] argues that investment incentives are more distorted under yardstick competition than under an individual one. Indeed, a firm's investment incentives is encourage by the prospective of future rents that an investment could generate. As yardstick competition can give the regulator accurate information on agents' productivity, when the regulator has limited commitment powers, he would be tempted to use such information to extract agents' rents stemming from their investments.[14] Anticipating this, agents will underinvest. Yardstick competition thus reinforces the hold-up problem, the regulator being able to have access to agents' private information in a less costly manner using yardstick competition.

The choice between yardstick competition and an individual incentive regulation scheme would depend on the shadow cost of public funds. When there is no cost in public funds, Sobel [1999] argues that the regulator should favor an individual incentive scheme and emphasize on providing adequate investment incentives. On the other hand, when the shadow cost of public funds is high, informational costs will also be high, and therefore, he should prefer implementing yardstick competition (and sacrificing some dynamic efficiencies).

In distinguishing different types of investments with respect to their impact on (dynamic) performance, Dalen [1998] shows that yardstick competition will only dampens those investments that have a spillover effect on the whole of an industry. Firms will be discouraged from investments that impact on general productivity of an industry (industry-specific investments), *i.e.* investments that would affect all firms in the reference group of a yardstick scheme. The reason is simple: such investments do not enhance the investing firm's performance relatively to that of its opponent. The investing firm will not stand to gain from such an investment. Moreover, yardstick competition permits the regulator to filter away this dimension of firms' private information, thereby reducing rents that firms could otherwise benefit from such investments.

[14] In Sobel [1999]'s framework, investments impact on the value of the future adverse selection parameter.

On the contrary, investments that have an impact only on a firm's private and idiosyncratic productivity (firm-specific investments) are encouraged under the yardstick scheme. Indeed, as yardstick competition does not allow the regulator to assess this part of the agents' private information, the prospective of securing some rents through such idiosyncratic private information (productivity) encourages the firms to invest on firm-specific technologies.

However, when a regulator is able to commit to the *ex ante* yardstick regulatory scheme, both studies show that the full information outcome can be achieved. The relative efficiency of yardstick competition and individual incentive regulation depends once more on the shadow costs of public funds.

The following proposition is used to resume our discussion above:

Proposition 4 (Investment incentives)**.** *When the regulator cannot commit* ex ante *to a regulatory scheme, in industry where specific investments are crucial, yardstick competition performs better than individual incentive regulation. Conversely, when investments involves heavy spillover effects, yardstick competition may be preferred over an individual scheme if shadow costs to public funds are high enough.*

One could see that an industry's technological configuration, is an important dimension to consider before deciding on yardstick competition or individual schemes. When technologies do not have important spillovers, it is reasonable to think that yardstick competition can perform better than an individual one. Otherwise, whether one scheme could outperform the other would depend on the arbitrage between informational externalities and investment incentives.

2.4 Some limits on relative performance evaluation

It should be pointed out that relative performance mechanism in general, and yardstick competition in particular, do have some limits. Quality could be a first issue, since yardstick competition may be expected to incite regulated firms to

drastic cost reductions. Quality may therefore be sacrificed in the process. Given that quality of service can be an important dimension of consumer welfare, it is reasonable to study the effects that yardstick competition may have on the quality of service when an industry is regulated in this way (subsection 2.4.1).

Another potential limit to using yardstick competition resides in how relative performance may be measured. In practice, there seem to be a range of statistical techniques that could be used to measure relative efficiency. Moreover, how such measure are constructed and specified under the regulatory scheme may induce undesirable actions from regulated firms. We will look into this aspect as well (subsection 2.4.2).

Last, but not least, is the possibility for firms to collude. Yardstick competition, as its name suggests, artificially creates some competition among regulated firms. This may create stakes for firms to collude. In particular, these stakes may be high, since a regulator could, at least theoretical, extract all informational rents with the slightest correlation in firms' private information, and over time too. Needless to say, firms may be better off from collusion than from competing against each other. We will briefly discuss existing work on this issue in this section (subsection 2.4.3).[15]

[15]We will return to this issue again in a later chapter of this thesis, since this could be an important limit to yardstick competition.

2.4.1 Quality of service

Overseeing to the quality of service or product produced by a monopoly is part of a regulator's job. However, quality often comes with a price, and the question is therefore: would firms sacrifice quality in order to reduce their costs under a yardstick scheme?

Tangerås [2003] examines this question, and shows that yardstick competition can in fact increase the quality of a service or a product. This astonishing result is due the fact that under an individual incentive scheme, the regulator would depress a firm's cost reducing efforts and quality so that he could reduce rents that have be to given up to ensure that a firm reveals truthfully its private information. As usual, because yardstick competition reduces informational costs for the regulator, he could then introduce less distortion into effort and quality provision, making yardstick competition better than an individual one where quality is concerned.

However, Tangerås [2003]'s result relies on a crucial assumption: that there is no quantity regulation, meaning that the regulator will not impose a certain quantity that the monopolist has to produce in the contract. An example where quantity is not regulated can be found in the case of hospitals, where the regulator do not impose upon the hospitals a quota or a number of patients for which he would reimburse the hospitals treatment costs. When quantity is regulated as well, Tangerås [2003] states: "*... yardstick competition would actually lead to a reduction in quality if expected quantity in equilibrium were a decreasing function of expenditures on quality improvements*". However, he argues that if there were quantity regulation, "*... the supply of quality would have been too high under an individual scheme in the first place ...*". Consequently, it would seem that the provision of quality is not compromised under yardstick competition, and as such, this scheme would perform better than an individual one.

2.4.2 Measurements and Incentive distortion in a static setting

Forms of incentive regulation rely on the ability of the regulator to measure relevant variables for a given policy. The measurement problem is especially acute in yardstick competition, as this scheme relies on some yardstick against which to measure firms' (relative) performances. In order to examine this aspect of the problem, we deliberately leave out regulatory schemes based on reporting mechanism, and briefly discuss the impact of measures.

In the principal agent literature, incentive contracts may be implemented by contracting upon the principal's objective. This may not be possible in regulation, as the regulator's objective is social welfare. In this case, the regulator will have to contract on other observable measures that are contractible. One of such measure is the firms' performances. Baker [1992] and Baker, Gibbons, and Murphy [1994] show that whenever the agent's actions do not respond in the same way to the performance measure than to the principal's objective, the sensitivity of the incentive contract to the performance measure should be reduced. In other words, principal should not make an agent's payoff too dependent on a performance measure when this measure is not sufficiently aligned with the principal's interest. Consequently, relative performance evaluation mechanisms should be used if it allows a better alignment between the measure used in a contract and the principal's objective.

Therefore, a relevant issue when using relative performance evaluation mechanism is whether the relative performance measure introduced in the scheme may lead to actions from agents that will deteriorate the principal's objective. As an example, Dye [1984] pointed out that a way for an agent to be seen in a more favourable light under relative performance evaluation mechanisms is to work towards thwarting its opponents' efforts, instead of working towards improving its own performance. It is clear that relative performance mechanisms would result in some inefficiencies if the measure used to evaluate agents' relative performances is not robust to such manipulations.

Gibbons and Murphy [1990] argue too in favour of the same danger. They em-

phasize the fact that payment schemes based on relative performance "... *instead of absolute performance distorts the* [agent's] *incentives whenever the* [agent] *can take actions that affect the average output of the reference group* ...". Under an individual scheme, such strategies do not appear, as an agent's payoff depends necessarily on its own efforts or actions. There will be no interest for an agent in trying to work towards anything else but to improve its own performance.

Baker [1992] confirms the statements above. He notes that relative performance mechanisms will provide non-distorting effects when one agent's actions do not have an impact on the reference group. More interestingly, he also shows that relative performance evaluation mechanisms may still be attractive when they lead to a reduction in the variance of the performance measure. This is true when a principal is confronted with risk–adverse agents: a relative performance measure that reduces variances in agents' payoff also lessens the need for a principal to provide insurance. This may therefore lead to better incentive provision, whose benefits may outweigh the adverse effects when agents attempt to influence the performance measure. This trade off may still play to the favor of relative performance mechanisms.

This leads us to the following question: how can the regulator measure relative performances? This question is all the more important when firms' will operate under very different conditions and they could have very different production technologies. Shleifer [1985] and Choné and Lesur [2001] provide a first answer to this question: yardstick against which to measure firms' performances could be constructed through econometric regressions by taking into account all heterogeneous factors affecting firms' performances. However, they also pointed out that this "reduced form regulation" is only optimal when the R^2 of the regression is closed to one. Choné and Lesur [2001] further precise that to filter out the common impact of variables on firms' costs, the variables used in the regression should be orthogonal (i.e. independent) from the residuals of the regression, which may include unobservable or immeasurable heterogeneity and firms' cost reducing efforts. They conclude that measurement problem in determining yardsticks is an important obstacle to the use of yardstick competition.

More generally, in addition to econometric methods, benchmarking methods to "measure" relative performances are also available. For instance, Bogetoft [1994] and Bogetoft [1995] shows that Data Envelopment Analysis (DEA) methods can be used to evaluate relative performances and create incentives. Agrell and Bogetoft [2002] pointed out however that DEA methods, being a deterministic measure of relative (in)efficiency, do not allow the principal to distinguish between firms' performances that are due to good practices or noise. Should the regulator uses this method to implement yardstick competition, he would take risk to mistake some firms as being efficient when in fact they are "lucky", and other "unlucky" firms to be inefficient. Other popular benchmarking methods include the Corrected Ordinary Least Square (COLS) method, which is deterministic as well, and the Stochastic Frontier Analysis (SFA), which allow for a stochastic error term when estimating relative efficiency. *A priori*, there are no guarantee that these different methods will yield consistent results. This is not surprising, since these methods are built are different assumptions. In addition to this, measures may differ even when one uses the same method, due to different working assumptions retained. As an example, one may use DEA methods to measure relative performance, but estimates will naturally differ depending on whether one assumes increasing returns to scale or constant returns to scale for the same set of data. An illustration of the difficulties with measuring relative efficiency is provided by Jamasb and Pollitt [2003]. In their benchmarking study on electricity distribution companies, Jamasb and Pollitt [2003] show that estimations of relative efficiency varies according to techniques used, model specifications and the choice of variables. From the regulator's point of view, such variations are not reassuring. Furthermore, this suggests that using yardstick competition can lead to introducing undesirable noise in the firms' payoff, and from the agency theory's point of view, this can never be optimal (Holmström [1979])). This could be an important obstacle, as arbitrariness is almost inevitable when it comes to measure relative performances empirically.

In a nutshell, measurement can be an obstacle to implementing yardstick competition. First of all, regulated firms may try to influence the relative performance measure in order to be seen under a better light. Secondly, the regulator may in-

troduce some undesirable noise into firms' compensation scheme if firms' relative performances are not measured "correctly".

2.4.3 Collusive behaviour

When the principal uses relative performance evaluation mechanisms, agents may have incentives to cooperate or to collude. Given that relative performance evaluation mechanisms generally leads to lower rents for agents, it may be in agents' better interest to cooperate instead of competing against each other. In such cases, relative evaluation performance would be inefficient in providing incentives. As collusion can seriously undermine yardstick competition, it is important to look at this issue.

Notice first that under individual incentive schemes, and being local monopolies in separated markets, firms do not have any incentives to collude because their payoff does not depend on their counterparts' actions. There is will no reason for them therefore to coordinate their actions in order to obtain a higher payoff.[16] Conversely, in making a firm's payoff dependent on other agents' performance, firms regulated under the same yardstick scheme will have interest to play cooperative strategies, especially if they can be better off playing such strategies than behaving in a non–collusive manner. Collusive behaviour could make yardstick competition completely inefficient, making the regulator worst off than under an individual scheme.

As Laffont and Martimort [2000] show, by using yardstick competition to exploit the correlation between firms, the regulator is in fact creating incentives for firms to collude. This collusion is made all the more easier by the fact that when firms are correlated, since defections are more easily detectable. Therefore, collusion is easier. Moreover, the higher the correlation between firms' environment, the homogeneous are their individual options, making the distance between

[16]Let us note however that collusive strategies are possible when firms compete to obtain a local monopoly market when the market is attributed through competition *for* the market mechanism. However, we leave the discussion on this aspect to later chapters.

a collusive agreement and their individual options smaller. Collusion is therefore a more interesting solution for firms when correlation among them is strong.

More specifically, in Laffont and Martimort [2000]'s setting, when correlation between the firms' private information is perfect, yardstick competition will be completely inefficient since firms may perfectly collude. Indeed, in order for a collusion to be successful, firms must be able to coordinate their actions under yardstick competition. In the author's setting, firms will be confronted with informational problems, since each of them retains some private information. A high correlation in their private information makes it easier or less costly for firms to coordinate on a collusive strategy, as firms may more easily infer each other's private information from its own information. An efficient collusive agreement can be easily reached. When correlation is perfect, Laffont and Martimort [2000] shows collusion is costless to the firms (since there firms are perfectly aware of each other's private information). Firms may collude perfectly. As a result, yardstick competition will never be efficient.[17]

Tangerås [2002] confirms this when he considers the case with an effort term, using a methodology similar in spirit to Laffont and Martimort [2000]. More precisely, he shows that the benefits of yardstick competition vanishes in the limit as the correlation between firms' private information becomes perfect. The author also shows that a way to make collusion harder is to limit or ban side–transfers among regulated firms.

On the empirical side, Potters, Rockenbach, Sadrieh, and van Damme [2004] study if yardstick competition could effectively lead to collusion using the experimentation method. They compare two yardstick schemes: discriminatory yardstick scheme and uniform yardstick scheme. In the former, the price cap for a firm is fixed at the level of its counterpart's observed costs, while the latter scheme uses the same cap for the two firms, set at the average of their respective observed costs. They argue that a uniform yardstick scheme provides less cost reducing

[17]We note here that the authors consider that collusion may be perfectly enforced. In Chapter 4, we show that when this is not the case, yardstick competition may still be efficient under certain circumstances.

incentives to firms and found that it is indeed less prone to collusion than the discriminatory scheme. They conjecture that this is because under the uniform scheme, players find it harder to decipher signals to collude. This leads players to adopt non–cooperative behaviour. An important lesson from their work is that players do not need to communicate beforehand to collude, *i.e.* tacit collusion is possible under yardstick competition. Another important lesson from this study is that incentives to collude also depends on the form of yardstick competition implemented.

It would seem that yardstick competition is particularly vulnerable to collusive behaviour. Collusion therefore a serious limit that has to be taken into consideration when one considers using yardstick competition. Indeed, yardstick competition is most attractive when firms' private information are highly correlated. However, this very correlation makes collusion plausible. In this case, there is not benefits to using yardstick competition, since firms are likely to collude in this case.

2.5 Conclusion

An important consequence of yardstick competition is that it reduces informational costs. When there are common underlying uncertainties on agents' private information, the regulator can solicit them more easily and costlessly using a yardstick competition. However, as we have seen, such benefit do not come without costs: for one, in using yardstick competition, the regulator introduces a more complex environment and agents will have more strategies to choose from. The resulting outcome may not be the one desired by the regulator, even in a static framework when agents' could work towards thwarting each other's performances. Collusion is another possible equilibrium strategy. Such possibilities could undermine the efficiency of the comparison mechanism. One solution might be to use international benchmarks to deter collusion, but then it would perhaps not be appropriate to include foreign monopolies regulated by a different principal with a different objective in the reference group. This question merits to be studied

further on.

Moreover, yardstick competition could have a negative impact on some important industrial variables. For instance, we have seen that it dampens investment incentives when there are important spillover effects. When such an issue is important to the regulator, yardstick competition should be avoided. Measurement problems are relevant under yardstick competition too: a noisy measurement of the firms' relative performance could lead to inefficiencies.

Where local public services are concerned, our theoretical literature review points out that using yardstick competition could in fact enhance social welfare, costs and benefits of institutional arrangement and political considerations notwithstanding. To assess whether this type of regulation should be used, a case–by–case examination is required. Nevertheless, the above discussion points out to two key dimensions that should be carefully looked into: firstly, the nature of investments in a sector; and secondly, the geographical fragmentation of a sector. As we have seen, when commitment is an issue, yardstick competition depresses incentives to undertake investments with strong spillover effects. The second question is related to measurement problems: when geographical fragmentation of a sector is high, a higher number of observations may be obtained to be used in forming estimations on relative performance, therefore enhancing accuracy of the measurement. Moreover, higher number of observations should make it harder for a regulated firm to use strategies that seek to sabotage performances of other firms in order to enhance its relative efficiency as measured by a regulator instead of enhancing its own efficiency. However, a larger geographical fragmentation may be obtained perhaps to the detriment of economies of scale and scope that are often present in such industries. In complement to this, the industrial structure of the sector at the national level should be accounted for: if regulated firms turns out to belong to few parent companies at the national level, caution should be exercised in recommending the use of yardstick competition. In particular, economics of organization may be used in this case to identify possible and feasible strategies that may be used by regulated firms to game the regulator under yardstick competition. This latter may be a concerned in the French water

sector. On this issue, we would like to stress again that the review of literature as discussed above is not sufficient to recommend the use of yardstick competition as a substitute or as a complement to the current system. Setting up and make such a system function is costly. To this end, a more detailed cost and benefit analysis is required.

In a nutshell, the theoretical state of art on regulation provides an optimistic picture for the efficiency of yardstick competition in general. However, literature on this issue remains relatively scarce and further research is needed to further clarify the strengths and weakness of yardstick competition. One important limit to the use of yardstick competitive is firms' incentives to collude when this type of regulation is used. Research into institutional aspects of using yardstick competition are also lacking and require attention. Question such as regulatory capture, task sharing between a regulator and local public authorities, the role of PPPs and/or auction mechanisms etc. are crucial to understand and have important consequences on the global effectiveness of yardstick competition.

A brief conclusion to Part I

The need for heavy infrastructure leads some local public services to exhibit a natural monopoly characteristics. While such characteristics preclude competition in the market, competitive solutions still exist when it comes to managing these services. Two such solutions discussed in the first part of this dissertation are franchise bidding and yardstick competition.

Auctions and PPPs provide an attractive theoretical solution to how local public services may be managed. Indeed, using this solution, "market failure" and "regulation failure" may be avoided when one organizes the provision of local public services. Through these instruments, local public services may be provided more efficiently to end users, and therefore leads to higher consumer and social welfare. Nevertheless, Transaction Costs Economics points out that contractual hazards may limit the benefits of these solutions. With this in mind, we empirically explore the efficiency of PPPs and the effects of competition in the French water sector. Both solutions are in used in this sector. The results of our work is discussed in the first chapter of this dissertation.

We found that while auctions contribute to lower water prices, PPPs lead to higher water prices indirectly. More particularly, consumers whose water services are run through a PPP is found to pay a premium to some operators, and water prices tend to decrease with the importance of intermodal competition and

the time left until a PPP contract expires. We believe that these results may be taken to indicate some inefficiencies that still prevail in the French water sector, despite the use of auctions and PPPs. This leads us to consider the whether formal regulations may be introduced to better pass on benefits of private expertise on local public service provision to consumers. In particular, we may think that local public authorities are already intervening *ex post* into PPP contracts, which could be considered as a form of "informal" regulation. Introducing formal regulations would be interesting only if a better coordination when intervening may beneficial. One benefit of a better coordination when intervening *ex post* in local public service provision could stem from informational externalities. This could be brought about when yardstick competition is used. We are therefore led to study the pros and cons of yardstick competition in the second chapter, through a literature review on the subject.

Yardstick competition could indeed enhance social welfare with respect to more traditional forms of regulation. This form of regulation allows a regulator to exploit correlation in operators' private information. Under this type of regulation, some informational costs may be saved up. This allows a regulator to provide better incentives to regulated firms to enhance their productive efficiency.

While these instruments provide attractive solutions to how local public services may be run, each solutions presents its own limits. While we have been able to consider their limits separately, a short–coming to our discussion is that we have not examine how these solutions articulate with one another. In particular, we have not been able to examine whether these two solutions could be substitutes for one another, or could be used in complement with one another. This is unfortunate because of the consequences on policy that such a question implies. We leave this question to future work.

An important common limit to these competitive solutions resides in the fact that they may also provide incentives for firms to collude. As we have seen, the existence of positive indirect operator related premia that consumers pay when their water services are provided under a PPP can potentially be explained

through collusion during auctions for contracts. In France, it is generally argued that the sector for local public services like water production and distribution, or public transportation, is highly concentrated. More generally, auctions may be vulnerable to collusion, as shown by the bulk of empirical literature on this issue (Porter and Zona [1993], Baldwin, Marshall, and Richard [1997], Porter and Zona [1999] etc.). Competitive authorities in various part of the world have also found evidence of collusion in auctions for public contracts and condamned such behaviours (Swedish Competition Authority [2003], Swedish Competition Authority [2005], Conseil de la Concurrence [2005b]).

Collusion is also a particularly serious limit when one consider using yardstick competition. Indeed, the literature has shown that firms have the highest incentives to collude when benefits from using yardstick competition are the highest. However, to the best of our knowledge, there are only two theoretical studies on the subject, and they both focused on informational obstacles that have to be overcome when firms wish to collude under yardstick competition. A particularly important obstacle that firms have to overcome also in order to collude concerns the enforcement of a collusive agreement.

Both observations lead us to place an emphasis on collusion in the following discussion of this dissertation. In particular, we are interested in knowing how PPP contracts may be tailored to make collusion harder during an auction. This is the object of Chapter 3. More specifically, we try to examine contractual length as a possible tool to discourage collusion. In doing so, we try to identify one simple way to constrain operators' potential collusive incentives. Chapter 4 looks at the same issue, but seeks to study operators' incentive to collude when yardstick competition is used. In particular, we will also consider possible "structural" responses to collusion, by studying the case when yardstick competition is used together with auctions to attribute market rights. In both chapters, we focus our attention to collusion that has to be self–sustainable, or the enforcement issue of collusion. Given that collusion is illegal under any judiciary system, agreements to support collusion are unlikely to be enforced by formal institutions. Hence, in order to collude, firms must ensure that any collusive agreement that they establish

is self–enforceable. Therefore, we have chosen to place an emphasis on this aspect in our study on firms' incentives to collude in the two following chapters.

Part II

COLLUSION, COMPETITIVE SOLUTIONS, AND LOCAL PUBLIC SERVICES

Chapter 3

Auctions, collusion and contractual length*

3.1 Introduction

Competition in the market is often impossible where public services are concerned. Public urban transportation and water provision are natural monopolies, at least on a local level, due to the need for extensive network structures in order to operate these services. As such, normal market competition is neither viable nor desirable. In spite of this, competitive solutions, which could limit the exercise of monopoly power by a firm operating such services, may still exist. Among them, competitive tendering (through the use of auctions) figures predominantly. This solution was first suggested by Chadwick [1859] and Demsetz [1968]. The authors pointed out that competition generated during an auction for the temporary rights to operate the public service in question could well substitute for the absence of *ex post* normal market competition. Such an idea has been increasingly advocated and put into practice where public procurement in generally, and procurement for public services are concerned. In the US, for instance, the Federal Acquisition Regulations (FAR) has institutionalized the use of auctions when it comes to pub-

*This chapter is derived from an ongoing working paper (Chong [2006a]). The author is indebted to Yannick Perez, Jean–Michel Oudot and Anne Yvrande–Billon for their comments and criticisms. The author bears all responsibility for any errors and/or omissions.

lic procurement, whereas the European Union is seeking to introduce Directives for the use of competitive tendering procedures in member countries. Along the same time, Guasch [2004] calls for a more extensive use of auction mechanisms to attribute markets for infrastructure in Latin American countries.

A pervasive problem related to the use of auctions in attributing public procurement contracts is collusion among bidders. As pointed out by Porter and Zona [1993] and Pesendorfer [2000], more than one half of the criminal cases filed by the Antitrust Division of the US Department of Justice between 1982 and 1988 concerned bid rigging or price fixing, with the main victim being a government agency and therefore taxpayers. More recently, in Europe, the Swedish Competition Authority detected a cartel in procurement contracts of road-surfacing (Swedish Competition Authority [2003], Swedish Competition Authority [2005]). Likewise, the French Competition Authority recently convicted three firms in the public urban transportation sector for market sharing between 1996 and 1998 (Conseil de la Concurrence [2005b]) and five firms for collusion in public road construction markets between 1991 and 1998 (Conseil de la Concurrence [2005a]).

Likewise, our empirical results from the first chapter may be an indication of possible collusive behaviour in the French water sector. We have found that consumers pay a premium for their water services when these services are run by some of the operators through Public Private Partnerships (PPPs). Two particular operators are entitled to the same amount of premium, while a joint venture is entitled to a significantly higher premium. These findings are consistent with an explanation based on collusion, although there are also other possible explanations.[1] Moreover, the high level of concentration in the French water industry has led many to suspect possible the existence of a cartel. In particular, the French Competition Authority has observed in 2000 that the Herfindahl index of the sector was as high as 4250. This is an indication that the industry was highly concentrated. The French High Council of Public Service (*Haut Conseil du Service Public*) noted in a report in 1999 that only 5% of contracts changed hand in the sector at the renewal stage (Haut Conseil du Service Public [1999]). The

[1]See chapters 1 and 2 for a more detailed discussion on this aspect.

report pointed out that market shares are quite stable over time in the sector. In the same way, a French consumer association, *Union Fédérale des Consommateurs* (UFC) complained about the lack of competition in the water sector in a study published in its magazine, *Que Choisir* (Union Fédérale des Consommateurs [2006]). Nevertheless, these observations do not imply that a cartel exists in the sector.

Needless to say, when collusion occurs among bidders, benefits from using the competitive tendering procedures or auctions are undermined. This may explain the tremendous amount of attention that such a topic has received in the economic literature, both at a theoretical level and at an empirical level. The empirical strand on this literature seeks to identify patterns of collusive bidding in an auction and to come up with statistical tools to identify collusive behavior that may occurs during an auction (Porter and Zona [1993], Baldwin, Marshall, and Richard [1997], Porter and Zona [1999], Bajari and Ye [2003] etc.). At the theoretical level, efforts have been taken to understand the formation of collusive bidding rings. Indeed, in order to form a successful cartel, four difficulties have to be overcome by the firms: namely, how to share the spoils, how to enforce a cartel agreement, how to deter entrance, and how to punish defecting firms.[2] McAfee and MacMillan [1992], Blume and Heidhues [2002], Aoyagi [2003], Marshall and Marx [2006], among others, contribute to understanding theoretically how bidders may overcome these obstacles in order to collude during an auction. Alongside with such advances, there have been some studies that seek to identify how bidders' capacity to collude may be influenced by the format of an auction (Fabra [2003]) or auction characteristics such as the auctioneer's choice of a reserve price (Thomas [2005]). Klemperer [2004] also provides some practical consideration that could be taken into account to render an auction more robust to bidders' strategic behaviour.

While these advances are useful to inform policy makers on how to make the design of an auction robust to collusive bidding behavior, an important dimension associated with public procurement auctions has been relatively ignored, namely

[2] McAfee and MacMillan [1992] for a discussion on bidders collusion, or Pénard [2003] for a more general discussion.

the contracts that are to be awarded in an auction. Indeed, where public procurement is concerned, the object of the auction is usually a contract that specifies various dimensions of a project in question, such as the payment scheme of the winner, the contractual length, investments requirements that have to be met etc. One may expect such contractual provisions to have an impact on bidders' capacity to collude during an auction. As such, contractual provisions may also be used in order to discourage any collusion initiatives when a contract is being auctioned. It is our intention in this chapter to study this issue. Namely, we intend to find out whether contractual length may be used as a variable to discourage bidders to collude when participating in public procurement auctions.

Our focus on contractual length is motivated by the fact that the stakes of using an auction by a public authority and payoffs of various bidders' strategies will obviously depend on the length of the contract that is to be signed. More precisely, when implementing a series of short–term contracts to procure a good or a service, the public entity could arguably benefit more frequently from competitive pressures, and could hence expect higher surplus from using auctions. On the other hand, the winner of an auction who is entitled to a longer contract will expect higher total revenue from the contract. Potential bidders may therefore choose to behave differently according to the contractual length specified in the auctioned contract. Moreover, contractual length can usually be freely decided by local public authorities (within the limits of legislations imposed on them). As a result, using contractual length to discourage collusion *ex ante* seems to be easily implementable for local public authorities.

In order to study the effects of contractual length on the likelihood of collusive behavior, we use an infinitely repeated game framework. More specifically, we assumed that a local public authority, which we will refer to as the buyer, attributes a temporary monopoly franchise to a firm through an auction. More particularly, we intend to focus on a specific form of collusion among bidders, namely bid rotation scheme, and restrict ourselves to the case where such a collusion scheme is sustained through a repeated game framework. A bid rotation scheme is the best possible collusive mechanism available to cartel members when

they may not use side transfers (McAfee and MacMillan [1992], Thomas [2005]). It seems to us that cartel members who use monetary side–payments to support a collusive mechanism take a higher risks in being detected, because evidence may be produced that may be found and used by competition authorities to prosecute the cartel. Indeed, it seems likely that when side–payments are being used to support collusion more coordination and communication among the members are needed. We show using this framework that the critical threshold discount factor is increasing in contractual length, thus suggesting that collusion in the form of bid rotation is harder to sustain when longer–term contracts are being auctioned. As a result, contractual length may be used as a means to discourage collusion initiatives when auctions are used to attribute public procurement contracts.

To the best of our knowledge, there has been relatively few works in the literature that try to assess the role of contractual provisions as responses to possible collusive initiatives by contracting agents in a competitive environment. Most related to our work are Calzolari and Spagnolo [2006] who study the effects of reputation and collusion on non-contractible quality using a repeated game framework. Using a mechanism design approach, the authors also find that collusion is harder to sustain under longer contracts, *ceteris paribus*. However, the authors consider a bid rotation scheme and assume complete information among firms participating in the auction. In our case, we allow for incomplete information between firms.

We will also examine econometrically whether such a variable is used in practice, using data on the water industry from the French Institute of Environment (IFEN, for *Institut Français de l'Environnement*) and the French Health Ministry (DGS, for *Direction Générale de la Santé*). Instead of relying on bid data, our data uses contracts that have been established between French local public authorities (municipalities) who are in charge of organizing water services and external operators that are chosen through a competitive tendering procedure. As a measure for potential for collusion, the Herfindahl index computed at a local level is used. We argue that collusion should be more likely if the industry is more concentrated at the local level.[3] However, we find no empirical evidence that contractual length

[3]Chapter 1, section 1.2.3 provides a more detailed discussion on this.

is correlated with the degree of industrial concentration at a local level.

This chapter is organized as follows: we start in the following section by presenting a simple model of repeated independent private value auctions (section 3.2). We then derive the optimal contractual length in the case when bidders behave competitively (section 3.3). We show that in this case, the buyer will want to keep to a minimum the contractual length. In the third section, we then turn to study how contractual length may influence the sustainability of bid rotation during an auction (section 3.4). To this end, we briefly discuss some of the obstacles that may arise under a collusive bid rotation scheme and identify how the bid rotation scheme may work. Then we focus our attention on the impact of contractual length on the critical threshold discount factor that may sustain the optimal bid rotation scheme. We show that the critical threshold discount factor is increasing in contractual length. In our section 3.5, we empirically test for a relation between contractual length and the degree of concentration at a local level in the French water sector. In this section, we will briefly review some other possible determinants of contractual length according to the economic literature, and discuss practical issues for empirical work in the French water sector. Ordinary Least Squares (OLS) and Heckman sample selection estimates are then given and discussed. The fifth section concludes and discusses some shortcomings of our work.

3.2 Model Setup

We will consider an infinitely repeated game framework. Such a framework is useful in our opinion to study self-enforceable collusion. In our model, a risk neutral buyer needs to provide to the community a good or service during every period, which we will denote by $t = 0, 1, \ldots$. For simplicity, let us assume that demand for the service is unitary and inelastic. The provision of the service will therefore generate per-period gross consumer surplus amounting to $S_t = S$, which is assumed to be such that provision is always desired. Considering that we are interested in local public services such as water production or distribution, such an

assumption on inelastic consumer demand does not seem *a priori* too restrictive.[4]

In order to provide the good or service in question, the buyer needs to rely on an outside operator, which we will generically refer to as firms.[5] There are potentially $N \geq 1$ risk neutral firms, denoted i, in the economy capable of providing the service. To produce the service, firm i has to incur cost $c_{i,t}$. For simplicity's sake, we introduce the following assumption on $c_{i,t}$:

Assumption 1. *Each firm draws its production costs $c_{i,t}$ at the beginning of each period independently from the cumulative distribution $F(c)$. Let $f(c)$ be the density of $F(\cdot)$ with support on $[\underline{c}, \overline{c}]$, with $\underline{c} < \overline{c}$.*

The assumption that firm i's cost be drawn anew from the same distribution during every period is necessary to study collusion using a repeated game framework (McAfee and MacMillan [1992]). We will denote the expected value of $c_{i,t}$ as $\mathbb{E}[c]$ in the following discussion and normalize the firms' outside option or reservation utility to 0.

We assume furthermore that the buyer is obliged by law to award the monopoly franchise through an auction. In our model, we will consider a first price sealed bid auction. In particular, the buyer is required to award the contract to the firm with the lowest bid, and in the event of ties, he has to randomly select a firm among the lowest bidding firms. In other terms, when there are several same low bids, each lowest bidding firm have the same probability of being awarded the contract. This assumption does not seem to be a very strong one, given that we are interested by procurement auctions. For instance, in the US, where procurement auctions are institutionalized, the Federal Acquisition Regulations (FAR) impose the use of sealed bid auctions where applicable, and explicitly stated that the award criteria must include price.[6] The Public Procurement Act in Sweden also

[4]Note however that consumer demand may be elastic where some other local public services are concerned. This should be the case for public urban transportation.

[5]One may also consider that the buyer's next best supply alternative, which could be for instance in–house provision, costs $c_B \geq \overline{c}$ without loss of generality. In this case, the buyer's per-period gain or utility from purchasing from one of the N sellers at the winning bid b^w is simply the supplementary gain from consumer welfare, *i.e.* $c_B - b^w$.

[6]The Federal Acquisition Regulations states in part 6.102 that "*The competitive procedures*

stipulates the use of a first-price sealed bid auction in accordance with directives from the European Union (Lundberg [2005]).

We will note a firm i's bid during a period t when an auction is run as $b_{i,t}$. We assume that the buyer may run an auction after every τ periods of time, with $\tau = 1, 2, \ldots$. When $\tau = 1$, the buyer runs the auction at all periods, while if $\tau = \infty$, the buyer awards the monopoly franchise once-and-for-all. τ can thus be interpreted as the contractual length, *i.e.* the amount of time (or number of periods) that a successful firm gets to keep its monopoly franchise. Prior to soliciting offers, the buyer imposes a commonly known reserve price r. In order to guarantee that firms will participate for any cost realized, the buyer must set the reservation price such that

$$r \geq \overline{c} + \delta \frac{1 - \delta^{\tau-1}}{1 - \delta} \mathbb{E}[c] > 0$$

Such a reservation price will satisfy the firms' participation constraints. Notice that we assume an interim participation decision on the part of the firms, *i.e.* firms accept to participate in the auction and the corresponding contract knowing only their costs for the period when the auction occurs and even if they do not know their subsequent costs. For simplicity's sake, we assume that the contract attributed is binding and the buyer's choice of reservation price is exogenously given and set such that all N firms will be willing to participate in the contract:

Assumption 2. $r = \overline{c} + \delta \frac{1-\delta^{\tau-1}}{1-\delta} \mathbb{E}[c]$

Throughout the contract's lifetime, the winning firm is paid its winning bid. In other words, our procurement contracts resemble a fixed price contract, in which the price paid to the winning firm is in fact its bid during the corresponding auction.[7] In particular, the timing of the game that we consider for our discussion

available for use in fulfilling the requirement for full and open competition are as follows: (a) Sealed bids. ... ". Moreover, in a preceding paragraph (part 6.101), it is stated that, "... *with certain limitations ... contracting officers shall promote and provide for full and open competition in soliciting offers and awarding Government contracts.*".

[7] We believe that such an *a priori* restriction on contractual form will not introduce any serious bias into our analysis. Indeed, according to McAfee and MacMillan [1986] and Bajari, McMillan, and Tadelis [2003], cost reimbursement contracts are suboptimal when auctions are used. The latter study furthermore provides empirical evidence that corroborate their theoretical findings, while the former has shown that it is never optimal to entirely reimburse the winning agent's costs when auctioning incentive contracts.

is as follows:

- At $t = -1$, the buyer decides on τ, the length of the contract.
- From $t = 0$ onwards, the following stage game is infinitely repeated:
  - At $t = t'$, an auction is organized by the buyer to award the monopoly franchise. Firms submit bids and the buyer chooses the lowest bidding firm.
  - During $t \in [t', t' + \tau[$, the good or service is procured and the successful firm is paid according to its winning bid.

To use the auction terminology, we have here a game of repeated symmetric independent private value (IPV) first-price auctions. Following the literature, we assume that the buyer can commit to the procurement format.

3.3 Repeated procurement auction with no collusion

In this section, we will study the case where firms behave non–cooperatively under the repeated auction game for a contract of length τ. More precisely, we seek to derive the Nash equilibrium of the repeated game under the assumption that firms do not collude.

The Nash equilibrium of firms' bidding strategy can be found as follows: denoting the bid by firm i as $b_i(c_{i,0}, \ldots, c_{i,\tau-1})$, one can see that at $t = 0$, the best prediction that firm i can make on its future costs during the contract's lifetime is $\mathbb{E}[c], \forall i$. Therefore for simplicity's sake, we can assume that firm i's bid depend only on $c_{i,0}$, *i.e.* firm i's bidding function can be written as $b_i(c_{i,0})$. Considering symmetric equilibrium, we have $b_i(c_{i,0}) = b(c_0)$, where c_0 is the cost realization at $t = 0$. Following McAfee and MacMillan [1987], if firm i wins the auction under a contract of length τ, its expected utility is simply

$$b_i - c_{i,0} - \frac{1 - \delta^{\tau-1}}{1 - \delta}\mathbb{E}[c]$$

Hence submitting a higher bid allows firm i to attain a higher utility. However, firm i's probability of winning the auction with a bid b_i is the probability that all the $N-1$ firms have costs $c_{-i,0}$ at $t=0$ such that firm i's bid is lower than bids submitted by its $N-1$ competitors given their realized costs at $t=0$, $b_{-i}(c_{-i,0})\ \forall -i$. Assuming that $b_{-i}(c_{-i,0})$ is strictly increasing in c_0[8], when face with a firm $-i$, $-i=1,\ldots,i-1,i+1,\ldots,N$, with cost $c_{-i,0}$, firm i will win the auction when $b_i \leq b_{-i}(c_{-i,0})$. Thus, the probability that firm i wins the auction when confronted with a firm $-i$ is given by

$$\begin{aligned}\Pr[b_i \leq b_{-i}(c_{-i,0})] &= \Pr[c_{-i,0} \geq b_{-i}^{-1}(b_i)] \\ &= 1-\Pr[c_{-i,0} \leq b_{-i}^{-1}(b_i)] \\ &= 1-F(b_{-i}^{-1}(b_i))\end{aligned}$$

where $b_{-i}^{-1}(\cdot)$ is the inverse function of firm $-i$'s bidding function.

Hence, the probability that firm i wins the contract when faced with $N-1$ competitors is simply $[1-F(b_{-i}^{-1}(b_i))]^{N-1}$. Firm i will thus choose its bids to maximize its expected utility during the auction stage, taking into account the impact of its submitted bid on its probability of winning the auction. Its expected utility during the auction stage can therefore written as

$$U_i = \left[b_i - c_{i,0} - \delta\frac{1-\delta^{\tau-1}}{1-\delta}\mathbb{E}[c]\right]\left[1-F(b_{-i}^{-1}(b_i))\right]^{N-1} \tag{3.1}$$

The following lemma describes firm i's optimal (Nash) equilibrium bid:

Lemma 1. *A firm i's Nash equilibrium bid is the IPV procurement game is written as*

$$b_i^{NE}(c_{i,0}) = c_{i,0} + \delta\frac{1-\delta^{\tau-1}}{1-\delta}\mathbb{E}[c] + \int_{c_{i,0}}^{\overline{c}}\left[\frac{1-F(s)}{1-F(c)}\right]^{N-1}ds$$

Firm i's expected utility under the Nash equilibrium when it has drawn cost c is

$$U_i^{NE,ex\ post}(c) = \int_{c_{i,0}}^{\overline{c}}[1-F(s)]^{N-1}ds$$

and its expected utility before costs are drawn is therefore

$$\begin{aligned}U_i^{NE,ex\ ante} &= \int_{\underline{c}}^{\overline{c}}F(c)[1-F(c)]^{N-1}dc \\ &= \frac{1}{N}\left[\mathbb{E}[cN(N-1)[1-F(c)]^{N-2}F(c)] - \mathbb{E}[cN[1-F(c)]^{N-1}]\right]\end{aligned}$$

[8]This has already been shown in the literature (for instance, in Milgrom [2004]).

Proof. See appendix. □

Lemma 1 illustrates some well–known results in the literature. In particular, we see that firms will bid their discounted expected costs in equilibrium plus a markup that depends on the number of its competitors. As the number of competitors increases, a firm's utility as well as the amount of markup in its bid decreases. One can also see that firms may expect *ex ante* (before costs are realized) to benefit from some positive informational rents. From Lemma 1, one can see that a firm i's informational rents correspond to the difference between the expected second lowest cost realization (given by $\mathbb{E}[cN(N-1)[1-F(c)]^{N-2}F(c)]$) and the expected lowest cost realization (given by $\mathbb{E}[cN[1-F(c)]^{N-1}]$) provided that firm i has the lowest cost realization (which could happen *ex ante* with probability $\frac{1}{N}$). As expected, firms' *ex ante* informational rents decreases with the number of firms participating in an auction.

We will now turn to the buyer's problem. As mentioned earlier, the buyer is assumed to be utilitarian and seeks to maximize consumer surplus. Let us first assume that the buyer uses a contract of length τ for the procurement of the good from $t = 0, \ldots, \tau - 1$. From the buyer's point of view, the firms are *ex ante* identical, so that for a contract of length τ, the expected per-contract net consumer surplus is simply the difference between the total discounted gross consumer surplus and the lowest bid:

$$S + \delta S + \ldots + \delta^{\tau-1} S - \mathbb{E}[\min(b_1^{\text{NE}}(c_{1,0}, \ldots, c_{1,\tau-1}), \ldots, b_N^{\text{NE}}(c_{N,0}, \ldots, c_{N,\tau-1}))]$$

Since all firms expect per period costs $\mathbb{E}[c]$ for $\tau > 0$, we have

$$\begin{aligned} & \mathbb{E}[\min(b_1^{\text{NE}}(c_{1,0}, \ldots, c_{1,\tau-1}), \ldots, b_n^{\text{NE}}(c_{n,0}, \ldots, c_{n,\tau-1}))] \\ = \; & \mathbb{E}[b^{\text{NE}}(\min(c_{1,0}, \ldots, c_{N,0}), \mathbb{E}[c])] \end{aligned}$$

From the buyer's perspective, the probability that a cost c is minimum can be written as follows:

$$\begin{aligned} \Pr[c \leq c_{1,0}, \ldots, c \leq c_{N,0}] &= 1 - \Pr[c_{1,0} > c, \ldots, c_{N,0} > c] \\ &= 1 - \Pr[c_{1,0} > c] \times \cdots \times \Pr[c_{N,0} > c] \\ &= 1 - [1 - F(c)]^N \end{aligned}$$

The density function is thus simply $N[1-F(c)]f(c)$. Expected per-contract net consumer surplus can therefore be written as

$$W(\tau) = \int_{\underline{c}}^{r} \left[\frac{1-\delta^{\tau-1}}{1-\delta} S - b^{\text{NE}}(c,\tau) \right] N[1-F(c)]^{N-1} f(c) dc$$

This yields the following net intertemporal consumer surplus:

$$\mathscr{W}(\tau) = \sum_{k=0}^{+\infty} \delta^{k\tau} \left[\frac{1-\delta^{\tau-1}}{1-\delta} S - b^{\text{NE}}(c,\tau) \right] N[1-F(c)]^{N-1} f(c) dc$$

In conformity with conventional wisdom, one can see that net expected consumer surplus (or the buyer's assumed objective function) is increasing with the number of firms participating in the auction. We will now turn to study the optimal contractual length under such a setting.

Proposition 1. *When firms participating in the auction behave non cooperatively in the repeated procurement auction game, net expected intertemporal consumer surplus is maximized when the buyer organizes the auction during every period,* i.e. *the contract will be in effect for only 1 period.*

Proof. See appendix. □

Proposition 1 is not surprising: in our setting, there is no costs in organizing an auction. By setting a contractual length higher than 1, the buyer is actually consenting to forego benefits from using competitive forces during auctions when contracting for the good or service in question. By setting lowest possible contractual length, expected net consumer surplus is therefore higher since the buyer may benefit from competition among the firms during auctions.

3.4 Repeated procurement auction with collusion

Let us now study the case where firms may collude. As McAfee and MacMillan [1992] noted, a successful cartel must overcome at least four obstacles: a mechanism to divide the spoils, a means to enforce the collusive agreement, the capacity

to deter entrance and the ability to resists to temptations to destabilize the cartel undertaken by victims of the cartel. Our framework using repeated procurement is readily available to study the second aspect of the cartel problem, namely enforcement of the collusive agreement. In other words, we will focus on the self–sustainable collusion enforced through repeated interaction. Furthermore, we will focus our attention on all–inclusive collusion (*i.e.* a bidding ring that involves all the firms participating in the auction).[9] In terms of spoils division among cartel members, we impose the following assumption on cartel members' ability to make side payments among themselves:

Assumption 3. *Collusive side transfers among firms are unavailable.*

With Assumption 3, we restrict our attention to weak cartels according to the nomenclature introduced by McAfee and MacMillan [1992].[10] It seems to us that enforcement through repeated interaction and the absence of side monetary transfers among cartel members conform best with the real workings of the economy. Indeed, cartel members can rarely transfer monetary payments among themselves. Moreover, if cartel members can set side transfers among themselves to sustain the collusive ring, it would be necessary that such transfers be credible and enforceable. One may then suspect that evidence be generated and could lead to detection and prosecution of its members. Strong cartels may therefore involve more risks and firms may be reluctant to have recourse to such a form of cartel. On the other hand, self-sustainable collusion and absence of side transfers will be less likely to generate hard physical evidence, making detection and prosecution harder. McAfee and MacMillan [1992] provide a more in-depth discussion on organization within a cartel, as well as different forms of collusion (explicit vs. tacit collusion), while Hendricks and Porter [1989] provide a survey of circumstances

[9]This is a simplifying assumption that we adopt. Bidding rings involving only some of the firms participating in the auction are already considered elsewhere in the literature (e.g. Graham and Marshall [1987], Malaith and Zemsky [1991] and McAfee and MacMillan [1992]). The two former studies show that bidder's profit are increasing in the size of the ring, suggesting that in equilibrium a bidding ring will be all inclusive. Nevertheless, it should be noted that the authors study second price auctions and English auctions. In a later study, Marshall and Marx [2006] show that some bidders may not want to join the ring.

[10]The other type of collusive rings considered in the literature is known as strong cartels where cartel members designate the winner of a ring and set transfers among cartel members (McAfee and MacMillan [1992]).

and mechanisms facilitating collusion.

Since side payments are unavailable as an instrument to enforce collusion, we consider a bid rotation scheme, which is the best collusive mechanism that cartel members could use in absence of side payments (McAfee and MacMillan [1992], Thomas [2005]).

3.4.1 Bid rotation

As mentioned above, a successful collusion in auctions would require the bidding ring to select a winning firm, a winning price, to detect and punish defections. Clearly, a weak cartel, just as a strong one, must devise schemes that satisfy these requirements.

Let us first address the first two aspects of the cartel's problem in designating a winner and the winning price in absence of side transfers.To this end, we will follow McAfee and MacMillan [1992] and consider the following bid rotation scheme for weak cartels:

(i) Firms with expected costs lesser than the buyer's reservation price submit the same bid at the reservation price r. Other firms refrain from participating or submit bids higher than the buyer's reservation price.

(ii) The winner is designated randomly.

Note that given the auction rules assumed above, the randomization device to designate the winning firm can be left to the buyer under our framework. Indeed, since the bid rotation scheme described above have members of the cartel whose expected costs are less than the buyer's reservation price submitting the same bid (which is equal to the buyer's reservation price), the buyer will have to select the winning firm randomly. As McAfee and MacMillan [1992] noted, such a bid rotation scheme is an optimal collusive mechanism[11] because "*... in the absence of side-payments, incentive compatibility requires that the good be awarded stochasti-*

[11] A formal proof of this is contained therein.

cally, with equal probability of being awarded to anyone whose value is larger than the minimum price: any attempted to arrange that the highest-value bidder wins generates incentives for the bidders to misstate their valuation. By submitting equal bids, bidders in effect use the [buyer] *as their randomizing device ...*".

At this stage, two aspects of such a collusive scheme has to be clarified: the first of which concerns whether such a bid rotation is realistic. To this question, McAfee and MacMillan [1992] answers positively, citing studies undertaken by Scherer [1970] and Green [1985] among others.[12] Likewise, Abrantes-Metz, Froeb, Geweke, and Taylor [2006] noted that the US Department of Justice has formed a unit to investigate identical bids phenomena in government procurement auctions during the 1970s. This suggests the importance of identical bids in procurement auctions.

A second issue concerns the role of the auction rule as a means that helps firms in their bid rotation scheme. One may argue that such a scheme will not work if the auction rule does not select the winning firm randomly with equal probability. While such an argument is valid, it does not preclude the use of bid rotation schemes as a collusive mechanism in auctions. Thomas [2005] for instance argues that bid rotation could still serve as a collusive mechanism if firms are able to communicate before an auction and designate a winner using some public random device. He suggested that an alphabetical ordering by name. Obviously, when the auction rule cannot be used as such a randomization device, more coordination will be needed in order for firms to collude and it can lead to increased difficulty in the formation of a collusion. Nevertheless, we believe that if the auction rules are unable to serve as the randomization device in a bid rotation scheme, firms are perfectly capable of finding some other devices that could be used instead when they are motivated enough to collude.

A firm i's expected discounted utility under such a bid rotation scheme and a contract of length τ is therefore the probability of winning the contract when a combination of $n \leq N$ firms have expected costs less than r and firm i's expected

[12]For instance, McAfee and MacMillan [1992], citing Green [1985], write: "... *for example, in one sealed-bid tender to a Canadian local government, all nine bids were for $ 6,009.15 ...*".

costs are less than r. Under the bid rotation scheme, all firms submit the same bid corresponding to the reservation price $r = \overline{c} + \frac{\delta(1-\delta^{\tau-1})}{1-\delta}\mathbb{E}[c]$, and firm i will be selected with probability $\frac{1}{N}$ as the auction's winner. The *ex post* expected utility of a firm i participating in the bidding ring when its realized costs is c_i when the auction is held is simply

$$\begin{aligned} U_i^{\text{C,ex post}}(c_i) &= \frac{1}{N}[r - c_i - \delta\frac{1-\delta^{\tau-1}}{1-\delta}\mathbb{E}[c]] \\ &= \frac{1}{N}(\overline{c} - c_i) \end{aligned}$$

and its expected *ex ante* utility from participating in the bidding ring is

$$\begin{aligned} U_i^{\text{C,ex ante}}(c_i) &= \frac{1}{N}\int_{\underline{c}}^{r}[r - s - \delta\frac{1-\delta^{\tau-1}}{1-\delta}\mathbb{E}[c]]f(s)ds \\ &= \frac{1}{N}(\overline{c} - \mathbb{E}[c]) \end{aligned}$$

Therefore, for a firm i, intertemporal expected discounted utility from participating in the bidding right amounts to

$$\begin{aligned} \mathscr{U}_i^{\text{C}} &= U_i^{\text{C,ex post}}(c_i) + \sum_{k=1}^{+\infty} U_i^{\text{C,ex ante}} \\ &= U_i^{\text{C,ex post}}(c_i) - U_i^{\text{C,ex ante}} + \frac{1}{1-\delta^{\tau}}U_i^{\text{C,ex ante}} \end{aligned}$$

Once the winner and the winning price are determined, defection can be dealt with during the next round of auction. We assume the winner and the winning price will be made known by the buyer: often, the winning firm's identity and its winning price seem readily available where auctions for public contracts are concerned, at least in principle due to transparency reasons.[13] Following Aoyagi [2003], we will consider that defections during an auction are punished by members of the ring through perpetual reversion to the "static" Nash equilibrium by submitting a bid amounting to b^{NE} given in Lemma 1. In other words, enforcement of the cartel is considered through the grim trigger strategy framework introduced by Friedman [1971]. This is the most severe equilibrium punishment in our setting.

[13] Where the winning price is not public information, defections are harder to detect.

Using grim trigger strategies, we know that collusion is sustainable if and only if the expected discounted utility from participating in the cartel is higher than the expected discounted utility from defection and the consequences of such a defection. In our setting, a firm may defect by submitting a bid that is slightly lower than the buyer's reservation price. In this way, the defecting firm is *certain* of winning the contract. In other words, a firm seeking to defect may submit a bid corresponding to $r - \varepsilon \approx r$, with $\varepsilon > 0$. Hence, defecting during the auction stage yields expected utility

$$\begin{aligned} U_i^{\mathrm{D}} &= r - c_i - \frac{\delta(1-\delta^{\tau-1})}{1-\delta}\mathbb{E}[c] \\ &= \overline{c} - c_i \end{aligned}$$

After a defection, firms revert back to playing their static Nash equilibrium during the next auction and in subsequent auction stages. Therefore, intertemporal discounted expected utility of a defecting firm i with cost $c_{i,0}$ during an auction stage could be written as

$$\begin{aligned} \mathscr{U}_i^{\mathrm{D}} &= U_i^{\mathrm{D}} + \sum_{k=1}^{+\infty} \delta^{k\tau} U_i^{\text{NE,ex ante}} \\ &= U_i^{\mathrm{D}} - U_i^{\text{NE,ex ante}} + \frac{1}{1-\delta^{\tau}} U_i^{\text{NE,ex ante}} \end{aligned}$$

where $U_i^{\text{NE,ex ante}}$ is the expected per contract utility of the static Nash equilibrium as define in Lemma 1.

As usual, from a repeated game perspective, the bid rotation scheme above is sustainable if and only if a firm i's discounted expected utility from participating in the cartel is greater than expected discounted utility from defecting, whatever its cost realization when the auction is being organized:

$$\mathscr{U}_i^{\mathrm{C}}(c_{i,0}) \geq \mathscr{U}_i^{\mathrm{D}}(c_{i,0}), \qquad \forall c_{i,0} \in [\underline{c}, \overline{c}]$$

Temptation to defect is the greatest for firm i when it has the most efficient cost realization, *i.e.* $c_{i,0} = \underline{c}$. Consequently, in order for the bid rotation scheme

to be self-sustainable through repeated interaction, it must be that a firm i with cost realization $c_{i,0} = \underline{c}$ when the auction is being held has no incentive to defect from the bid rotation scheme. Bid rotation scheme is therefore sustainable if and only if

$$\mathscr{U}_i^{\mathrm{C}}(\underline{c}) \geq \mathscr{U}_i^{\mathrm{D}}(\underline{c}) \tag{3.2}$$

The following lemma describes when the bid rotation scheme is sustainable in terms of a critical threshold:

Lemma 2. *A bid rotation scheme is sustainable under a repeated game framework if and only if firms' discount factor δ is greater than a critical threshold δ^*:*

$$\delta \geq \delta^* = \left[\frac{U_i^D(\underline{c}) - U_i^{C,ex\ post}(\underline{c})}{(U_i^D(\underline{c}) - U_i^{C,ex\ post}(\underline{c})) + (U_i^{C,ex\ ante} - U_i^{NE,ex\ ante})} \right]^{\frac{1}{\tau}}$$

Proof. Developping equation 3.2 and rearranging the terms. □

Lemma 2 has a straightforward interpretation: notice that the numerator is just the expected utility that a firm (with the lowest costs during an auction) can immediately gain from defecting (with respect to behaving in conformity with the bid rotation scheme), while the denominator is simply the loss in terms of expected utility given the current defection and foregone future cooperation.[14] Since the auction takes place after every τ periods, the critical threshold is elevated to the power of $\frac{1}{\tau}$.

We are now able to study the impact of contractual length on firms' capacity to sustain the bid rotation scheme as defined above. We resume these effects in the following proposition:

Proposition 2. *Whenever expected* ex ante *utility from collusion is higher than expected* ex ante *utility from competing in auction (*i.e. $U_i^{C,ex\ ante} > U_i^{NE,ex\ ante}$*), the critical threshold factor that sustain the bid rotation scheme is increasing in τ.*

Proof. See appendix. □

[14] To see this, we can rewrite the denominator as $[(U_i^{\mathrm{C,ex\ ante}} - U_i^{\mathrm{NE,ex\ ante}}) - (U_i^{\mathrm{C,ex\ post}}(\underline{c}) - U_i^{\mathrm{D}}(\underline{c}))]$.

Proposition 2 states that the longer the contractual length, the harder firms will find it to sustain the bid rotation scheme. In other words, the longer the contractual length, the more patient firms will need to be in order to sustain the bid rotation scheme. Intuitively, in order to sustain collusion, expected utility from collusion must be higher than expected utility when firms compete against each other. This is measured by the term $U_i^{\text{C,ex ante}} - U_i^{\text{NE,ex ante}}$. From Lemma 2, we can see that the larger this term, the lower the critical threshold factor will be. However, firms discount this future expected utility when they choose whether to abide by the bid rotation scheme or not during an auction stage. Hence, the further away in the future the upcoming auctions are, the more they will have to be patient so that they would find it worthwhile to forego the rents from defecting during the current auction. Consequently, the longer the contractual length, the more difficult it will be for firms to sustain the bid rotation scheme.

3.5 Contractual length and the level of competition: Application to the French water sector

As we have seen above, contractual length may be a variable that the buyer could use to destabilize collusion during an auction. Where local public services are concerned, such an instrument is clearly available: when local public authorities choose to outsource the provision of local public services to an external operator, the contract usually establishes the contractual length of the awarded monopoly franchise. Here we suggests that local public authorities should increase the contractual length of the awarded monopoly franchise when suspicion for collusion during an auction is high. We will check to see if local public authorities use this particular instrument in this section, using the same data from the French water sector as in the first chapter. The goal of such an empirical work is twofold: firstly, to indirectly test whether our theoretical predictions are corroborated by practice where local public services are concerned; and secondly, to better understand the workings of the French water sector. To this end, we seek to study empirically the relation between contractual length as observed in 2001 and the level of local industrial competition, as measured by the Herfindahl index.

While the task of testing our theoretical propositions would best be addressed using data on bids and the level of participation in the auction, our empirical work on this dimension is not devoid of interest. Indeed, a concern that could arise when directly using data on bids and the firms' participation in an auction to study bid rotation is the following one: firms in a cartel may wish to refrain from submitting any proposals during an auction when they know that they are designated to lose. This type of behavior has been identified in theoretical studies on collusion and auction.[15] Researchers wishing to do empirical studies on collusion during an auction will have to identify the set of potential candidates that could have participated in the auction, but have chosen not to because they have been identified as losers in a bid rotation scheme. This would clearly involve some arbitrariness. The problem could be more acute where auctions for local public services are concerned: participating in an auction for a contract may involve submitting proposals that could be costly in terms of time and effort, and therefore designated losers under a bid rotation scheme could be discouraged from submitting any proposals, and are therefore absent from the auction.

Our empirical approach, on the other hand, seeks to estimate the relation between contractual length and the level of competition that exists at a local level using the Herfindahl index to measure the level of industrial concentration for water services in a given *Département*.[16] Arguably, when an operator has shown interest in a given market on the local basis, it is likely that it should be interested in winning contracts in adjacent markets. Local industrial concentration may therefore be an interesting indicator for the level of competition during auctions. However, a clear shortcoming to our empirical strategy is its indirect dimension: competitive pressures are measured indirectly using our Herfindahl index. This problem is further aggravated because of how we measure our Herfindahl index. More precisely, the index is computed at the level of a *Département*. It seems likely that the level of competition in municipalities located near the border of a *Département* would depend more on the situation of neighbouring municipalities.

[15] See for instance Aoyagi [2003] on this subject.

[16] A *Département* is a French geographical administrative division. The 26 French regions are subdivided into 100 *Départements*, which is again subdivided into municipalities.

Before discussing further our empirical approach, we will start in the following subsection by identifying some other factors that may contribute to explaining contractual length.

3.5.1 Determinants of contractual length

While we are interested in knowing whether contractual length is being used by local public authorities to discourage any collusive initiatives by external operators, we should nevertheless note that there are a number of factors that contribute to explaining contractual length. For our empirical work, it is necessary to control for such factors. We will rely principally on Transaction Costs Economics for this purpose. Indeed, having recognized that contractual length is an important dimension in contractual design, and therefore a choice variable decided by the contracting parties, Transaction Costs Economics has devoted great attention to study how contractual length are determined by contracting parties (Masten and Saussier [2000]). As a result, a number of studies into contractual length have been conducted using this framework. Moreover, as pointed out by Shelanski and Klein [1995], this framework has also proved to be useful in empirical studies on regulations and franchises. Both issues are closely related to our empirical study. Therefore, we are convinced that Transaction Costs Economics provides an adequate framework to help us identify determinants of contractual length.

The theoretical argument provided by the Transaction Costs Economics can be intuitively resumed by the following mechanism: the contractual length is chosen to minimize the transaction costs that depend on the characteristics of a transaction for which a contract serves as a support. As it is well known by now, asset specificity and uncertainty are two dimensions that have an important impact on transaction costs (Williamson [1979], Williamson [1985], Williamson [1996]), and hence, could be expected to influence contractual length.

According to this line of analysis, when a contractual relation involves invest-

ments in specific assets[17], a long–term contract is needed to safeguard against possible *ex post* opportunistic behaviours from contracting parties. Indeed, when the contracting parties rely on short–term contracts to support their transaction, once investments on specific assets are sunk, the *ex post* bargaining power of the contracting parties may be modified, allowing for one or the other contracting parties to "hold up" its contracting partner at the contract execution stage. This will undermine the contracting parties' *ex ante* incentives to invest efficiently. In anticipation of this, a long–term contract that specifies terms and conditions for some set of future transactions *ex ante* provides a safeguard against *ex post* opportunistic behaviours due to the necessity to invest in specific assets. This theoretical argument can be traced back to as early as Klein, Crawford, and Alchian [1978] and Williamson [1979].

On the other hand, Transaction Costs Economics predicts that relatively short–term contracts will allow the contracting parties to minimize transaction costs when uncertainty underlying future transactions is high. The basic argument raised by Transaction Costs Economics is the following one: longer–term contracts with contractual safeguards built in could generate higher transaction costs because the terms decided *ex ante* might be maladapted to future contingencies. This will be more likely when uncertainty is high. Moreover, at the *ex ante* stage, when uncertainty is important, contracting parties will have more difficulty in identifying and anticipating future contingencies.[18] Consequently, contracting parties will prefer more flexibility when uncertainty is high (Athias and Saussier [2005]). A long–term contract with rigid contractual safeguards built in would be more likely to be maladapted to future transactions. This results in higher transaction costs. In order to minimize transaction costs, contracting parties should therefore choose a shorter–term contract when uncertainty is important (Crocker

[17]An asset is specific to a transaction if the value generated by the asset when used within the transaction in question is higher than when it were to be redeployed to other uses (or transactions). Williamson [1985] argues that transaction specific assets are non-deployable physical or human investments that are specialized and unique to a task.

[18]Two theoretical arguments can be advanced to justify this:traditionally, Transaction Costs Economics justifies this through the assumption that agents are boundedly rational. As such, they are incapable of anticipating all future contingencies and optimally tailor their contracts to these contingencies. Another possible reason is that high uncertainty may imply a higher cost for agents to identify all contingencies and adopt precise and mechanical contractual terms as responses to these contingencies (Segal [1999], Saussier [2000]).

and Masten [1988], Crocker and Reynolds [1993], Yvrande-Billon [2002]).

Joskow [1987], Crocker and Masten [1988], Crocker and Reynolds [1993], Masten and Saussier [2000] and Yvrande-Billon [2002], among others, have found supporting empirical evidence for the theoretical propositions advanced by Transaction Costs Economics. For instance, in a well–known study on contracts from the coal market in the US, Joskow [1987] empirical tests the link between contractual length and asset specificity. He found that higher asset specificity does lead to longer contractual length. Subsequent work conducted in other sectors have also shown that contractual length increases with asset specificity and decreases with the level of uncertainty.

Contractual length between contracting parties is therefore determined by asset specificity and uncertainty underlying the transaction between contracting parties. In general, both dimensions are present in the contractual relationship between a local public authority and an external operator for operating water services. As it is well known, the infrastructure necessary for bringing water to end consumers includes treatment plants for raw water, storage plants and a distribution system. These physical assets are often long lived and involve intensive fixed investments. Consequently, fixed sunk costs made up a high proportion of total costs in providing water services. For instance, Armstrong, Cowan, and Vickers [1994] estimated that sunk costs made up of about 80% of total costs in the water industry in England and Wales.

One can easily see that the types of infrastructure necessary to provide and distribute water are specific assets in the sense of Transaction Costs Economics. More specifically, these infrastructures are site-specific according to the typology on transaction-specific investments identified by Williamson [1985]. Indeed, a large proportion of water infrastructure is built on the site of the municipality where water is to be distributed. These infrastructures rarely have any alternative uses. Furthermore, once the infrastructures are in place, they could difficultly be moved around. A good example concerns water pipes, which are an essential part of the water distribution network and represents a substantial part of investments that

have to be undertaken. Water pipes are buried underground. It is clear that once the water pipes are in place, they are unlikely to be available for alternative uses, nor could they be easily and costlessly dug up by the party that has invested in them to be redeployed elsewhere. Water distribution network can therefore be qualified as specific assets (Klein [1998], Meister [2005]). More generally, other infrastructures in the water industry also exhibit the same characteristics.

In the same way, one may expect uncertainty to play a role when it comes to the management of water services. Sources of uncertainty may include, *inter alia*, climate conditions (amount of rainfall, drought etc.) economic development of a local area and variation of future population in an area (Ménard and Saussier [2002]). For instance, climate conditions could be expected to have an impact of raw water supply, hence how water services have to be run to meet consumer demands. Dimension of the water production and distribution network clearly depends on future economic and demographic conditions of a municipality.

Therefore, for our empirical work on contractual length, we will have to account for asset specificity and uncertainty. In the following, we will precise our empirical methodology and discuss variables that could be used to control for asset specificity and uncertainty in the French water sector.

3.5.2 Empirical methodology and data description

3.5.2.1 Empirical model

To examine the impact of various economic variables on a local public authority's choice of contractual length, a simple and direct approach is to estimate the following specification on contractual length using ordinary least squares (OLS) method:

$$\mathsf{Duration}_i = \boldsymbol{X}_i'\boldsymbol{\beta} + u_i \tag{3.3}$$

where $\mathsf{Duration}_i$ is the observed contractual length for observation i, $\boldsymbol{X}_i$ is the vector of independent variables for observation i, $\boldsymbol{\beta}$ is the vector of coefficients

to be estimated and u_i is the error term. As usual, the vector of error terms $\boldsymbol{u}' = (u_1, \ldots, u_i, \ldots)'$ is assumed to have zero mean and possibly heteroskedastic:

$$\boldsymbol{u} \rightsquigarrow (0, \Sigma)$$

A slight complication that may arise for the econometrician is that contractual length may not be randomly observed. Indeed, we are only able to observe contractual length for those observations for which a local public authority has decided to externalize his water services to an external operator. In other words, when local public authorities have decided to management their water services in–house, contractual length is not observable to the econometrician. Consequently, estimates will be biased if a local public authority's choice on the governance structure for his water services is not random. In this latter case, the missing data for contractual length will not be random.

There is some evidence that suggests that a local public authority's decision to outsource a local public service is found on economic and possibly political concerns.[19] More specifically, since the governance structure is endogenous, OLS estimates on equation 3.3 may be biased. A way to overcome this problem is to estimate a sample selection model as developed by Heckman [1979]. In order to control for sample selection bias, we will estimate the following system of equation:

$$\begin{cases} \mathsf{Duration}_i &= \boldsymbol{X}_i'\boldsymbol{\alpha} + v_i \\ \mathsf{PPP}_i &= \mathbb{I}(\boldsymbol{Z}_i'\boldsymbol{\gamma} + w_i > 0) \end{cases} \tag{3.4}$$

where $\boldsymbol{X}_i$ and $\boldsymbol{Z}_i$ are respectively vectors of independent variables for observation i that might explain contractual length and governance choice, PPP_i is a dummy variable that takes on value 1 if observation i's has decided to outsource the service (through a Public Private Partnership), $\mathbb{I}$ is an indicator variable, and v_i and w_i are zero terms with respect to the contractual length equation and governance choice equation. We will use a parametric form of the model and assume that the

[19] In addition to the first chapter, econometric evidences on this issue can be found in Chong, Huet, Saussier, and Steiner [2006b], Levin and Tadelis [2005], Ménard and Saussier [2002], Ménard and Saussier [2003] etc. Masten and Saussier [2000] provide a discussion on how such effects can be estimated.

error terms are normally distributed as follows:

$$\left(\begin{array}{c} v_i \\ w_i \end{array} \right) \Bigg| \boldsymbol{X}_i, \boldsymbol{Z}_i \rightsquigarrow \mathscr{N} \left(\left(\begin{array}{c} 0 \\ 0 \end{array} \right), \left(\begin{array}{cc} \sigma_v^2 & \rho\sigma_v \\ \rho\sigma_v & 1 \end{array} \right) \right)$$

where σ_v^2 is the variance of the error term in the equation for duration, and ρ measures the correlation between the equation for duration and governance structure. The variance of w_i is normalized to 1.

In the following, we will briefly discuss our data, and in particular, the contains of $\boldsymbol{X}_i$ and $\mathbf{Z}_i$.

3.5.2.2 Data and variables

The same set of data in the first chapter is used to run regressions for our empirical model specified above. We briefly remind the sources of our data: part of our data comes from a combination of a survey conducted in 2001 by the French Environment Institute (IFEN, for *Institut Français de l'Environnement*) in cooperation with the Service of Survey and Statistical Studies (SCEES, for *Service Central des Enquêtes et des Études Statistiques*), and data by the French Health Ministry (DGS, for *Direction Générale de la Santé*), on 5000 local public authorities, corresponding to 5000 municipalities. There are 3650 usable observations from this dataset after eliminating observations with missing data.[20] We then merge this sample with data collected from several French Water Agencies[21] to compute market shares of the private operators. We are able to gather such data on 46 *Départements*, representing 16000 municipalities and about one third of the French population. Merging both datasets yields a total of 1113 common observations.

To estimate our empirical models as discussed above, we will restrict our at-

[20] We have also eliminated observations for which local public authorities do not make the same governance choice structure for water production and water distribution, *i.e.* when water production is managed through a different contract arrangement from water distribution. 557 observations (about 11.14% of the original sample) correspond to this case. We eliminated these observations because water prices as measured in our dataset are charged to end users for water production *and* distribution services.

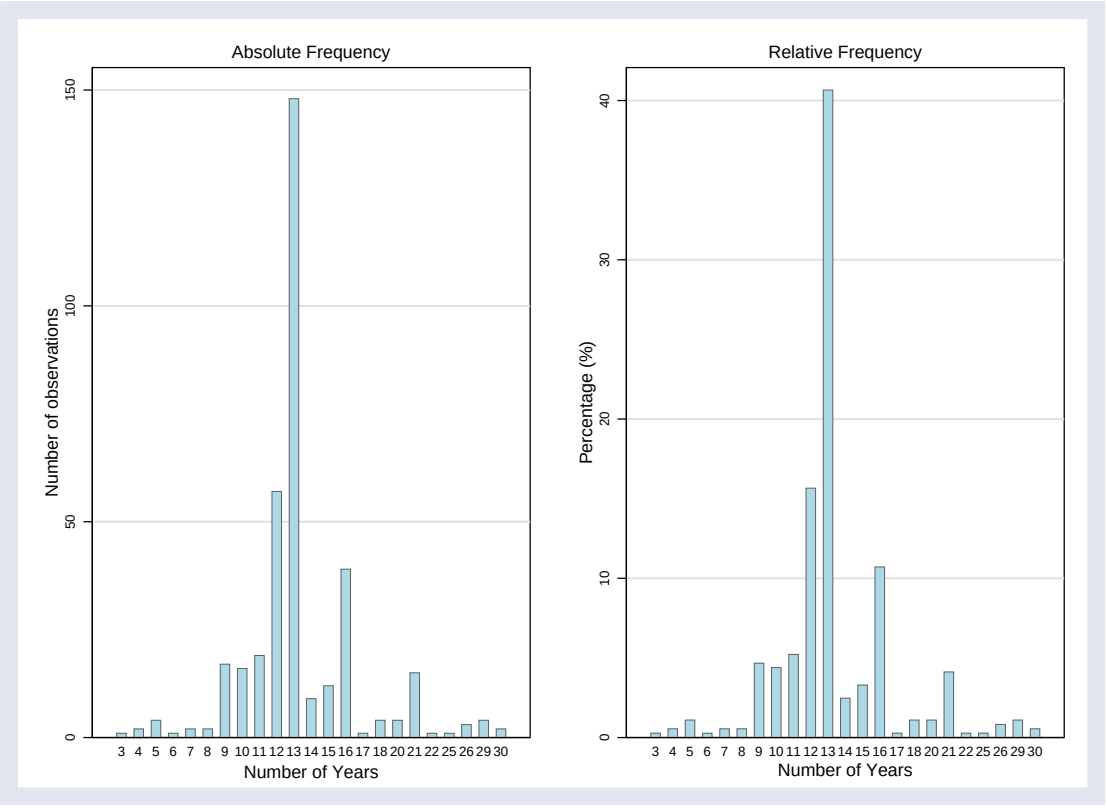
[21] A Water Agency (*Agence de l'Eau*) is a State establishment that is in charge of coordinating the development and management of water ressources in France. There are altogether 6 Water Agencies in France, corresponding to the 6 water bassins.

tention to contracts that are signed after 1993. Such a decision is motivated principally by four reasons: first of all, local public authorities were unable to choose their contractual provision before 1982 (see Ménard, Saussier, and Staropoli [2003]). For our purpose, there seems to be little reason to empirically study these contracts, as local public authorities had no choice to make when it came to contractual provisions specified in their contracts. Secondly, local public authorities are obliged by law to organize a public tendering offer since 1993 whenever they intend to outsource a local public service. This lead us to believe that auctions are used more systematically for contracts that are awarded after 1993 than those awarded before. Moreover, including contracts that are signed before 1993 may lead to a sample that overly represents long–term contracts: since our set of data is observed in 2001, it is likely that shorter–terms contracts would be absent from our dataset if they are signed too long ago. Lastly, since our Herfindahl index is measured in 2001, we may reasonably expect this variable to have an impact on contractual length only for contracts that are recent enough. A Herfindahl index computed in 2001 is more likely to be a proxy the level of competition for more recent contracts than those awarded a long time ago.

Our final sample therefore comprises of 758 observations inclusive of observations that organize their water services through direct public management (in–house provision). This correspond to usable observations from the original IFEN–SCEES–DGS sample that have either chosen to run their water services in–house (through direct public management), or have signed a PPP contract after 1993, and for which we have been able to compute the Herfindahl index. For convenience, we will refer to the original usable sample with 3650 observations from IFEN–SCEES–DGS as "original sample" and the sample with 758 observations on which we carry out our empirical work as the "reduced sample".

A summary of definition and descriptive statistics of all variables used in our regression will be provided in table 3.2 and table 3.3. We will briefly discuss some of the more important variables to our empirical work and rationales for our control variables in the following.

Figure 3.1: Distribution of contractual length



Note: Relative frequency (in percentage) is computed relatively to the total number of outsourced contracts in the sub-sample in question.

Contractual length

Contractual length, given by the variable Duration, is measured in terms of number of years. This variable is computed as the difference between the year when the contract is expected to end and the year when a contract is signed. To account for the case that a contract was signed and is expected to end in the same year, we add a supplementary one year to this difference. In this latter case, the contract lasts for one year. When a local public authority has not chosen to outsource its water services, contractual length is coded as missing.

The distribution of contractual length of contracts signed after 1993 is provided in figure 3.1.[22] One could see from figure 3.1 that a large majority of contracts

[22]For a view on the distribution of the year when contracts are signed and when they are expected to end in our sample, we refer the reader to Chapter 1, figure 1.3 and figure 1.4.

has a length of 13 years (over 40% of all contracts our sample). Nevertheless, contractual length exhibits some important variations: a large proportion of contracts can last from 9 years to 21 years. Moreover, figure 3.1 does not seem to indicate any censoring problems that may arise due to upper legal limits fixed on the length of contract that a local public authority may choose[23]: observations are not concentrated for high values of contractual length.

Governance structure

Our data also allows us to identify the governance structure chosen by local public authorities to manage their water services. In particular, we provide the distribution of various governance structures available to local public authorities, ranging to direct public management to concession (see table 3.1).

Table 3.1: Distribution of observed governance structures in sub-samples

Governance Structure	*All Observations*		*Reduced Sample*	
	N	%	N	%
Direct Public Management	1132	31.01%	394	51.98%
Gérance	128	3.51%	6	0.79%
Intermediary Management	152	4.16%	0	0.00%
Lease	2074	56.82%	351	46.31%
Concession	164	4.49%	7	0.92%
Total	3650	100.00%	758	100%

Source: IFEN, DGS & French Water Agencies

It would seem from table 3.1 that municipalities that organize water services through direct public management are proportionally more represented in our reduced sample than in the original representative dataset. Where major organizational forms are concerned, concession contracts are relatively absent from both our sample too. We will check whether such a high proportion of observations using direct public management can have an impact on our estimation of the Heckman model.

[23]The Sapin Law also imposes an upper limit to the length of contract that a local public authority may choose when using a PPP.

Level of competition

We measure the level of potential competition using a constructed Herfindahl index, given by the variable Herf. To compute this index, we use market shares of French water companies in each of the 43 *Départements* for which we manage to find data. We use the percentage of population served by the water company in a given *Département* as a proxy for its market shares. The Herfindahl index is given by the following formula:

$$\text{Herf} = \sum_{i=1}^{n} \text{market shares}_i^2, \quad \text{with} \sum_{i=1}^{n} \text{market shares}_i = 1$$

A high index value thus indicates a high concentration at the level of a *Département*, and thus potentially low competition.

Another measure of potential competition used together with the Herfindahl index is Share DM, which measures that percentage of the population in a given *Département* served in water through direct public management. Indeed, the Herfindahl index does not account for potential competition that could stem from direct public management. Given the importance of this latter governance structure in the French water sector, one may expect that some potential competition between public and private management. This is confirmed by our estimations in Chapter 1. Hence we use Share DM as a complement measure for potential competition at the local level.[24]

We expect a higher Herfindahl index to lead to longer contractual length, *ceteris paribus* if local public authorities seek to prevent collusive initiatives through this means, and for the same reason, a higher Share DM to lead to a shorter contractual length, *ceteris paribus*.

Notice that we measure the level of potential competition at a local level, and not at the national level. As we have discussed in Chapter 1, we believe that this is a relevant measure of competition in the industry. Indeed, local conditions have an important influence on how water services are done. Moreover, in the

[24]The first chapter provides a more elaborated discussion on why potential competition between organizational mode may be expected.

French water sector, there are some small firms that are only active in certain regions. Potential competition is therefore relatively more vibrant at the local level. Another advantage, as we have mentioned in previous paragraphs, is that operators who are already running water services in a region or *Département* may be more motivated to run the same services in other municipalities in the same region. This dimension is captured in our measures. As a result, we believe that potential competition measured at a local level is relevant to our analysis.[25]

Other control variables common to contractual length and governance structure

As we have seen above, according to Transaction Costs Economics, asset specificity and uncertainty are two dimensions that could determine contractual length. The same theoretical framework also accounts for the choice of governance structure: the theory predicts that the choice between in–house provision and externalizing service provision also depends on asset specificity and uncertainty. Thus, the first set of explanatory variables that enters in both estimating equations concerns variables that measure asset specificity and uncertainty.

To account for the level and degree of specificity of the assets involved in the French water sector, we follow previous studies (Ménard and Saussier [2002], Ménard and Saussier [2003], and Ménard, Saussier, and Staropoli [2003]) and use the following proxies: the type of treatment raw water needs to undergo, the existence of an investment program in 2001, and several variables concerning the characteristics of the water distribution network.

The type of treatment that raw water needs to receive before being distributed to end users is a good proxy for asset specificity mainly because complex treatments will often involve high level of investments and be specific to the site from which raw water is taken (Ménard and Saussier [2003]). In France, raw water treatments are classified according to their complexity into three main categories by the French administration:

[25]See Chapter 1 for a more detailed discussion on this issue, and on the drawback of our measures.

(i) A1-type treatments are relatively simple treatments. They only involve some raw water filtering technology and light disinfection.

(ii) A2-type treatments involve some mechanical or chemical treatments before disinfection and distribution.

(iii) A3-type treatments involve previous treatments and a supplementary operation to "refine" water. Arguably, this type of treatment is the most complex according to this classification.

We use the dummy variables TreatA1, TreatA2, TreatA3, TreatMix A1&2, TreatMix A3 to indicate the type of treatment that raw water undergoes in a local area. The last two dummies account for situations where a mixture of different raw water treatment technologies are used due to several different sources of raw water in a local area.

The origin of water (surface or underground) can also be seen as a good proxy for the level of investment. Indeed, underground water is known to be more stable over time with respect to its quality. When raw water comes from underground, we may expect less uncertainty over the type of treatment that has to be used before water can be distributed to end users, and hence less extensive investments to be put in place. Therefore, we expect contractual length to be shorter when raw water comes from underground. The dummy variable Underground is used in this sense as a proxy for the level of investment.

The third proxy we used to measure the level of investment is the dummy variable Invst Prg. We believe that this variable may be an indicator of investments that need to be undertaken, and therefore, may have an impact on contractual length and choice of governance structure. In the same spirit, other variables will be used as proxies for the level of investments in general and asset specificity in particular: these include the density of the water distribution network, Density; the length of network replaced, Replacement; and the length of network extended, Extension. These three variables are expected to have a positive effect on contractual length, since a higher value of these variables indicate more heavy specific

investments.[26] Note, in particular, that given the way Density is defined, a high value of this variable indicate a less dense network. The variable Leak Ratio, which measures the amount of water loss to the distribution network, can also be seen as a proxy for investments necessity. Indeed, a high Leak Ratio may be seen to indicate that a water distribution network is in a bad state, and may therefore require more investment needs. We expect Leak Ratio to have a positive impact on contractual length.

The variable Interauthority is included in both equations in our estimations. This variable indicates whether water services in a municipality is organized through an association comprising of several municipalities in neighbouring areas. Such association may use PPP as well as direct public management. In general, the use of an association to organize water services is an indication of the difficulty in running these services: associations are used for water services that are difficult to operate. One could reasonably think that services that are difficult to run may involve more important investments, and therefore we expect this variable to have a positive impact on contractual length.

Tourist, which indicates if a municipality is a tourist area, is also included in both regression equations. This variable may be expected to proxy for investment levels, as well as for uncertainty. A municipality that has to cater to tourists' needs will have to ensure that its infrastructure for water is adequately dimensioned to meet such seasonal needs. On top of this, there will doubtlessly be some uncertainty as to the comings and goings of tourists, hence the supply of water needed to meet such demand. This variable is therefore included in both equations in our regression.

Indep Ratio is also another variable that may be used as a proxy for uncertainty. This variable measures the extent to which a municipality relies on other surrounding municipalities for its water supply: a higher Indep Ratio indicates that the municipality is more autonomous in terms of water "endowment", and

[26] As we have mentioned, water distribution network are specific asset in the sense of Transaction Costs Economics. Consequently, these variables measure the importance of investment in specific assets that have to be incurred.

therefore a lesser need to import water from surrounding areas. Consequently, a low Indep Ratio may imply more uncertainty when it comes to managing water provision: a municipality in this case will have to rely more on conditions of surrounding municipalities, and therefore faces more uncertainty in managing its water provision services. In the same spirit, we included the dummy variable Water Limitations indicating whether regulation to restrict water consumption has been introduced any time in 2001. Such regulation could reflect low water endowment in a local area or frequent dry spell in an area,. This could lead to higher uncertainty in managing water services.

Population, given by the variable Population, is also included in both equations. The population size in a given area could be expected to influence not only a local public authority's choice of governance structure, but also his choice of contractual length.

While we would also like to account for regional fixed effects in our estimation of contractual length; we are unable to do so here. Indeed, in our reduced sample, there is a high correlation between our measures of potential competition and the regional dummy variables. This is because there are some regions for which we only have observations belong to one or two particular *Départements* (5 out of 11 regions are concerned by this in the reduced sample consisting of only PPP contracts). To avoid multicollinearity, we have therefore decided to include on regional fixed effects in the selection equation.

Control variables specific to contractual length estimation

A first set of control variables that has been included in estimating contractual length, but not in the selection equation, concerns variables that could only be observed when a local public authority has chosen to externalize the provision of water services. One such variable is the identity of the operator chosen to run the service. To account for possible operator fixed effects, we include a set of dummy variables for the major operators in the French water industry (Operator 1, Operator 2 and Operator 3) and a dummy variable, Operator 4, when the chosen

operator is in fact a joint venture between Operator 1 and Operator 2. As we have seen from Chapter 1, consumers pay a premium that varies according to the operator chosen to run their water services. It seems therefore reasonable to control for such effects as well when we study contractual length.

Another such variable that is included in our regression on contractual length is the share of water prices[27] charged to end users that reverts back to the local public authority. Under the French legislation, a local public authority is entitled to a share of water prices paid by end users in order finance investments in water sector that he undertakes (Chong and Huet [2005]). The same legislation also restricts the use of such funds only for investment purposes in the water sector. As such, we believe that this variable is a good proxy for the amount of investments that is left to the responsibility of a local public authority, and could therefore lead to shorter contractual length.

A slight complication arises from using such a variable directly. Indeed, one may expect the amount of investment that a local public authority decide to undertake by himself (instead of delegating to the private operator) is endogenous to contractual length. This share may be determined by the characteristics of investments to be undertaken, and hence determined by the same factors as those influencing contractual length. To overcome this possible endogenous bias in our estimation of contractual length, we decided to use the variable LPA Share, which is the predicted value of the share of water prices that reverts back to a local public authority. These estimations are obtained by regressing the share of water prices that reverts back to the local public authorities on variables that may explain why a local public authority may prefer to undertake higher or lower amounts of investments. The same set of variables used for our study on contractual length, except our measures of potential competition, is used to estimate the decision of a local public authority on this issue. Regional dummy variables are also included to predict the share of investment that a local public authority would decide to undertaken by himself.[28][29] Since a higher LPA Share indicates that an operator has

[27] Water prices are measured in euros per 120 m^3.

[28] For the reasons mentioned above, we do not account for regional fixed effects in our estimations on contractual length.

[29] A more general and detail discussion on this estimation can be found in Chong and Huet

less investment responsibilities, we expect this variable to have a negative impact on contractual length.

Control variables specific to the governance choice equation

In the selection equation for governance choice, we have included the governance structure chosen for water sanitation services, Sanitation. There is no straightforward reason to believe that a local public authority's choice on governance structure for sanitation should impact on the contractual length. However, this variable may have an impact on a local public authority's choice on a certain governance structure for water production and distribution services, especially if he has some preferences over certain organizational forms due to political reasons. Hence, their choice of governance structure for water and sanitation services may be correlated. We believe therefore that this variable may be used as an instrument. Theoretically, only one instrument should be sufficient for identification purposes.

Another instrument that we have used in the selection equation is the variable Left Wing, which the average share (taken to all susceptible voters) of left wing voters during the 1995 and the 2002 presidential elections. This variable could approximately capture the political tendency of the local public authority in municipality. While a left wing municipality may tend to favor in–house provision to using PPPs, this should not have any impact on the choice of contractual length chosen. This makes the variable Left Wing a suitable instrument.

We have also decided to include the square of population in our selection equation to account for possible quadratic effects due to population size in a local area. Indeed, quadratic effects in population size have been econometrically shown to play a role in a local public authority's decision to outsource or to provide water services in–house.[30] This leads us to the decision to include population size quadratic effects in our estimation on a local public authority's choice on gover-

[2005].

[30]See our first chapter.

nance structure. However, we are unable to find any convincing argument that may lead us to believe that quadratic effects may be present in a local public authority's choice of contractual length. We have thus decided to include the square of population size in a local area, the variable $\mathsf{Population}^2$ only in our selection equation.

Finally, we will also control for fixed regional effects in our governance structure choice equation.

Table 3.2: Definition of variables used in the estimation of duration

Variable	*Definition*
Duration	Contractual length measured in bumber of years
PPP	Dummy takes value 1 if water services are outsourced
Sanitation	Dummy takes value 1 if sanitation services are externalized
Left Wing	Average share of left–wing voters (with respect to the population legitimate to vote) during the presidential election of 1995 and 2002 in a *Département*
Herf	Herfindahl index computed at the *Département* level
Share DM	Share of population served through a public direct management at the *Département* level
LPA Share	Predicted share of water price per $120m^3$ in 2001 that reverts to the local public authority using estimations from Chong and Huet [2005]
TreatA2	Dummy takes value 1 if type A2 treatment is required
TreatA3	Dummy takes value 1 if type A3 treatment is required
TreatA1&2	Dummy takes value 1 if a mixture of type A1 and A2 treatments are required
TreatA3Mix	Dummy takes value 1 if a mixture of type A3 and other types of treatment are required
Underground	Dummy takes value 1 if raw water comes from underground
Tourist	Dummy takes value 1 if a municipality is a tourist area
Invst Prg	Dummy takes value 1 if there is an investment program in 2001
Density	Length of network (in km)/Number of inhabitants
Extension	Length of network extended in 2001 (in km)
Replacement	Length of network replaced in 2001 (in km)
Leak Ratio	Volume of water loss to the network/size of the network
Indep Ratio	Total volume of water distributed/(Total volume distributed + volume imported)
Interauthority	Dummy takes value 1 if a local public authority organizes his water services in association with other municipalities
Water Limitations	Dummy takes value 1 if regulations limiting water consumption are introduced in 2001
Population	Number of inhabitants concerned by the contract /10 000
$Population^2$	Square of population
Operator 1	Dummy variable for Operator 1
Operator 2	Dummy variable for Operator 2
Operator 3	Dummy variable for Operator 3
Operator 4	Dummy variable for Operator 4

Table 3.3: Descriptive statistics of variables used in the estimation of duration

Variable	*Original Sample Sample*			*Reduced Sample*			*Reduced Sample (PPP only)*		
	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.	Obs	Mean	Std Dev
Duration	2022	22.902	18.154	364	13.495	3.771	364	13.495	3.771
PPP	3650	0.690	0.463	758	0.480	0.500	364	1.000	0.000
LPA Share	—	—	—	758	0.685	0.340	364	0.398	0.102
Herf	—	—	—	758	0.459	0.152	364	0.435	0.133
Share DM	—	—	—	758	36.528	23.334	364	26.045	18.001
Sanitation	3650	0.419	0.493	758	0.306	0.461	364	0.522	0.500
Left Wing	3618	0.298	0.069	758	0.310	0.069	364	0.301	0.067
Operator 1	—	—	—	758	0.137	0.344	364	0.286	0.452
Operator 2	—	—	—	758	0.096	0.295	364	0.201	0.401
Operator 3	—	—	—	758	0.133	0.340	364	0.277	0.448
Operator 4	—	—	—	758	0.021	0.144	364	0.044	0.205
TreatA2	3650	0.163	0.369	758	0.183	0.387	364	0.206	0.405
TreatA3	3650	0.186	0.389	758	0.102	0.302	364	0.110	0.313
TreatMix A1&2	3650	0.047	0.211	758	0.024	0.152	364	0.019	0.138
TreatMix A3	3650	0.050	0.218	758	0.061	0.239	364	0.049	0.217
Underground	3650	0.650	0.477	758	0.675	0.469	364	0.717	0.451
Density	3650	22.523	36.477	758	30.466	35.606	364	31.086	29.282
Extension	3650	0.464	1.722	758	0.492	2.181	364	0.637	2.986
Replacement	3650	0.542	1.252	758	0.451	0.911	364	0.412	0.869
Touristic	3650	0.879	0.326	758	0.166	0.373	364	0.162	0.369
Invst Prg	3650	0.660	0.474	758	0.627	0.484	364	0.635	0.482
Leak Ratio	3650	0.259	0.139	758	0.307	0.150	364	0.311	0.119
Indep Ratio	3650	0.902	0.203	758	0.917	0.190	364	0.914	0.192
Water Limitations	3650	0.030	0.172	758	0.015	0.120	364	0.014	0.117
Interauthority	3650	0.675	0.468	758	0.639	0.481	364	0.742	0.438
Population	3650	9.376	42.161	758	5.160	10.714	364	4.047	6.956
Population^2	3650	1864.939	75606.550	758	141.259	938.117	364	64.633	344.012

Source: IFEN, SCEES, DGS & French Water Agencies

3.5.3 Estimation and results

Our estimation of equation 3.3 and equation 3.4 on our reduced sample are provided in table 3.4. We have used the Huber–White variance estimator in place of traditional variance estimator in all our regressions to ensure that our estimations are robust to any heteskedasticity problems. We have also used a maximum likelihood procedure to estimate the Heckman selection model specified above. The first two columns shows estimates of OLS regression using our sample on contracts that are signed after 1993, in absence and in presence of variables indicating the level of competition in a *Département*. The third and fourth column of table 3.4 provide estimates yielded by our Heckman regressions on contracts that are signed after 1993.

As we have noted before, a possible bias may stem from the fact that direct public management is over–represented in our reduced sample with respect to the original sample. To check whether this would have consequences on estimates of our Heckman model, we have decided to randomly choose 164 observations among observations that uses direct public management to provide water. These observations are then used together with all observation having chosen a PPP for their water services to estimate our Heckman specification. The choice of 164 observations allows us to respect the proportion of observations that has chosen to provide water services in house in the original representative sample, given that we have data only on 364 observations that outsourced water services. In this case, the 164 chosen observations will constitute approximately 31% of total observations that is used in the Heckman regression, the same proportion that has been observed in the original sample from IFEN–SCEES and DGS. Arguably, this may allow us to get an idea on possible bias in our sample due to disproportionally large share of observations that provide water services in–house. This yields estimate of given in the fourth column of table 3.4, which we refer to as *Heckman (2)*.

From table 3.4, it would seem that our estimates on contractual length are generally consistent. One could also see from *Heckman (2)* that our estimates on contractual length do not seemed to be affected by the high presence of observa-

Table 3.4: Estimation results on contractual length

Sample	*OLS (1) After 93 PPP only*	*OLS (2) After 93 PPP only*	*Heckman (1) Merged Sample*		*Heckman (2) Resampled*	
Indep. Variable	Duration	Duration	PPP	Duration	PPP	Duration
LPA Share	1.453	1.721	—	-2.032	—	-2.685
	(3.949)	(3.989)		(4.061)		(4.006)
Herf	—	2.696+	-0.790	1.564	-0.385	1.878
		(1.545)	(0.495)	(1.573)	(0.632)	(1.504)
Share DM	—	-0.018	-0.032***	-0.054*	-0.027***	-0.049**
		(0.011)	(0.004)	(0.022)	(0.004)	(0.015)
Operator 1	2.278***	2.205***	—	2.079***	—	2.018***
	(0.562)	(0.540)		(0.528)		(0.518)
Operator 2	1.351*	1.197+	—	1.137+	—	1.092+
	(0.647)	(0.661)		(0.632)		(0.631)
Operator 3	0.581	0.466	—	0.326	—	0.216
	(0.577)	(0.554)		(0.549)		(0.549)
Operator 4	2.499*	2.240+	—	1.916	—	1.861
	(1.213)	(1.226)		(1.178)		(1.186)
TreatA2	-0.184	-0.084	0.211+	0.005	0.388+	0.182
	(0.492)	(0.528)	(0.121)	(0.527)	(0.204)	(0.556)
TreatA3	-0.634	-0.845	0.308+	-0.800	0.389	-0.736
	(1.080)	(1.054)	(0.184)	(0.980)	(0.309)	(1.010)
TreatMix A1&2	-3.599**	-3.534**	0.313	-2.379+	0.476	-2.100
	(1.095)	(1.165)	(0.257)	(1.405)	(0.393)	(1.305)
TreatMix A3	-0.090	-0.205	0.452*	0.273	0.431	0.437
	(1.048)	(1.099)	(0.216)	(1.052)	(0.329)	(1.107)
Underground	-1.792**	-1.705**	0.267+	-1.275+	0.204	-1.262*
	(0.641)	(0.623)	(0.149)	(0.680)	(0.234)	(0.641)
Tourist	0.339	0.201	-0.183	-0.157	-0.172	-0.223
	(0.709)	(0.698)	(0.138)	(0.651)	(0.226)	(0.680)
Invst Prg	-0.042	-0.191	0.083	-0.206	0.128	-0.231
	(0.391)	(0.395)	(0.092)	(0.388)	(0.154)	(0.408)
Density	0.010	0.009	-0.000	0.008	0.002	0.012
	(0.010)	(0.010)	(0.001)	(0.009)	(0.003)	(0.010)
Extension	-0.065	-0.073	0.167***	-0.002	0.153*	-0.008
	(0.049)	(0.051)	(0.034)	(0.047)	(0.071)	(0.041)
Replacement	-0.428*	-0.350+	-0.087+	-0.195	-0.114	-0.196
	(0.193)	(0.198)	(0.050)	(0.213)	(0.075)	(0.201)
Leak Ratio	-0.477	-0.963	0.070	-1.948	-0.374	-2.510
	(1.673)	(1.659)	(0.262)	(1.633)	(0.554)	(1.650)
Indep Ratio	-1.947	-2.152	0.074	-1.927	0.068	-1.886
	(1.345)	(1.333)	(0.232)	(1.249)	(0.401)	(1.276)
Interauthority	0.868	0.794	0.725***	1.708*	0.406*	1.448*
	(0.536)	(0.541)	(0.104)	(0.690)	(0.172)	(0.588)
Water Limitations	-1.403+	-1.611*	-0.128	-1.568+	-0.547	-1.980*
	(0.774)	(0.806)	(0.254)	(0.899)	(0.380)	(0.971)
Population	0.143**	0.137**	-0.028*	0.100*	-0.029	0.095*
	(0.048)	(0.046)	(0.012)	(0.048)	(0.021)	(0.045)
Population^2	—	—	0.000	—	0.000	—
			(0.000)		(0.000)	
Left Wing	—	—	-2.365***	—	-2.239*	—
			(0.711)		(0.928)	
Sanitation	—	—	1.408***	—	1.300***	—
			(0.204)		(0.256)	
Const	13.784***	13.582***	0.568	14.597***	1.318	15.077***
	(2.235)	(2.386)	(0.691)	(2.374)	(0.869)	(2.390)
Regional Fixed Effect	Excl.	Excl.	Incl.	Excl.	Incl.	Excl.
ρ	—	—	0.633+		0.744**	
R^2	0.150	0.165	—		—	
N	364	364	758		528	

*Note: Levels of significance: +10% *5% **1% ***0.1%. Regional fixed effects are globally significant at 5%. Robust standard errors within parentheses.*

tions that organize their water services through in–house provision in our reduced sample: the regressions yield estimates that are globally consistent, whether regression is run on our reduced sample, or on the sample from which we have randomly eliminated some observations using in house provision. This latter sample is constructed to respect the proportion of observations using in house provision as given by the original IFEN–SCEES–DGS sample. Indeed, with the exception of TreatMix A1&2, all coefficients that are significant in *Heckman (1)* are also significant in *Heckman (2)*. Similar conclusions could be drawn for the estimates of our selection equation. Nevertheless, we should note some variables that are marginally significant in *Heckman (1)* cease to be so in *Heckman (2)*, even if they do not differ much in their estimated magnitudes. We believe therefore that the estimations run on our reduced sample are only minimally affected by the high presence of direct public management.

Notice as well that Sanitation and Left Wing are significant in our selection equation. These estimates are consistent with what we found in the first chapter, *i.e.* local public authorities who have chosen to use a PPP for their sanitation services, and whose electorate comprises a lower proportion of left–wing voters, are more likely to choose a PPP for their water services, all else being equal. The estimated coefficients of these variables are highly significant. This confirms that political variables should be included in our regressions. These observations also show that political considerations play a role in a local public authority's choice of using a PPP for his water services.

Beyond political considerations, the estimations of our Heckman models also underscore economic rationality in local public authorities' decision of using a PPP. In particular, we could see that variables such as Underground and Interauthority contribute significantly and positively to a local public authority's propensity to use a PPP for water services. As we have argued, Underground is used as a proxy for the level of investment, since the quality of raw water that comes from underground is more stable over time. This reduces the need to rely for different technologies to be used to treat water, and hence possibly lower investments. The estimation of Underground shows therefore that local public au-

thorities are more likely to outsource when investment needs may be high. The estimated coefficient of Interauthority also shows that water services are more likely to be left to an external operator when they are more difficult to run.

We also found that the level of industrial concentration at the *Département* level does not have any significant impact on whether a local public authority chooses a PPP for his water services. On the other hand, Share DM is found to have an significant and negative effect on a local public authority's decision to use a PPP. In other words, a local public authority who is located in a *Département* where direct public management is the dominant way to organize water services, the local public authority would also be more likely to choose this organizational form, all else being equal.

Again, we see that PPPs are not randomly chosen by local public authorities to run their water services. The interequation correlation ρ is estimated to be positive and significant in our Heckman regressions. This suggests that OLS estimations of contractual length are biased.

Turning to our Heckman regressions on contractual length, we see economic considerations are not altogether absent when this has to be determined by local public authorities. In particular, estimates show that Underground, Interauthority and Water Limitations contributes significantly to explaining contractual length. As we have mentioned before, Underground can be seen as a proxy for the level of investments. Consistently with what we expected, our estimates show that local public authority will use shorter contracts when raw water comes from underground. When water services are more difficult to run, contracts are longer. This can be seen from the estimation of Interauthority. This variable is used as a proxy for water services that are more difficult to run, and its coefficient is found to have a positive impact on contractual length.

Uncertainty is also found to have the expected effect on contractual length, consistently with the theoretical predictions of Transaction Costs Economics. This can be seen from the estimation of Water Limitations, which indicate if a municipality has used regulations to restrict the use of water. Regulations to limit

the use of water among a municipality's population are likely in areas where raw water endowment is uncertain. Our estimates show that Water Limitations contribute negatively to contractual length: PPP contracts in municipalities where regulations to restrict the use of water have been introduced tends to be shorter, *ceteris paribus*. Higher uncertainty concerning water endowment therefore leads to shorter contracts, all else being equal.

We are unable to conclude on the effects of raw water treatment technologies on contractual length. We have argue that these variables (TreatA2, TreatA3, TreatMix A1&2 and TreatMix A3) are good proxies for the degree of asset specificities. In our estimations, only TreatMix A1&2 is marginally significant in *Heckman (1)*, and points to a negative impact on contractual length. However, this variable loses significance in model *Heckman (2)*. The other dummy variables for the type of raw water treatment technology are never significant. In general, our estimates do not clearly show any effects of the type of treatment on contractual length.

Our estimates also show no significant relationship between a local public authority's choice of contractual length and the level of industrial concentration in a *Département*'s water sector. Indeed, although the estimations of Herf are positive in *Heckman (1)* and *Heckman (2)*, they are not significant, even at a threshold of 10%. This shows that local public authorities do not impose a longer contract when water industry is more concentrated at the *Département* level, or equivalently, when there could be a higher potential for collusive in auctions. Contrary to what we expected, it do not seemed that local public authorities use contractual length as a way to discourage possible collusion.

Nevertheless, estimates on Share DM indicate a negative and significant effect on contractual length. PPP contracts are shorter in *Départements* where more municipalities use direct public management for their water services, *ceteris paribus*. One possible explanation for this result is that in these areas, there is a higher level of indirect competition from direct public management, making potential competition higher as a whole, and collusion potentially harder. This is consistent with our proposition on the possible use of contractual length as a way to

discourage collusive initiatives. However, this is a partial and indirect support to our proposition.

Our Heckman regressions also detected some operator fixed effects. More specifically, it would seem that Operator 1 and Operator 2 tends to sign significantly longer contracts than other operators.[31] Contracts attributed to Operator 1 is approximately 2 years longer than average, *ceteris paribus*. A Wald test also suggests that contracts attributed to Operator 2 is not significantly different on the average from those attributed to Operator 1 in terms of duration. Conversely, contracts attributed to Operator 3 and Operator 4 do not seem to be shorter nor longer than those attributed to other small operators not affiliated with any of the three major operators (Operator 1, Operator 2 and Operator 3).[32]

To conclude briefly, our empirical study provides some partial corroboration to our claims that contractual length may be used by local public authorities as a way to discourage collusion. Indeed, while Herf is not found to have any impact on contractual length, the estimation of Share DM shows that a higher level of indirect competition from direct public authorities does lead to shorter contracts, all else being equal. This is consistent with our interpretation between the choice of contractual length and the level of competition. Indeed, we may expect the level of competition to be globally higher when the level of indirect competition is higher. We also find that contracts attributed to some operators tend to be longer on the average, after controlling for factors that could influence the length of contracts. This concerns Operator 1 and Operator 2, whose contracts are significantly longer on the average by 1 to 2 years. We have also found that contractual length are influenced by some economic factors. For instance, contracts are shorter for municipalities whose raw water comes from underground, and when uncertainty in water endowment is high, *ceteris paribus*. Conversely, when water services are hard to run, contractual length tends to be longer. Nevertheless, from our OLS estimates, it seems that we are only able to explain a small part of variation in

[31] We use operators not belonging to any of the three major operators at the national level as our reference group.

[32] We remind the reader that Operator 4 is in fact a joint venture between Operator 1 and Operator 2.

contractual length. Future work to further understand how contractual length are determined are therefore welcomed.

3.6 Conclusion

Collusion seems to be a pervasive problem when auctions are used to attribute contracts for PPP. While a considerable amount of effort has been dispensed to understand how collusion may take place in auctions, or how such a phenomenon can be econometrically detected, there are still relatively little work in the literature that suggests how contractual provisions could be used to discourage collusion initiatives in auctions. This is what we sought to do in this chapter. To be more precise, we are interested in knowing whether a specific contractual provision, namely contractual length, could be used to discourage collusive initiatives when PPP contracts are attributed through auctions. Our choice of focusing on contractual length is motivated by the fact that such a contractual provision is present in any contracts. Using a simple infinitely repeated game framework and independent private value auction model, we find that bidding rings are indeed more vulnerable when contractual length is long. This suggests that contractual length could be a variable to use when suspicions of collusive bidding behaviour may take place.

We then investigate whether this is already being used by French local authorities when they auction off contracts for water services in France. Using OLS regressions and Heckman sample selection model to control for possible endogenous bias due to local public authorities' choices of governance structure, and controlling for other possible determinants of contractual length, we found that contractual length are shorter in *Départements* that are rich in direct public management. A higher share of municipalities running their water services through direct public management can be translated into higher indirect competition (or intermodal competition). As such, this result is consistent with the view that contractual length is used as a means to discourage collusion. However, we found no evidence that a high concentration in the water industry in a *Département* will

lead to a higher contractual length. This may indicate that contractual length is not used as a way to discourage potential collusion when suspicion for this is high. Another possible explanation would be that direct competition among private operators is badly measured by the variable that we have used for our study. Indeed, this variable is measured at the level of a *Département*. Indeed, while it is relevant to consider the level of competition for PPP contracts at a local level, there is no objective reason why this should be measured within the scale of a *Département*. In particular, one may think that municipalities located at the border of a *Département* are more likely to be subjected to competitive forces that exist in nearer municipalities in a neighbouring *Département* than municipalities further away within the same *Département*. If this should be true, it is not surprising that we are unable to detect any relation between contractual length and the level of local direct competition.

Nevertheless, it would seem that contractual length could be an interesting instrument to deter collusion when public procurement contracts are awarded through auctions. However, we should exercise some caution before recommending the use of such an instrument. Indeed, there are two important limits to the theoretical framework that we have mobilized to such an end: firstly, we have largely ignored the other types of contractual provisions; and secondly, we are not certain that this is effectively the most efficient way to deter collusion. In fact, both short-coming are related in our approach. More specifically, we have treated the cost of providing a service as exogenous, while reality seems to suggest that costs may be partly endogenous through efforts that could be undertaken to reduce them, or investments that could be undertaken. These aspects are ubiquitous in contracts that concerns provision of public services, and altering such contractual provision may prove to be more efficient to deter collusion during a public procurement auction. A more sophisticate treatment of public procurement contracts is needed to account for this. In the same spirit, empirical studies that could provide guidance to theory on how contractual length is determined for such contracts are also needed. Only then could we have a better idea of what role contractual length plays, and if it is suitable as an instrument to discourage collusion.

On a more general level, one may also ask if the task of discouraging collusion should best be left to the competitive authorities, or addressed through another means, such as some regulation. It is not straightforward to think that potential collusion problems should be treated *ex ante* through contractual provisions. Contractual provisions might in fact be used in complement with other means to this end. To partially account for this last aspect, the next chapter will study operators' incentives to collude under yardstick competition, and when both auctions and yardstick competition are used. In this case, we are interested in a possible "organizational" and more coordinated or centralized response to the potential problem of collusion, in contrast with the more "bilateral" response considered here. Nevertheless, the more global aspect of how best different authorities may take responsibility to discourage collusion is still an open question.

In conclusion, given the pervasiveness of collusion in auctions for PPP contracts, as shown by the bulk of empirical evidence available on the subject, further investigations on how best such a problem could be addressed are doubtlessly needed.

Appendix

A. Proofs

A.1 Proof for Lemma 1

The proof is analogous to McAfee and MacMillan [1987]: A firm i will choose its bid b_i such that $\frac{\partial U_i}{\partial b_i} = 0$ in order to maximize its utility under the contract of length τ. By differentiating U_i with respect to $c_{i,0}$, we have

$$\frac{dU_i}{dc_{i,0}} = \frac{\partial U_i}{\partial c_{i,0}} + \frac{\partial U_i}{\partial b_i}\frac{db_i}{dc_{i,0}}$$

Firm i's optimal bid must therefore satisfy

$$\frac{dU_i}{dc_{i,0}} = \frac{\partial U_i}{\partial c_{i,0}} = -[1 - F(b_{-i}^{-1}(b_i))]^{N-1}$$

since $\frac{\partial U_i}{\partial b_i} = 0$ at firm i's optimal bid. Symmetry (any two firms with the same cost must submit the same bid) and Nash requirement implies that $b_i = b_{-i}(c_{i,0})$. Substituting this into the equation above, we can obtain an equation defining firm i's expected utility at a Nash equilibrium:

$$\frac{dU_i}{dc_{i,0}} = -[1 - F(c_{i,0})]^{N-1}$$

At a Nash equilibrium, all N firms must be maximizing simultaneously, so that the above condition must hold for all firms $i = 1, \ldots, N$. We solve for this differential equation by integrating and by using the condition that if a $\overline{c}$ type of firm will have a level of utility equals to its outside option *i.e.* 0. We can therefore write:

$$\begin{aligned} U_i(c_{i,0}) = U_i^{\text{NE,ex post}} &= U_i(\overline{c}) - \int_{c_{i,0}}^{\overline{c}} \frac{dU(s)}{ds} ds \\ &= \int_{c_{i,0}}^{\overline{c}} [1 - F(s)]^{N-1} ds \end{aligned}$$

This is firm i's expected utility when it has realized costs $c_{i,0}$. To solve for firm i's equilibrium bid, we use equation 3.1 together with the Nash requirement:

$$\begin{aligned} \left[b_i - c_{i,0} - \delta \frac{1 - \delta^{\tau-1}}{1 - \delta} \mathbb{E}[c] \right] &= \frac{\int_{c_{i,0}}^{\overline{c}} [1 - F(s)]^{N-1} ds}{[1 - F(c_{i,0})]^{N-1}} \\ b_i^{\text{NE}} &= c_{i,0} + \delta \frac{1 - \delta^{\tau-1}}{1 - \delta} \mathbb{E}[c] + \int_c^{\overline{c}} \left[\frac{1 - F(s)}{1 - F(c)} \right]^{N-1} ds \end{aligned}$$

The *ex ante* expected utility (before costs are realized) is then

$$\begin{aligned} U_i^{\text{NE,ex ante}} &= \int_{\underline{c}}^{\overline{c}} \int_{c_{i,0}}^{\overline{c}} [1 - F(s)]^{N-1} ds f(c) dc \\ &= \int_{\underline{c}}^{\overline{c}} \int_{c_{i,0}}^{\overline{c}} [1 - F(s)]^{N-1} ds f(c) dc \end{aligned}$$

Integrating by parts using $z = \int_{c_{i,0}}^{\overline{c}} [1 - F(s)]^{N-1} ds$ and $dv = f(c)dc$, this expression can be written

$$\begin{aligned} U_i^{\text{NE,ex ante}} &= \left[F(c) \int_{c_{i,0}}^{\overline{c}} [1 - F(s)]^{N-1} ds \right]_{\underline{c}}^{\overline{c}} + \int_{\underline{c}}^{\overline{c}} F(c)[1 - F(c)]^{N-1} dc \\ &= \int_{\underline{c}}^{\overline{c}} F(c)[1 - F(c)]^{N-1} dc \end{aligned}$$

since $F(\underline{c}) = 0$ and $\int_{\overline{c}}^{\overline{c}} [1 - F(s)]^{N-1} ds = 0$.

We will now show that $U_i^{\text{NE,ex ante}}$ can also be written as $\frac{1}{N}[\mathbb{E}[cN(N-1)[1-F(c)]^{N-2}F(c)]-\mathbb{E}[cN[1-F(c)]^{N-1}]]$: *ex ante* the probability that a firm i's realized cost will be the lowest at period k when an auction takes place is simply $1-[1-F(c_{i,k})]^{N-1}$. Hence, this is the probability that firm i will win the auction organized during period k. Hence, *ex ante* (before cost is realized), a firm i may expect to win an auction with probability $\int_{\underline{c}}^{\overline{c}}[1-F(c_{i,k})]^{N-1}f(c)dc_{i,k}=\frac{1}{N}$. To see this, we first note that

$$\frac{d\,(\frac{1}{N}[1-F(c)]^N)}{d\,c}=-[1-F(c)]^{N-1}f(c)$$

Hence, we have

$$\int_{\underline{c}}^{\overline{c}}[1-F(c_{i,k})]^{N-1}f(c)dc_{i,k}=\left[\frac{1}{N}[1-F(c)]^N)\right]_{\underline{c}}^{\overline{c}}=\frac{1}{N}$$

The *ex ante* expected lowest cost that will be realized is simply

$$\int_{\underline{c}}^{\overline{c}}cN[1-F(c)]^{N-1}f(c)dc$$

since the probability that a cost c is the lowest is given by the probability $1-[1-F(c)]^N$ whose density is therefore $N[1-F(c)]^{N-1}f(c)$. Integrating by parts using $dz=N[1-F(c)]^{N-1}f(c)dc$ and $v=c$ yields

$$\begin{aligned}&\left[c(1-([1-F(c)]^N)\right]_{\underline{c}}^{\overline{c}}-\int_{\underline{c}}^{\overline{c}}(1-[1-F(c)]^N)dc\\ =\;&\overline{c}-\int_{\underline{c}}^{\overline{c}}(1-[1-F(c)]^N)dc\end{aligned}$$

Likewise, the probability that a cost c is the second lowest is given by two disjoint events: firstly, that all N cost realizations are greater or equal to c; and secondly, $N-1$ values are greater or equal to c and one value is lower than c. Hence, this probability can be written as

$$1-([1-F(c)]^N+NF(c)[1-F(c)]^{N-1})$$

with the density function $N(N-1)F(c)[1-F(c)]^{N-2}f(c)$. The *ex ante* expected second lowest cost is therefore:

$$\int_{\underline{c}}^{\overline{c}}cN(N-1)F(c)[1-F(c)]^{N-2}f(c)dc$$

Integrating by parts using $dz = N(N-1)F(c)[1-F(c)]^{N-2}f(c)dc$ and $v = c$ yields

$$\begin{aligned} & \left[c[1-([1-F(c)]^N + NF(c)[1-F(c)]^{N-1})]\right]_{\underline{c}}^{\overline{c}} \\ & \quad - \int_{\underline{c}}^{\overline{c}} [1-([1-F(c)]^N + NF(c)[1-F(c)]^{N-1})]dc \\ = \; & \overline{c} - \int_{\underline{c}}^{\overline{c}} [1-([1-F(c)]^N + NF(c)[1-F(c)]^{N-1})]dc \end{aligned}$$

Hence, the difference between the second expected lowest cost and the lowest cost is given by

$$\begin{aligned} & \overline{c} - \int_{\underline{c}}^{\overline{c}} [1-([1-F(c)]^N + NF(c)[1-F(c)]^{N-1})]dc \\ & \quad -\overline{c} + \int_{\underline{c}}^{\overline{c}} (1-[1-F(c)]^N)dc \\ = \; & \int_{\underline{c}}^{\overline{c}} NF(c)[1-F(c)]^{N-1}dc \end{aligned}$$

Multiplying this expression with the probability that a firm i wins the auction with the lowest realized costs $\frac{1}{N}$ yields exactly a firm's *ex ante* utility:

$$\begin{aligned} & \frac{1}{N}[\mathbb{E}[cN(N-1)[1-F(c)]^{N-2}F(c)] - \mathbb{E}[cN[1-F(c)]^{N-1}]] \\ = \; & \frac{1}{N}\int_{\underline{c}}^{\overline{c}} NF(c)[1-F(c)]^{N-1}dc \\ = \; & \int_{\underline{c}}^{\overline{c}} F(c)[1-F(c)]^{N-1}dc \\ = \; & U_i^{\text{NE,ex ante}} \end{aligned}$$

The two expressions are thus equal. □

A.2 Proof for Proposition 1

Intertemporal net expected consumer surplus can be expanded and rewritten as follows:

$$\begin{aligned}
\mathscr{W}(\tau) &= \sum_{k=0}^{+\infty} \delta^{k\tau} W(\tau) \\
&= \frac{1}{1-\delta^{\tau}} \mathbb{E}\left[\left[(S-c) + \delta \frac{1-\delta^{\tau-1}}{1-\delta}(S-\mathbb{E}[c]) \right.\right. \\
&\quad \left.\left. - \int_c^r \left[\frac{1-F(s)}{1-F(c)}\right]^{N-1} ds \right] N[1-F(c)]^{N-1} \right]
\end{aligned}$$

The derivative of $\mathscr{W}$ with respect to τ is therefore

$$\begin{aligned}
\frac{\partial \mathscr{W}}{\partial \tau} &= \frac{\delta^{\tau} \ln \delta}{(1-\delta^{\tau})^2} \mathbb{E}\left[\left[S - c - \int_c^r \left[\frac{1-F(s)}{1-F(c)}\right]^{N-1} ds \right.\right. \\
&\quad \left.\left. + \frac{\delta(1-\delta^{\tau-1}) - (1-\delta^{\tau})}{1-\delta}[S-\mathbb{E}[c]] \right] N[1-F(c)]^{N-1} \right] \\
&= \frac{-\delta^{\tau} \ln \delta}{(1-\delta^{\tau})^2} \mathbb{E}\left[\left[c + \int_c^r \left[\frac{1-F(s)}{1-F(c)}\right]^{N-1} ds - \mathbb{E}[c] \right] N[1-F(c)]^{N-1} \right] \\
&\leq 0
\end{aligned}$$

To see this, we first note that $\int_{\underline{c}}^{\overline{c}} (c - \mathbb{E}[c])\, N(1-F(c))^{N-1} f(c) dc = 0$. Indeed, integrating by parts using $dz = (c - \mathbb{E}[c])\, f(c) dc$ and $v = N(1-F(c))^{N-1}$, we can notice that $z = 0$. Consequently,

$$\begin{aligned}
\frac{\partial \mathscr{W}}{\partial \tau} &= -\frac{\delta^{\tau} \ln \delta}{(1-\delta^{\tau})^2} \int_{\underline{c}}^{\overline{c}} \int_c^{\overline{c}} \left[\frac{1-F(s)}{1-F(c)}\right]^{N-1} ds N[1-F(c)]^{N-1} dc \\
&\leq 0
\end{aligned}$$

Hence, intertemporal expected net consumer surplus is maximized when τ take the smallest possible value, *i.e.* when $\tau = 1$. $\square$

A.3 Proof for Proposition 2

We will first verified that $\delta^* \in]0, 1]$. To this end, we let

$$A \equiv \frac{U_i^{\mathrm{D}}(\underline{c}) - U_i^{\mathrm{C,ex\ post}}(\underline{c})}{(U_i^{\mathrm{D}}(\underline{c}) - U_i^{\mathrm{C,ex\ post}}(\underline{c})) + (U_i^{\mathrm{C,ex\ ante}} - U_i^{\mathrm{NE,ex\ ante}})}$$

Note that $U_i^{\mathrm{D}}(\underline{c}) \geq U_i^{\mathrm{C,ex\ post}}(\underline{c})$. Indeed, $U_i^{\mathrm{C,ex\ post}}(\underline{c}) = \frac{1}{N} U_i^{\mathrm{D}}(\underline{c})$. Given that $U_i^{\mathrm{C,ex\ ante}} > U_i^{\mathrm{NE,ex\ ante}}$, one can see that $A \in]0,1[$. If $U_i^{\mathrm{C,ex\ ante}} = U_i^{\mathrm{NE,ex\ ante}}$ then $A = 1$. Consequently $\delta^* \in]0,1]$.

Deriving δ^* with respect to τ yields:

$$\frac{\partial \delta^*}{\partial \tau} = -\frac{1}{\tau^2} A^{\frac{1}{\tau}} \ln A$$

This expression is positive if $A \in]0,1]$ since $\ln A < 0$ when $A \in]0,1[$. In this case, the critical threshold factor is increasing in τ. When $A = 1$, then $\frac{\partial \delta^*}{\partial \tau} = 0$ $\forall \tau > 0$. $\square$

Chapter 4

Yardstick competition, franchise bidding and collusion*

4.1 Introduction

A simple and direct way for a local public authority to benefit from competitive pressures when they organize provision of local public services is to appeal to an auction mechanism to attribute a contract. Such a policy is being institutionalized in more developed countries[1], and is being advocated by economists for less developed ones. However, collusion among the potential during an auction private operators seems to be a pervasive problem. For instance, Porter and Zona [1993] noted that more than one half of the criminal cases filed by the Antitrust Division of the US Department of Justice between 1982 and 1988 concerned bid

*This chapter is based on a joint work with Fréddy Huet (Chong and Huet [2006b]). An earlier version of this chapter was published as Chong and Huet [2006a]. The author gratefully acknowledges help from his coauthor. We are also grateful to Masahiko Aoki, Claudine Desrieux, David Encaoua, Pierre Fleckinger, Pierre Garrouste, Sébastien Lécou,Thierry Pénard, Yannick Perez, Jérôme Pouyet, Michael Rimler, Jean-François Sattin, Marcelo Saguan, Brian Silverman, Howard Shelanski, Carine Staropoli, Ed Steinmueller, Anne Yvrande-Billon and participants of the ATOM seminar, of the GRJM seminar, of the Atéliers de la MSE, of ESNIE 2005, of EARIE 2005, of the LVI Congès Annuel de l'AFSE, of the 4th Conference on Applied Infrastructure Research, of the IDEI–Institut Veolia Environnement Conference on Public Services and Management, of the 4th International Industrial Organization Conference, and of Journées de la Microéconomie Appliquée 2006 for their helpful comments and criticisms.

[1]For instance, the US Federal Acquisition Regulation oblige public entities wishing to procure goods and/or services to use an auction mechanism

rigging. It is also common knowledge these days that collusion has plagued the spectrum auctions organized by the US Federal Communications Commission in 1996-1997 (Cramton and Schwartz [2000]). Klemperer [2004], Milgrom [2004] and Klemperer [2002] documented a similar case in the German spectrum auctions in 1999. More recently, in Europe, the Swedish Competition Authority exposed a cartel in procurement contracts of road-surfacing (Swedish Competition Authority [2003], Swedish Competition Authority [2005]). Likewise, the French Competition Authority recently convicted three firms in the public urban transportation sector for market sharing between 1996 and 1998 (Conseil de la Concurrence [2005b]) and five firms for collusion in public road construction markets between 1991 and 1998 (Conseil de la Concurrence [2005a]).

When collusion occurs, public authorities are unable to pass on the efficiency gains expected from the privatization of these services to consumers and/or taxpayers. In the previous chapter, we have sought to study if contractual variables can be used to dampen firms' incentives to collude. In particular, we have focused on one specific contractual variable: the length of a contract. We found that firms' may find it harder to sustain collusion in the form of bid rotation when a longer–term contract is attributed through auctions. A limit to our approach in the previous chapter is that we have confined ourselves to a "bilateral" solution to the problem of discouraging collusion. Indeed, in the previous chapter, we argued that a local public authority should make a contract longer for the winner of an auction to make collusion in the form of bid–rotation harder for potential bidders. However, it is not clear that this is the most efficient way to procede. In particular, there could be a more collective and more coordinated response to this problem, especially when there are several local public services to be run. A competition authority may also be able to better address this problem *ex post*. Contractual length could also be used in complement with a more centralized and coordinated response. This chapter seeks to explore this latter aspect.

More specifically, we intend to know how firms' incentive to collude may be influenced by the use of yardstick competition instead of, and in complement with, auction mechanisms. As we have seen from chapter 2, yardstick competition is po-

tentially one of the best solution for local public services when a more coordinated and centralized response is desired: better social welfare can be achieved under yardstick competition than other more individualistic regulation when the former is feasible. Indeed, yardstick competition is another through which competitive forces may be created in industries characterized by a local natural monopoly structure. To the extent that there are some common factors that influence firms' performances, yardstick competition also would allow a regulator to enhance social welfare, if firms' relative performance could be adequately measured. Arguably, this should be the case when local public services are concerned. This leads us to focus our attention on yardstick competition when we consider such a centralized response to the problem of collusion, and for our study on how firms' incentives to collude are altered when both schemes are used in complement.

To the best of our knowledge, there have been relatively few studies on the issue of collusion under yardstick competition. We are aware of only two studies this subject: Laffont and Martimort [2000] and Tangerås [2002]. The authors derived the optimal collusion-proof yardstick competition, and showed that the regulator should trade off costly rents and productive efficiency. In their settings, collusion between firms was coordinated and enforced by a benevolent third party. In a static context, this could be seen as a short cut to capturing the self-enforceability of collusion that could emerge from repeated relationships. They show that it is when the stakes for using yardstick competition are high that firms find it the easiest to collude.

Given the implications on policy that this issue may have and the relevance of the matter[2], it is our objective in this chapter to analyze the capacity of firms to collude when yardstick competition is used, and when a franchise bidding mechanism is used together with yardstick competition. In particular, we seek

[2]For instance, a French consumer association recently raises this question. This association published a study in its magazine revealing that the high water prices in large cities in France that could be due to the high level of concentration in the industry (Union Fédérale des Consommateurs [2006]). It called for the creation of a public entity to oversee the fixing of water prices and establish comparisons between different water services in different municipalities. In other words, in this particular sector in France, regulation through yardstick competition, as a substitute, or in complement to auctions, is being considered as a response to potential problems posed by the high degree of concentration of the water industry in France.

to complement the previous literature by considering firms' incentives to collude under yardstick competition using a repeated game setting. Hence, collusion in our setting is *explicitly* self-enforcing. Indeed, in the previous studies cited above, collusion is enforced by a benevolent third party. In reality, the enforcement of a collusive agreement may be more problematic, since collusion is generally illegal under any countries' judiciary system. Hence, cartel members may not rely on a country's judiciary system to enforce their collusion agreement. Our approach therefore allows us to complement the previous literature on this issue. Moreover, we will also consider the possibility that a franchise bidding mechanism may be used in addition to yardstick competition to attribute rights to operate in different geographical markets, and we study how this would alter firms' incentives to collude. Market rights may be attributed for several periods of time. In this sense, we provide a complementary analysis to the previous chapter, by looking at how firms' incentives to collude are altered by contractual length and the use of a supplementary centralized tool—yardstick competition.

For this purpose, we cast our model in a world where self-enforceable collusion should be the easiest. This is motivated by our belief that should firms be unable to collude under propitious conditions, collusion would therefore be unlikely when the operating of the firms is more hostile with respect to their capability to sustain collusion. As a result, the firms in our model are perfectly symmetric with respect to their production costs: arguably, it is more difficult for collusion among heterogeneous firms to be self-sustaining (Cabral [2000], Jacquemin and Slade [1989], and Rothschild [1999]).[3] This aspect also complements our previous chapter, in which firms' private information are independently distributed. Here, we will consider the case where their private information is perfectly correlated. We will also use grim trigger strategies *à la* Friedman [1971] to study collusion sustainability

We find that even under conditions propitious to sustaining collusion, firms may have an incentive to back out of a collusion agreement. If the regulator uses only yardstick competition, this will be true if the regulator can compensate

[3]For instance, Cabral [2000] states in pg. 138 that, "*Collusion is normally easier to maintain among few and similar firms*".

the more efficient firms instead of penalizing the less efficient firms. In this case, collusion would be sustainable only when firms are sufficiently patient. If both franchise bidding and yardstick competition are used, collusion would be harder to sustain when the monopoly rights to operate in a market are granted for a sufficiently long period of time and firms are "moderately" patient. Quite surprising, a supplementary franchise bidding mechanism may actually *help firms to sustain collusion*. Indeed, we find that when both mechanisms are used, firms are able to sustain collusion even when they are very impatient! This is explained by the fact that a defection in our model implies that the defecting firm would give up current rents for future ones.

This chapter will be organized as follows: we set up the simple model in section 4.2. Section 4.3 considers franchise bidding and yardstick competition in a static asymmetric information context. We then study firms' incentives to collude when the static game is infinitely repeated under the various configurations (section 4.4). We will also discuss some policy recommendations. Concluding remarks follow with proofs to support our findings in the in the appendix.

4.2 The model

4.2.1 Firms and markets

We consider two geographically separate monopolistic markets, each with a unitary inelastic demand. Gross consumer surplus in each market is assumed to be $S/2$ and such that production is always desirable. These markets can be thought of as belonging to the water industry or urban public transport sector.

Two firms, denoted $i, i = 1, 2$, are capable of producing the good in question. To produce the good in one market, firm i needs to incur costs C_i which, following Laffont and Tirole [1993], are assumed to be written as

$$C_i = \beta_i - e_i$$

β_i is firm i's productivity parameter. We suppose that firms are perfectly sym-

metric or correlated in the sense that they have the same productivity parameter, i.e. $\beta_1 = \beta_2 = \beta$. We can think of β as the industry's productivity parameter. We further suppose that β can take on two values: $\underline{\beta}$ with probability v and $\overline{\beta}$ with probability $(1 - v)$, with $\overline{\beta} > \underline{\beta}$, and let $\Delta\beta \equiv \overline{\beta} - \underline{\beta}$. In the repeated version of the game, β is assumed to be identically and independently drawn (with respect to time) at the beginning of each period. Firms can also bring down costs by undertaking certain efforts, captured through the term e_i. Cost-reducing efforts are costly in terms of disutility to the firms. This is denoted by $\varphi(e_i)$,and we assume that $\varphi > 0$ for $e > 0$, $\varphi' > 0, \varphi'' > 0$. Thus disutility of efforts is always non-negative. It is increasing in effort at an increasing rate. We further suppose that cost-reducing efforts in a market have no impact on the disutility of cost-reducing efforts on another market.

4.2.2 Regulator

Since these regional markets are monopolistic in nature, we assume that there is a national regulator in place to supervise the provision of the service in question for both markets. The regulator is confronted with an asymmetric information problem: he does not know the firms' exact productivity level β_i nor is he able to monitor the firms' efforts e_i. In order to overcome his informational problems, we suppose that the regulator could choose between two types of mechanisms: either attribute the monopoly rights of each market through franchise bidding, or regulate firms by using yardstick competition. The regulator could also choose to use both mechanisms.

Whatever mechanism is chosen, the regulator totally reimburses the firms for their production costs C_i observed *ex post*. In addition, he will make a supplementary net transfer, noted t_i, to firm i. Firm i's rents in terms of utility are therefore

$$U_i = t_i - \varphi(e_i)$$

The regulator is assumed to be utilitarian: he seeks to maximize social welfare

which is simply the sum of social surpluses in each market:

$$\mathscr{W} = S - (1+\lambda)\sum_i(\beta_i - e_i + \varphi(e_i)) - \lambda\sum_i U_i$$

where λ is the shadow costs of public funds, i.e. the regulator's costs of raising his funds.

4.2.3 Collusion

Whether firms regulated under the various competition-oriented schemes can collude will depend on their incentives to stick to the collusive strategy. In other words, in order to collude, regulated firms under the various schemes must be able to sustain a collusive agreement: collusive contracts are illegal and therefore, will not be enforced by a country's formal institutions. Consequently, collusion between the firms is plausible if firms are able to sustain the collusive agreement. In other words, a collusion has to be *self-enforceable*. We use an infinitely repeated game framework with grim trigger strategies (Friedman [1971]) to study this question. In reality, regulated firms will interact repeatedly with each other (through and with the regulator); a repeated relationship is thus a means for the firms to sustain their collusive agreement.

Under grim trigger strategies, a firm will choose to stick to a collusive strategy if there has been no defection in the previous period. In the opposite case, firms will revert to playing their non cooperative strategy. This correspond in our setting to the optimal punishment in the sense of Abreu [1988]. Collusion is sustainable whenever the discounted expected utility stemming from collusion is greater than the discounted expected utility stemming from a defection and from the consequent non cooperative behavior. We assume that both firms have the same discount factor, denoted δ.

4.2.4 Timing of the game

Before the game starts, the regulator will choose to use franchise bidding, yardstick competition, or both. In each period, nature chooses β and reveals it to the firms. The regulator then offers the corresponding contract to the firms and commits to it. This contract will be based on the firms' reports on their productivity parameter, and a net transfer based on these reports.[4] Firms can either accept or decline the offer. If a firm declines the offer, it has utility U_R, which is the utility guaranteed by the firm's outside option. We normalize this to $U_R = 0$. If the firms accept the offer, they will submit a report on the productivity parameter. Production and transfers are then carried out according to the terms of the contract proposed by the regulator. A new period starts with a new realization of β. The game is infinitely repeated.

Clearly, if the regulator is not confronted with asymmetric information, he will offer the full information contract which specifies a first-best level of effort, denoted e^{FI}. e^{FI} is such that $\varphi'(e^{FI}) = 1$. The net transfer under the full information contract is set at $t^{FI} = \varphi(e^{FI})$ to exactly compensate the firms for their disutility of efforts. Firms will receive no rents.

4.3 Competition, natural monopolies and asymmetric information

When the regulator is confronted with an asymmetric information problem, he cannot use the full information contract: a firm will have an incentive to declare itself as being inefficient when in reality it is efficient if the regulator uses the optimal full information contract. Baron and Myerson [1982] and Laffont and Tirole [1993] have characterized the optimal individual incentive contract to regulate the firms in this case. Throughout this paper, we will rather look at mechanisms that allow the regulator to "artificially simulate" competition among the firms in order

[4]The revelation principle ensures that there is no loss of generality by focusing only on direct revelation mechanisms.

to overcome its asymmetric information problem. Two mechanisms of this type are considered here: franchise bidding and yardstick competition.

4.3.1 Yardstick competition in a static setting

When the regulator uses yardstick competition, he *compares* relative performances of both firms and links the firms' financial outcome based on their relative performance. Under a revelation game, we could consider that a regulator who uses yardstick competition compares the firms' reports and sets transfers to the firms based on the comparison. We therefore suppose if a regulator uses yardstick competition, each firm is already granted a market. A contract under yardstick competition can be seen as a cost and net transfer pair based on both reports given by both firms: $\{t(\tilde{\beta}_i, \tilde{\beta}_j), C(\tilde{\beta}_i, \tilde{\beta}_j)\}$ where $\tilde{\beta}_i$ is firm i's own report on the industry-wide productivity parameter and $\tilde{\beta}_j$ that of firm j's, $j \neq i$.

Since firms have an incentive to report $\overline{\beta}$ only when $\underline{\beta}$ is realized (in which case firms will receive positive informational rents measured in terms of economies on disutility of cost-reducing efforts) and they are perfectly correlated, any incompatible reports in the sense that $\tilde{\beta}_i \neq \tilde{\beta}_j$ would allow the regulator to deduce that the industry-wide productivity parameter is $\underline{\beta}$ and that the firm reporting $\overline{\beta}$ is lying. Let us consider the following mechanism adapted from Auriol [1993, 2000] and Auriol and Laffont [1992][5]:

(i) if $\tilde{\beta}_i = \tilde{\beta}_j$, then $C_c(\tilde{\beta}_i, \tilde{\beta}_j) = \tilde{\beta}_i - e_c$ and $t(\tilde{\beta}_i, \tilde{\beta}_j) = t_c$: when reports are compatible then the contract will totally reimburses firms' costs according to the reported industry-wide productivity parameter, and set transfers to t_c

(ii) if $\tilde{\beta}_i \neq \tilde{\beta}_j$, then $C_c(\tilde{\beta}_i, \tilde{\beta}_j) = \underline{\beta} - e_c$ and $t(\overline{\beta}, \underline{\beta}) = t_c - P$ and/or $t(\underline{\beta}, \overline{\beta}) = t_c + A$: when reports are incompatible, the regulator will only reimburse the level of costs intended for a $\underline{\beta}$ type firm. Moreover, he will set transfers to include a compensation A for the firm reporting $\underline{\beta}$, and/or a fine P for a

[5]These authors consider using only very high fines to dissuade information dissimulation. Here, we also consider the role of compensations.

firm reporting $\overline{\beta}$.

t_c, C_c and e_c are the transfers, costs that will be reimbursed and the resulting level of cost reducing effort specified in the contract by the regulator. table 4.1 and table 4.2 give the firms' utility according to the realized productivity and their respective reports while Proposition 1 summarizes the result of the equilibrium of the static game.

Table 4.1: Payoff matrix under yardstick competition when the productivity parameter is favorable

	Reports $\underline{\beta}$	Reports $\overline{\beta}$
Reports $\underline{\beta}$	$t_c - \varphi(e_c), t_c - \varphi(e_c)$	$t_c - \varphi(e_c) + A, t_c - \varphi(e_c) - P$
Reports $\overline{\beta}$	$t_c - \varphi(e_c) - P, t_c - \varphi(e_c) + A$	$t_c - \varphi(e_c - \Delta\beta), t_c - \varphi(e_c - \Delta\beta)$

Table 4.2: Payoff matrix under yardstick competition when the productivity parameter is unfavorable

	Reports $\underline{\beta}$	Reports $\overline{\beta}$
Reports $\underline{\beta}$	$t_c - \varphi(e_c + \Delta\beta), t_c - \varphi(e_c + \Delta\beta)$	$t_c - \varphi(e_c + \Delta\beta) + A,$ $t_c - \varphi(e_c + \Delta\beta) - P$
Reports $\overline{\beta}$	$t_c - \varphi(e_c + \Delta\beta) - P,$ $t_c - \varphi(e_c + \Delta\beta) + A$	$t_c - \varphi(e_c), t_c - \varphi(e_c)$

Proposition 1. *In equilibrium, the regulator can propose the full information contract and both firms will report truthfully. When the regulator uses only fines, i.e.* $P > 0$ *and* $A = 0$*, then truthful reports form a Bayesian-Nash equilibrium. On the contrary, when the regulator uses compensation in yardstick competition, truthful reports form an equilibrium in dominant strategy if* $\varphi(e_c) - \varphi(e_c - \Delta\beta) \leq A \leq \varphi(e_c + \Delta\beta) - \varphi(e_c)$.

We denote $\overline{U} \equiv \varphi(e^{FI}) - \varphi(e^{FI} + \Delta\beta)$ (resp. $\underline{U} \equiv \varphi(e^{FI}) - \varphi(e^{FI} - \Delta\beta)$) as the informational rents under the full information contract of the $\overline{\beta}$-type (resp. $\underline{\beta}$-type) firm when it reports as being a $\underline{\beta}$ (resp. $\overline{\beta}$) type. Notice that $\overline{U} < 0$ and $\underline{U} > 0$.

Note that truthful reports do not comprise a unique Bayesian-Nash equilibrium in the game.[6] The other Bayesian-Nash equilibrium of the game, when $\underline{\beta}$ is realized and when only fines are used in yardstick competition, results in both firms reporting $\overline{\beta}$ when $\underline{\beta}$ is realized.[7] Therefore, regulated firms are incited to collude even under the static revelation game with yardstick competition based only on fines. Consequently, to be certain that truthful reports will be the unique equilibrium in a revelation game, the regulator should prefer using a dominant strategy implementation in which he compensates for truthful revelations in the event of incompatible reports. In this latter case, the structure of the game has the essence of a prisoner's dilemma and the amount of compensations that the regulator can use is in fact upwardly bounded if he does not want to induce an inefficient-type firm to report itself as being efficient. The lower bound, on the other hand, guarantees that firms will prefer to report honestly when they are efficient. In the remaining discussion, we will suppose that the regulator fixes A within this interval.

This static game shows that the value of yardstick competition lies in the fact that a regulator could exploit the correlation between firms' private information. This provides the regulator with a supplementary instrument to solicit firms' private information, and allows him to save costly informational rents. As Crémer and McLean [1985, 1988] showed, any correlation, however mild, in agents' private information will enable the principal to extract all their informational rents.

4.3.2 Franchise bidding in a static setting

When a franchise bidding scheme is used, normal market competition (which is non viable) can be substituted with *ex ante* competition (Demsetz [1968]). In this setting, the regulator will define the market rights for each local monopoly and

[6] This has been shown in previous literature. See for instance Demski and Sappington [1984] or Mookherjee [1984].

[7] Nevertheless, Auriol [2000] has shown that an implementation of yardstick competition based on fines through a menu of linear contracts will still deliver a unique first best equilibrium, contrary to this game of simultaneous revelation: firms will find it in their best interest to choose the first-best level of cost reducing efforts under a yardstick competition based on fines implemented through a menu of linear contracts.

grant the rights to operate in a market to the firm with the lowest costs. To study this setting, we continue to restrict ourselves to direct revelation mechanisms: instead of bidding directly on their cost levels, firms bid by submitting reports on the industry-wide productivity parameter. The regulator therefore attributes the rights to operate a market through a contract specifying the reimbursed cost level $C(e_c)$[8] and net transfer t_c to the firm reporting the lowest β. We will further consider the following tie-breaking rule: each firm will be attributed rights to operate in one market when their reports coincide. The rationale behind this rule is that the results obtained can be compared when we consider other configurations in later parts of the discussion. Notably, when we study the setting where franchise bidding is used together with yardstick competition, the regulator will want to have different firms on both markets, so that he could credibly compare their performances.

The major difference of this game with yardstick competition lies in that the regulator no longer has access to fines or compensations when reports differ: simply, he encourages truthful revelations through his choice to attribute the rights to operate in the markets to one firm or the other when reports differ. table 4.3 and table 4.4 present the firms' payoff according to their reports and the realized β for a given transfer t_c. Proposition 2 provides a summary of the outcome of the game.

Table 4.3: Payoff matrix under franchise bidding when the productivity parameter is favorable

	Reports $\underline{\beta}$	Reports $\overline{\beta}$
Reports $\underline{\beta}$	$t_c - \varphi(e_c), t_c - \varphi(e_c)$	$2[t_c - \varphi(e_c)], 0$
Reports $\overline{\beta}$	$0, 2[t_c - \varphi(e_c)]$	$t - \varphi(e_c - \Delta\beta), t - \varphi(e_c - \Delta\beta)$

Proposition 2. *When franchise bidding is used, the regulator will auction off the full information contracts. Firms report truthfully in a Bayesian-Nash equilibrium. A full information outcome can be achieved.*

[8]This can be seen as a cost target to which the regulator credibly commits.

Table 4.4: Payoff matrix under franchise bidding when the productivity parameter is unfavorable

	Reports $\underline{\beta}$	Reports $\overline{\beta}$
Reports $\underline{\beta}$	$t_c - \varphi(e_c + \Delta\beta), t_c - \varphi(e_c + \Delta\beta)$	$2[t_c - \varphi(e_c + \Delta\beta)], 0$
Reports $\overline{\beta}$	$0, 2[t_c - \varphi(e_c + \Delta\beta)]$	$t_c - \varphi(e_c), t_c - \varphi(e_c)$

Note however that according to the proposition above, truthful reports are not the only Bayesian-Nash equilibrium. More specifically, when $\underline{\beta}$ is realized, firms may be better off by both reporting $\overline{\beta}$: it would then be possible for them to earn positive informational rents. Similar to when yardstick competition with fines is used, collusion is possible even in this static game.

4.4 Self enforceable collusion

The regulator's use of artificial competition could induce the firms to behave cooperatively instead of competitively. Even under a static framework, as we have seen above, collusion may be an equilibrium under some circumstances when competition is being simulated. Should this be the case, these instruments that allow the regulator to simulate competitive pressure might have adverse consequences on social welfare. As such, it is important to assess the plausibility of collusive behavior when regulatory tools simulating competition are used. This is the goal of this section. Collusion sustainability is discussed under three possible configurations: firstly, when only yardstick competition is used; secondly, when only a franchise bidding mechanism is used; and thirdly, when the regulator uses franchise bidding to attribute market rights and then regulates the firm(s) using yardstick competition. A discussion in terms of policy follows.

From table 4.1 and table 4.2, we can see that it is mutually beneficial for both firms if they report themselves as being a $\overline{\beta}$-type when the industrial-wide productivity parameter is $\underline{\beta}$: they would each gain $\underline{U} > 0$. When the industry-wide productivity parameter is $\overline{\beta}$, firms can do no better than report truthfully. As such, the collusion agreement between the firms can be seen as firms agreeing to report $\overline{\beta}$ whatever the realized industry-wide productivity parameter. Moreover, firms will be tempted to defect by reporting truthfully only when $\underline{\beta}$ is realized. As a result, to sustain collusion, firms must not defect when $\underline{\beta}$ is realized. This yields the following proposition:

Proposition 3. *When the regulator uses yardstick competition based only on fines, then firms can always sustain collusion. When the regulator uses yardstick competition based on compensations, then collusion is sustainable if and only if compensations are sufficiently low and/or firms are sufficiently patient. In terms of a critical threshold $\delta^*_{YC,c}$, collusion is sustainable when yardstick competition with compensation is used if and only if*

$$\delta \geq \delta^*_{YC,c} = \frac{A - \underline{U}}{A - (1 - v)\underline{U}} \tag{4.1}$$

Proposition 3 is quite expected: a firm has no interest in defecting from collusion when yardstick competition based on fines is used. This is because defection provides no benefit to the defecting firm: only the other firm, behaving collusively, is fined. On the other hand, when yardstick competition with compensations is used, firms may be tempted by the perspective of compensations and, therefore, may choose to defect. Firms would be more tempted to defect if the compensations are high, and/or they discount future periods at a lower rate.

The following corollary provides insights into the impact of some variables on the critical threshold:

Corollary 1. *For any $\underline{U} < A \leq -\overline{U}$ fixed by the regulator, the critical threshold factor decreases in $\Delta\beta$ and in v.*

Corollary 1 suggests that firms will find it easier to sustain collusion under compensation-based yardstick competition when difference in the industry-wide productivity level is large and the probability that the industry-wide productivity parameter $\underline{\beta}$ is high. In both cases, higher future informational rents from collusion can be expected, thus firms can afford to be less patient in order to sustain collusion.

4.4.2 Collusion in franchise bidding

As in the above proposition, one can see from table 4.3 and table 4.4 that when a franchise bidding mechanism is used to auction off the first best contract, firms may have an incentive to collude by reporting the $\overline{\beta}$ industry-wide productivity parameter regardless of its true realization. This way, they will share the markets, and at the same time, benefit from informational rents. In this dynamic setting, we suppose that the contract that is being auctioned will grant the winning firm(s) one period of monopoly rights. In other words, the regulator will auction off the monopoly rights for each market during each period. This can be justified by the fact that the firms' private information changes for each period.

In order to sustain collusion to share markets by always reporting $\overline{\beta}$, firms must resist the temptation to defect when the true realization of this parameter is $\underline{\beta}$. As in the previous discussion, a $\overline{\beta}$ firm stands to lose in this case by reporting being a $\underline{\beta}$-type. It is clear that firms will have no incentive to defect when such a mechanism is used, hence Proposition 4.

Proposition 4. *When a franchise bidding mechanism is used to attribute monopoly rights for the various markets, collusion is always sustainable.*

This result can be easily explained: winning both markets does not provide any benefits to the defecting firms because the contracts that are auctioned here are full-information contracts. Therefore, firms will always prefer to behave collusively and share the markets when franchise bidding is used, and collusion is stable.

4.4.3 Collusion when both schemes are used

The regulator may consider using both schemes together to introduce competitive forces in order to regulate these regional monopolies. In this case, the regulator first uses a franchise bidding mechanism to grant market rights for $n+1$ periods, and then regulates the winning firm(s) using yardstick competition during the subsequent n periods. In the repeated game, at the end of the $(n+1)$ period, the rights will be available for bids again for another $n+1$ periods, *ad infinitum*.

Since the goal of collusion is to maximize joint profits, we define the firms' collusive strategy here as reporting $\overline{\beta}$ regardless of the realized industry-wide productivity parameter for all periods of the game. Under such a collusion, firms share markets and benefit from informational rents when the markets are franchised, and they coordinate their reports under yardstick competition in order to benefit from informational rents. However, note that if a firm wins both markets, it is able to coordinate its own reports in the consequent n periods when yardstick competition is used. As such, it could benefit from informational rents stemming from *both* markets during the regulation period. A firm may therefore want to defect by reporting truthfully when $\underline{\beta}$ is realized, and by reporting $\underline{\beta}$ even when $\overline{\beta}$ is realized. In the first case, a defecting firm's utility is

$$U_{\underline{\beta}}^{\mathscr{D}}(\underline{\beta}) = 2v\frac{\delta(1-\delta^n)}{1-\delta}\underline{U}$$

where $U_{\beta}^{\mathscr{D}}(\tilde{\beta})$ is the defecting firm's utility when the industry-wide productivity parameter is β and it reports $\tilde{\beta}$.

When $\overline{\beta}$ is realized, a defecting firm may want to report itself as being $\underline{\beta}$ in order to secure the monopoly rights for both markets for the subsequent $(n+1)$ periods at stake. In this case, the defecting firm's utility is

$$U_{\overline{\beta}}^{\mathscr{D}}(\underline{\beta}) = 2\overline{U} + 2v\frac{\delta(1-\delta^n)}{(1-\delta)}\underline{U}$$

As such, collusion is sustainable if and only if

$$\underline{U} + \frac{v\delta}{(1-\delta)}\underline{U} \geq 2v\frac{\delta(1-\delta^n)}{(1-\delta)}\underline{U} \tag{4.2}$$

when $\underline{\beta}$ is realized, and

$$\frac{v\delta}{(1-\delta)}\underline{U} \geq 2\overline{U} + 2v\frac{\delta(1-\delta^n)}{(1-\delta)}\underline{U} \tag{4.3}$$

when $\overline{\beta}$ is realized.

One can easily see that if equation 4.2 is satisfied, then equation 4.3 will automatically be satisfied. Indeed, as $|\overline{U}| > |\underline{U}|$ and $\overline{U} < 0$, equation 4.2 implies that $\frac{v\delta}{(1-\delta)}\underline{U} \geq 2v\frac{\delta(1-\delta^n)}{(1-\delta)}\underline{U} - \underline{U}$. This latter term should be greater than $2\overline{U} + 2v\frac{\delta(1-\delta^n)}{(1-\delta)}\underline{U}$. As such, collusion is sustainable if equation equation 4.2 holds.

equation 4.2 can be rewritten as

$$2v\delta^{n+1} - (1+v)\delta + 1 \geq 0 \tag{4.4}$$

We define $f(v, \delta, n) \equiv 2v\delta^{n+1} - (1+v)\delta + 1$. We plot the graphs of this equation according to δ and for $v = 0.2, 0.5$ and $v = 0.8$. For each given v, the figures trace graphs for $n = 1, 4, 9, 24$ and 34, which correspond to a length of $2, 5, 10, 25$ and 35 periods of monopoly rights. Collusion is sustainable in the interval of δ where $f(\cdot)$ is positive.

Several observations may be made from figure 4.1–figure 4.3: all things equal, firms will find collusion relatively harder to sustain when v is high, and when the monopoly rights are granted for a relatively long period of time. Intuitively, a higher v implies a higher possibility for firms to benefit from future informational rents, since $\underline{\beta}$ is more likely to be realized. This means that the stakes from collusion and defection become more important. A longer number of periods for which monopoly rights are granted will also change the stakes of defection for firms: the longer they detain these rights, the higher the perspective of future rents from defection.

Surprisingly, the figures also show that there may be two critical threshold discount factors in this game: firms may sustain collusion if they are patient enough,

Figure 4.1: Graphs of $f(\delta, n)$ when $v = 0.2$

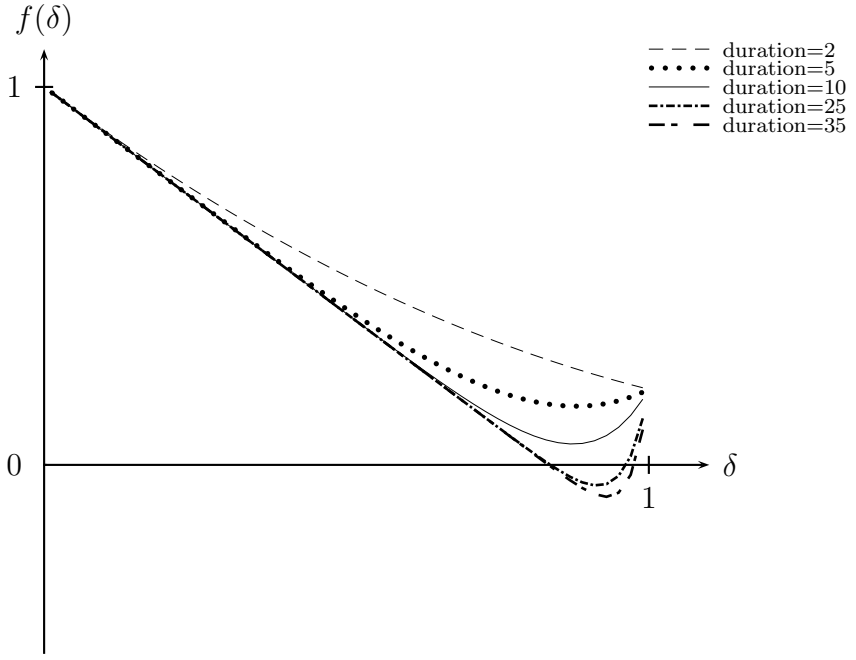
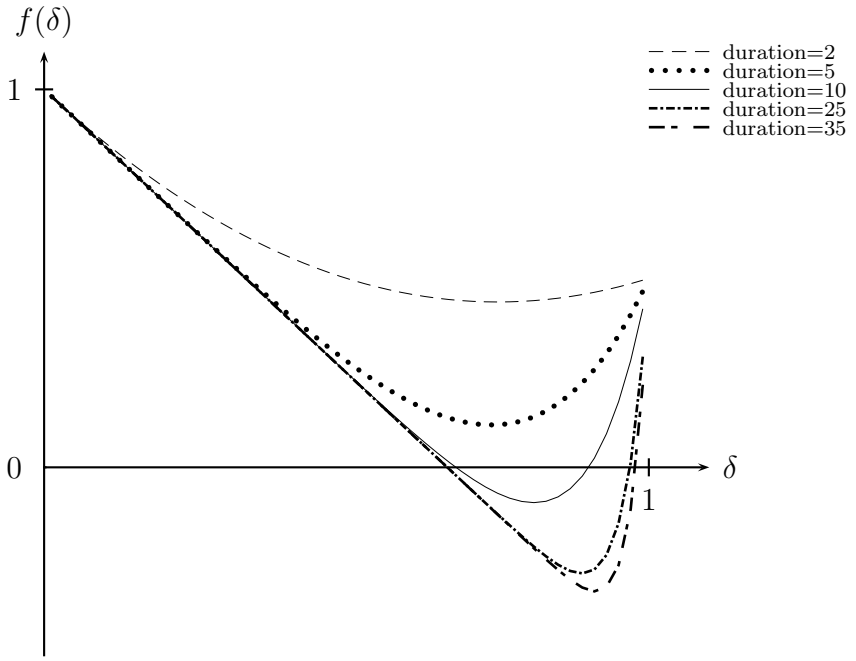
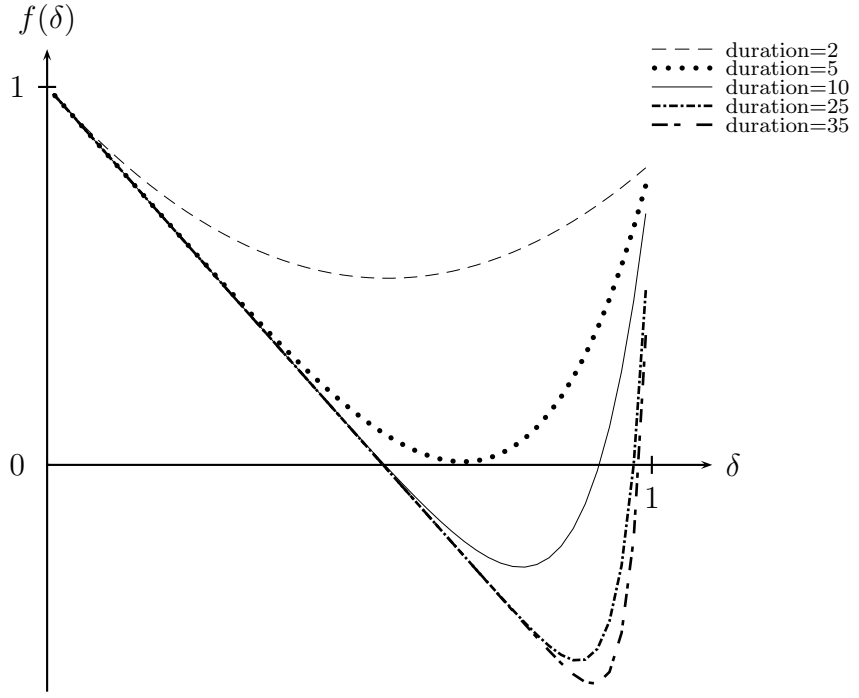


Figure 4.2: Graphs of $f(\delta, n)$ when $v = 0.5$



and if they are sufficiently impatient! These critical threshold factors correspond to the value of δ when $f(v, \delta, n) = 0$ in the figures. This finding contrasts with the usual result found in the literature on self-enforcing collusion in a repeated game.

Figure 4.3: Graphs of $f(\delta, n)$ when $v = 0.8$



This means that, in our case, the use of both competitive schemes may actually help firms sustain collusion! If we denote $\underline{\delta}^*_{\text{FB,YC}}$ the first critical threshold factor and $\overline{\delta}^*_{\text{FB,YC}}$ the second critical threshold factor, with $\overline{\delta}^*_{\text{FB,YC}} > \underline{\delta}^*_{\text{FB,YC}}$, then collusion is sustainable if $\delta \leq \underline{\delta}^*_{\text{FB,YC}}$ or $\delta \geq \overline{\delta}^*_{\text{FB,YC}}$. We summarize these observations in the following proposition:

Proposition 5. *When the regulator attributes the markets using a franchise bidding mechanism before regulating the firms under yardstick competition, collusion is always sustainable if v and the length of monopoly rights are sufficiently low. When v and the length of the monopoly rights are high enough, firms may sustain collusion only if they are patient enough, or if they are impatient enough.*

The intuition behind these results is as follows: notice that when a firm defects, it must to forego the informational rents in the first period when franchise bidding is used in order to win the monopoly rights for *both* markets. This allows the defecting firm to benefit from *expected* informational rents stemming from both markets during the subsequent periods granted by the monopoly rights. As such, if these rents are unlikely (v low), or these expected rents are low (because monopoly

rights expire too soon), then firms will not be incited to forego the present gains by defecting. More importantly, even when these expected rents are high, firms may not be interested in defecting when they are impatient: they would prefer to benefit from the current informational rents by sticking to the collusion agreement when monopoly rights are being franchised. Hence $\delta \leq \underline{\delta}^*_{\text{FB,YC}}$.

The intuition behind the second part of the results is more classic: after a defection, under grim trigger strategies, firms revert to behaving non cooperatively. In our case, this implies that once the monopoly rights expired and are franchised again in the future, a firm will also be required to forego future rents after defection. Hence, firms will have to be sufficiently patient to sustain collusion. In other words, the firms' discount factor has to satisfy $\delta \geq \overline{\delta}^*_{\text{FB,YC}}$ in order to sustain collusion.

Notice that when $n = 0$, this corresponds to the case where only franchise bidding is used. Collusion is then always sustainable as concluded previously. The following corollary studies the case when monopoly rights are granted once and for all:

Corollary 2. *As $n \to +\infty$, $f(v, \delta, n) \to 1 - (1 + v)\delta$. Collusion is sustainable if $\delta \leq \frac{1}{1+v}$. More particularly, if $v \to 1$ then collusion is sustainable if $\delta \leq \frac{1}{2}$. On the contrary, if $v \to 0$, then collusion is always sustainable.*

From Corollary 2, it would seem that the lower critical threshold factor is downwardly bounded by $\frac{1}{2}$, i.e. $\underline{\delta}^*_{\text{FB,YC}} \geq \frac{1}{2}$. Thus, for very impatient firms, a supplementary franchise bidding mechanism may contribute to helping them sustain collusion. Furthermore, notice that the upper critical threshold disappears when monopoly rights are granted infinitely. This suggests that collusion will not be sustainable even for very patient firms in this case when v is high enough. Intuitively, this is because when $n \to +\infty$, a defection will never be "punished". Hence, there is no need for a defecting firm to forego future informational rents following a defection.

In a nutshell, the main insight is that the use of a supplementary franchise

bidding mechanism could in fact help firms to sustain collusion, contrary to what may be expected.

4.4.4 Some policy considerations

Collusion can be a concern when the regulator tries to introduce competitive forces into regional monopolies. Nevertheless, the firms' ability to sustain a collusive agreement changes according to the type of mechanism used by the regulator. As seen from the analysis above, yardstick competition based on fines should be avoided: in this case, firms are always able to sustain collusion. When a yardstick competition scheme is used repeatedly, collusion is not sustainable unless firms are sufficiently patient. Moreover, the higher the amount of compensations, the more difficult it is for firms to sustain collusion. This suggests that when the regulator is faced with very patient firms, in order to discourage any collusive initiative, he will have to commit to providing very high amounts of compensation.

However, high compensations may introduce adverse incentives. Furthermore, compensations that are too high may not be credible, and consequently, may not be sufficient to deter firms' collusive incentives. This is where a supplementary franchise bidding mechanism to attribute market rights can help the regulator. Indeed, when monopoly rights are being attributed for a *sufficiently long period of time*, collusion may be sustainable when firms are patient only to a certain extent. By using both schemes together, the regulator can destabilize collusion for such firms.

One should also note that using both mechanisms together may in fact help firm sustain collusion. According to our analysis, this could happen when firms are impatient. Therefore, one could suggest using only yardstick competition based on compensations when firms are impatient, and using both schemes when both firms are patient. In the former case, another advantage is that compensations can be less important. Notice that if firms are extremely patient, then collusion should be sustainable. In this case, the regulator might want to consider some

other types of incentive regulation and not introduce competitive forces into such markets.

One may notice that the choice of type of regulation is influenced by the likelihood of the more efficient productivity parameter $\underline{\beta}$. When yardstick competition is repeatedly used, the critical threshold factor decreases as v increases: firms can afford to be less patient to sustain collusion. On the other hand, when temporary monopoly rights are first attributed through auctions before yardstick competition is used, firms have to be less patient than the lower critical threshold factor to sustain the collusive agreement. One can see that this critical threshold factor decreases to a certain extent as v increases. This implies that firms must be more impatient, to a certain extent, in order to sustain collusion as v increases. The choice between using both schemes, or only yardstick competition, could therefore depend on this parameter, especially when firms are neither too patient nor too impatient.

In summary, when collusion could be a problem, using both franchise bidding to attribute market rights and yardstick competition *ex post* to regulate may not be the solution to discouraging firms from behaving collusively. Franchise bidding may in fact help firms to sustain their collusive agreement! The length for which the monopoly rights for the markets are granted can also play a role in helping the regulator prevent collusion.

4.5 Conclusion

In this chapter, we have adopted an infinitely repeated game framework to study firms' collusive incentives when the regulator tries to introduce competitive forces into regional monopolies. It was found that firms are able to sustain collusion when the yardstick competition that is used is based on fines. However, when the yardstick competition scheme includes compensations in the event of incompatible reports, collusion is sustainable only when firms are sufficiently patient.

Using a supplementary franchise bidding mechanism with yardstick competition may not always help the regulator destabilize the firms' capability to collude. This latter objective can be achieved only if firms are "moderately" patient, and on the condition that the temporary monopoly rights are attributed for sufficiently long periods of time. The use of both schemes therefore seems appropriate when firms are moderately patient. Otherwise, when firms are impatient, a supplementary franchise bidding mechanism may help to sustain collusion!

We believe that our Proposition 3 could also be used to shed some light on the ongoing debate between the use of leniency programs and whistle-blowing programs in the antitrust arena against cartels. In the former, competition authorities impose fines on all cartel members except the defecting one, while in the latter, competition authorities offer compensation to the defecting cartel member. While our model has not been specifically constructed to study this issue, this propostion nevertheless seems to argue in favor of the use of whistle-blowing programs. However, the danger of a whistle-blowing program could lie in the amount of compensation that should be fixed.

A related question concerns whether a regulation authority or a competition authority should be placed in charge of deterrence of collusive behavior when an industry is submitted to regulations. Our results seem to tilt favorably towards the regulation authority. Indeed, a competition authority works on collusion problems *ex post*, even if the policy introduces an *ex ante* impact on a firm's incentive to collude, while a regulation authority can directly act *ex ante* and prevent collusion through adequately designed regulatory instruments. However, one still has to compare costs and benefits of delegating this task to a regulation authority, and it is likely that they may complement each other in this endeavor.

Nevertheless, we must admit that there are limits to our analysis. The most important is perhaps the fact that we may have oversimplified the stakes that firms could have in winning temporary market rights. One may think that a firm that wins the rights to operate on a market will develop advantages over firms that "stayed out of the business" (Williamson [1976]), enhancing its chances of winning

future markets. This may erode some of the collusive incentives that firms may have.

Another possible limit could be that we have not accounted for the fact that regulatory procedures and franchise bidding mechanisms are costly to implement. For instance, Yvrande-Billon [2005] mentions that costs for preparing a bid in the French urban transport sector range from 30,000€ for a small network to 500,000€ for a large one. A regulator may want to trade off the costs of benefits of discouraging collusion through the length of monopoly rights or effort distorsion.

Nonetheless, we believe that our results help recognize that when a regulator tries to simulate competitive forces, firms may collude. Whether they could in fact do this will partly depend on the regulatory scheme being used. A regulator intending to use schemes that simulate market forces should keep this in mind, and evaluate the extent to which such behavior is possible. A mixture of several instruments may either sustain or destabilize collusion. Great care should therefore be exercised before implementing various possible regulatory tools.

Appendix

A. Proofs

A.1 Proof for Proposition 1

In order for truth telling to be a (Bayesian-)Nash equilibrium of the game, for firm i we must have:

$$U_i(\overline{\beta},\overline{\beta},\overline{\beta}) \geq U_i(\underline{\beta},\overline{\beta},\overline{\beta}), \qquad i=1,2 \tag{4.5}$$

$$U_i(\underline{\beta},\underline{\beta},\underline{\beta}) \geq U_i(\overline{\beta},\underline{\beta},\underline{\beta}), \qquad i=1,2 \tag{4.6}$$

where $U_i(\tilde{\beta}_i,\tilde{\beta}_j,\beta)$ is the utility of firm i when it submits a report $\tilde{\beta}_i$ and firm j submits a report $\tilde{\beta}_j$ in the event that β is realized, $\tilde{\beta}_i,\tilde{\beta}_j,\beta \in \{\underline{\beta},\overline{\beta}\}$. Under the

proposed mechanism, these constraints, can be rewritten as:

$$\begin{aligned} t_c - \varphi(e_c) &\geq t_c - \varphi(e_c + \Delta\beta) + A \\ t_c - \varphi(e_c) &\geq t_c - \varphi(e_c) - P \end{aligned}$$

Thus, truthful reporting is a Bayesian Nash equilibrium when $P \geq 0$ and $A \leq \phi(e_c + \Delta\beta) - \phi(e_c)$. In particular, this is true for $A = 0$ and for the contract that specifies $e_c = e^{FI}$, $t_c = \varphi(e^{FI})$. Thus, the regulator can impose the full information contract and it is sufficient to achieve truthful reporting and punish firms when reports are incompatible.

Truthful reporting is an equilibrium in dominant strategy if and only if, in addition to the two inequalities above, the following conditions are satisfied:

$$\begin{aligned} U_i(\overline{\beta}, \underline{\beta}, \overline{\beta}) &\geq U_i(\underline{\beta}, \underline{\beta}, \overline{\beta}), \qquad i = 1, 2 \\ U_i(\underline{\beta}, \overline{\beta}, \underline{\beta}) &\geq U_i(\overline{\beta}, \overline{\beta}, \underline{\beta}), \qquad i = 1, 2 \end{aligned}$$

They will be satisfied if $P = 0$ and $\varphi(e_c) - \varphi(e_c - \Delta\beta) \leq A \leq \varphi(e_c + \Delta\beta) - \varphi(e_c)$. In particular, this is true if the regulator specifies C_c such that $e_c = e^{FI}$ and $t_c = \varphi(e^{FI})$. Indeed, given that $\varphi''(\cdot) > 0$, $\varphi(e^{FI} + \Delta\beta) - \varphi(e^{FI}) > \varphi(e^{FI}) - \varphi(e^{FI} - \Delta\beta)$. Consequently, such a range exists for A. The regulator can thus offer the full information contract under yardstick competition based only on compensation. □

A.2 Proof for Proposition 2

Under the franchise bidding game, truthful reports are a Bayesian-Nash equilibrium if and only if the set of equation 4.5–equation 4.6 are satisfied. From table 4.3 and table 4.4 and for a contract specified by the regulator, these conditions are:

$$\begin{aligned} t_c - \varphi(e_c) &\geq 2[t_c - \varphi(e_c + \Delta\beta)] \\ t_c - \varphi(e_c) &\geq 0 \end{aligned}$$

Therefore, for any t_c and e_c specified (through the reimbursed costs level) in the contract satisfying these constraints, firms will report truthfully in (a Bayesian-Nash) equilibrium. In particular, these incentive compatibility constraints are

satisfied by $e_c = e^{FI}$ and $t_c = \varphi(e^{FI})$, the first-best level of efforts and the first-best level of net transfers. Under this contract, the second constraint is automatically satisfied:

$$\varphi(e^{FI}) - \varphi(e^{FI}) = 0$$

This first constraint can be rewritten as

$$\begin{aligned} 0 &\geq 2[\varphi(e^{FI}) - \varphi(e^{FI} + \Delta\beta)] \\ \rightleftharpoons \quad \varphi(e^{FI} + \Delta\beta) &\geq \varphi(e^{FI}) \end{aligned}$$

Given that $\varphi' > 0$, we have $\varphi(e^{FI} + \Delta\beta) > \varphi(e^{FI})$. Therefore, this constraint is satisfied as well. Moreover, firms are willing to accept this contract as it guarantees them their reservation utility. $\square$

A.3 Proof for Proposition 3

To sustain collusion, firms must not be tempted to defect when $\underline{\beta}$ is realized and after it has been revealed to the firm. In this case, a firm's discounted expected rent is $\underline{U} + v\frac{\delta}{(1-\delta)}\underline{U}$. If the regulator uses yardstick competition based on fines, a defecting firm's expected utility is 0 and firms revert back to behaving non cooperatively. Under grim trigger strategies, collusion is sustainable if and only if

$$\begin{aligned} \underline{U} + \sum_{t=1}^{\infty} \delta^t v \underline{U} &\geq 0 \\ \delta \leq \delta^*_{\text{YC},f} &= \frac{1}{1-v} \end{aligned}$$

where $\delta^*_{\text{YC},f}$ is the critical threshold. Since $(1-v) < 1$, $\delta^*_{\text{YC},f} > 1$. Thus, firms will always be able to sustain collusion.

When the regulator uses yardstick competition based on compensation, defection brings A to the firm but firms subsequently revert to behaving non-cooperatively. As such, under this type of yardstick competition, collusion is sustainable if and only if

$$\begin{aligned} \underline{U} + v\frac{\delta}{(1-\delta)}\underline{U} &\geq A \\ \delta \geq \delta^*_{\text{YC},c} &= \frac{A - \underline{U}}{A - \underline{U}(1-v)} \end{aligned}$$

where $\delta^*_{\text{YC},c}$ is the critical threshold factor. Since $0 < (1-v) < 1$ by assumption, we have $(1-v)\underline{U} < \underline{U}$ and so $[A-(1-v)\underline{U}] > [A-\underline{U}]$. As such $\delta^*_{\text{YC},c} < 1$: $\delta^*_{\text{YC},c}$ is bounded by 1. Furthermore, if $A > \underline{U}$. Hence $\delta^*_{\text{YC},c} > 0$. Given that $\delta \in]0,1[$, firms are therefore able to sustain collusion under this type of yardstick competition if they are patient enough (so that $\delta \geq \delta_{\text{YC},c}$).

We will now show that the higher the amount of compensation, the more patient firms will have to be to sustain collusion:

$$\frac{\partial \delta^*_{\text{YC},c}}{\partial A} = \frac{v\underline{U}}{[A-\underline{U}(1-v)]^2} > 0$$

since $v, \underline{U} > 0$. Therefore, the critical threshold increases with the amount of compensations. □

A.4 Proof for Corollary 1

Recall that $\underline{U} \equiv \varphi(e^{FI}) - \varphi(e^{FI} - \Delta\beta) > 0$ and $\overline{U} \equiv \varphi(e^{FI}) - \varphi(e^{FI} + \Delta\beta) < 0$. We thus have

$$\begin{aligned} \underline{U}'_{\Delta\beta} \equiv \frac{\partial \underline{U}}{\partial \Delta\beta} &= \varphi'(e^{FI} - \Delta\beta) > 0 \\ \overline{U}'_{\Delta\beta} \equiv \frac{\partial \overline{U}}{\partial \Delta\beta} &= -\varphi'(e^{FI} + \Delta\beta) < 0 \end{aligned}$$

Therefore, for any given A, we have

$$\begin{aligned} \frac{\partial \delta^*_{\text{YC},c}}{\partial \Delta\beta} &= \frac{-\underline{U}'_{\Delta\beta}[A-(1-v)\underline{U}] + (1-v)\underline{U}'_{\Delta\beta}[A-\underline{U}]}{[A-(1-v)\underline{U}]^2} \\ &= \frac{-vA\varphi'(e^{FI} - \Delta\beta)}{[A-(1-v)\underline{U}]^2} < 0 \end{aligned}$$

as $\varphi'(\cdot), v, A > 0$. Hence the critical threshold discount factor decreases in $\Delta\beta$ for $\underline{U} < A < -\overline{U}$.

Similarly, we have

$$\frac{\partial \delta^*_{\text{YC},c}}{\partial (1-v)} = \frac{\underline{U}(A-\underline{U})}{[A-(1-v)\underline{U}]^2} > 0$$

$\delta^*_{\text{YC},c}$ thus increases in $(1-v)$. Therefore, $\delta^*_{\text{YC},c}$ is decreasing in v. □

A.5 Proof for Proposition 4

When $\underline{\beta}$ is realized, the expected rents from collusion are $\underline{U} + \frac{v\delta}{(1-\delta)}\underline{U}$. Defection allows the defecting firm to obtain monopoly rights for both markets but the contract auctioned yields utility that is equal to the winning firm's outside option, i.e. 0. Moreover, firms will revert back to playing non cooperatively, therefore expected utility from defection is 0. Collusion is therefore sustainable if and only if

$$\begin{aligned} \underline{U} + \frac{v\delta}{(1-\delta)}\underline{U} &\geq 0 \\ \delta \leq \delta^*_{\text{FB}} &= \frac{1}{1-v} \end{aligned}$$

where δ^*_{FB} is the critical threshold. Given that $\delta^*_{\text{FB}} > 1$ as $v < 1$, this condition is always verified. Therefore, collusion is always sustainable. □

A brief conclusion to Part II

As we have seen from the Part I, public authority(ies) may appeal to competitive solutions to organize the provision of local public services. Using such solutions can in fact enhance efficiency from a consumers' welfare perspective. In particular, these solutions may allow more efficiency gains from using private expertise in the provision of these services to be passed on to consumers. As an example, we have found that auctions may contribute to lower water prices for consumers, despite some prevailing (indirect) inefficiencies of PPPs: consumers pay higher prices when their water services are run through a PPP by certain private operators.

However, collusion may hinder the workings of these competitive forces. The economic literature, as well as judiciary decisions, have shown that collusion is a pervasive and real problem when one seeks to use franchise bidding mechanisms. Given that such a mechanism is widespread in our days, it is important to address this issue. The objective of this second of part of our dissertation seeks to see if firms or operators may collude when competitive solutions are used to run local public services. In particular, we attempted in Chapter 3 to find out whether certain provisions in a contract to be attributed through auctions may be altered to make collusion harder to sustain for potential firms. Focusing on a ubiquitious variable in contracts, namely the contractual length, we have shown that firms may find it harder to sustain a cartel agreement when a longer–term contract is being auctioned. However, subsequent empirical tests conducted in the French

water sector does not provide strong indications to support that contractual length is used to such an end. More specifically, we have found that when indirect competition from direct public management is high, contractual length for PPP contracts tends to be shorter. However, a higher degree of concentration of private operators in a *Département* does not lead to longer contracts, as would be the case if contractual length is used to discourage collusive initiatives during auctions. This may also be due to the fact that our measure for industrial concentration used in the empirical study is inadequate.

A shortcoming to Chapter 3 is that we restrict our attention to a bilateral situation, where a local public authority decides on the length of contract to be attributed to a winner of an auction. Where local public services are concerned, there may be other ways than contractual length that could be used to make collusion harder to sustain for operators. In particular, we consider a more collective and coordinated response to this potential problem in Chapter 4. More precisely, we have studied firms' capacity to collude when yardstick competition is used instead of auction mechanisms. We have also studied the case when both yardstick competition and auctions are used together. Indeed, we have seen from Chapter 2 that yardstick competition is particularly interesting when a coordinated and centralized approach to oversee the provision of local public services is desired. The use of yardstick competition in this case may lead to a higher social welfare when compared to individualistic types of regulation such as price–cap regulation or cost of service regulation. This leads us to consider to restrict our attention to yardstick competition in Chapter 4.

In particular, in Chapter 4, we asked how will firms' incentives to collude respond to yardstick competition. Indeed, yardstick competitive is another way competitive pressures may be created in industries characterized by a (local) natural monopoly structure. We found if the yardstick competition used penalizes a firm for below–average performances, then firms will always collude. On the other hand, firms find it more difficult to sustain collusion when above–average performances are compensated through the yardstick competition used. We then consider the case when contractual variables and organizational arrangements are

used. More specifically, we also studies how firms' incentives to collude changes when both auction and yardstick competition are used when a contract has been attributed. We found that contractual length continues to play a role in discouraging firms' collusive behaviour. Quite surprising, the use of auction together with franchise bidding may in fact help firms to sustain collusion. In our case, this is because a defecting firm during the auction would need to given up first period rents in order to benefit from subsequent rents arising from being a monopolist on all local markets. When firms are impatient, contrary to classical results in the study of collusion, they will not have sufficient incentives to defect. This enhances the sustainability of collusion.

A common feature in our approach to study collusion in both of the chapters is the emphasis we place on the issue of sustainability of a collusive agreement. We believe that in order for firms to collude, they must be able to sustain any collusive agreement that serves to "support" the collusion. Indeed, legal institutions cannot be rely on to enforce such agreements, since collusion is generally considered to be illegal. Hence, any collusion agreement needs to be self–enforced.

We should also note that an important shortcoming in both our chapters is that we have not derived the optimal policy under the various configurations we examined. This is unfortunate, as we are unable to be sure of the optimality of these various instruments. We leave this aspect for future work.

More generally, we believe that this second part of our dissertation emphasizes the importance of interaction between contractual variables and organizational arrangements on firms' strategic behaviour. While a variety of contractual instruments and organizational instruments may be mobilized to deter collusion, as we have seen from Chapter 4, a mix of various instruments may enhance or introduce adverse incentives on the way that firms will react on them. Therefore, care should be exercised when considering various configurations.

General Conclusion

In this dissertation, we sought to understand how public authorities (and the general consumer) could benefit from competitive pressures where local public services are concerned. Provision of such services often involve technologies that exhibit natural monopoly characteristics at a local level, and therefore preclude normal market competition. Nevertheless, there are two formal mechanisms that could allow public authorities to benefit from competitive pressures. One of such mechanism, first advocated by Chadwick [1859] and Demsetz [1968], concerns the use of auctions to attribute temporary monopoly rights through a contractual arrangement to a private operator. This has come to be known in the literature as "franchise bidding". The other such mechanisms is in fact a form of regulatory policy, under which compensations to a private operator is based on its relative performance with respect to other comparable firms. This mechanism was first termed by Shleifer [1985] as "yardstick competition".

As it is well known by now, Transaction Cost Economists have pointed out that the efficiency of franchise bidding mechanisms may be limited by potential contracting problems. In particular, specifying complete contracts for public service provision may be costly or impossible, leading to the need for public authorities and operators to renegotiate the initial contract. This may provide room for *ex post* opportunistic behaviour from contracting parties, and hence lead to some inefficiencies. Auctions may be unable to entirely solve for this problem.

To assess the efficiency of competition through auctions for local public services, and to account for these criticisms, we have conducted an empirical analysis into the French water sector. In particular, we exploited a change in institutional rule, the Sapin Law introduced in 1993, to approximate efficiency gains from auctions in terms of water prices. The Sapin Law makes the use of competitive tendering procedure compulsory for local public authorities when these latter choose to outsource their water services. We found that water prices are significantly lower when contracts are signed after 1993. Moreover, we account for the effect of Public Private Partnership (PPP) contracts, *ex post* competition and intermodal competition as a means to moderate possible inefficiencies due to *ex post* opportunism as suggested by Transaction Cost Economics. Theoretically, we justify this using arguments based on the relational contracting literature (Baker, Gibbons, and Murphy [2006] etc.). Empirically we find some partial supporting evidence that "informal" mechanisms such as *ex post* competition and *intermodal* competition do play a role on water prices. Moreover, some of the operators are paid a premium for running water services. We take such effects to mean as there may be some persisting inefficiencies in the way the French water services are organized.

Yardstick competition is another means by which competitive pressures may be introduced into local public services. These services are often being operated at a local level. Hence, a regulator at the national level has (or can have) observations on how these services are being run, and to evaluate the performance of private operators in running such services. In order to get a clearer picture on the benefits and limits of this regulatory scheme, we have reviewed the theoretical literature on this mechanism. We found that yardstick competition can in fact lead to higher static efficiency when compared to individualistic types of regulation. This is true whenever operators detain private information that may be correlated. We believe that this should be true where local public services are concerned: operators' private information may be correlated in this case because operators may share some common features in their technology of production. After all, they do provide the same kind of public services, albeit in different areas. However, under yardstick competition, investments incentives may be depressed, limiting dynamic efficiency. This is true for investments with sector spillovers. Another limit to using yardstick

competition involve measurement problems. To be more precise, different methods of measuring and specifying relative performance yields different results. This may introduce some randomness when yardstick competition is used. In practice, such randomness will lead to inefficiencies when yardstick competition is used.

While competitive pressures may enhance efficiency in the way local public services are provided to end users, one should also note the danger that such mechanisms may induce collusive behaviour from firms. In general, collusion could undermine efficiency gains that are expected from the use of such mechanisms. In particular, previous studies (Porter and Zona [1993], Pesendorfer [2000], Klemperer [2004] etc.) have found empirical evidence supporting collusion during auction mechanisms. Likewise, American and European Competition Authorities have also condemned private operators for behaving collusively when auctions are used to attribute public contracts for services. Collusion is therefore a real problem that local public authorities might face when they intend to use auction mechanisms to benefit from competitive pressures. Firms may also have incentives to collude when yardstick competition is used, at least theoretically. Even though empirical evidence is lacking on this issue, Laffont and Martimort [2000] and Tangerås [2002] have shown that a major danger when yardstick competition is used concerns collusion.

In this respect, we are interested in knowing whether contractual variables in a contract to be auctioned could be adapted in order to discourage any collusive initiative. More specifically, we study whether contractual length can play such a role. Using a symmetric independent private value auction framework, we show that firms' capacity to collude is in fact decreasing as the contractual length of a contract to be auctioned increases. This suggests that when suspicion for collusion is high, local public authorities intending to use an auction could increase the length of the contract to be attributed. This may discourage collusion during an auction. We then empirically study if local public authorities in France adopt such a strategy to dissuade collusion. To this end, we run some regressions on a sub–sample of data that comes from IFEN–SCEES–DGS and two French regional water agencies. Again, we found only partial supporting evidence that contractual

length if used to this end. More specifically, higher indirect competition from direct public management is found to have a negative impact on the length of contract attributed through an auction. Hence, we are not able to tell whether contractual length is being used by local public authorities to this end. This is not surprising for at least two reasons: firstly, the level of local competition may be badly measured in our study, and secondly, we are unable to be sure from a theoretical perspective whether it is indeed efficient for local public authorities to use contractual length as a means to discourage collusive. Other contractual variables, or *ex post* intervention by a competitive authority, could perhaps be used to discourage collusion more effectively and efficiently.

Turning to yardstick competition, we show theoretically that firms may have incentives to collude as well when this type of regulation is used. More specifically, firms may find it harder to sustain a collusive agreement when the yardstick competition used entitle a relatively better performing firm to some compensations. We also looked into the case where yardstick competition is used together with an auction mechanism. We show in this case that the use of a supplementary auction mechanism may in fact help firms to sustain their collusive agreement. In other words, when both schemes are used, firms may find it easier to collude. We show that a way to destabilize collusion is again to make contractual length longer.

More generally, the discussion conducted throughout this dissertation makes us realized the importance of formal and informal institutional settings. For instance, our empirical work points out the necessity to adopt a more global perspective when evaluating efficiency of how local public services are organized and provided. In particular, *ex post* dimensions of a contractual relationship between private operators and local public authorities should be taken into account. Political considerations and economic rationality may also impact on the choice on organizational structure. Empirical work focusing too restrictively only on the *ex ante* dimension of this question may lead miss out some important aspects of how efficiently the sector is organized. If yardstick competition were to be used in the French water sector, our empirical work also points out to important operator–specific premia. Clearly, one could try to identify as much as possible the source

of such premia, and account for them in order to yield sound estimates.of relative performance. Otherwise, yardstick competition can be expected to yield inefficient social outcome.

On a theoretical level, to fully assess the pros and cons of these competitive solutions, one has to take into consideration the costs and benefits of centralization and decentralization. To use yardstick competition, for instance, centralization would be necessary and beneficial. While it is also possible to use auctions at a centralized level, local authorities may have better knowledge on local conditions, where these services are to be run. There could therefore be some advantage to a decentralized organization when auctions are used. When one considers using both schemes, how should responsabilities be shared? Should conducting auctions be still left to local authorities, or should this reponsability be left at a centralized level? Should the decision to use PPP or manage the service directly under public management falls on a local public authority? Clearly, these questions play a role in determining how well consumers may better benefit from local public services.

We are again confronted with these questions when we seek ways to deter collusion. Collusion and competition is inextricably related. Contractual variables and regulations may be used together or separately to discourage collusive initiative. However, a relevant question that arise here is the following one: who should be responsible for preventing collusion? Would it be more efficient to leave this tasks to competition authority? Or should local authorities or a regulator intervene as well? Again, a more global picture, taking into account institutions and political economy considerations, would not only be beneficial, but are also necessary, in order to assess the benefits and limits of these competitive solutions that could be used to run local public services.

To conclude, while the use competition solution(s) to organize local public service provisions could be beneficial from a social welfare point of view, an important limit to these solutions resides in strategic responses to these solutions by private operators. One of the more important strategic responses is collusion. Such a dimension should be carefully accounted for when attempts are taken to

introduce competition where local public services are concerned. Moreover, relative efficiency of the type of competition, or a combination of both types, depends partially on how best institutions are organized, and on political economy considerations. Research into such issues could clearly help to clarify debats on the merits and limits of yardstick competition and/or auctions.

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