The Cost of Contract Renegotiation For Public Transport Services[1]

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We construct and estimate a structural principal/agent model of contract renegotiation in the French urban transport sector in a context where operators are privately informed on their innate costs and can exert cost-reducing managerial effort. This model captures two important features of the industry. First, only two types of regimes are used in practice by local public authorities (principals) to regulate the service: Cost-plus and fixed-price contracts. Second, the subsidies paid to operators (agents) increase over time. Patterns of increasing subsidies arise when principals cannot commit not to renegotiate and contractual arrangements are renegotiation-proof. We compare this situation to the hypothetical case where principals can commit not to renegotiate. The efficiency of the operators is overestimated if the hypothetical solution is considered. The welfare gains of being able to commit are significant and accrue mostly to operators. Estimates of the weights that local governments give to the operator's profit in their objective functions and of the social value of managerial effort are obtained as by-products.

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1 Introduction

Real world contractual relationships are ongoing processes in an ever changing environment. Parties lay down arrangements for trading goods and services covering several periods. However they may renegotiate them as new information on market demand and costs structure becomes available. Although economic theory has devoted a considerable attention to understanding dynamic contractual relationships and especially how contracts may be renegotiated over time, the empirical literature on those issues lags much behind both in terms of volume and scope. In a nutshell, the lessons of the theoretical literature is that renegotiation matters for contract design. Renegotiation has indeed a positive impact because it improves contracting *ex post* but, once those efficiency gains are anticipated, renegotiation has also perverse effects on parties' *ex ante* incentives: Information may be incorporated in contract design only at a slow pace;[1] the threat of regulatory hold-up may impede specific investments and require costly governance and safeguards arrangements;[2] and finally optimal risk-sharing arrangements may be disrupted.[3] Overall, renegotiation imposes transaction costs on contracting and those costs prevent from achieving the informationally constrained efficient solution that could be reached under full commitment. Hence, measuring the welfare gains that could be achieved when the commitment abilities of parties is improved is an important empirical issue. Beyond, another question is also to understand how those welfare gains are distributed between principals and their agents.

The outcomes of the empirical investigation of these questions are crucial both for researchers to ascertain the relevance of a whole set of theoretical models on contract renegotiation, but also for practitioners to evaluate the real world contractual practices and institutional constraints in view of changing those practices. In this respect, the French urban transportation sector offers a particularly attractive field for study. Pushed by a concern towards improving *ex ante* competition among potential operators, a 1993 law on transportation imposes indeed that franchise contracts have to be re-auctioned and "re-negotiated" every 5 years by public authorities in charge with the service. Since then, practitioners in the industry have repeatedly complained on the fact that this institutional

[1] See the seminal paper by Dewatripont (1989) and the literature on adverse-selection under imperfect commitment. Laffont and Martimort (2002, Chapter 9) provide some entries.

[2] See Williamson (1985).

[3] See Fudenberg and Tirole (1990).

constraint on contract duration is certainly too tight. In other words, their expectation that some welfare gains could be achieved by increasing the duration of the contract is at the source of an ongoing political debate and, needless to say, of some political activism by operators for relevant reasons as we confirm below.

The goal of this paper is twofold. First, we construct and estimate a structural principal/agent model of contract renegotiation in the French urban transport sector in an asymmetric information context where operators are privately informed on their innate costs. Second, we use those estimates to recover the welfare gains and their distribution if contracting under full commitment were feasible. These gains are significant although unevenly distributed: Operators would indeed be the winner if contract length was extended whereas taxpayers/consumers may lose.

Our model accounts for two important features of the industry under scrutiny. First, only two types of contracts are used in practice by local public authorities (principals) to regulate the service: Cost-plus and fixed-price contracts. It is well-known from the works of Laffont and Tirole (1993, Chapter 1), Rogerson (1987), Melumad, Mookherjee and Reichelstein (1992) and Mookherjee and Reichelstein (2001) that such menus of linear contracts have strong incentive properties under asymmetric information. Menus facilitate self-selection of operators according to their private information on innate costs. In addition, linear contracts have also nice robustness properties under cost uncertainty.[4] More importantly, from an implementation viewpoint, menus well approximate, or sometimes, are even able to achieve what more complex nonlinear contracts would do.[5] In an important paper, Rogerson (2003) argues that, in most real world procurement contexts, the simple two-item menu often applied in reality (cost-plus/fixed-price) may suffice to achieve much of the gains from trade, even under asymmetric information.[6]

A second important feature of the urban transportation sector adressed by our model is

[4]See for instance Laffont and Tirole (1993, Chapter 1, p.109) and Caillaud, Guesnerie and Rey (1992).

[5]Laffont and Tirole (1993, Chapter 1) showed that the optimal nonlinear cost reimbursement rules can be implemented with a menu of linear contracts when it is convex. Convex functions in turn can be readily approximated with a discrete number of their tangencies when they are convex enough as it has been pointed out by Wilson (1993) and McAfee (2002).

[6]More specifically, Rogerson (2003) supposes that the firm's innate cost which is its private information is uniformly distributed and shows that this simple menu can secure three fourth of the surplus that an optimal contract would achieve. Chu and Sappington (2007) challenges this result beyond the case of a uniform distribution. On a related note, Bower (1993), Gasmi, Laffont and Sharkey (1999), Schmalensee (1989), Reichelstein (1992), investigate the performances of a single linear contract and conclude also on the good performances achieved with such rough contract design.

that subsidies (or "compensations" as they are called by practitioners) paid to operators (agents) increase over time no matter what are the characteristics of the service. As shown by our theoretical model, the rationale for these increasing subsidies lies in the limited ability of local authorities to commit as time goes on and the cost structure of the operator gets better known. This argument is already familiar from the agency literature on limited commitment (Dewatripont (1989), Laffont and Tirole (1993, Chapter 10), and Laffont and Martimort (2002, Chapter 9) among others). We revisit it below in an institutional context where only two-item menus are allowed and there is a continuum of possible realizations of the firm's innate costs.[7] In this regard, our theoretical model imports much of the tractability of Rogerson's model into a framework where contracts can evolve over time.[8] Doing so, we add more structure to the theoretical model and make it quite consistent with our data set. Note that considering a continuum of types is a prerequisite to evaluate a meaningful distribution of cost parameters. It allows us to provide a neat characterization of the probabilities of various contractual regimes (cost-plus, fixed-prices, changes over time between those two options) which is an important preliminary step of our estimation procedure based on a maximum likelihood criterion.

Turning more specifically to the empirical part of our study, our first goal is to consider the two scenarii of full and limited commitment with renegotiation, and estimate the parameters of the model under each hypothesis. To understand the estimation bias that arises when wrongly assuming full commitment, it is useful to come back on the basic intuition behing the trade-off between *ex post* efficiency and *ex ante* incentives that appears under renegotiation. Roughly speaking, since renegotiation raises subsidies in later periods of contracting, even less efficient operators may choose fixed-price contracts at the renegotiation stage. The process increases informational rents for the most efficient operators, which makes them less eager to reveal their types earlier, even though this also yields efficiency gains. Renegotiation is found more attractive *ex post* as the operator's rent is less socially costly or the social value of managerial effort is greater. Neglecting the possibility of renegotiation amounts to underestimate the efficiency of operators so that information rents "count less." From the estimation of the distribution of the effi-

[7] Note that the above quoted literature has developed theoretical models that only allowed for discrete types and fully optimal contracts.

[8] Indeed, Rogerson's analysis is static and cannot account for the rich dynamic patterns observed in our data set, noticeably the steady increase in subsidies that takes place over time irrespectively of the political preferences of local governments and other considerations. We thus extend his framework to account for these dynamical elements.

ciency parameter for the set of transportation operators of our database either under full commitment or renegotiation, we find indeed that operators are slightly more efficient in the latter scenario but provide on the other hand less effort than under full commitment.

In the course of the empirical analysis, we also obtain estimates of various parameters of the model, in particular, the weight of the operator's profit in the public authority's objective function. We show how such a weight depends on the political color of the local government and in particular, we stress that right-wing principals are more prone to give up information rent to operators.

Finally, using our estimates of the operator's innate cost distributions and other parameters of the model, we evaluate the welfare gains obtained when moving to the full commitment solution. Although the intertemporal subsidies under full commitment are higher than under renegotiation, highlighting thereby that taxpayers are the net losers from a hypothetical increase in the duration of contracts, the overall welfare gains are significant. Taxpayers see an increase in tax burden of 3.8 per cent whereas operators see their expected rent increase by roughly 12.2 per cent. This result clearly explains the operators' political activism in pushing for reforms increasing the duration of contracts.

Our model shares many ingredients with the recent empirical literature on contracts and regulation. First, as already explained, we contribute to the ongoing empirical debate on whether complex menus of contracts are actually implemented in practice, or, on the contrary, regulators use menus with a reduced number of items. In a pioneering paper, Wolak (1994) estimates the production function of a regulated Californian water utility, and argues that incentive mechanisms *à la* Baron and Myerson (1982) are used and achieve a second-best welfare level. Assuming instead cost observability as in Laffont and Tirole (1993), Gasmi, Laffont and Sharkey (1997), Brocas, Chan and Perrigne (2006) and Perrigne and Vuong (2007) also consider complex regulatory schemes to estimate costs and demand parameters of structural regulatory models. However, other empirical studies explicitly argue that actual regulatory authorities do not use such complex mechanisms. Bajari and Tadelis (2001) focus on the private construction industry in the U.S. and argue that the vast majority of observed contracts are variants of cost-plus and fixed-price regimes. The reason for such a simple binary choice is that public authorities look for an appropriate trade-off between providing *ex ante* incentives with fixed-price contracts and avoiding *ex post* transaction costs due to costly renegotiation with cost-plus arrangements. Chiappori and Salanié (2000), considering contracts in the automobile insurance industry, restrict the analysis to simple menus with two types of coverage. Gagnepain and Ivaldi (2002) take also a regime with two kinds of contracts as given and focus on the incentive effects of contracts on operators' costs. They measure actual welfare related to real regulatory practices, and compared this measure to what could be achieved if more complex second-best mechanisms were implemented. The present paper improves significantly upon Gagnepain and Ivaldi (2002) by explicitly modeling contract design by public authorities as well as the choice of contract by transport operators.

A second feature of our empirical model is related to the dynamic nature of the contractual relationship between the principal and the agent. Dionne and Doherty (1994) focus on the car insurance industry in California and suggest that insurers may use commitment to long-term contracts as a device to enhance efficiency and attract portfolios of dominantly low-risk drivers. We illustrate here how commitment to long-term contracts may benefit both to public authorities and transport operators.

Finally, our analysis assumes that local public authorities may be tempted to favor private interests when designing contracts. The political color of the local government may influence the distribution of the welfare gains of transportation services among the different actors involved in their provision. Empirical tests on capture and ideology in politics are given in Kalt and Zupan (1984, 1990) for instance. Those papers provide evidence on the fact that policymakers' ideology may have a significant impact on regulatory outcome, in a way that is similar to what happens in the French transportation sector.

Section 2 presents an overview of the French urban transportation industry. Section 3 presents our theoretical model and solves for the optimal menu of contracts (fixed-prices or cost-plus) both under full commitment and when renegotiation-proof schemes are considered. We derive in particular the important property that subsidies have to be increasing over time under a renegotiation-proof scenario. Section 4 develops our empirical method. Section 5 evaluates the magnitude of welfare gains when moving to full commitment but also the distribution of those gains between operators and taxpayers. Section 6 concludes by highlighting a few alleys for further research. Proofs of the theoretical model are developed in an Appendix.

2 The French Urban Transportation Industry

As in most countries around the world, urban transportation in France is a regulated activity. Local transportation networks cover each urban area of significant size. For each network, a local authority (a city, a group of cities or a district) contracts with a single operator to provide the service. Regulatory rules prevent the presence of several suppliers of transportation services on the same urban network. A distinguishing feature of France compared to most other OECD countries is that about eighty percent of local operators are private and are owned by three large companies, two of them being private while the third one is semi-public.[9, 10]

2.1 Economic environment

The 1982 law on the organization of transport in France was enacted to facilitate decentralized decision-making on urban transportation and to provide a guide for regulation. As a result, each local authority organizes now its own transportation system by setting the route structure, the capacity level, the quality of service, the fare structure, the conditions for subsidizing the service, the level of investment and the nature of ownership. It may operate the network directly or it may concede service to an operator. In this case, a formal contract defines the regulatory rules that the operator must follow as well as the payment and cost-reimbursement rules between the public authority and the operator.

In principle, since the 1993 law, beauty contests are required to allocate the building and management of new infrastructures for urban transportation and the renewal of contracts comes to an end. In practice, however, very few networks change operators from one regulatory period to the other. Documentary investigation sheds light on the fact that awarding transport operations through tenders does not necessarily guarantee ex ante competition since local transport authorities usually receive an offer from one single candidate, namely the operator already in place. Several reasons potentially explain this phenomenon: First, the local authorities are either reluctant to really implement the law

[9] For an overview of the regulation of urban transit systems in the different countries of the European Union, in the United States and Japan, see IDEI (1999).

[10] These companies, with their respective type of ownership and market share (in terms of number of networks operated) are in 2002: KEOLIS (private, 30%), TRANSDEV (semi-public, 19%), CONNEX (private, 25%). In addition there are a small private group, AGIR, and a few public firms under local government control.

or do not have enough expertise to launch complex calls for tenders. Second, the three groups owning most of the urban transport operators in France are usually committed to specific geographical areas, which restricts competition in awarding transport operations in urban areas where regulatory contracts come to an end. These groups also operate other municipal services such as water distribution or garbage collection, which makes it even harder for the regulator to credibly punish the operator in case of bad performance.

In most urban areas, operating costs are twice as high as commercial revenues on average. Budgets are rarely balanced without subsidies. One reason is that operators face universal service obligations and may have to operate in low demand areas. Prices are maintained at a low level in order to ensure affordable access to all consumers of public transportation. Moreover, special fares are provided to targeted groups like pensioners and students. The subsidies come from the State's budget, the local authority's budget, and a special tax paid by any local firm (employing more than nine full-time workers). In addition to the price distortions causing deficits, informational asymmetries that affect the cost side make it more difficult to resume these deficits. This is discussed in more details in the sequel.

Performing a welfare analysis of regulatory schemes in a one authority/one operator setting requires a database that encompasses both the performance and the organization of the French urban transport industry. The basic idea is to consider each system in an urban area during a time period as a realization of a regulatory contract. Such a database has been created in the early 1980s. It results from an annual survey conducted by the *Centre d'Etude et de Recherche du Transport Urbain* (CERTU, Lyon) with the support of the *Groupement des Autorités Responsables du Transport* (GART, Paris), a nationwide trade organization that gathers most of the local authorities in charge of a urban transport network. This rich source is probably unique in France as a tool of comparing regulatory systems both across space and over time. For our study, we have selected all urban areas of more than 100,000 inhabitants for homogeneity purposes. Indeed, smaller cities may entail service and network characteristics that differ significantly from the ones of bigger urban areas. Discarding them allows us to identify in a more satisfactory manner differences in inefficiencies and cost reducing activities across operators. Note that the sample does not include the largest networks of France, i.e., Paris, Lyon and Marseille, as they are not covered by the survey. The result is that the panel data set covers 49 different urban transport networks over the period 1987-2001.[11]

We assume that the network operator has both private information about its innate technology and that its cost-reducing effort is unobserved by the public authority. Because French local authorities exercise their new powers on transportation policy since the 1982 law only, and since they usually face serious financial difficulties, their limited auditing capacities is recognized among practitioners. A powerful and well-performed audit system needs effort, time and money. French experts on urban transportation blame local authorities for being too lax in assessing operating costs, mainly because of a lack of knowledge of the technology. The number of buses required for a specific network, the costs incurred on each route, the fuel consumption of buses (which is highly dependent on drivers' skills), the drivers' behavior toward customers, the effect of traffic congestion on costs, are all issues for which operators have much more data and a better understanding than public authorities. This suggests the presence of adverse selection on innate technology in the first place. Given the technical complexity of these issues, it should be even harder for the local authority to assess whether and to what extent operators undertake efforts to provide appropriate and efficient solutions. Moral hazard issues arise on top of the adverse selection problem. When compounded, those informational asymmetries play a crucial role in the design of contractual arrangements and financial objectives.

Before turning to the description of the contracts, two additional remarks are worth being stressed: First, private information about demand is not a relevant issue in our industry. Local governments are well-informed about the transportation needs of citizens. The number of trips performed over a certain period are easily observed, and the regulator has a very precise idea of how the socio-demographic characteristics of a urban area fluctuate over time. Given the level of transportation demand, the regulator sets the service capacity provided by the operator. Second, we do not address the issue of determining what should be the good rate-of-return on capital. The rolling stock is owned by the local government in a majority of networks. In this case, the regulator is responsible for renewing the vehicles, as well as guaranteeing a certain level of capital quality.

[11] Note that we focus only on transport networks where the operator is a different entity than the regulator. This rules out the so-called *Regies* where the service is provided by the regulator himself (this is mostly the case in large cities such as Paris, Lyon and Marseille).

2.2 Regulatory contracts

Table 1 sheds light on several features of the regulatory contracts, which are worth emphasizing. As already mentioned, two types of regulatory contracts are implemented in the French urban transport industry, namely cost-plus and fixed-price schemes. Over our period of observation, fixed-price contracts are employed in 55.5% of the cases. Under fixed-price contracts, operators receive subsidies to finance the expected operating deficits; under cost-plus regulation, subsidies are paid to local authorities to finance ex-post deficits. Hence, fixed-price regimes are very high powered incentive schemes, while cost-plus regimes do not provide any incentives for cost reduction.

An important characteristic of the industry is related to the evolution of subsidies over time. The volume of service supplied rises over our period of observation. Operating costs are expected to increase proportionally (or less than proportionally if economies of scale are found to be significant). Once having corrected for the increase of input prices over time, it appears that the average subsidies (per unit of supply, i.e., per seat-kilometer) paid to the operators increase in a significant share of networks. Figure 1 illustrates this pattern for a sample of 10 urban areas.

On average, contracts are signed for a period of 5 to 6 years, which allows us to observe in most cases several regulatory arrangements for the same network. Overall, we observe 136 different contracts. We observe the contract from its starting point for 94 cases. In the same network, the regulatory scheme may switch from cost-plus to fixed-price or from fixed-price to cost-plus between two regulatory periods. We thus observe 20 changes of regulatory regimes, most of them (i.e., 17) being switches from cost-plus to fixed-price regimes. These changes occur because the same local governments may be willing to change regulatory rules, or because a new government is elected and changes the established rules. Note however that the arrival of a new government does not imply an early renegotiation of the contract before its term. New governments are committed to the contracts signed by the former authority. We detect 22 changes of local governments in our database.

Finally, as already suggested, very few changes of operators are observed over our period of observation: Only 2 new operators proposed services between 1987 and 2001.

3 Theoretical Model

Our theoretical model takes into account the various features of the French urban transport industry discussed so far and adapts the lessons of the contracting literature under imperfect commitment to fit with those empirical features. First, in our regulatory framework, service providers have the choice within menus of only two types of contracts, either fixed-price or cost-plus. Second, contracts may evolve over time with a path of increasing subsidies. We will argue below that such patterns arise naturally when subsidies are "renegotiation-proof." This positive model is then compared to an hypothetical setting where regulators could commit and optimal subsidies remain constant over time.

Consider a local authority (sometimes referred to as the "principal" in the sequel), whose preferences are defined as:[12]

$$W = S - (1+\lambda)t(C) + \alpha U \qquad \text{where } \alpha < 1+\lambda \text{ and } \lambda > 0.$$

The gross surplus generated by the service S is supposed to be fixed.[13] The payment offered by the local government to the firm (sometimes referred to as the "agent" in the sequel) depends on the kind of contractual arrangement in place, i.e, whether fixed-price or cost-plus contracts are used. For a fixed-price contract, the principal offers a fixed payment $t(C) \equiv b$ for any realized cost C. When a cost-plus contract is in place, the principal reimburses the cost C incurred by the firm, $t(C) \equiv C$ for all C. Raising subsidies from the local government's general budget entails some distortions. This is captured by introducing a cost of public funds $\lambda > 0$.[14]

Local governments differ in terms of the weights they give to the operator's profit U in their objective functions. To have a meaningful trade-off between the dual objectives of extracting the contractor's information rent and inducing efficient cost-reducing effort, we assume that $\alpha < 1+\lambda$ so that, overall, one extra euro left to the firm is socially costly. Various motivations can be found for such modeling of the preferences of local governments. For instance, the parameter α might capture the firm's bargaining power

[12] This objective function generalizes those used respectively in Baron and Myerson (1982) and Laffont and Tirole (1993).

[13] Implicitly, we consider a setting where the elasticity of demand is very small which seems a reasonable assumption in the case of transportation. See Oum et al. (1992).

[14] The reasonable estimate for developed countries is $\lambda = 0.3$ (see Ballard, Shoven, and Whalley, 1985, and Hausman and Poterba, 1987). Gagnepain and Ivaldi (2002) used such estimate in their study of the French transportation sector.

at the time of awarding franchises and reflect *ex ante* competition on these markets.[15, 16]

In view of our empirical study, we have to distinguish local governments according to their political inclination, which corresponds to different weights left to the private operator in their objective functions. We assume that $\alpha = \bar{\alpha}$ (resp. $\alpha = \underline{\alpha} < \bar{\alpha}$) for a rightist (resp. leftist) local government since it is certainly eager to defend (resp. to fight) the private firm's owners.[17]

Turning now to the cost structure, we follow Laffont and Tirole (1993, Chapter 1) and Rogerson (2003) in considering that the observable cost of one unit of the service C blends together an adverse selection component θ related to the innate efficiency of the service and a managerial effort e targeted at reducing this cost. We postulate the following functional form:

$$C = \theta - e.$$

Effort is costly to provide for the firm's management and the corresponding non-monetary disutility function $\psi(e)$ is increasing and convex ($\psi' > 0$, $\psi'' > 0$) with $\psi(0) = 0$. The intrinsic efficiency parameter θ is drawn once for all before contracting from the interval $[\underline{\theta}, \bar{\theta}]$ according to the common knowledge cumulative distribution $F(\cdot)$ which has an everywhere positive and atomless density $f(\cdot)$. Following the screening literature, we assume that the monotone hazard rate property holds, $\frac{d}{d\theta}(R(\theta)) > 0$ where $R(\theta) = \frac{F(\theta)}{f(\theta)}$ so that all optimization problems considered below are quasi-concave.[18]

With those notations in hand, we may as well write the firm's profit as:

$$U = t(C) - C - \psi(e)$$

where $t(C)$ is the payment received from the regulator.

[15] *Ex ante* competition in this sector with different operators avoiding head-to-head competition and running for markets in different urban areas may not be so fierce. The decision n^0 05-D-38 of the French *Conseil de la Concurrence* shows that competition authorities are well-aware of the important risk of downstream collusion between potential operators. In more than 60 % of cases, there is only a single bidder in such competition. This potential horizontal collusion is modeled in ad hoc way in our framework through an increase in the parameter α which may also be viewed as an index of the operator's bargaining power. The benefit of such ad hoc specification of the potential downstream competition is to fit real-world practices while it fortunately eases the analysis of the contractual dynamics.

[16] Following Baron (1989), Laffont (1996) and Faure-Grimaud and Martimort (2003) , these preferences might also result from the fight of various political forces within the local authority.

[17] Laffont (1996) presents related political economy models of regulation relying on such arguments.

[18] It is worth noticing for the sake of our empirical analysis that the same operator could have different realizations of the innate cost parameter on two different markets. This assumption captures the fact that costs of a particular network are idiosyncratic to a large extent. In the same vein, we also assume that all operators, whatever their identity, see that their cost parameters are drawn from the same cumulative distribution $F(\cdot)$.

3.1 Full Commitment

In this section, we assume that the local government offers to the contractor a long-term contract which covers two contracting periods and has all bargaining power at the contracting stage when doing so. The principal can commit himself to any pattern of subsidies and cost reimbursement rules over time. Of course, this ability to commit allows to reach the highest possible intertemporal welfare. This gives us an attractive benchmark against which to assess the alternative model under limited commitment and renegotiation. This benchmark is also useful when we move to our empirical analysis and evaluate the costs of renegotiation.

Let δ be the discount factor and let us normalize the length of the first-period accounting period with the weight $\beta = \frac{1}{1+\delta}$.

Consider first the case of a long-term fixed-price contract. Such a contract entails subsidies (b_1, b_2) over both periods. With a fixed-price contract, the principal is able to pass onto the firm's management all incentives to save on costs. Let e^* be the corresponding first-best effort such that $\psi'(e^*) = 1$, and denote by $k = e^* - \psi(e^*)$ its social value.[19] Such a long-term contract yields to the firm the (normalized) intertemporal payoff

$$\beta b_1 + (1-\beta) b_2 - \theta + k.$$

Instead, with a long term cost-plus contract, the firm's manager exerts no effort and the firm's payoff is zero.

It is straightforward to check that only the most efficient operators such that $\theta \leq \theta^*$ choose fixed-price contracts. The corresponding cut-off θ^*, corresponds to an operator being just indifferent between the cost-plus and the fixed-price contracts:

$$\theta^* = \beta b_1 + (1-\beta) b_2 + k.$$

Taking into account that the space of types is split between those taking the fixed-price and those taking the cost-plus long-term contracts, the principal's intertemporal expected welfare under full commitment can be expressed as:

$$W^F(b_1, b_2) = S-(1+\lambda)\left((\beta b_1 + (1-\beta) b_2)\, F(\beta b_1 + (1-\beta) b_2 + k) + \int_{\beta b_1 + (1-\beta) b_2 + k}^{\bar{\theta}} \theta f(\theta) d\theta \right)$$

[19] This parameter is by construction related to the firm's internal organization and incentive structure. Any agency costs coming from the separation of ownership and control between the firm's management and shareholders is encapsulated into the $\psi(\cdot)$ function.

$$+\alpha \int_{\underline{\theta}}^{\beta b_1+(1-\beta)b_2+k} (\beta b_1 + (1-\beta)b_2 + k - \theta) f(\theta) d\theta.$$

The term $(\beta b_1 + (1-\beta)b_2)F(\beta b_1 + (1-\beta)b_2 + k)$ represents the expected subsidy paid out under a long-term fixed-price contract. The term $\int_{\beta b_1+(1-\beta)b_2+k}^{\bar{\theta}} \theta f(\theta)d\theta$ represents instead the expected payment under a cost-plus contract. Finally, the last term represents the expected rent left to the most efficient firms under the fixed-price contract. On the contrary, the least efficient firms under a cost-plus earn no such rent.

Optimization of the above objective function yields the values of the optimal subsidies under full commitment.

Proposition 1 *Under full commitment, the optimal fixed-price contract is the twice-repeated version of the static optimal fixed-price contract. It entails a subsidy b^F which is constant over time $b_1^F = b_2^F = b^F$ and satisfies:*

$$k = \left(1 - \frac{\alpha}{1+\lambda}\right) R(b^F + k). \tag{1}$$

Only the most efficient firms with types $\theta \leq \theta^F = b^F + k$ take this long-term fixed-price contract. Only the least efficient firms with types $\theta \geq \theta^F = b^F + k$ take a long-term cost-plus contract.

The result that, under full commitment, the optimal contract is the twice replica of the optimal static contract is by now standard in the dynamic contracting literature.[20] In particular, given that the economic environment is stationary, there is no chance of moving from a cost-plus to a fixed-price contract over time which explains our initial focus on the dichotomic choice between either a long-term fixed-price and a long-term cost-plus contract. This simplified presentation without affecting the results. Patterns with cost-plus contracts followed by fixed-prices are certainly suboptimal under full commitment.[21]

The optimal menu of contracts trades off efficiency and rent extraction. Offering a fixed-price with a sufficiently large subsidy to all types would indeed ensure that the operator exerts the first-best effort whatever its innate technology. However, doing so

[20] See Baron and Besanko (1984) and Laffont and Martimort (2002, Chapter 8) for similar results in more general environments.

[21] Note that the principal could commit to only offer a fixed-price contract in a single period and obtain thereby the respective payoffs $\beta(b_1 - \theta + k)$ or $(1-\beta)(b_2 - \theta + k)$. Those "mixed" strategies are strictly dominated by the constant subsidy strategy found above.

also provides too much information rent to the operator and this is socially costly. Offering instead a cost-plus contract to all types nullifies this rent while it also destroys any incentives to exert effort.

The intuition behind condition (1) can be cast as follows. Suppose that the principal offers a fixed subsidy b in both period. By raising this subsidy by db, the principal makes it sure that with probability $f(b+k)db$, the firm with type in the interval $[b+k, b+k+db]$ will now incur effort e^* which generates a social gain k. This yields an expected social benefit $(1+\lambda)kf(b+k)db$. On the other hand, raising the subsidy entails a budgetary cost worth $(1+\lambda)F(b+k)db$ since even firms with infra-marginal types will enjoy such an increase. This also raises the social value of the rent left to the most efficient firms by a quantity $\alpha F(b+k)db$. Finally, an optimal subsidy b^F trades off the expected efficiency gains with the net cost of increasing the firm's rent and b^F must solve:

$$(1+\lambda)kf(b^F+k)db + \alpha F(b^F+k)db = (1+\lambda)F(b^F+k)db.$$

Simplifying yields (1).

It is straightforward to check that increasing k or α increases the optimal subsidy b^F. Intuitively, when the firm's effort is more socially valuable or when its rent is found more valuable by the public authority, the optimal subsidy under a fixed-price contract should be raised to induce higher powered incentives and command more rent.

Remark 1 *An interesting question is to investigate the welfare loss that the principal incurs by offering just a menu with only two items in a full commitment environment. This question is particular important for practitioners. Using our estimates of the full commitment solutions, we address that question in a companion paper (Gagnepain, Ivaldi and Martimort, 2009).*

3.2 Renegotiation

Overview and modeling choices: The full commitment assumption used in Section 3.1 turns out to be excessive in view of real world practices as casual observations suggest and as explained above. Although the 1993 law invites local authorities to re-auction the concession for a fixed period of 5 years, they are either reluctant to really implement the law or do not have enough expertise to launch complex calls for tenders. This leads to think that, in practice, local authorities consider the requirement of re-auctioning the contract at fixed dates as the opportunity to renegotiate it with the same operator (the so-called historical operator) at these dates instead of really envisioning the possibility to contract with a new operator.

Theoretical studies to date have distinguished between two kinds of paradigms when it comes to model intertemporal contracting under limited commitment. The first concept is that of long-term contracting with contracts which can be renegotiated if parties find it attractive to do so.[22] The second one considers short-term contracting where parties cannot write any binding agreement for future rounds of contracting and only spot contracts for the current period can be enforced.[23] Although contracts in the French transportation sector have a limited duration, the second of these paradigms does not capture the kind of relational contracting that characterizes a long-lived relationship between a local authority and its "historical" operator. The first of these paradigms better fits evidence, although it must be adapted to take into account that, even though a long-term contract cannot be signed in practice, the promise of having a future round of contracting between the public authority and the incumbent is sufficiently credible. In other words, although no long-term contracts really bind parties together, everything happens as if those parties can credibly commit to promises for further rounds of contracting. The renegotiation paradigm can then be replaced by a "re-negotiation" view of contracting that, although technically similar, captures somewhat different real-world practices.

As soon as the local authority suffers from imperfect information on the operator's type, the selection of a contract within the simple two-item menu at the early contracting stage reveals some information on the firm's type. The choice of a fixed-price contract is interpreted by the principal as being "good news" since it signals that the firm's type is below some cut-off. Instead, the choice of cost-plus contracts bring rather "bad news."In a dynamic environment, contractual relationships cover several periods, and information revealed by past choices is incorporated into newly drafted agreements. In particular, an increase over time in the subsidies that fixed-price contracts offer allows operators that have revealed themselves as not being very efficient earlier on to achieve productivity gains later. Such increases in subsidies might thus be viewed as *ex post* attractive. However, the major lesson of the renegotiation literature is that these *ex post* gains also come with ex

[22]Dewatripont (1989), Laffont and Tirole (1993, Chapter 10), Hart and Tirole (1990) and Rey and Salanié (1990) in adverse selection contexts.

[23]Guesnerie, Freixas and Tirole (1985) and Laffont and Tirole (1993, Chapter 9) among others.

ante costs in delaying information revelation. Some of the most efficient firms may prefer adopting cost-plus contracts earlier on to enjoy the greater subsidies that future fixed-price contracts will bring later on. This important trade-off and its impact on information revelation are at the core of our model.

Timing: To describe more carefully the dynamics of the relationship between the principal and his contractor, let us make more explicit the timing of the overall game of contracting that we consider below:

- Date 0: The firm learns its efficiency parameter θ.
- Date 0.25: The principal commits to a menu of subsidies (b_1, b_2) that would be given under fixed-price contracts. Otherwise, cost-plus contracts are used in each period.
- Date 0.50: The firm chooses whether to accept this profile of subsidies or not. The principal updates his beliefs on the firm's innate cost following that choice.
- Date 1.00: First-period costs are realized and payments are made accordingly.
- Date 1.25: The principal makes a renegotiated offer corresponding to a new subsidy $\tilde{b}_2$ under a fixed-price contract if he wishes so.
- Date 1.50: The firm chooses whether to accept this renegotiated offer or not and chooses his second-period effort accordingly. If the offer is refused, the old contract be it fixed-price or cost-plus is enforced.
- Date 2: Second-period costs are realized and payments are made.

Equilibrium notion: An *almost* perfect Bayesian equilibrium (in short equilibrium) of the contractual game consists of the following strategies and beliefs:

• **Principal's strategy:** The principal offers the profile of subsidies under fixed-price contracts (b_1, b_2) at date 1, and a renegotiated offer $\tilde{b}_2$ which might supersede b_2 at date 2. This second-period offer is made at a point where the principal has updated his beliefs over the firm's type parameter following its first-period decision to accept or not the subsidies profile (b_1, b_2).

• **Agent's strategy:** The firm follows a cut-off strategy and accepts to work on a profile of subsidies (b_1, b_2) if and only if it is sufficiently efficient, i.e., $\theta \in \Theta_1 = [\underline{\theta}, \theta_1^*]$. A firm with an intermediary type in the interval $\Theta_2 = [\theta_1^*, \theta_2^*]$ (where $\theta_2^* \geq \theta_1^*$) refuses this profile in the first period but accepts to work on a fixed-price contract for the second period if the subsidy is renegotiated towards a level $\tilde{b}_2$ which is large enough. Such a firm moves thus from a cost-plus to a fixed-price contract over time. Finally, a firm being sufficiently inefficient, i.e., $\theta \geq \theta_2^*$, sticks on cost-plus contracts in both periods.

Remark 2 ***"Almost" equilibrium and limited updating:*** *It is important to stress that the principal takes into account only the updated beliefs that he has at date 0.50 when making a renegotiated offer. This is a slight departure of full rationality to the extent that the principal should have updated beliefs with the more precise information obtained by observing first-period costs under a cost-plus contract. This departure of full rationality justifies the use of the qualifier almost for our notion of equilibrium. Suppose instead that the principal was fully rational and would update beliefs for all realizations of that first-period cost. Inefficient firms under a first-period cost-plus contract would certainly not reveal their type in the first-period and, anticipating future renegotiation of the contract, might claim having a first-period cost worth* $C_1 = \bar{\theta}$. *This strategy certainly increases information rent for the first period. It has also a benefit for the second period by hiding valuable information away from a fully rational principal. If the real-world practices were in lines with such strategy, one would observe point masses of observations for cost-plus contracts. This certainly contradicts our data set where no such point masses in realized costs under cost-plus contracts are found.*

If an inefficient firm was to adopt a more naive first-period behavior, the fully rational principal would just learn its type $C_1 = \theta$ *by observing the realized first-period cost in the cost-plus contract. Then, for the second period, that principal would recommend that operator to work at cost* $C_2^* = \theta - e^*$ *and would compensate the firm for incurring that effort. This is clearly a naive strategy because hiding information in the first period makes it more likely that a renegotiated offer will have an increased subsidy that can provide second period rent to that inefficient operator.*

Our modeling strategy of having only an "almost" rational principal doing only some partial updating avoids those dilemmas. It keeps all the flavor of the dynamic rent-efficiency trade-off familiar from the theoretical literature on renegotiation without making the analysis "untractable." It also satisfies our desire of making the theoretical model as close as possible to the existing data set and this certainly requires some concessions on *the theory side.*

In the sequel, we will focus on profiles of subsidies that come unchanged through the renegotiation process. We thus mimic the earlier theoretical literature on renegotiation and adopt the following definition of a renegotiation-proof long-term contract.

Definition 1 *A profile (b_1, b_2) of subsidies is renegotiation-proof if offering $\tilde{b}_2 = b_2$ is found optimal by the principal at date 1.25.*

The theoretical literature on renegotiation has shown that focusing on renegotiation-proof mechanisms is without loss of generality.[24] The intuition is as follows. Any long-term contract which is renegotiated in the second period of the relationship could be replaced by a long-term contract with a second-period contract equal to this renegotiated offer. This renegotiated offer is not itself superseded by any new offer for the second period because, if it was so, this would contradict the optimality of the renegotiated offer in the first place. Our focus on renegotiation-proof profiles follows the same logic and is without loss of generality. For any given second-period subsidy b_2, there exists an optimal second period subsidy $\tilde{b}_2 \geq b_2$ which maximizes the principal's expected payoff for the second period conditionally on what he has learned from seeing or not the first-period acceptance of the profile (b_1, b_2), i.e., that the firm's innate cost is below some threshold θ_1^*. Of course, this threshold is itself determined by the perspective of having a renegotiated offer $\tilde{b}_2$ in the second period. By the very principle of optimality, if this optimal subsidy had already been offered in the continuation of the long-term contract for the second period, there would be no scope for improving the principal's payoff at that point.

Remark 3 *The whole theoretical literature on renegotiation focuses on cases where private information is modeled as a discrete type. Working in a model with a continuum of types as we do here is important for two reasons. First, it helps clarify the pattern of information revelation, i.e., how less efficient types end up adopting fixed-price contracts and how the corresponding subsidies increase over time. Second, it is made necessary to take*

[24] See Hart and Tirole (1988), Dewatripont (1989), and Laffont and Tirole (1993, Chapter 10). In a model with a discrete number of types for the privately informed agent, Bester and Strausz (2001, 2007) show more generally that there is no loss of generality in looking for the optimal contract in the set of mechanisms having as much options as the set of possible types. A weak version of the Revelation Principle applies but one has to be cautious and take into account that information is gradually revealed over time so that mixed strategies in information revelation prevail.

into account the significant heterogeneity in the firm's cost. A model with a continuum of types provides a nice division of the space of types into three intervals whose respective theoretical probabilities (obtained from the behavior of types at the limits delineating these intervals) can be matched with the empirical distribution of behaviors observed on our data. Models with discrete types could allow a more detailed analysis of the pattern of information revelation[25] *and are thus attractive from a theoretical viewpoint. However, such models would also certainly be less amenable to empirical analysis. As we argued above, mass points in the distribution of realized costs do not seem to fit in any way the smoothness of the existing data.*

Renegotiation-proof profiles: To be accepted, a renegotiated offer $\tilde{b}_2$ has to increase the firm's information rent with respect to what it gets with the initial contract. Otherwise a firm that already chose the profile of fixed-price contracts in the first period would still have the option of keeping the precommitted subsidy b_2. Any renegotiated offer $\tilde{b}_2$ must therefore raise subsidies:

$$\tilde{b}_2 \geq b_2. \tag{2}$$

Solving the game backwards, we first consider how the principal updates his beliefs and makes a new offer at the renegotiation stage given the first-period cut-off strategy followed by the firm. Two cases should be distinguished depending on whether the firm has already accepted to work on a profile of fixed-price contracts ($\theta \leq \theta_1^*$) or not ($\theta \geq \theta_1^*$).

Case 1: Renegotiation following "good news", i.e., $\theta \in \Theta_1 = [\underline{\theta}, \theta_1^*]$**.** Following the first-period acceptance of the profile (b_1, b_2), the principal is led to think that the firm is rather efficient. Updated beliefs are easily obtained from Bayes' rule using the cut-off strategy of the agent. The revised density is $\frac{f(\theta)}{F(\theta_1^*)}$ for $\theta \in \Theta_1 = [\underline{\theta}, \theta_1^*]$.

A renegotiated offer $\tilde{b}_2$ is accepted in the second period when $\theta \leq \theta_2^*$ where

$$\theta_2^* = \tilde{b}_2 + k. \tag{3}$$

The new renegotiated offer $\tilde{b}_2$ maximizes the principal's expected welfare for the second period where expectations are taken with those updated beliefs. We immediately find:

[25] By means of the branching processes along the lines of Hart and Tirole (1988) for instance.

Lemma 1 *Assume that all types* $\theta \in \Theta_1 = [\underline{\theta}, \theta_1^*]$ *accept the profile* (b_1, b_2)*. A second-period offer* b_2 *is part of renegotiation-proof profile* (b_1, b_2) *following acceptance of that profile when:*

$$b_2 \geq b^F. \tag{4}$$

Intuitively, a second-period subsidy can only be renegotiation-proof when it is greater than under full commitment. Such subsidies are so large than marginally increasing them is more costly in terms of added information rent for all inframarginal firms than the efficiency gains that one could withdraw from such an increase for the marginal type.

Case 2: Renegotiation following "bad news", i.e., $\theta \in \Theta_1^c = [\theta_1^*, \bar{\theta}]$**.** The first-period refusal of a profile of subsidies is interpreted by the principal as coming from the least efficient firms. The revised density function is now $\frac{f(\theta)}{1-F(\theta_1^*)}$ for $\theta \in \Theta_1^C$.

A renegotiated offer is again accepted by a firm with type θ when (2) holds and $\theta \geq \theta_2^*$ where

$$\theta_2^* = \tilde{b}_2 + k \geq \theta_1^*.$$

Lemma 2 *Assume that all types* $\theta \in \Theta_1 = [\underline{\theta}, \theta_1^*]$ *accept the profile* (b_1, b_2)*. A second-period offer* b_2 *is part of a renegotiation-proof profile following first-period refusal of that profile when:*

$$kf(b_2 + k) - \left(1 - \frac{\alpha}{1+\lambda}\right)(F(b_2 + k) - F(\theta_1^*)) \leq 0. \tag{5}$$

Condition (5) expresses the fact that raising the subsidy for those firms which have revealed themselves as being rather inefficient in the first period by refusing a profile of subsidies for both periods should not be an attractive strategy for the principal. This means that any efficiency gain obtained by increasing the subsidy b_2 by an amount db so that the marginal type indifferent between the cost-plus and the fixed-price moves up, namely $(1+\lambda)kf(b_2+k)db$, should be less than the net cost of raising the rent of all types that were not under a fixed-price contract before and now find that option attractive, i.e., $(1 + \lambda - \alpha)(F(b_2 + k) - F(\theta_1^*))\, db$.

Taken altogether, the constant subsidy profile $b_1 = b_2 = b^F$ and the cut-off rule $\theta_1^* = b^F + k$ found under full commitment never satisfy (5). The optimal long-term contract and the corresponding pattern of information revelation are not renegotiation-proof. Intuitively, upon learning that the firm is rather inefficient, i.e., after an initial refusal of subsidies, the principal has always some incentives to slightly raise the subsidy to make some efficiency gains. Clearly, a firm with a type close to (but below) $\theta_1^* = b^F + k$ has then an incentive to refuse the first-period subsidy because it gives little rent; it prefers a first-period cost-plus contract and waits for the increase in the second-period subsidy which comes out of the renegotiation.

Turning now to the firm's strategy, the cut-off type θ_1^* must be indifferent between either choosing the profile (b_1, b_2) at date 0.5 so that it reveals its type earlier on, and taking first a cost-plus contract and taking only the offer b_2 at date 1.5.:

$$\beta b_1 + (1-\beta)b_2 + k - \theta_1^* = (1-\beta)(b_2 + k - \theta_1^*)$$

or

$$\theta_1^* = b_1 + k. \tag{6}$$

Given that cut-off, we have the following pattern of information revelation:

- Types $\theta \in \Theta_1 = [\underline{\theta}, \theta_1^*]$ choose the profile (b_1, b_2).
- Types $\theta \in \Theta_2/\Theta_1 = [\theta_1^*, \theta_2^*]$ where $\theta_2^* = b_2 + k$ choose only the subsidy b_2 in the second-period. Those types move thus over time from a cost-plus to a fixed-price contract.
- Types $\theta \in [\theta_2^*, \bar{\theta}]$ choose cost-plus contracts for both periods.

Inserting (6) into (5) yields the more compact expression of the renegotiation-proofness constraint:

$$-kf(b_2 + k) + \left(1 - \frac{\alpha}{1+\lambda}\right)(F(b_2 + k) - F(b_1 + k)) \geq 0. \tag{7}$$

As a direct consequence of (7), we also immediately get

Proposition 2 *Any renegotiation-proof profile* (b_1, b_2) *entails subsidies which are strictly increasing over time:*

$$b_1 < b_2.$$

Optimal renegotiation-proof profiles: The optimal renegotiation-proof profile of subsidies maximizes the principal's intertemporal welfare subject to the renegotiation-proofness constraints (4) and (7).

It turns out that (4) is slack at the optimum, i.e, renegotiation following "good news" is not a concern. Intuitively, to avoid renegotiating a fixed-price contract that has been refused, the principal is forced to commit to a subsidy above the full commitment outcome. Such subsidy is not renegotiated either if the firm accepts it already in the first period.

Denoting by μ the non-negative multiplier of (7), assuming that the corresponding Lagrangean is concave, and optimizing yields the following characterization of the optimal renegotiation-proof contract.

Proposition 3 *The optimal renegotiation-proof profile* (b_1^R, b_2^R) *entails a pattern of strictly increasing subsidies such that:*

$$b_1^R < b_2^R \text{ with } b_1^R < b^F \tag{8}$$

where

$$k - \frac{\mu}{\beta(1+\lambda)}\left(1 - \frac{\alpha}{1+\lambda}\right) = \left(1 - \frac{\alpha}{1+\lambda}\right) R(b_1^R + k); \tag{9}$$

$$k + \frac{\mu}{(1-\beta)(1+\lambda)}\left(1 - \frac{\alpha}{1+\lambda}\right) - \frac{\mu k}{(1-\beta)(1+\lambda)} \frac{f'(b_2^R + k)}{f(b_2^R + k)} = \left(1 - \frac{\alpha}{1+\lambda}\right) R(b_2^R + k); \tag{10}$$

and

$$-kf(b_2^R + k) + \left(1 - \frac{\alpha}{1+\lambda}\right)(F(b_2^R + k) - F(b_1^R + k)) = 0. \tag{11}$$

4 Empirical Model

Section 4.1 presents our data and the different variables that enter the estimation procedure. This procedure is presented in Section 4.2. Results follow in Section 4.3.

4.1 Data

We discuss first the construction of the different variables which enter the estimation procedure. Second, we explain how we organize our dataset for the estimation. In particular, we define precisely what a contractual period is, and which networks are selected under each contractual scenario.

Construction of the variables: Table 1 presents statistics on the different variables available in our data set. To understand how contracts are designed by public authorities and how operators choose those contracts, we gather observations on subsidies and operating costs. Costs are not directly used as an estimation device but are useful when putting the estimated inefficiency of the operators into perspective and deriving the effort levels. Information on subsidies is required to recover the distribution of the efficiency parameter. Total costs include wages and charges related to fuel consumption. Subsidies entail all payments to the operator, either at the beginning of the production process which are needed to reimburse expected costs (in the case of fixed-price regimes), as well as payments to the operator at the end of the contracting period to guarantee full reimbursement of total operating costs (in the case of cost-plus regimes).

Recall that our theoretical model makes the accounting simplification that commercial revenues are kept by the public authority and that costs are reimbursed to the operator. In our data, however, observed subsidies are the differences between expected or final costs and commercial revenues. To make our data coincide with the model, we add commercial revenues to the observed subsidy. Finally, we distinguish between nominal and real terms. Costs and subsidies are deflated using consumer price indexes (all items) for France. Only real costs and subsidies are used during the estimation process.

Operators' characteristics include the size of the network, the number of lines operated, the size of the rolling stock, the share of the labor bill in total costs, the share of drivers in the total labor force, and the identity of the industrial group owning the operator. We thus assume that some firms are more likely to perform efficiently than others due to intrinsic advantages of larger stakes, size, and concentration of skills.

The size of the network is the total length of the network measured in kilometers. The number of lines operated in each network as well as the total size of the rolling stock measured in the number of vehicles are also constructed. The share of the wage bill in total costs is computed by dividing the wage bill by total costs. The total labor force includes bus drivers as well as engineers who are keys to improve the operator's productivity. The share of engineers is simply obtained by dividing the number of engineers in each network by the total labor force. Finally, the four important municipal corporations who might own the local operator are Keolis, Transdev, Agir, and Connex. We construct a dummy variable for each of these corporations.

Institutional variables describing the public authority comprise the number of cities involved in organizing the service, the size of the population of the total urban area where the service is provided, and the political color of the local regulator. As explained at the beginning of our text, the urban network may include several municipalities. We observe the number of cities that form each urban area as well as the total population of these areas. We also construct a dummy variable that takes value one if the local government is right-wing, and zero when it is left-wing. Data on the political color of the local government are published by the French national newspaper *Le Figaro*. Note that, over the period of investigation, local governments may belong to one of the main political groups, ranked according to their position on the political line from extreme right to extreme left: Extreme Right, Right, Center Right, Left, and Extreme Left.[26]

Definition of a contractual period and network selection: Our raw database includes 49 networks observed over the 1987-2001 period. This corresponds to 138 contracts. As a contractual period lasts on average for 5 years, we typically observe series of 3 contracts per network over 1987-2001. Very few cases entail networks where 1, 2, or 4 contracts are observed.

The selection of the relevant sample required for the estimation depends on the nature of the contractual arrangement that is considered:[27]

Full commitment: Contractual arrangements entail series of contracts which are, in principle, identical. When evaluating the distribution of θ, we consider all the contracts of our database (results in Table 2). To estimate Proposition 1, we consider only the 80 fixed-price contracts of our sample (results in Table 3).

Renegotiation-proof: We restrict our attention here to networks where a newly elected

[26] A public authority (principal) has its members coming from municipal councils, who are elected by direct universal suffrage for a renewable six-year term. The mayor is elected by the municipal council.

[27] Note that one contract in one network should in principle correspond to a unique observation in our theoretical model, i.e., the contract items should remain constant over the - say - 5 years of a contract period. The data reality may be slightly different. In practice, the dataset shows that over a single contract period, many items may be affected by small fluctuations. This may for instance be the case of the operator's supply measured by the number of seat-kilometers available, which, in turns, makes the costs and subsidy levels fluctuate too. These fluctuations follow from exogenous shocks that may affect the activity of the operator over the contract length and are assumed to be iid in our model: Changes in traffic conditions, changes in network configuration, road constructions which may cut a service route over a certain period, strikes are all such examples. The economic responses to these predictable shocks are written in the contract. Hence, although the contract items may fluctuate over the contract period, they constitute the objective of the same contract. Instead of calculating a simple average value of each item over the contractual period when fluctuations are present, we choose to treat each different fluctuation as a separate observation so that the number of degrees of freedom of our study is increased.

principal contracts for two periods with an operator. This results in a first sample of 66 contracts that is used to compute the distribution of θ (results in Table 4). Then, to estimate the parameters of interest in Proposition 3, we restrict this last sample to series of fixed-price contracts only. This yields a final sample of 26 contracts (results in Tables 5 and 6).

4.2 Full Commitment Versus Renegotiation-Proof

We have suggested above that the French urban transportation industry shows several features making it a good candidate for illustrating renegotiation-proof profiles of subsidies. In particular, subsidies increase over time. The renegotiation-proof scenario is our positive representation of reality while perfect commitment is our hypothetical scenario that will be tested against our positive model.

A renegotiation-proof scenario corresponds to the following possibilities.

- A series of two fixed-price contracts over two contracting periods denoted by (FF). From the theoretical model, the operator is then rather efficient $(\theta \leq \theta_1^*)$.
- A series of cost-plus contracts first followed by a fixed-price contracts (CF herein). The operator is then only mildly efficient $(\theta_1^* \leq \theta \leq \theta_2^*)$.
- A series of two cost-plus contracts (CC herein). The operator is then rather inefficient $(\theta \geq \theta_2^*)$.

A full-commitment scenario corresponds instead to the following possibilities.

- A series (F) of fixed-price contracts when the operator is rather efficient $(\theta \leq \theta_F)$.
- A series (C) of cost-plus contracts when the operator is rather inefficient $(\theta \geq \theta_F)$.

Full commitment: We start with the hypothetical and simpler case of full commitment. This corresponds to the subsidy b^F defined in equation (1). The parameters k, α, and λ are unknown to the econometrician and need to be estimated, while b^F is observed only when a fixed-price contract is taken. For the purpose of the estimation, we rewrite this equation as follows:

$$k_i = \left(1 - \frac{\alpha_i}{1+\lambda}\right) R\left(b_i^F + k_i\right), \quad i = 1, .., N, \tag{12}$$

where i denotes network i, and N is the total number of networks in the sample.

The social value of effort k, as well as the weight α, are allowed to vary across networks. These parameters might depend on a set of explanatory variables X_i which account for the characteristics of the operator, and a set of explanatory variables Z_i which characterize the local authority:

$$k_i = k\left(X_i, \omega\right), \tag{13}$$

and

$$\alpha_i = \alpha\left(Z_i, \gamma\right), \tag{14}$$

where ω and γ are two vectors of parameters to be estimated.

These explanatory variables will be discussed in more details when the results of the estimation are presented. Note that we cannot identify separately the weight α on the operator's profit and the cost of public funds λ since only the ratio $\frac{\alpha}{1+\lambda}$ matters in defining the optimal subsidy from (1). We will assume several possible values for λ, which are consistent with the cost of an administration operating in a developed country.[28]

Note that the monotone hazard rate $R(\cdot)$ in (12) is also a priori unknown to us. It needs to be identified to compute our estimation. Assuming a specific distribution for $F(\cdot)$, we can write the probability of observing a fixed-price contract as follows: If an operator does not accept a fixed-price contract, it must be because θ is too high. By matching the distribution of θ to an empirical probability of accepting a fixed-price contract, we can recover the parameters of that distribution. Assume that the θs are independent draws across networks from the same normal distribution with mean ν_{pc} and variance σ_{pc}, the probability of accepting a fixed-price contract is the probability of θ_i being less than $b_i^F + k_i$, namely:

$$\Pr\left(\theta_i \leq b_i^F + k_i\right) = F\left(b_i^F + k_i, \nu_{pc}, \sigma_{pc}\right), \tag{15}$$

where $F(\cdot, \nu_{pc}, \sigma_{pc})$ is the cumulative distribution function for that normal distribution (with density $f(\cdot, \nu_{pc}, \sigma_{pc})$).

[28] For instance, Ballard, Shoven and Whalley (1985) provided estimates (namely, 1.17 to 1.56) of the welfare loss due to a one-percent increase in all distortionary tax rates. In the case of Canadian commodity taxes, Campbell (1975) found that this distortion is equal to 1.24. More generally, it seems that the distortion falls in the range of 1.15 to 1.40 in countries with an efficient tax collection system.

We estimate the system made of equations (12) and (15). As these two equations are sequential, we can present their estimation procedure separately for ease of exposition. To first recover the values of ν_{pc} and σ_{pc}, we write the likelihood $L_i(\nu_{pc}, \sigma_{pc})$ of observing a specific contract in network i at period t as:

$$L_i(\nu_{pc}, \sigma_{pc}) = F\left(b_i^F + k_i, \nu_{pc}, \sigma_{pc}\right)^{\Gamma}\left(1 - F\left(b_i^F + k_i, \nu_{pc}, \sigma_{pc}\right)\right)^{1-\Gamma}, \tag{16}$$

where Γ is a dummy that takes value one if the observed contract is a fixed-price, and zero otherwise. Assuming that observations are independent across networks, then the log-likelihood function for our sample is just the sum of all individual log-likelihood functions.

$$L(\nu_{pc}, \sigma_{pc}) = \Pi_{i=1}^{N} L_i(\nu_{pc}, \sigma_{pc}). \tag{17}$$

With the estimates $\widehat{\nu}_{pc}$ and $\widehat{\sigma}_{pc}$ in hands, we can calculate the distribution $F(., \widehat{\nu}_{pc}, \widehat{\sigma}_{pc})$, as well as the monotone hazard rate $R(., \widehat{\nu}_{pc}, \widehat{\sigma}_{pc})$. Once this is done, we appraise $\widehat{k}_i$ and $\widehat{\alpha}_i$ in (12), which entails obtaining estimates $\widehat{\omega}$ and $\widehat{\gamma}$. Rewriting equation (12) as:

$$G\left(b_i^F, k_i, \alpha_i, \lambda, \nu_{pc}, \sigma_{pc}, \varepsilon_i\right) = 0, \tag{18}$$

where ε_i is a two-sided error term, we can obtain maximum likelihood estimates $\widehat{\omega}$ and $\widehat{\gamma}$, which allows us to evaluate the estimated $\widehat{k}_i$ and $\widehat{\alpha}_i$.

Renegotiation-proof contracts: We turn now to the case of limited commitment. As stated in Proposition 3, the optimal renegotiation-proof profile entails increasing subsidies (b_1^R, b_2^R) which satisfy the system of equations (9) to (11). Our goal is to estimate these equations together with the distribution of θ. In this system, the parameters that are unknown to us and need to be recovered are k, α, λ, ν, β, as well as ν_{rp} and σ_{rp}, the mean and the standard error respectively of the θ's normal distribution. We observe the two variables b_1^R and b_2^R, the first and second period subsidy levels respectively. As under full commitment, those parameters might vary across networks. Hence, we rewrite the system (9) to (11) as:

$$k_i - \frac{\mu_i}{\beta_i(1+\lambda)}\left(1 - \frac{\alpha_i}{1+\lambda}\right) = \left(1 - \frac{\alpha_i}{1+\lambda}\right) R\left(b_{1,i}^R + k_i\right), \tag{19}$$

$$k_i + \frac{\mu_i}{(1-\beta_i)(1+\lambda)}\left(1 - \frac{\alpha_i}{1+\lambda}\right) - \frac{\mu_i\, k_i}{(1-\beta_i)(1+\lambda)} \frac{f'\left(b_{2,i}^R + k_i\right)}{f\left(b_{2,i}^R + k_i\right)} = \left(1 - \frac{\alpha_i}{1+\lambda}\right) R\left(b_{2,i}^R + k_i\right), \tag{20}$$

$$-k_i\ f\left(b_{2,i}^R + k_i\right) + \left(1 - \frac{\alpha_i}{1+\lambda}\right)\left(F\left(b_{2,i}^R + k_i\right) - F\left(b_{1,i}^R + k_i\right)\right) = 0, \quad i = 1, .., N. \tag{21}$$

We assume again that the social value of effort k, as well as the weight α given by the regulator to the operator's utility, are allowed to vary across networks. We expect these parameters to depend on a the same sets of explanatory variables X_i and Z_i:

$$k_i = k\left(X_i, \varphi\right), \tag{22}$$

and

$$\alpha_i = \alpha\left(Z_i, \chi\right), \tag{23}$$

where φ and χ are two vectors of parameters to be estimated. As under full commitment, we will assume several possible values for λ.

To estimate the above system, we proceed as follows. First equations (19) and (20) can be solved for μ_i and β_i

$$\mu_i = \mu\left(b_{1,i}^R, b_{2,i}^R, k_i, \alpha_i, \lambda, \nu_{rp}, \sigma_{rp}\right), \tag{24}$$

$$\beta_i = \beta\left(b_{1,i}^R, b_{2,i}^R, k_i, \alpha_i, \lambda, \nu_{rp}, \sigma_{rp}\right), \tag{25}$$

while (21) is rewritten as

$$J\left(b_{1,i}^R, b_{2,i}^R, k_i, \alpha_i, \lambda, \nu_{rp}, \sigma_{rp}, \xi_i\right) = 0, \tag{26}$$

where ξ_i is an error term.

The estimates $\widehat{k}_i$ and $\widehat{\alpha}_i$ are obtained from (21). Moreover, the estimates $\widehat{\nu}_{rp}$ and $\widehat{\sigma}_{rp}$ are derived from the estimation of θ's distribution, which is computed following the same method than under full commitment. First, assuming a specific normal distribution for $F(\cdot)$ in the monotone hazard rate $R(\cdot)$, we can write the probability of observing a specific contractual arrangement over two periods.

To recover the characteristics of the distribution of the θs, we replicate the methodology implemented when assuming full commitment as above. However, three types of contractual arrangements are now used (instead of two previously). If an operator does not accept any fixed-price contract (in any period), it must be because it has too large a θ. Likewise, if the operator accepts a fixed-price contract in both periods (resp. second period only), it is efficient enough (resp. mildly efficient). By matching the theoretical probabilities of each of those regimes with their empirical probabilities, we can recover the distribution of θ.

The operator accepts a fixed-price contract in both periods when $\theta_i \leq \theta_1^* = b_{1,i}^R + k_i$ so that the probability of accepting a fixed-price contract in both periods is:

$$\Pr\left(\theta_i \leq b_{1,i}^R + k_i\right) = F\left(b_{1,i}^R + k_i, \nu_{rp}, \sigma_{rp}\right), \tag{27}$$

where $F(\cdot, \nu_{rp}, \sigma_{rp})$ is the cumulative distribution function with density $f(., \nu_{rp}, \sigma_{rp})$. We assume again that the θs are independent draws from a normal distribution that is common across networks.

The operator goes from a cost-plus to a fixed-price contract when $\theta_1^* \leq \theta_i \leq \theta_2^* = b_{2,i}^R + k_i$. The probability of such pattern is thus the probability of θ being greater than $b_{1,i}^R + k_i$ and less than $b_{2,i}^R + k_i$:

$$\Pr\left(b_{1,i}^R + k_i \leq \theta_i \leq b_{2,i}^R + k_i\right) = F\left(b_{2,i}^R + k_i, \nu_{rp}, \sigma_{rp}\right) - F\left(b_{1,i}^R + k_i, \nu_{rp}, \sigma_{rp}\right). \tag{28}$$

Finally, the operator takes cost-plus contracts in both periods when $\theta_2^* = b_{2,i}^R + k_i \leq \theta_i$. The probability of accepting such arrangement is thus:

$$\Pr\left(b_{2,i}^R + k_i \leq \theta_i\right) = 1 - F\left(b_{2,i}^R + k_i, \nu_{rp}, \sigma_{rp}\right). \tag{29}$$

The likelihood of observing one specific contractual arrangement in network i over period t can thus be written as:

$$L_i\left(\mu_{rp}, \sigma_{rp}\right) = F\left(b_{1,i}^R + k_i, \nu_{rp}, \sigma_{rp}\right)^{\Delta}\left(F\left(b_{2,i}^R + k_i, \nu_{rp}, \sigma_{rp}\right) - F\left(b_{1,i}^R + k_i, \nu_{rp}, \sigma_{rp}\right)\right)^{\Pi}\left(1 - F\left(b_{2,i}^R + k_i, \nu_{rp}, \sigma_{rp}\right)\right)^{\Sigma}, \tag{30}$$

where $\{\Delta, \Pi, \Sigma\}$ are three dummies taking value one if the observed contractual arrangement is of type $\{FF, CF, CC\}$ respectively, and zero otherwise.

Since observations are independent, the likelihood function for our sample is just the product of all individual log-likelihood functions:

$$L\left(\mu_{rp}, \sigma_{rp}\right) = \Pi_{i=1}^N L_i\left(\mu_{rp}, \sigma_{rp}\right).$$

Inserting into equations (19) to (21) allows to estimate $\widehat{\nu}_{rp}$ and $\widehat{\sigma}_{rp}$ together with $\widehat{k}_i$ and $\widehat{\alpha}_i$ in (22) and (23). This finally allows us to retrieve $\widehat{\mu}_i$ and $\widehat{\beta}_i$.

4.3 Estimation Results

We now present the results of our estimation for both regulatory scenarios: The hypothetical full commitment environment, and the renegotiation-proof profile which we believe fits better with the French urban transport industry. In both cases, results are presented in two steps: First, we discuss the set of results associated to the estimation of θ's distribution, $F(\cdot)$. This sheds light on which factors affect significantly the social value of effort k. In a second step, we focus on the regulatory arrangements induced by Propositions 1 and 3, and discuss our results on the estimated weight α on the firm's profit in the authority's objective, the intertemporal weight β from one contractual period to another, and the multiplier μ of the renegotiation-proofness constraint.

Full commitment: To estimate $F(\cdot)$, we need to determine which variables X affect the social value of effort k. Explanatory variables are related to the characteristics of the operator, i.e., its skills and managerial ability, as well as its effort technology. These variables are a constant, a trend, the total size of the service network in kilometers, the number of lines operated, the size of the rolling stock in number of vehicles, the share of the labor bill in total costs, the percentage of engineers in the total labor force, a dummy variable that takes value 1 if the operator belongs to the corporation Keolis and 0 otherwise, a dummy variable that takes value 1 if the operator belongs to the corporation Agir and 0 otherwise, and a dummy variable that takes value 1 if the operator belongs to the corporation Connex and 0 otherwise.

Results are presented in Table 2. In the course of the estimation, we realized that the patterns which explain the social value of effort highly differ from one network to another, i.e., we could not obtain unique significant effects for all operators. Hence, we allow estimation results to vary from one group to another. We present three different estimations.

In (I), k depends on four dummy variables which account for the identity of the group the operator belongs to (Connex is the reference group). Only Trandev has a significant and positive effect on k, suggesting that an operator belonging to Transdev seems to guarantee a higher social return on managerial effort compared to operators from any other group.[29]

[29]The social value of effort is inversely related to the technological cost of effort, which implies that Transdev also enjoys a less costly effort technology. It would be interesting to relate these findings to the

In (II), the explanatory variables are a constant for each group and the size of the network interacted with each one of the group dummy variables. The results show that the size of the network significantly and positively affects the social value of effort in networks where Agir and Transdev operate. This is probably an illustration of the fact that economies of scale in effort technology are greater for larger networks.

In (III), the explanatory variables are a constant for each group and the share of engineers interacted with each one of the group dummy variables. The share of engineers provides a measure for the endowment of skills embodied in the firm. Engineers are generally responsible for research and development, quality control, maintenance, and efficiency. Their action is particularly important to improve the average speed of the network. We expect thus the share of engineers in the total labor force to positively affect the social value of effort. However, the results rather suggest an ambiguous effect: If the operator belongs to Transdev, the share of engineers has the expected effect; if the operator belongs instead to Agir, the effect goes in the opposite direction.

Other variables such as the number of lines operated, the size of the rolling stock, or the share of the labor bill in total costs have not provided significant results. The four estimation procedures yield very similar estimates of ν_{pc} and σ_{pc}, the mean and standard deviation of θ's normal distribution respectively. Our results are strongly significant, and suggest that the average innate cost θ is close to 22 millions Euros. By comparing this value to the average (real) operating costs given in Table 1, we get an average effort level of around 5 millions Euros for the whole industry, which represents a 23% reduction of the initial adverse selection parameter θ. This shows that managerial effort is of significant value for that industry.

Once we have estimated ν_{pc} and σ_{pc}, we evaluate $\widehat{\alpha}_i$, the weight of the operator's profit in social welfare. The explanatory variables which enter Y are a constant, the number of cities that form the local authority in charge of the organization of the service, the size of the population of the relevant urban area, and the political color of the local regulator. With the first two variables, we want to test whether the size of the city or a greater division of the network into distinct urban areas affects the bargaining power of the operator. We expect the latter to be more important in small networks or networks composed of many urban areas. With respect to the political color of the local government,

internal structure of managerial incentives within the operator but we did not have access to any related information.

casual evidence suggests that a right-wing local government to be more eager to provide favors to private operators. $\widehat{\alpha}_i$ should thus be higher with a right-wing local government.

Results are presented in Table 3. The estimation of the average α are made under the assumption that the local cost of public funds takes values $\lambda = \{0.1, 0.2, 0.3, 0.4\}$ respectively. Several comments are worth being emphasized. First, the number of cities that constitute the local authority and the size of the population were not significant and have been discarded. Second, whether the government is right-wing or not has a positive and very significant impact on α, confirming thereby our prior intuition. Third, α increases with λ but our initial restriction $\alpha \leq 1 + \lambda$ holds always, even though it is not imposed in the estimation.

Renegotiation-proof profiles: The estimation procedure is similar to the full commitment case.

First, we need to estimate the distribution of θ, $F(\cdot)$. Explanatory variables for k are the same as before. Three different estimations are also considered here, depending on which group of explanatory variables is used: (I) Four dummy variables denoting the identity of each group, (II) a constant plus the effect of the network size for each group, and (III) a constant plus the share of engineers for each group.[30]

The first set of results is presented in Table 4. With respect to the estimation of k, several comments are worth emphasizing: First, as far as only dummy variables are concerned, Transdev is the group with the highest social value of effort. In (II), the different groups seem to react differently to an increase in the size of the network. In (III), they also react differently to an increase of the share of engineers.[31]

Again, the three estimations yield very similar estimates of ν_{rp} and σ_{rp}, the mean and standard deviation of θ's. Our results are strongly significant, and suggest that the average θ is close to 20 millions Euros whereas the average level of effort for the whole industry lies around 3 millions Euros. This represents a 15% reduction of the initial adverse selection parameter θ. Thus, the renegotiation-proof scenario implies more efficient operators exerting lower levels of effort on average.

[30] The reader might remember that a major difference is that now three regulatory arrangements are considered instead of two as under full commitment.

[31] Note that the effects go sometimes in an opposite direction than the ones obtained in the full commitment case.

With the estimated $\widehat{\nu}_{rp}$ and $\widehat{\sigma}_{rp}$, in hands, we turn to the evaluation of $\widehat{\alpha}_i$, $\widehat{\beta}_i$ and $\widehat{\mu}_i$. Average values of these parameters are presented in Table 5. Again, we perform these estimations assuming that the local cost of public funds takes values $\lambda = \{0.1, 0.2, 0.3, 0.4\}$. Whether the government is right-wing or not has a positive and very significant impact on α, but the estimated parameter in this case is much lower than $1 + \lambda$. More generally, and comparing estimates of α across regimes, we observe that those estimates are systematically higher under full commitment than under a renegotiation-proof scenario.

Second, the average intertemporal weight β is equal to 0.53, suggesting that both first and second periods are perceived as equally important in the contractual arrangement. Finally, the average multiplier ranges from 0.14 to 0.18.

The explanation for the difference in estimates between the full commitment and the renegotiation-proof scenarios is easily understood when coming back on the renegotiation-proofness constraint (7). Remember first that renegotiation is more of a concern when the parameter $1 - \frac{\alpha}{1+\lambda}$ is greater, i.e., when the net social cost of the operator's rent is small enough so that the efficiency gains from renegotiation in the second period outweigh the costs in terms of extra information rents. By the same token, renegotiation is also more of a concern when efficiency gains are high, i.e., when k is greater. Considering a renegotiation-proof scenario amounts thus to "choose" a higher value of this parameter. Looking at (7), a higher estimate of k under a renegotiation-proof scenario than under full commitment comes also with a higher estimate of $1 - \frac{\alpha}{1+\lambda}$, i.e., a lower weight on the firm's profit in the renegotiation proof scenario.

Our estimation results in Tables 2 and 4 go in the expected directions. First, note that α is greater in the full commitment case than in the renegotiation proof one. Second, k is greater under renegotiation proof than under full commitment. Estimated $\widehat{\omega}$ and $\widehat{\varphi}$ allow us to compute average $\widehat{k}$ under both situations. Full commitment entails average values of $\widehat{k}$ equal to 0.13 (I), 0.18 (II), and 0.14 (III), while renegotiation-proofness entails values equal to 0.17 (I), 0.51 (II), and 1.04 (III).

Lastly, as it can be seen from the right-hand side of the renegotiation-proofness constraint (7), renegotiation is more costly when increasing subsidies over time significantly shifts rents towards the operator which arises when types are "on average" rather efficient. Neglecting that constraint biases the types distribution towards considering operators with higher costs, which is confirmed by our estimations.

5 The Welfare Gains of Commitment

The goal of this section is twofold. First, we want to assess what is the magnitude of the welfare gains once one moves from the renegotiation-proof setting to the less constrained full commitment scenario. Second, we want also to evaluate how those gains are distributed between private operators and taxpayers. This is an important issue for practitioners since they have often complained on the insufficient length of concession contracts in this sector.

Starting from our estimates of the various parameters of the model obtained from the estimation of the renegotiation-proof scenario, we can reconstruct estimates of the average social cost of subsidies and the average rent left to operators under both scenarios.[32] We proceed as follows:[33]

• **Step 1**: Using our set of renegotiation-proof estimates $\Upsilon^R = \left(\widehat{\nu}^R, \widehat{\sigma}^R, \widehat{k}^R, \widehat{\alpha}^R, \widehat{\beta}^R\right)$ conditional on λ and its expression from the maximand in renegotiation-proof program $\mathcal{P}^R$, we compute expected welfare W_i^R for each network of our database. As emphasized throughout this section, the renegotiation-proof arrangements discussed in this paper are the actual contractual practices implemented in the French urban transport industry. Hence, the estimates Υ^R provides the econometrician information on the real characteristics of the operator and the public authority.

• **Step 2**: We simulate the hypothetical subsidy level $\widehat{b}_i^F$ that would be paid under full commitment. To do so, we solve (1) with respect to $\widehat{b}_i^F$, using the real networks characteristics Υ^R.

• **Step 3**: We reconstruct the hypothetical welfare measures $\hat{W}_i^F$ for each network of our database, as predicted by our full commitment program $\mathcal{P}^F$, and using our estimates $\widehat{b}_i^F$, and Υ^R.

We compute the total welfare gains as well as the gains for taxpayers and operators from commitment by considering an average network of the database, using estimates Υ^R conditional on $\lambda = 3$ and k_i specified as in (II) in Tables 2 to 5.[34]

[32]Remember that our theoretical model has normalized the value of the service at some fixed level S so that consumers' gross surplus does not change when considering different regimes. This variable will thus be omitted in our analysis.

[33]See the Appendix for details.

[34]Note that the final welfare results do not vary in a significant manner if other values of λ or k_i are chosen.

The estimates reported in Table 6 shed light on several interesting results. First, commitment always improves welfare, compared to the situation where renegotiation puts further constraints on contracting. Hence, the important question is not whether one gains by committing but how those gains are distributed. Second, it turns out that $\widehat{b}_i^F > \widehat{\beta}_i^R b_{i,1}^R + (1 - \widehat{\beta}_i^R) b_{i,2}^R$, i.e., switching from renegotiation-proof to full commitment entails a higher intertemporal subsidy. In fact, the intertemporal payment to the operator increases, on average, by 27.3 %. Hence, taxpayers lose from an increase in the commitment period of concession contracts, even though it is not a major loss in expected terms as suggested by the small increase in welfare cost (+3.8%).

Turning now to operators, our estimates show that their intertemporal rent increases when moving to the full commitment by 12,2%: This is a significant gain that explains why operators are so eager to extend the length of the concession contract in this sector.

6 Conclusion

In this paper, we have developed a principal-agent model under limited commitment that features the main characteristics of contracts in the French urban transportation sector. On top of estimating key parameters of the economic and political landscape in this sector, this model has allowed us to evaluate the cost of renegotiation and how welfare gains would be redistributed by increasing contract duration and improving commitment.

In this conclusion, we would like to make a few remarks and suggest a few alleys for further investigation. First, we have deliberately restrained the general feature of theoretical models of limited commitment in order to be able to bring the lessons of those models to the data. Computing the optimal renegotiation-proof contract with a continuum of types (already a first-magnitude theoretical challenge) in the perspective of estimating it econometrically would be a very messy and painful project. Taking data and institutional constraints seriously forced us instead to focus on the case of simple two-item menus which, although suboptimal, allows us to bring the extra benefits of tractability when it comes to a dynamic analysis. This "applied theory" procedure seems to us extremely promising in areas like dynamic contract theory where "pure theory" is either producing untractable models or would make progresses at the cost of imposing heroic assumptions on the underlying type distribution (assuming typically discrete types), assumptions that would be hardly corroborated by data. Our approach could certainly be fruitful also for other industries and contractual environments.

Second, even though our estimates show that welfare gains of commitment are significant, we are certainly underestimating these gains here. Indeed, we have no ideas on how renegotiation weakens the operator's incentives to make any relationship-specific investment in this sector except through informal talks with practitioners in the field. Introducing those considerations would even further push for an increase in contract length.

Third, our estimation has highlighted a few systematic differences between operators of different companies in their abilities to generate social value through managerial efforts. It would be worth linking those different abilities to the internal organizations and incentive structures of these firms. But again, we have no information on this issue at this stage.

Lastly, our estimate of the cost distribution allows us to ascertain whether the restriction to simple menus is relevant or not even in the static context. Echoing the theoretical works of Rogerson (2003) and Chu and Sappington (2007), we could now ask whether the simple two-item menu fares well compared with more complete menus of contracts given the estimated distributions. In this respect, our conjecture is that, yes, simple menus do well and the gains from more complex design is unlikely of being of the same magnitude as the welfare gains from commitment. Overall, our conjecture is that major sources of contractual benefits come more from better institutional design than from complex contractual engineering.

We hope to investigate some of those issues in future research.

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Appendix

• **Proof of Proposition 1:** Under full commitment, the principal's problem can be rewritten as:

$$(\mathcal{P}^F): \quad \max_{(b_1,b_2)} W^F(b_1,b_2)$$

The monotone hazard rate property ensures quasi-concavity of this objective.[35] The corresponding first-order conditions yield finally the characterization of the optimal subsidy in (1). ■

• **Proof of Lemma 1:** The optimal subsidy $\hat{b}_2$ should thus solve the following problem at the renegotiation stage:

$$(\mathcal{P}_2^R): \quad \max_{\tilde{b}_2} W_{2G}(\tilde{b}_2) \text{ subject to (2).}$$

where the second-period welfare following "good news" is given by

$$W_{2G}(\tilde{b}_2) = S - (1+\lambda)\left(\tilde{b}_2 \frac{F(\tilde{b}_2+k)}{F(\theta_1^*)} + \int_{\tilde{b}_2+k}^{\theta_1^*} \frac{\theta f(\theta)}{F(\theta_1^*)} d\theta\right) + \alpha \int_{\underline{\theta}}^{\tilde{b}_2+k} \frac{\tilde{b}_2+k-\theta}{F(\theta_1^*)} f(\theta) d\theta$$

Differentiating the above maximand with respect to $\tilde{b}_2$ yields

$$W'_{2G}(\tilde{b}_2) = (1+\lambda)kf(\tilde{b}_2+k) - (1+\lambda-\alpha)F(\tilde{b}_2+k).$$

The maximum of the principal's expected welfare is thus achieved for $\hat{b}_2 = b_2$ as requested by the renegotiation-proofness constraint (2) when $b_2 \geq b^F$. ■

• **Proof of Lemma 2:** The optimal subsidy $\hat{b}_2$ that can be offered at the renegotiation stage solves now the principal's second period welfare when evaluated with the updated beliefs following "bad news" (i.e., the decision to stick to a cost-plus contract in the first period):

$$(\mathcal{P}_2^R): \quad \max_{\tilde{b}_2} W_{2B}(\tilde{b}_2) \text{ subject to (2)}$$

where

$$W_{2B}(\tilde{b}_2) = S-(1+\lambda)\left(\tilde{b}_2 \frac{\left(F(\tilde{b}_2+k) - F(\theta_1^*)\right)}{1-F(\theta_1^*)} + \int_{\tilde{b}_2+k}^{\bar{\theta}} \frac{\theta f(\theta) d\theta}{1-F(\theta_1^*)}\right) + \alpha \int_{\theta_1^*}^{\tilde{b}_2+k} (\tilde{b}_2+k-\theta) \frac{f(\theta) d\theta}{1-F(\theta_1^*)}.$$

Differentiating the above maximand with respect to $\tilde{b}_2$ yields

$$W'_{2B}(\tilde{b}_2) = (1+\lambda)kf(\tilde{b}_2+k) - (1+\lambda-\alpha)(F(\tilde{b}_2+k) - F(\theta_1^*)).$$

[35] See for instance Bagnoli and Bergstrom (2005).

The maximum of the principal's expected welfare is thus achieved for $\hat{b}_2 = b_2$ as requested by the renegotiation-proofness constraint (2) when (5) holds. ■

• **Proof of Proposition 2:** Since $\alpha < 1 + \lambda$ and the density function is positive, (7) implies: $F(b_2 + k) - F(b_1 + k) > 0$, i.e., $b_1 < b_2$. ■

• **Proof of Proposition 3:** The optimal renegotiation-proof subsidies maximize the principal's intertemporal welfare subject to the renegotiation-proofness constraints (4) and (7).

$$(\mathcal{P}^R): \quad \max_{(b_1,b_2)} W^R(b_1, b_2) \text{ subject to (4) and (7)}$$

where

$$\begin{aligned} W^R(b_1, b_2) &= S - (1+\lambda)(\beta b_1 F(b_1+k) + (1-\beta) b_2 F(b_2+k)) \\ &\quad -(1+\lambda)\left(\beta \int_{b_1+k}^{\bar{\theta}} \theta f(\theta) d\theta + (1-\beta) \int_{b_2+k}^{\bar{\theta}} \theta f(\theta) d\theta\right) \\ &\quad +\alpha\left(\beta \int_{\underline{\theta}}^{b_1+k} (b_1+k-\theta) f(\theta) d\theta + (1-\beta) \int_{\underline{\theta}}^{b_2+k} (b_2+k-\theta) f(\theta) d\theta\right) \end{aligned}$$

Because $\mu > 0$, $\alpha < 1+\lambda$ and $R(\cdot)$ is increasing, (9) immediately implies that $b_1^R < b^F$. Proposition 2 implies then $b_1^R < b_2^R$. ■

• **Welfare Estimates:** Using our estimates from the case where renegotiation-proof contracts are considered, we get the following expression of welfare in locality i:

$$W_i^R = S - T_i^R + \widehat{\alpha}_i^R U_i^R, \tag{31}$$

where

$$\begin{aligned} T_i^R &= (1+\lambda)(\widehat{\beta}_i^R b_{i,1}^R F(b_{i,1}^R + \widehat{k}_i^R) + (1-\widehat{\beta}_i^R) b_{i,2}^R F(b_{i,2}^R + \widehat{k}_i^R)) \\ &\quad +(1+\lambda)\left(\widehat{\beta}_i^R \int_{b_{i,1}^R+\widehat{k}_i^R}^{\bar{\theta}} \theta f(\theta) d\theta + (1-\widehat{\beta}_i^R) \int_{b_{i,2}^R+\widehat{k}_i^R}^{\bar{\theta}} \theta f(\theta) d\theta\right), \end{aligned}$$

and

$$U_i^R = \widehat{\beta}_i^R \int_{\underline{\theta}}^{b_{i,1}^R+\widehat{k}_i^R} (b_{i,1}^R + \widehat{k}_i^R - \theta) f(\theta) d\theta + (1-\widehat{\beta}_i^R) \int_{\underline{\theta}}^{b_{i,2}^R+\widehat{k}_i^R} (b_{i,2}^R + \widehat{k}_i^R - \theta) f(\theta) d\theta.$$

Likewise, from our full commitment program $\mathcal{P}^F$, we define welfare as the weighted sum of surplus S, expected taxes T_i^F and operator's expected rent U_i^F weighted by the corresponding weight $\widehat{\alpha}_i^R$:

$$W_i^F = S - T_i^F + \widehat{\alpha}_i^R U_i^F, \tag{32}$$

where

$$T_i^F = (1+\lambda)\left(\widehat{b}_i^F F\left(\widehat{b}_i^F + \widehat{k}_i^R\right) + \int_{\widehat{b}_i^F+\widehat{k}_i^R}^{\bar{\theta}} \theta f(\theta) d\theta\right),$$

and

$$U_i^F = \int_{\underline{\theta}}^{\widehat{b}_i^F+\widehat{k}_i^R} (\widehat{b}_i^F + \widehat{k}_i^R - \theta) f(\theta) d\theta.$$

Note that the gross surplus S vanishes at the moment of calculating the difference between both welfare measures WC_i^R and WC_i^F. Hence, we evaluate the welfare differential between both renegotiation-proof and prefect commitment situations as

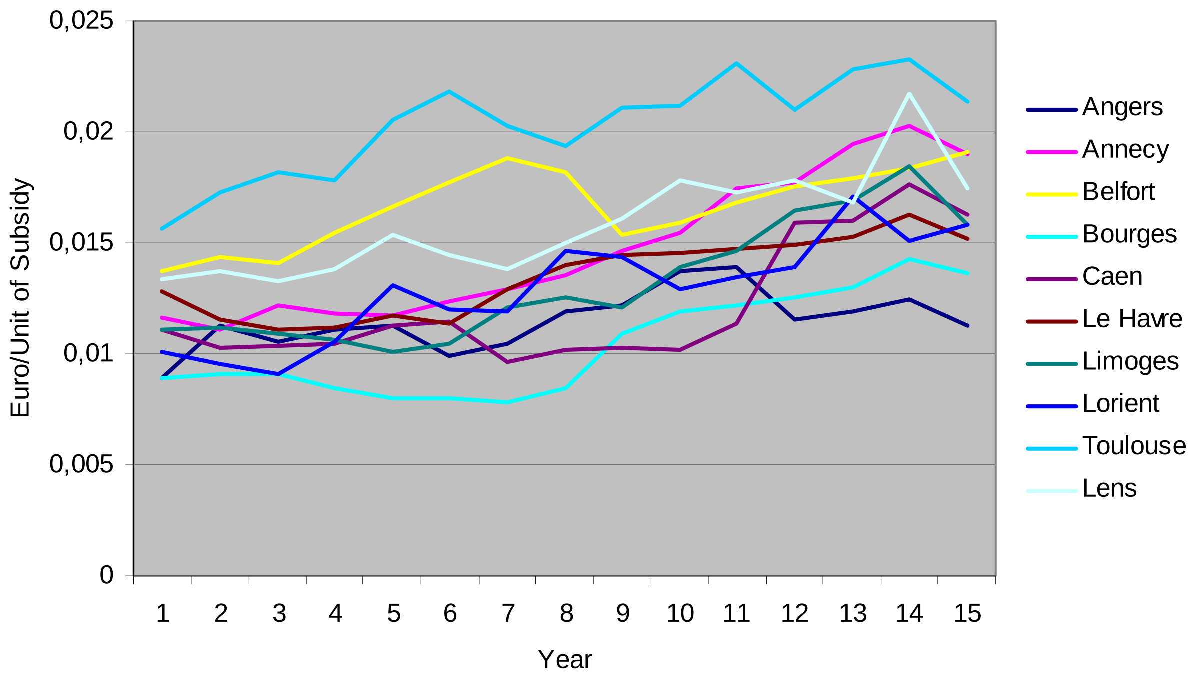
$$\Delta W_i = W_i^F - W_i^R. \tag{33}$$

Similar definitions follow for ΔT_i^F and ΔU_i. ■

Name	Quantity
Period of observation	1987-2001
Number of networks	49
Changes of operators	2
Changes of local governments	22
Number of contracts	136
Fixed-price contracts	75
New contracts	94
Switch contract type	20
Switch Cost-plus to Fixed-price	17

Table 1: Contracts

Figure 1: Subsidy per unit of supply



Variables	Mean	Stand. Dev.
Nominal Cost (Euros)	20,549,568	19,273,852
Nominal Subsidy (Euros)	20,702,141	19,239,199
Including Revenue (Euros)	9,608,629	10,526,903
Subsidy per unit of supply (Euro)	0.016	0.005
Real Costs (Euros)	16,997,693	15,483,483
Real Subsidy (Euros)	18,760,150	17.395,482
Size of the network (km)	288.3	200.1
# of lines	23.6	13.2
# of vehicles	168.1	119.5
# of cities in the urban network	18.3	16.7
Size of population	236,799	177,641
Share of Labor in total costs	0.64	0.10
Share of engineers	0.29	
Share right-wing government	0.52	
Share Fixed Price contracts	0.55	
Share Keolis	0.32	
Share Agir	0.16	
Share connex	0.22	
Share Transdev	0.24	

Table 2: Data

	Social value of effort k		
Variables	**I**	**II**	**III**
Agir	-0.08	-1.31***	-4.42***
	(0.07)	(0.46)	(1.22)
Keolis	0.05	-0.09	-0.10
	(0.06)	(0.13)	(0.27)
Transdev	0.52***	0.26	2.09***
	(0.11)	(0.18)	(0.90)
Agir×size		5.07***	
		(1.72)	
Keolis×size		0.52	
		(0.39)	
Transdev×size		1.60**	
		(0.83)	
Agir×Engineers			-5.99***
			(1.65)
Keolis×Engineers			-0.21
			(0.37)
Transdev×Engineers			2.22***
			(1.20)
Agir×Trend			
Keolis×Trend			
Transdev×Trend			
Mean θ (×10000)	0.22***	0.23***	0.22***
	(0.04)	0.06	(0.04)
Stand. Dev. θ (×10000)	0.47***	0.51***	0.48***
	(0.08)	0.16	(0.09)
# of Contracts		138	

Table 3: Full Commitment: Inefficiency distribution and social value of effort

	$\alpha\times$right wing		
λ	**I**	**II**	**III**
0.4	1.29***	1.38***	1.37***
	(0.03)	(0.01)	(0.01)
0.3	1.19***	1.28***	1.27***
	(0.03)	(0.01)	(0.01)
0.2	1.10***	1.18***	1.17***
	(0.03)	(0.02)	(0.01)
0.1	1.01***	1.08***	1.07***
	(0.02)	(0.01)	(0.01)
# of Contracts		80	

Table 4: Full Commitment: Parameter of interest in Proposition 1

	Social value of effort k		
Variables	**I**	**II**	**III**
Agir	0.02	-0.26**	-2.19***
	(0.05)	(0.12)	(0.73)
Keolis	0.07*	0.32***	-0.08
	(0.04)	(0.08)	(0.46)
Transdev	0.41***	0.41***	2.04**
	(0.07)	(0.11)	(0.80)
Agir×size		1.25**	
		(0.49)	
Keolis×size		-0.76***	
		(0.21)	
Transdev×size		-0.06	
		(0.34)	
Agir×Engineers			3.05***
			(1.00)
Keolis×Engineers			0.21
			(0.63)
Transdev×Engineers			-2.27**
			(1.09)
Agir×Trend			
Keolis×Trend			
Transdev×Trend			
Mean θ (×10000)	0.20***	0.20***	0.20***
	(0.03)	(0.03)	(0.03)
Stand. Dev. θ (×10000)	0.22***	0.21***	0.22***
	(0.02)	(0.02)	(0.02)
# of Contracts		66	

Table 5: Renegotiation-proof: Inefficiency distribution and social value of effort

Parameter		I				II			
	λ	0.1	0.2	0.3	0.4	0.1	0.2	0.3	0.4
$\alpha\times$right wing		0.61^{***}	0.67^{***}	0.73^{***}	0.78^{***}	0.64^{***}	0.70^{***}	0.76^{***}	0.82^{***}
		(0.13)	(0.14)	(0.14)	(0.16)	(0.13)	(0.14)	(0.15)	(0.16)
β		0.53^{***}	0.53^{***}	0.53^{***}	0.53^{***}	0.53^{***}	0.53^{***}	0.53^{***}	0.53^{***}
		(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
μ		0.14^{**}	0.16^{**}	0.17^{**}	0.18^{**}	0.14^{**}	0.16^{**}	0.17^{**}	0.18^{**}
		(0.07)	(0.07)	(0.08)	(0.08)	(0.07)	(0.07)	(0.07)	(0.08)
σ_ϵ		0.04^{***}	0.04^{***}	0.04^{***}	0.04^{***}	0.04^{***}	0.04^{***}	0.04^{***}	0.04^{***}
		(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
# of Contracts					26				

Table 6: Renegotiation-proof: Parameters of interest in Proposition 2

Welfare Items	**Total (in Million Euros)**
Subsidy	
- Full commitment (estimated)	21.7
- Renegotiation-proof 1	15.5
- Renegotiation-proof 2	18.9
Differential 1	+6.2
Differential 2	+2.9
Social cost	
- Renegotiation-proof	23.8
- Full commitment	24.7
Differential	+0.9
Rent operator	
- Renegotiation-proof	21.2
- Full commitment	23.8
Differential	+2.6
Total welfare	
- Renegotiation-proof	-0.35
- Full commitment	1.65
Differential	+2.0
# of Contracts	26

Table 7: Welfare differentials for the average network