

# The Cost of Contract Renegotiation: Evidence from the Local Public Sector<sup>1</sup>

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The renegotiation of regulatory contracts prevents regulators from achieving the full commitment efficient outcome. Assessing the cost of renegotiation remains an open issue from an empirical viewpoint. To address this question, we fit a structural principal-agent model with renegotiation on a set of urban transport service contracts. The model captures two important features of the industry. First, the local authorities use only two types of contract. Second, the subsidies increase over time. We compare a scenario with renegotiation and a hypothetical situation with full commitment. We conclude that the welfare gains from commitment are significant and accrue mostly to operators.

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Real world regulatory relationships are ongoing processes in changing environments. Parties lay down arrangements for trading goods and services covering several periods. However they often recontract as new information on market demand and costs structure becomes available. Although economic theory has devoted 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. This gap is a real concern both for theorists who may need empirical evidence to target their effort towards sensible issues but also for applied economists who might be missing the theoretical models that could be amenable to empirical analysis.

The main lesson of the theoretical literature is that renegotiation matters for contract design. Renegotiation has a positive impact because it improves contracting *ex post*. However, if those efficiency gains are anticipated, renegotiation has also perverse effects on the contractual parties' *ex ante* incentives: information may be incorporated in contract design only at a slow pace;<sup>1</sup> the threat of regulatory hold-up may impede specific investments which requires costly governance and safeguards arrangements;<sup>2</sup> and finally optimal risk-sharing arrangements may be disrupted.<sup>3</sup> Overall, renegotiation imposes transaction costs on *ex ante* contracting. Those costs prevent contracting parties from achieving the informationally constrained efficient solution that could have been reached if the parties had been able to commit themselves to a long-term contract. An open issue from an empirical viewpoint is how to assess the welfare losses associated with a limited commitment. Furthermore, another important question is to understand the distribution of those losses between the contracting parties.

Answering those questions is crucial both for researchers in order to ascertain the relevance of a whole body of theoretical literature on renegotiation, but also for practitioners who want to evaluate the performances of real-world contractual practices. In this respect, the French urban transportation sector offers a particularly attractive field for study. Motivated by a concern for improving *ex ante* competition among potential operators, the 1993 Transportation Law imposed that franchise contracts must

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<sup>1</sup>See the seminal paper by Dewatripont (1989) and the literature on adverse-selection under imperfect commitment (Hart and Tirole, 1988, Laffont and Tirole, 1993, Chapter 10, Rey and Salanié, 1996, Laffont and Martimort, 2002-Chapter 9, among others).

<sup>2</sup>Williamson (1985).

<sup>3</sup>Fudenberg and Tirole (1990).

be re-auctioned and “re-negotiated” every 5 years by public authorities in charge of regulating the service. Since then, practitioners in the industry have repeatedly complained that this institutional constraint on contract length is too tight. Expectations that welfare gains could be achieved by increasing contract duration is at the source of an ongoing political debate and some political activism by operators.

*Motivation.* This paper has two main objectives. First, we construct and estimate a structural principal-agent model of contract renegotiation in the French urban transport sector. A basic assumption of this model is that contracting takes place under asymmetric information: operators are privately informed on their innate costs at the time of contracting with public authorities. Second, we use those estimates to recover not only the welfare gains but also their distribution if full commitment were feasible. These gains are significant although unevenly distributed: operators are net winners when the length of the contract is extended whereas taxpayers/consumers lose.

Our model accounts for an important feature of the industry. In practice, only two kinds of contracts are used 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.<sup>4</sup> Importantly, from an implementation point of view, menus approximate quite well the optimal contract, and are sometimes even able to achieve what more complex nonlinear contracts would do.<sup>5</sup> Rogerson (2003) argued that, in most real-world procurement contexts, a simple two-item menu (cost-plus/fixed-price) may suffice to achieve much of the gains from trade, even under asymmetric information.<sup>6</sup>

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<sup>4</sup>In addition, linear contracts also have nice robustness properties under cost uncertainty (Laffont and Tirole 1993, Chapter 1, p.109, and Caillaud, Guesnerie and Rey, 1992).

<sup>5</sup>Laffont and Tirole (1993, Chapter 1) showed that the optimal nonlinear cost reimbursement rule can be implemented with a menu of linear contracts when this nonlinear contract is convex. Wilson (1993) and McAfee (2002) demonstrated that such menus might already fare well with only a few items.

<sup>6</sup>More specifically, Rogerson (2003) supposed that the firm’s innate cost which is its private information is uniformly distributed and showed that this simple menu can secure three-fourth of the surplus that an optimal contract would achieve. Chu and Sappington (2007) challenged this result beyond the case of a uniform distribution. On a related note, Schmalensee (1989), Reichelstein (1992), Bower (1993), and Gasmi, Laffont and Sharkey (1999) investigated the value of relying on a single linear contract and concluded also on the good welfare performances achieved with such a rough contract design.

A second important feature of the urban transportation sector is that subsidies (or “*compensations*” as they are often referred to by practitioners) proposed to operators increase over time no matter the characteristics of the service. Our theoretical model provides a rationale for such pattern. They result from the limited ability of local authorities to commit and the fact that, as time goes on, the operator’s cost structure gets better known to the public authorities. This argument is already familiar from the agency literature on limited commitment.<sup>7</sup> We revisit this general insight in a specific institutional context where two-item menus are the only feasible incentive mechanisms. Whereas the existing theoretical literature on limited commitment has focused on discrete type models to derive fully optimal renegotiation-proof contracts but is often criticized for its lack of tractability, our model imports much of the tractability of Rogerson (2002)’s model into a framework where contracts are renegotiated over time.<sup>8</sup> In doing so, we look for a theoretical modeling consistent with our data set. Considering a continuum of types is a prerequisite for evaluating a meaningful distribution of cost parameters in our empirical model. This allows us to neatly characterize the probabilities of various contractual regimes (cost-plus, fixed-price, and changes over time between those two options). This is an important preliminary step for our estimation procedure based on a maximum likelihood criterion.

*Empirical analysis.* Turning to the empirical part of our study, we consider a framework of limited commitment with renegotiation and estimate the structural parameters of the model. To understand the estimation bias that arises when wrongly assuming full commitment, it is useful to come back on the basic intuition behind 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 operators which are only mildly efficient may end up choosing fixed-price contracts at the renegotiation stage. Even though renegotiation brings efficiency gains, it also increases informational rents for the most efficient operators which makes them less eager to reveal their types at earlier stages of the relationship. From the public authorities’ point of view, renegotiation is more attractive *ex post* when the social value of managerial effort is greater so that the efficiency gains from renegotiation dominate its

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<sup>7</sup>Dewatripont (1989), Laffont and Tirole (1993, Chapter 10) and Laffont and Martimort (2002, Chapter 9) among others.

<sup>8</sup>Rogerson’s analysis is static and cannot by definition describe the rich dynamic patterns observed in our data set, in particular the steady increase in subsidies over time and the move towards fixed-price contracts as time goes on.

costs in terms of extra information rents left to operators. Neglecting the possibility of renegotiation and wrongly assuming that a full commitment regime prevails therefore amounts to underestimate the social value of managerial effort. This would introduce biases in the estimation of the distribution of innate costs that tend to overestimate information rents.

In our empirical analysis, we also estimate the weight of the operator's profit in the public authority's objective function. This weight depends on the political color of the public authority. In particular, right-wing municipalities are more prone to give up information rents to private operators.

Finally, using our estimates of the operator's innate cost distributions and other parameters of the model, we evaluate the welfare gains that would be obtained when moving to the full commitment solution. The intertemporal subsidies under full commitment are higher than under renegotiation, so that taxpayers are the net losers from a hypothetical increase in the contract length. However, the overall welfare gains are significant. Taxpayers bear an increase in tax burden of 8 million Euros whereas operators see their expected information rent increase by roughly 8.2 million Euros. This result clearly explains the operators' political activism in pushing for reforms that would increase contracts length.

*Literature review.* Our model borrows from 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) estimated the production function of a Californian water utility, and argued that regulatory mechanisms *à la* Baron and Myerson (1982) are used. 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) considered complex regulatory schemes to estimate costs and demand parameters of structural regulatory models. Other empirical studies argue instead that principals do not use such complex mechanisms. Bajari and Tadelis (2001) focused on the private construction industry in the U.S. and argued that most contracts are either cost-plus or fixed-price. The reason for such restricted menus 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. Considering contracts in the automobile insurance industry, Chiappori and Salanié (2000) restricted the analysis to simple menus with two types of coverage. In the field of transportation, Gagnepain and Ivaldi (2002) focused on the incentive effects of cost-plus and fixed-price contracts. They measured actual welfare related to real regulatory practices, and compared this measure to what would have been achieved if more complex second-best mechanisms were implemented. The present paper improves upon Gagnepain and Ivaldi (2002) by modeling contract design by public authorities and giving more attention to the dynamic choice of contracts by operators.

A second important feature of our empirical model is related to the dynamic nature of contractual relationships. Dionne and Doherty (1994) focused on the car insurance industry in California and suggested that insurers may use long-term contracts as a device to enhance efficiency and attract portfolios of dominantly low-risk drivers. Our empirical analysis shows how long-term contracts may benefit both the public authorities and the 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 influences the distribution of welfare among taxpayers, operators and consumers. Empirical tests on capture and ideology in politics are given in Kalt and Zupan (1984, 1990). Those papers provided 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.

*Organization of the paper.* Section 1 gives an overview of the French urban transportation sector. Section 2 presents our theoretical model and solves for the optimal menu of contracts (fixed-prices/cost-plus) both under full commitment and renegotiation. We derive the important property that subsidies increase over time under a renegotiation-proof scenario. Section 3 develops our empirical method. Section 4 evaluates the magnitude of the welfare gains when moving to full commitment but also the distribution of those gains between operators and taxpayers. Section 5 concludes by highlighting a few alleys for further research.<sup>9</sup>

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<sup>9</sup>Proofs of the theoretical model are developed in an Appendix.

# 1 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.<sup>10</sup> In 2002, these companies, with their respective type of ownership and market share (in terms of number of networks operated) were 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.

## 1.1 Economic Environment

The 1982 French Law was enacted to facilitate decentralized decision-making on urban transportation and to provide guidelines for regulation. As a result, each local authority now organizes 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. The local authority may operate the network directly or it may delegate that task to an operator. In this case, a formal contract defines the regulatory rules that the operator must follow as well as the cost-reimbursement scheme between the public authority and the operator.

Since 1993, beauty contests are in principle required to allocate the building and management of new infrastructures for urban transportation when the renewal contracts comes. However, and until recently, very few networks have changed operators from one regulatory period to the other. Documentary investigations shed light on the fact that awarding transport operations through tenders does not necessarily guarantee ex ante competition since local transport authorities usually receive bids from one single candidate, namely the operator already in place. Several reasons can potentially

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<sup>10</sup>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).

explain this phenomenon. First, local authorities are either reluctant to implement the law or do not have enough expertise to launch complex calls for tender. Second, the three groups owning most of the urban transport operators in France are located on specific geographical areas. This 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 public authorities to credibly punish operators following bad performances.

In most urban areas, operating costs are on average twice as high as commercial revenues. Budgets are rarely balanced without subsidies. One reason is that operators face universal service obligations and may have to operate in low demand areas. Low prices are maintained to ensure affordable access to all consumers of public transportation. Moreover, special fares are given to targeted groups like seniors and students. Subsidies come from the State's budget, the local authority's budget, and a special tax paid by local firms (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 avoid these deficits. This aspect is discussed in more details in the sequel.

Performing a welfare analysis of regulatory schemes 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 was 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. In France, this rich source is a unique tool for comparing regulatory systems both across space and over time. For our study and for homogeneity purposes, we have selected all urban areas of more than 100,000 inhabitants. Indeed, smaller cities may entail service and network characteristics that differ significantly from those in bigger urban areas. Discarding these smaller cities allows us to identify in a more satisfactory manner differences in inefficiencies and cost-reducing activities across operators. The sample does not include the largest networks of France, i.e., Paris, Lyon and Marseille, as they are not



covered by the survey. Overall, the panel data set covers 49 different urban transport networks over the period 1987-2001. Note finally that we focus only on transport networks where the operator is not public. This rules out the so-called *Regies municipales* where the service is provided by a public entity (this is mostly the case in large cities such as Paris, Lyon and Marseille). We may indeed expect that those cases are less concerned with the principal-agent problem at the heart of our investigation.

We assume that the network operator private information about its innate technology (adverse selection) and that its cost-reducing effort is non-observable (moral hazard). Because French local authorities exercise their new powers on transportation policy since the enactment of 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.<sup>11</sup> 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 aspects 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 management. 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.<sup>12</sup>

Before turning to the description of the contracts, three additional remarks should be made. First, private information on 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 is easily observed, and the regulator

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<sup>11</sup>The French urban transport expert O. Domenach has argued that "*the regulator is not able of determining the number of buses which is necessary to run the network. The same comment can be made regarding the fuel consumption of each bus. The regulators are generally general practitioners instead of transport professionals. Hence, the (re)negotiation of contracts between regulators and operators is not fair.*" See Domenach (1987).

<sup>12</sup>Gagnepain and Ivaldi (2002) confirmed through a test that adverse selection and moral hazard are two important features of the industry. They showed that a regulatory framework which encompasses these two ingredients performs well to explain data.

has a very precise idea of how the socio-demographic characteristics of a urban area fluctuate over time. Given the level of demand, the regulator sets the service capacity provided by the operator. Second, we do not address the issue of determining what should be the optimal rate-of-return on capital. The rolling stock is owned by the local government for a vast majority of networks. In this case, the regulator is responsible for renewing the vehicles, as well as guaranteeing a certain level of capital quality. Finally, we rule out the possibility of risk sharing in the contractual relationships between the operators and the regulators since the provision of transport services does not entail unpredictable cost fluctuations for the operators. Uncertainty on costs and demand is potentially relevant in small networks; as suggested above, we focus only on big networks, i.e., those above 100,000 inhabitants.

## 1.2 Regulatory Contracts

Several features of the regulatory contracts are worth emphasizing. As already mentioned, two types of regulatory contracts are implemented in the French urban transport industry. Over the period of observation, fixed-price contracts are employed in 55.5% of the cases. Fixed-price regimes are high-powered incentive schemes, while cost-plus regimes do not provide any incentives for cost reduction.

On average, contracts are signed for a period of 5 to 6 years, which in most cases allows us to observe 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 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 authority 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 local 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.

An important feature of the industry is that the volume of subsidies paid to the operator under a fixed-price regime depends on the contractual arrangement from one period to another. Subsidies are higher for fixed-price regimes when a cost-plus scheme is implemented in the previous period, compared to subsidies paid if a series of two fixed-price schemes is enforced. To establish that this feature is present in the data, we run a simple regression of the log subsidy paid on a set of covariates, which are the log number of vehicles in the operator’s rolling stock, the log size of the transport network in kilometers, whether the observed regulator is right-wing or not, whether the observed fixed-price contract is implemented after a cost-plus regime or not, and a set of firms fixed effects.<sup>13</sup> The *CF* dummy indicating that the observed fixed-price regime is implemented after a cost-plus scheme is positive and significant at the 1% level. On average, subsidies paid under fixed-price after a cost-plus are 40.9% higher than those given to the operator operated under a series of fixed-price regimes. In this paper, we will show that this important feature can be rationalized in a dynamic setting where regulators increase subsidies over time to give mildly efficient operators incentives to choose fixed-price regulatory arrangements instead of cost-plus regimes.

## 2 Theoretical Model

Our theoretical model takes into account the various features of the French urban transport industry stressed above and adapts the lessons of the contracting literature under imperfect commitment to fit those empirical features. First, in our regulatory framework, operators choose between either a fixed-price or a cost-plus contract. Second, contracts may evolve with increasing subsidies over time. We will argue below that such patterns arise 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 (the “principal”). Generalizing the objective functions used respectively in Baron and Myerson (1982) and Laffont and Tirole (1993), the preferences of this principal are defined as:

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

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<sup>13</sup>Estimation results are (392 observations, firms’ fixed effects included, standard errors in parenthesis):  $\log Subsidy = 4.87 + 0.68 \log Rolling\ Stock + 0.23 \log network - 0.11 Right-Wing + 0.34 CF.$   
(0.26) (0.05) (0.03) (0.03) (0.09)

The gross surplus  $S$  generated by the service is fixed. Implicitly, we consider a setting where the elasticity of demand is small even in the long-run which seems a reasonable assumption in the case of transportation.<sup>14</sup>

The local government's payment to the firm (the "agent") depends on 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  $c$ . With a cost-plus contract, the principal reimburses the cost  $c$  incurred by the firm and  $t(c) \equiv c$  for all  $c$ . Raising subsidies from the local government's general budget with distortionary taxation entails some dead-weight loss that is captured by introducing a cost of public funds  $\lambda > 0$ .

Local public authorities might 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. The parameter  $\alpha$  might also capture the firm's bargaining power at the time of awarding franchises and reflect *ex ante* competition.<sup>15,16</sup>

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. Rightist (resp. leftist) local governments are certainly more eager to commend more (resp. less) rent for the private firm.<sup>17</sup>

Turning 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  $\theta$ , the innate efficiency of the service, and a cost-reducing managerial effort  $e$ . We postulate the standard functional form:

$$c = \theta - e.$$

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<sup>14</sup>Oum et al. (1992).

<sup>15</sup>In this sector, *ex ante* competition is not so fierce. Indeed, different operators avoid head-to-head competition and generally make tenders for markets in distinct urban areas. The decision n<sup>o</sup> 05-D-38 of the French *Conseil de la Concurrence* shows that competition authorities are well-aware of this downstream collusion between potential operators. In more than 60 % of cases, there is indeed only a single bidder. This potential horizontal collusion is captured in ad hoc way in our framework through the parameter  $\alpha$ . The benefit of such ad hoc specification of the intensity of potential downstream competition is to fit real-world practices while it fortunately eases the analysis of the contractual dynamics.

<sup>16</sup>Following the insights of Baron (1989), Laffont (1996) and Faure-Grimaud and Martimort (2003), these preferences might also result from the fight of various political forces within local public authority.

<sup>17</sup>Laffont (1996) developed related political economy models of regulation relying on such arguments.

Effort is costly for the firm's management and the corresponding non-monetary disutility function  $\psi(e)$  is increasing and convex ( $\psi' \geq 0$ ,  $\psi'' > 0$ ) with  $\psi(0) = 0$ . The intrinsic efficiency parameter  $\theta$  is drawn once and 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.<sup>18</sup>

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 public authority.

## 2.1 Full Commitment

In this section, we assume that the local government offers a long-term contract which covers two contracting periods and he has all bargaining power at the contracting stage. The principal can commit to any pattern of subsidies and cost reimbursement rules over time. Of course, it is when the principal has such ability to commit that he can 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  $\delta$  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. In period  $i$ , the regulatory payment is thus  $t_i(c) = b_i$ . With such a fixed-price contract, the principal is able to pass onto the operator 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.<sup>19</sup> Such a long-term contract

<sup>18</sup>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 to a large extent idiosyncratic.

<sup>19</sup>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 its shareholders is encapsulated into the  $\psi(\cdot)$  function.

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 operator is reimbursed for his costs so that he exerts no effort and his payoff is zero.<sup>20</sup>

Only the most efficient operators such that  $\theta \leq \theta^*$  choose fixed-price contracts. By incentive compatibility, if any given type prefers a fixed-price contract, it must be that all types which are more efficient also do so. The types space is thus split into two subsets. Efficient operators take fixed-price contracts whereas inefficient operators are on cost-plus contracts.

The corresponding cut-off  $\theta^*$  characterizes a marginal operator who is just indifferent between choosing either the long-term cost-plus or the fixed-price contracts:

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

In particular, the most efficient operators such that  $\theta \leq \theta^*$  earn an information rent worth  $\theta^* - \theta$  whereas inefficient operators such that  $\theta \geq \theta^*$  earn no such rent.<sup>21</sup>

Although the public authority offers a menu of two possible long-term contracts with either fixed-price or cost-plus in both periods, the actual choice made by the operator consists in selecting only one item. From an empirical point of view, the econometrician is only able to observe the resulting choice made by operators, i.e., a single choice (either long-term fixed-price or cost-plus) and not the specific negotiation process that leads to this choice. Details of the negotiation remain unknown. This process is captured in our theoretical model, and following the mechanism design tradition, by having principals offering not a single offer but instead menus among which agents with different types self-select.

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<sup>20</sup>The operator is not responsible for improving the quality of the service since the latter is set by the local authority and focuses on cost-reducing effort only. Quality entails various dimensions of the public transit operations such as the size of the network, the number and size of lines, the number of stops, the frequency of the service, and the age of the rolling stock.

<sup>21</sup>The operator's choice between taking either a long-term fixed price contract or a cost-plus one reveals information on his type. After this choice becomes publicly known, the public authority can assess whether that type is above the threshold  $\theta^*$  or not. Under full commitment, the public authority does not use such information to refine contractual offers in the future since no such offer is ever made.

The principal's intertemporal welfare under full commitment can be expressed as:

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

The term  $(\beta b_1 + (1 - \beta)b_2) F(\beta b_1 + (1 - \beta)b_2 + k)$  represents the expected subsidy under a long-term fixed-price contract knowing that only a mass of those type worth  $F(\beta b_1 + (1 - \beta)b_2 + k)$  is ready to accept such contract. The term  $\int_{\beta b_1 + (1 - \beta)b_2 + k}^{\bar{\theta}} \theta f(\theta) d\theta$  is meant for the expected payment under a cost-plus contract. Finally, the last term represents the expected information rent which is left only to the most efficient firms under the fixed-price contract.

Optimization of this 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:*

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

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

Under full commitment, the optimal contract is the twice replica of the optimal static contract: a by-now standard result in the dynamic contracting literature.<sup>22</sup> Given that the economic environment is stationary, there is no reason to move from a cost-plus to a fixed-price contract over time. This explains why we initially focused on the binary choice between either a long-term fixed-price or a long-term cost-plus contract and do not consider asymmetric dynamic patterns with cost-plus contracts followed by fixed-prices for instance. Such profiles are certainly suboptimal under full commitment although, as we will see, they play a significant role under limited commitment.

<sup>22</sup>Baron and Besanko (1984) and Laffont and Martimort (2002, Chapter 8) for similar results in more general environments.

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 also leaves 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) is as follows. Suppose that the principal offers a fixed subsidy  $b$  in both period. By raising this subsidy by  $db$ , the principal ensures that with probability  $f(b+k)db$ , a firm with type in the interval  $[b+k, b+k+db]$  will now exert effort  $e^*$  which generates 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 nevertheless 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 information rent and solves:

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

Simplifying yields (1).

Increasing  $k$  or  $\alpha$  increases the optimal subsidy  $b^F$ . Intuitively, when the firm's effort is more socially valuable or when its rent is given a greater weight by the public authority, the optimal subsidy under a fixed-price contract should be raised to induce more firms to operate under higher powered incentives which commands more rent for those firms.

## 2.2 Renegotiation

**Overview and modeling choices.** The full commitment assumption used in Section 2.1 turns out to be misleading in view of real-world practices as explained above. Although the 1993 Law invites local authorities to re-auction the concession for a fixed period of 5 years, these authorities are either reluctant to really implement the law or do not have enough expertise to launch complex calls for tenders. In practice, local authorities consider the requirement of re-auctioning the contract at fixed dates as the opportunity to renegotiate a contract with the incumbent (the so-called "historical operator") instead



of really envisioning the possibility to contract with a new operator.

Theory has 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.<sup>23</sup> The second paradigm 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.<sup>24</sup> 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 paradigm 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 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 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 brings “bad news.” In a dynamic environment, information on the cost structure is revealed over time and the principal would like to draft new agreements that incorporate this new knowledge. In particular, an increase over time in the subsidies under fixed-price contracts allows operators who have revealed themselves as being not very efficient earlier on to achieve productivity gains later on. Such increases in subsidies might thus be viewed as *ex post* attractive from the principal’s viewpoint. However, these *ex post* efficiency gains also come with *ex ante* costs so that, overall, renegotiation is costly from the principal’s viewpoint. Some of the most efficient firms may indeed prefer adopting cost-

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<sup>23</sup>Dewatripont (1989), Laffont and Tirole (1993, Chapter 10), Hart and Tirole (1988) and Rey and Salanié (1996) in adverse selection contexts.

<sup>24</sup>Guesnerie, Freixas and Tirole (1985) and Laffont and Tirole (1993, Chapter 9) among others.

plus contracts earlier on to enjoy the greater subsidies that future fixed-price contracts will bring later on. This important dynamic trade-off and its impact on information revelation are at the core of our model.

**Menus of contracts.** To fit with patterns of contracting found in our data set, we allow the principal to make an initial offer entailing a whole menu of options: A long-term fixed-price contract, a first-period cost-plus contract followed by a second-period fixed-price and a long-term cost-plus contract.

Denote by  $C_1^0 = (b_1, b_2^0)$  the subsidies under a long-term fixed-price contract, and by  $C_2^0 = (\theta, b_3^0)$  those if a fixed-price contract is only taken at date 2 whereas a cost-plus contract is used at date 1 (taking into account that effort is then zero at this date). Let  $C_3^0 = (\theta, \theta)$  denote a long-term cost-plus contract which reimburses costs in each period and induces no effort. Let also define by  $C^0 = (b_1, b_2^0, b_3^0)$  the overall menu of subsidies offered at the initial contracting stage. Let finally denote by  $R^0 = (b_2^0, b_3^0)$  the continuation of  $C^0$  for date 2.

**Timing.** Let us describe the timing of the contracting game.

- Date 0: The firm learns its efficiency parameter  $\theta$ .
- Date 0.25: The principal commits to a menu  $(C_1^0, C_2^0, C_3^0) \equiv C^0 = (b_1, b_2^0, b_3^0)$ .
- Date 0.50: The firm makes its choice among those three possible options. 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 according to the contract enforced at that date.
- Date 1.25: If he wishes so, the principal makes a renegotiated offer corresponding to a new subsidy. Depending on whether the firm has already accepted  $C_1^0$  or made another choice (i.e., either  $C_2^0$  or  $C_3^0$ ) the renegotiated subsidy following each of those paths is denoted respectively by  $\tilde{b}_2$  or  $\tilde{b}_3$ .
- Date 1.50: The firm chooses whether to accept this new offer or not and chooses his second-period effort accordingly. If the offer is refused, the initial contract  $C_i^0$  (be it a fixed-price or cost-plus for the second-period) is enforced. Otherwise the new renegotiated offer supersedes the initial contract.

- Date 2: Second-period costs are realized and payments are made.

Let respectively index by  $j = G, I, B$ , the three following different histories. First, the agent may choose the long-term fixed-price contract  $C_1^0$  which is “good news” on his type. Second, the agent may choose the fixed-price contract for the second-period only  $C_2^0$  which is “intermediate news”. Finally, the agent may choose the long-term cost-plus contract  $C_3^0$  with no subsidies in either period which is “bad news”.

Let denote  $\tilde{R} = (\tilde{C}_2, \tilde{C}_3) \equiv (\tilde{b}_2, \tilde{b}_3)$  any profile of subsidies offered at the renegotiation stage following the initial offer  $C^0$ .<sup>25</sup>

**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 menu  $C^0$  at date 1, but might offer a renegotiated offer  $\tilde{R}$  at date 2. This second-period offer is made once the principal has already updated his beliefs over the firm’s type parameter following the latter’s first-period decision.
- **Firm’s strategy.** The firm anticipates (perfectly in equilibrium) what the second period subsidies may be following renegotiation. Denote those anticipated subsidies as  $R = (b_2, b_3)$ . The firm follows a cut-off strategy which gives the following pattern of information revelation.

1. Types in the interval  $\Theta_G = \left[ \underline{\theta}, b_1 + k + \frac{1-\beta}{\beta}(b_2 - b_3) \right]$  adopt already contract  $C_1^0$  anticipating that  $b_2^0$  and  $b_3^0$  will be renegotiated respectively to  $b_2$  and  $b_3$ . The cut-off type  $\theta_1^* = b_1 + k + \frac{1-\beta}{\beta}(b_2 - b_3)$  is just indifferent between taking the long-term fixed-price contract with subsidies  $(b_1, b_2)$  and a first-period cost-plus contract followed by a second-period fixed-price with subsidy  $b_3$ .
2. Types in the interval  $\Theta_I = [b_1 + k + \frac{1-\beta}{\beta}(b_2 - b_3), b_3 + k]$  choose contract  $C_2^0$  with the same anticipations than above. The cut-off type  $\theta_2^* = b_3 + k$  is just indifferent between taking a first-period cost-plus contract followed by a fixed-price  $b_3$  and taking a cost-plus contract covering both periods.
3. Types in the interval  $\Theta_B = [b_3 + k, \bar{\theta}]$  choose contract  $C_3^0$  anticipating the renegotiated fixed-price offer won’t be attractive for them anyway.

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<sup>25</sup>We omit the dependence of  $\tilde{R}$  on  $C^0$  for notational simplicity.

This pattern summarizes incentive compatibility in this dynamic environment. For instance, if the cut-off type  $\theta_1^*$  is just indifferent between adopting subsidies in both periods or only at date 2, more efficient types  $\theta \leq \theta_1^*$  certainly also prefer subsidies in both periods. Those types reveal that they belong to the interval  $\Theta_G$ .

**“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 his beliefs with the more precise information obtained by observing first-period costs if the firm has chosen a cost-plus contract for that period and has indeed been reimbursed for its first-period cost. This justifies the use of the qualifier “almost” for our notion of equilibrium.<sup>26</sup>

**Renegotiation.** The theoretical literature on renegotiation has shown that focusing on renegotiation-proof mechanisms which come unchanged through the renegotiation process is without loss of generality.<sup>27</sup> 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 continuation for the second period which is equal to this renegotiated offer. This second-period offer is not itself superseded by any new

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<sup>26</sup>Let instead assume that the principal is instead fully rational and updates his beliefs following all possible realizations of first-period cost. Inefficient firms under a first-period cost-plus contract would certainly not fully reveal their type in the first-period and, anticipating future renegotiation of the contract, might claim having the worst possible first-period cost  $c_1 = \bar{\theta}$ . This strategy increases the firm’s information rent for the first period and it also hides valuable information away from the fully rational principal in view of the second-period contracting. Suppose instead that a firm with innate cost  $\theta$  was to adopt a more naive first-period behavior and reveal its type not anticipating the subsequent use of that information by the principal. Such fully rational principal would just learn the firm’s type  $c_1 = \theta$  by observing and reimbursing the realized first-period cost. Then, for the second period, that principal would recommend to that operator to work at cost  $c_2^* = \theta - e^*$  and would just compensate the firm for incurring that first-best effort. This is clearly a naive strategy for the firm because hiding information early on may induce the principal to increase subsidies at the renegotiation stage and the operator can grasp some second-period rent by doing so.

If real-world practices were in lines with such strategy, one would observe mass points of observations for cost-plus contracts. This certainly contradicts our data set where no such masses in realized costs are found with cost-plus contracts. Moreover, assuming that regulators have limited rationality is fair given their poor expertise capacity, as described in Section 1.1.

Our modeling strategy of having an “almost” rational principal who updates his beliefs only with the rough information revealed by the first-period choice  $C_i^0$  is therefore relevant. Our model keeps then all the flavor of the dynamic rent/efficiency trade-off familiar from the theoretical literature on renegotiation without rendering the analysis untractable in our context with a continuum of types. It also satisfies our desire of making the theoretical model as close as possible to the existing data set.

<sup>27</sup>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) showed 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 number of possible types.

contract 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 as we now show.

Consider indeed a profile of renegotiated offers  $\tilde{R} = (\tilde{b}_2, \tilde{b}_3)$ . To be accepted at the renegotiation stage, such subsidies must satisfy the following constraints:

$$\tilde{b}_2 \geq b_2^0 \text{ and } \tilde{b}_3 \geq b_3^0. \quad (2)$$

The first inequality in (2) stipulates that types in  $\Theta_G$  can always refuse any renegotiated offer following history  $j = G$  if it does not increase the second-period subsidy above  $b_2^0$  and thus their payoff. The second inequality is similar for types in  $\Theta_I$ .

Fix now any initial contract  $C^0$  and renegotiated offer  $\tilde{R}$  that satisfies (2). Given the agent's conjectures about the renegotiated subsidies  $R = (b_2, b_3)$  (which are correct at equilibrium), the principal's expected welfare at date 2 can be written as:

$$W_2(C^0, \tilde{R}, R) = \int_{\underline{\theta}}^{b_1+k+\frac{1-\beta}{\beta}(b_2-b_3)} \left( S - (1+\lambda)\tilde{b}_2 + \alpha(\tilde{b}_2 + k - \theta) \right) f(\theta) d\theta \quad (3)$$

$$+ \int_{b_1+k+\frac{1-\beta}{\beta}(b_2-b_3)}^{\tilde{b}_3+k} \left( S - (1+\lambda)\tilde{b}_3 + \alpha(\tilde{b}_3 + k - \theta) \right) f(\theta) d\theta \quad (4)$$

$$+ \int_{\tilde{b}_3+k}^{\bar{\theta}} (S - (1+\lambda)\theta) f(\theta) d\theta. \quad (5)$$

This expression takes into account that operators with types in  $[\underline{\theta}, b_1 + k + \frac{1-\beta}{\beta}(b_2 - b_3)]$  are already committed to a long-term fixed price contract anticipating the equilibrium subsidies for the second period. They nevertheless welcome any principal's deviation that increases the second-period subsidy  $\tilde{b}_2$  above  $b_2$  at the renegotiation stage and the principal's payoff from such deviation must be computed with this new subsidy. This gives us a contribution to expected second period welfare equal to the first-term in (3). Operators with types in  $[b_1 + k + \frac{1-\beta}{\beta}(b_2 - b_3), b_3 + k]$  are committed to operate under a fixed-price contract only in the second period. But increasing this subsidy from  $b_3$  to  $\tilde{b}_3$  attracts some even less efficient operators who are now willing to operate under a fixed-price contract whereas the most inefficient types in  $[\tilde{b}_3 + k, \bar{\theta}]$  remain on a cost-plus. This yields the expressions of the last two terms (4) and (5).

At date 1.25, the principal looks for a menu that maximizes this expression subject

to condition (2). The renegotiated offers  $R = (b_2, b_3)$  must solve the following problem:

$$(\mathcal{R}^0) : \quad R = \arg \max_{\tilde{R}} W_2(C^0, \tilde{R}, R) \text{ subject to (2).}$$

In the sequel, we will focus on profiles of subsidies that come unchanged through the renegotiation process. This restriction is warranted because the following Renegotiation-Proofness Principle holds in our context.

**Proposition 2** *There is no loss of generality in restricting the analysis to contracts of the form  $C = (b_1, R)$  that come unchanged through the renegotiation process, i.e., such that  $R$  solves*

$$(\mathcal{R}) : \quad R = \arg \max_{\tilde{R}} W_2((b_1, R), \tilde{R}, R) \text{ subject to}$$

$$\tilde{b}_2 \geq b_2 \text{ and } \tilde{b}_3 \geq b_3. \quad (6)$$

The whole theoretical literature on renegotiation focuses on cases where the agent's type is drawn from distributions with discrete supports. Working in a model with a continuum of types as we do here is important for two reasons. First, it clarifies the pattern of information revelation, i.e., how types with intermediate efficiency parameters end up adopting fixed-price contracts in the second period and how the corresponding subsidies increase over time. Second, it is also necessary to take into account the significant heterogeneity in the firm's realized costs that comes from our data set. As we show below, a model with a continuum of types provides a nice division of the space of types into three intervals whose respective probabilities (obtained from the equilibrium behavior of cut-off types that define those intervals) can be matched with the empirical distribution of behaviors observed in our data. Models with discrete types might allow a more detailed analysis of the pattern of information revelation and are thus attractive from a theoretical point of view. However, such models are not consistent with our data set. As we argued above, mass points in the distribution of realized costs are not found in our data.

**Renegotiation-proof profiles.** Let us now characterize renegotiation-proof allocations.

**Proposition 3** *A first-period menu of contracts  $C = (b_1, b_2, b_3)$  is renegotiation-proof if and only if the two following conditions hold:*

$$b_3 \geq \beta b_1 + (1 - \beta)b_2, \quad (7)$$

$$kf(b_3 + k) - \left(1 - \frac{\alpha}{1 + \lambda}\right) \left(F(b_3 + k) - F\left(b_1 + k + \frac{1 - \beta}{\beta}(b_2 - b_3)\right)\right) \leq 0. \quad (8)$$

Condition (7) ensures that the interval  $\Theta_I$  is non-empty. It is just a feasibility condition on the possible subsidies profiles that are relevant. Condition (8) expresses the fact that raising the second-period subsidy for those firms which have revealed themselves as being of an intermediate type by taking contract  $C_2^0$  is not an attractive strategy for the principal. The efficiency gains  $(1 + \lambda)kf(b_3 + k)db$  obtained when increasing the subsidy  $b_3$  by an amount  $db$  (so that the marginal type  $\theta_2^*$  who is just indifferent between taking the long-term cost-plus contract and a fixed-price contract for the second period only moves up) should be less than the net cost of raising the rent of all inframarginal who already chose  $C_2^0$  and enjoy that subsidy increase. That cost is worth  $(1 + \lambda - \alpha)(F(b_3 + k) - F(\theta_1^*))db$ .<sup>28</sup>

**Optimal renegotiation-proof menus of contracts.** Define the principal's intertemporal welfare when offering  $C = (b_1, b_2, b_3)$  as:

$$\begin{aligned} \mathcal{W}(C) = & \int_{\underline{\theta}}^{b_1 + k + \frac{1 - \beta}{\beta}(b_2 - b_3)} (S - (1 + \lambda)(\beta b_1 + (1 - \beta)b_2) + \alpha(\beta b_1 + (1 - \beta)b_2 + k - \theta)) f(\theta) d\theta \\ & + \int_{b_1 + k + \frac{1 - \beta}{\beta}(b_2 - b_3)}^{b_3 + k} (S - (1 + \lambda)(\beta \theta + (1 - \beta)b_3) + \alpha(1 - \beta)(b_3 + k - \theta)) f(\theta) d\theta \\ & + \int_{b_3 + k}^{\bar{\theta}} (S - (1 + \lambda)\theta) f(\theta) d\theta. \end{aligned}$$

The optimal renegotiation-proof menu solves the following optimization problem:

$$(\mathcal{P}^R) : \quad \max_C \mathcal{W}(C) \text{ subject to (7) and (8).}$$

The solution  $C^R = (b_1^R, b_2^R, b_3^R)$  to problem  $(\mathcal{P}^R)$  is straightforward. Assuming quasi-concavity in  $(b_1, b_2, b_3)$  of the corresponding Lagrangean, it is characterized as follows.

<sup>28</sup>Taken altogether, a constant subsidy profile  $b_1 = b_2 = b_3 = b^F$  and the cut-off rule  $\theta_1^* = b^F + k$  never satisfy (8). The optimal long-term contract under full commitment and the corresponding pattern of information revelation are not renegotiation-proof. Intuitively, upon learning that the firm is rather inefficient following its earlier choice of producing under a cost-plus contract, the principal wants to slightly raise the second-period subsidy to increase efficiency. Clearly, a firm with a type close to (but below)  $\theta_1^* = b^F + k$  refuses the first-period subsidy because it gives little rent. It prefers to take a first-period cost-plus contract and wait for the increase in the second-period subsidy which comes out of the renegotiation towards a second-period fixed-price contract.

**Proposition 4** *The optimal renegotiation-proof menu of contracts  $C^R = (b_1^R, b_2^R, b_3^R)$  entails the following properties.*

- *The long-term fixed-price contract  $b_1^R = b_2^R = \underline{b}^R$  and the short-term fixed-price contract for the second period only with  $b_3^R = \bar{b}^R$  altogether satisfy*

$$k = \left(1 - \frac{\alpha}{1 + \lambda}\right) \left( R \left( \underline{b}^R + k + \frac{1 - \beta}{\beta} (\underline{b}^R - \bar{b}^R) \right) + \frac{\mu}{\beta(1 + \lambda)} \right), \quad (9)$$

$$k = \left(1 - \frac{\alpha}{1 + \lambda}\right) \left( \frac{F(\bar{b}^R + k) - F\left(\underline{b}^R + k + \frac{1 - \beta}{\beta} (\underline{b}^R - \bar{b}^R)\right)}{f(\bar{b}^R + k) - f\left(\underline{b}^R + k + \frac{1 - \beta}{\beta} (\underline{b}^R - \bar{b}^R)\right)} \right) - \mu \frac{\left( \left(1 - \frac{\alpha}{1 + \lambda}\right) \left( \frac{f(\bar{b}^R + k)}{1 - \beta} + \frac{f\left(\underline{b}^R + k + \frac{1 - \beta}{\beta} (\underline{b}^R - \bar{b}^R)\right)}{\beta} \right) - \frac{k f'(\bar{b}^R + k)}{1 - \beta} \right)}{(1 + \lambda) \left( f(\bar{b}^R + k) - f\left(\underline{b}^R + k + \frac{1 - \beta}{\beta} (\underline{b}^R - \bar{b}^R)\right) \right)} \quad (10)$$

where  $\mu > 0$  is the Lagrange multiplier of (8).

- *Subsidies are increasing*

$$\bar{b}^R > \underline{b}^R. \quad (11)$$

- *The renegotiation-proofness constraint (8) holds as an equality*

$$k f(\bar{b}^R + k) = \left(1 - \frac{\alpha}{1 + \lambda}\right) \left( F(\bar{b}^R + k) - F\left(\underline{b}^R + k + \frac{1 - \beta}{\beta} (\underline{b}^R - \bar{b}^R)\right) \right). \quad (12)$$

Our model of limited commitment predicts thus increasing profiles of subsidies in the following sense: types who choose only a second-period fixed-price contract receive greater subsidies than those who choose fixed-price arrangements earlier on.

### 3 Empirical Model

We now turn to the empirical part of our analysis. Our objective is to assess the welfare gains that could be obtained if parties to the contract could fully commit instead of the current limited commitment situation. To do so, we first need to estimate the ingredients under renegotiation scenario. We organize this empirical section as follows. First, Section 3.1 presents our data and the different variables that enter the estimation procedure. Second, we explain in Section 3.2 how we are able to recover missing



items of the menus of subsidies which are offered to the operators. Then, we present in Section 3.3 the procedure which allows us to estimate the ingredients of our limited commitment scenario. Results follow in Section 3.4.

### 3.1 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 the limited commitment 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. Such information is required to recover the distribution of the efficiency parameter. 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. Subsidies are deflated using consumer price indexes (all items) for France. Only real subsidies are used during the estimation process.

The characteristics of the operators 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 which owns the operator. We thus assume that some firms are more likely to perform efficiently than others due to intrinsic advantages of larger stakes, size, managerial practices and concentration of skills.

The size of the network is its total length 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 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, population size for the total urban area where the service is provided, and the political color of the local regulator. As explained before, the urban network may include several municipalities. We observe the number of cities in 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*. 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). We restrict the political landscape to two groups, i.e., left-wing, and right-wing.

**Definition of a contractual period and network selection.** Our raw dataset includes 49 networks observed over the 1987-2001 period. As each contractual period lasts for 5 to 6 years, although there are some exceptions and some missing data, our database contains 136 contracts, i.e., three contracts on average per network. Very few cases entail networks where 1, 2, or 4 contracts are observed.<sup>29</sup>

In order to compute the distribution of  $\theta$ , we use all the contracts of our dataset since we are interested in the probabilities of choosing one series of contracts among all the possible arrangements (see results in Table 4). Then, to estimate the parameters

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<sup>29</sup>Note that using series of more than two contracts for a network is not incompatible with our two-period theoretical model. If a series of fixed-price regimes or a series of cost-plus regimes is considered, we keep all the contractual periods for our empirical analysis, given that the subsidies are constant from one period to another. When considering series where a fixed-price regime is implemented after a cost-plus, we restrict our attention to two-period contractual arrangements after the arrival of a new local government.

of interest in Proposition 4, we restrict this last sample to fixed-price contracts only, given that this proposition focuses on short-term and long-term fixed-price regimes. This yields a final sample of 80 contracts.<sup>30</sup> (See results in Table 5).

Note that having series of more than two contracts for one network is not that our period of observation is an instantaneous picture of the regulation of the industry.

### 3.2 Menus of Subsidies: Recovering Missing Information

The limited commitment scenario corresponds to different observations with series of fixed-price contracts, cost-plus contracts, or cost-plus contracts followed by fixed-price contracts. The efficiency  $\theta$  of each operator, and therefore the subsidies  $\underline{b}^R$  and  $\bar{b}^R$  of the proposed menu affect the operator's choice of contract. A renegotiation-proof scenario corresponds to the following possibilities.

- A series  $FF$  of two fixed-price contracts over two contracting periods. The operator is rather efficient ( $\theta \leq \theta_1^* = \underline{b}^R + k + \frac{1-\beta}{\beta}(\underline{b}^R - \bar{b}^R)$ ).
- A cost-plus contract followed by a fixed-price contract ( $CF$  herein). The operator is only mildly efficient ( $\theta_1^* \leq \theta \leq \theta_2^* = \bar{b}^R + k$ ).
- A series of two cost-plus contracts ( $CC$  herein). The operator is rather inefficient ( $\theta \geq \theta_2^*$ ).

To exploit the two cut-offs  $\theta_1^*$  and  $\theta_2^*$  in order to recover the distribution of  $\theta$ , we need to observe the subsidies ( $\underline{b}^R$  and  $\bar{b}^R$ ) specified in an optimal menu of contracts. Unfortunately, our data do not allow us to observe all subsidies included into a renegotiation-

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<sup>30</sup>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 data set 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 i.i.d. 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 some items may fluctuate over the contract period, they constitute the objectives 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 contract-year as a separate observation so that the number of degrees of freedom of our study is increased. This is why the number of observations is much larger in practice than the number of contracts.

proof menu. Instead, only the actual subsidies paid to the operators are available. Hence, if the contractual arrangement is respectively

- $FF$ , we observe  $\underline{b}^{FF}$  directly in the data and we need to recover  $\bar{b}^{FF}$ ,
- $CF$ , we observe  $\bar{b}^{CF}$  directly in the data and we need to recover  $\underline{b}^{CF}$ ,
- $CC$ , we need to recover  $\bar{b}^{CC}$ .

We propose to recover the missing values of  $\bar{b}^{FF}$ ,  $\underline{b}^{CF}$ , and  $\bar{b}^{CC}$  empirically. In each municipality  $i$ , we expect all these subsidies to depend on a set  $Y$  of characteristics which pertain to the regulating authority, the operator, and the transportation service itself. We write

$$\underline{b}_i^R = \underline{B}(Y_i, \tau) + \epsilon_i, \quad (13)$$

$$\bar{b}_i^R = \bar{B}(Y_i, \nu) + \varkappa_i, \quad (14)$$

where  $\epsilon_i$ , and  $\varkappa_i$  are two error terms. The *engineering* relationships between the set of variables  $Y_i$  and each level of subsidy  $b_i$  are identified through two distinct vectors of parameters  $\tau$  and  $\nu$ , which have to be estimated. We thus expect to identify two distinct marginal impacts of a given characteristic on the choice of  $\underline{b}^R$  and  $\bar{b}^R$ . According to our theoretical model, we need to check that  $\underline{b}_i^R < \bar{b}_i^R$ . We verify *ex post*, i.e., on our estimates, that these inequalities hold.

The estimation procedure works then as follows. (i) If we select in our dataset  $FF$  arrangements only, the observed subsidies are the  $\underline{b}_i^R$ . Using observations  $Y_i^{FF}$  related to these specific arrangements, we obtain maximum likelihood estimates of  $\tau$ . We then derive the value  $\hat{\underline{b}}_i^{CF}$  using our estimates  $\tau$  and a set of characteristics  $Y_i^{CF}$  if a  $CF$  arrangement is instead considered. (ii) Likewise, if we select in our dataset  $CF$  arrangements only, the observed subsidies are the  $\bar{b}_i^R$ . Using observations  $Y_i^{CF}$  for these specific arrangements, we obtain maximum likelihood estimates of  $\nu$ . We then derive the value  $\hat{\underline{b}}_i^{FF}$  (resp.  $\hat{\underline{b}}_i^{CC}$ ) using our estimates  $\nu$  and a set of characteristics  $Y_i^{FF}$  (resp.  $Y_i^{CC}$ ) if a  $FF$  (resp.  $CC$ ) arrangement is considered.

### 3.3 Limited Commitment

With the estimates  $\hat{b}^{FF}$ ,  $\hat{b}^{CF}$ , and  $\hat{b}^{CC}$  in hands, we now estimate other parameters of the model under the limited commitment scenario.<sup>31</sup> We apply a two-step estimation procedure. In the first step, we focus on the operator's side. Given the menu of contracts designed by the regulator, the operator chooses the contract that maximizes his payoff. Since we observe the contract choice, subsidy levels, as well as several characteristics of the operator, we are able to identify several features such as the distribution of efficiency  $\theta$  or the social value of effort  $k$ . Once these ingredients are identified, we turn to the principal's side in order to recover missing information and especially his preferences parameter  $\alpha$  for the operator's rent.

From Proposition 4, the optimal renegotiation-proof menu entails subsidies  $(\underline{b}^R, \bar{b}^R)$  which satisfy the renegotiation-proofness constraint (12).<sup>32</sup> The parameters  $k$ ,  $\alpha$ ,  $\lambda$ , and  $\beta$  are unknown to the econometrician and need to be estimated. Also, the monotone hazard rate  $R(\cdot)$  is a priori unobserved and needs to be identified. To do so, we take a parametric approach and assume that the distribution  $F(\cdot, \nu_{lc}, \sigma_{lc})$  is normal with mean  $\nu_{lc}$ , variance  $\sigma_{lc}$  and density  $f(\cdot, \nu_{lc}, \sigma_{lc})$ .<sup>33</sup>

Our goal is to estimate the renegotiation-proofness equation together with the normal distribution  $F(\cdot, \nu_{lc}, \sigma_{lc})$  of  $\theta$ . The unobserved parameters might vary across networks. Hence, we rewrite (12) as

$$-k_i f\left(\bar{b}_i^R + k_i, \nu_{lc}, \sigma_{lc}\right) + \left(1 - \frac{\alpha_i}{1 + \lambda}\right) \left(F\left(\bar{b}_i^R + k_i, \nu_{lc}, \sigma_{lc}\right) - F\left(\underline{b}_i^R + k_i + \frac{1 - \beta}{\beta} (\underline{b}_i^R - \bar{b}_i^R), \nu_{lc}, \sigma_{lc}\right)\right) = 0, \quad i = 1, \dots, N. \quad (15)$$

Again, we may observe or recover each of the two variables  $\underline{b}_i^R$  and  $\bar{b}_i^R$ , depending on which contractual arrangement is observed. In particular, we consider the pair

<sup>31</sup>For ease of exposition, we omit the labels  $FF$ ,  $CF$ , or  $CC$  in what follows.

<sup>32</sup>We omit the superscript  $R$  in what follows.

<sup>33</sup>Our theoretical model assumes finite support for the distribution of innate costs. This is mainly to avoid negative cost parameters. In our empirical analysis, those events have very low probabilities and we simplify the analysis by using normal distributions. Note that using a normal guarantees us that our estimated distribution has short flat tails, i.e., a very small share of the operators rests within the tails of the probability distribution. Using distributions supported on a bounded interval, such as the Beta or the truncated normal, is not unproblematic. A beta distribution would impose a strong normalization on costs, which is potentially damageable for the relevance of our structural model. At the same time, identifying the additional parameters of a truncated normal is not feasible with the data we have at hand.

$(\underline{b}_i^R, \widehat{b}_i^R)$  if the observed arrangement is  $FF$ , and  $(\widehat{b}_i^R, \bar{b}_i^R)$  if it is  $CF$ . The social value of effort  $k$ , as well as the weight  $\alpha$  given by the regulator to the operator's utility, 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:

$$k_i = k(X_i, \varphi), \quad (16)$$

$$\alpha_i = \alpha(Z_i, \chi), \quad (17)$$

where  $\varphi$  and  $\chi$  are two vectors of parameters to be estimated. Moreover, we cannot identify separately the weight  $\alpha$  on the operator's profit and the cost of public funds  $\lambda$  since only the ratio  $\frac{\alpha}{1+\lambda}$  matters in Equation (12). We will thus let  $\lambda$  take several values which are consistent with the cost of an administration operating in a developed country.<sup>34</sup> Note that here we only present estimation results when  $\lambda = 0.3$ . Alternative estimates of  $\alpha$  can easily be calculated when  $\lambda \neq 0.3$ .

To be estimated, Equation (15) is rewritten as

$$J(\underline{b}^R, \bar{b}^R, k_i, \alpha_i, \lambda, \nu_{rp}, \sigma_{lc}, \xi_i) = 0, \quad (18)$$

where  $\xi_i$  is an error term.

The estimates  $\widehat{\alpha}_i$  are obtained from (18). Moreover, the estimates  $\widehat{\nu}_{rp}$ ,  $\widehat{\sigma}_{rp}$ ,  $\beta$ , and  $\widehat{k}_i$  are derived from the estimation of the distribution of  $\theta$ .

To recover the mean and standard deviation for the normal distribution  $F(\cdot, \nu_{lc}, \sigma_{lc})$ , we proceed as follows. Three types of contractual arrangements are observed and by matching the theoretical probabilities of each regimes  $FF$ ,  $CF$  and  $CC$  with their empirical probabilities, we can recover the distribution of  $\theta$ .

Let us compute this log-likelihood assuming that the  $\theta_i$ s are independent draws from a normal distribution that is common across networks. The operator accepts a fixed-price contract in both periods when  $\theta_i \leq \theta_{1i}^* = \underline{b}_i^R + k + \frac{1-\beta}{\beta}(\underline{b}_i^R - \widehat{b}_i^R)$  so that the probability of accepting such fixed-price contract is:

$$\Pr(\theta_i \leq \theta_{1i}^*) = F\left(\underline{b}_i^R + k + \frac{1-\beta}{\beta}(\underline{b}_i^R - \widehat{b}_i^R), \nu_{lc}, \sigma_{lc}\right). \quad (19)$$

<sup>34</sup>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 (see also Hausman and Poterba (1987) on this). 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. Gagnepain and Ivaldi (2002) obtained a similar result in their study of the French transportation sector.

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

$$\Pr(\theta_{1i}^* \leq \theta_i \leq \theta_{2i}^*) = F\left(\bar{b}_i^R + k_i, \nu_{rp}, \sigma_{lc}\right) - F\left(\hat{\underline{b}}_i^R + k + \frac{1-\beta}{\beta}(\hat{\underline{b}}_i^R - \bar{b}_i^R), \nu_{lc}, \sigma_{lc}\right). \quad (20)$$

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

$$\Pr(\theta_{2i}^* \leq \theta_i) = 1 - F\left(\hat{\bar{b}}_i^R + k_i, \nu_{lc}, \sigma_{lc}\right). \quad (21)$$

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

$$\begin{aligned} L_i(\nu_{lc}, \sigma_{lc}) = & \Delta_i \log\left(F\left(\underline{b}_i^R + k + \frac{1-\beta}{\beta}(\underline{b}_i^R - \hat{\underline{b}}_i^R), \nu_{lc}, \sigma_{lc}\right)\right) + \\ & \Pi_i \log\left(F\left(\bar{b}_i^R + k_i, \nu_{lc}, \sigma_{lc}\right) - F\left(\hat{\underline{b}}_i^R + k + \frac{1-\beta}{\beta}(\hat{\underline{b}}_i^R - \bar{b}_i^R), \nu_{lc}, \sigma_{lc}\right)\right) \\ & + \Sigma_i \log\left(1 - F\left(\hat{\bar{b}}_i^R + k_i, \nu_{lc}, \sigma_{rp}\right)\right), \end{aligned}$$

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

Observations being independent, the log-likelihood for our sample is just the sum of all individual log-likelihood functions:

$$L(\mu_{lc}, \sigma_{lc}) = \sum_{i=1}^N L_i(\nu_{rp}, \sigma_{lc}).$$

Once estimates  $\hat{\nu}_{lc}$ ,  $\hat{\sigma}_{lc}$ ,  $\hat{\beta}$  and  $\hat{k}_i$  are obtained,  $\hat{\alpha}_i$  is derived from (18).

We test *ex post* that our estimates  $\hat{\nu}_{lc}$ ,  $\hat{\sigma}_{lc}$ ,  $\hat{\beta}$ ,  $\hat{k}_i$ , and  $\hat{\alpha}_i$  satisfy the constraint implied by the optimality conditions (9) and (10).

### 3.4 Estimation Results

Results are presented in three steps. First, we discuss the estimates of the subsidy levels  $\underline{b}^R$  and  $\bar{b}^R$ , following our procedure described in Section 3.2. Second, we comment

on the estimation of the distribution  $F(\cdot)$ , and we shed light on which factors affect significantly the social value of effort  $k$ . Finally, we focus on the regulatory arrangements induced by Proposition 4.

**Recovering menus of subsidies.** We assume a linear relationship between a subsidy level and a set of characteristics  $Y_i$  in our equations (13) and (14). The characteristics we focus on are related to the regulator, the operator, or the network. These are the size of the rolling stock, the size of the transport network, the share of the labor bill in total costs, a dummy variable which takes value one if the local government is right-wing, and 0 otherwise, 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. We also introduce operators' fixed effects.

The results are presented in Table 2. Unsurprisingly, each subsidy level increases with the volume of the rolling stock, or the network size. However, the network size is a more important factor to explain the volume of the first-period subsidy  $\underline{b}^R$ , compared to  $\bar{b}^R$ , while the size of second-period subsidy  $\bar{b}^R$  seems to be more sensitive to fluctuations in the rolling stock. Note also that subsidies decrease if the share of labor in total operating expenses is higher. Likewise, right-wing municipalities have a tendency to pay lower subsidies to operators, everything else being equal. Note nevertheless that the right/left margin is more pronounced when it comes to explaining  $\bar{b}^R$  compared to  $\underline{b}^R$ . Moreover, our results suggest that the identity of corporation that owns the operator matters as well. Operators owned by Agir tend to receive lower subsidies compared to operators of other groups. Likewise, operators owned by Keolis receive higher  $\underline{b}^R$  and lower  $\bar{b}^R$ .

In Table 3, we present the average and the standard deviation of the estimated  $\hat{\underline{b}}^R$  and  $\hat{\bar{b}}^R$ . Note that, as expected,  $\hat{\underline{b}}^R < \hat{\bar{b}}^R$ .

**Limited 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 4. 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 Transdev has a significant and positive effect on  $k$ , suggesting that an operator belonging to Transdev seems to guarantee a higher social return on effort compared to operators from other groups.<sup>35</sup>

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 operates. 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. Instead, the results suggest ambiguous effects. If the operator belongs to Transdev, the share of engineers has the expected effect. If the operator belongs to Agir or Keolis, the effect goes in the opposite direction.

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<sup>35</sup>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 internal structure of managerial incentives within the operator but we did not have access to any related information.

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 three estimation procedures yield very similar estimates of  $\nu_{lc}$  and  $\sigma_{lc}$ , the mean and standard deviation of  $\theta$ 's normal distribution respectively. Our results are strongly significant, and suggest that the average innate cost  $\theta$  varies between 14 and 15 millions Euros.

We also obtain a direct estimate of the intertemporal weight  $\beta$ . Values are between 0.25 and 0.41, indicating that the second period is perceived as more important than the first period in the contractual arrangement.

Once we have estimated  $\hat{\nu}_{lc}$ ,  $\hat{\sigma}_{lc}$ ,  $\hat{\beta}$  and  $\hat{k}_i$ , we evaluate  $\hat{\alpha}_i$ , the weight of the operator's profit in the public authority's objective function. The explanatory variables which enter  $Z_i$  are a constant, the number of cities within the local authority in charge of the service, the size of the population of the relevant urban area, and the local political color.<sup>36</sup> 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 made of many urban areas. With respect to the political color of the local government, casual evidence suggests that a right-wing local government is more eager to provide favors to private operators. The estimate  $\hat{\alpha}_i$  should thus be higher with a right-wing local government.<sup>37</sup>

Results are presented in Table 5. The estimation of the average  $\alpha$  are made under the assumption that the local cost of public funds takes value  $\lambda = 0.3$ . Several comments are worth being made. 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  $\alpha$ , confirming thereby our prior intuition. Note that  $\alpha$  in this case takes value 0 for left-wing governments while it is strictly positive for the right-wing ones. Third, our initial restriction  $\alpha \leq 1 + \lambda$  holds, even though it is not imposed in the estimation.

Finally, we check *ex post* that our estimates  $\hat{\nu}_{lc}$ ,  $\hat{\sigma}_{lc}$ ,  $\hat{\beta}$ ,  $\hat{k}_i$ , and  $\hat{\alpha}_i$  verify the regulatory constraints made of equations (9) and (10). To do so, we replace  $\mu$  in (9) by its expres-

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<sup>36</sup>When the local authority includes several cities, we consider the political color of the main municipality.

<sup>37</sup>This point is corroborated in additional works such as Levin and Tadelis (2009).

sion from (10) in order to generate an equation (9'). Then, we compute a  $t$ -test to check whether the left-hand side of equation (9') is significantly different from its right-hand side. We cannot reject the hypothesis that both sides are equal.

## 4 The Welfare Gains of Commitment

We assess now the magnitude of the welfare gains which can be obtained once one moves from the renegotiation-proof setting to the less constrained full commitment scenario. We also investigate how these gains are distributed between private operators and taxpayers. This is an important issue for practitioners since they often have complained about 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.<sup>38</sup> We proceed as follows.<sup>39</sup>

**Step 1.** Using our set of renegotiation-proof estimates  $\Upsilon^R = (\widehat{\nu}^R, \widehat{\sigma}^R, \widehat{k}^R, \widehat{\alpha}^R, \widehat{\beta}^R)$  conditional on  $\lambda$  and its expression from the maximand in renegotiation-proof program  $\mathcal{P}^R$ , we compute expected welfare levels  $\mathcal{W}_i^R$  for each network of our data set. As emphasized throughout this section, the renegotiation-proof scenario corresponds to the actual contractual practices encountered in the French urban transport industry. Hence, the estimates  $\Upsilon^R$  provide the econometrician with some information on the true 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  $\Upsilon^R$ .

**Step 3.** We reconstruct the hypothetical welfare measures  $\widehat{\mathcal{W}}_i^F$  for each network of our data set, as predicted by our full commitment solution, and using our estimates  $\widehat{b}_i^F$  and  $\Upsilon^R$ .

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<sup>38</sup>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.

<sup>39</sup>See the Appendix for details.

We compute the total welfare gains as well as the gains for taxpayers and operators from commitment by considering an average network of the data set, using estimates  $\Upsilon^R$  conditional on  $\lambda = 0.3$  and  $k_i$  specified as in (II) in Table 4.<sup>40</sup>

The estimates reported in Table 6 shed light on several interesting results. Of course, commitment always improves welfare, compared to the situation where renegotiation puts further constraints on contracting. This is not surprising, and the important question is how those gains are distributed. It turns out that  $\widehat{T}_i^F > \widehat{T}_i^R$ , i.e., switching from limited to full commitment entails a higher intertemporal subsidy. In fact, the intertemporal payment to the operator increases, on average, by 6.1 million Euros. Hence, taxpayers lose from an increase in the length of concession contracts, given that social costs increase by 8 million Euros on average.

Turning now to operators, our estimates show that their intertemporal rent increases when moving to full commitment by 8.2 million Euros. This is a significant gain that explains why operators are so eager to extend the length of the concession contract in this sector.

## 5 Conclusion

We have developed a principal-agent model under limited commitment that features the main characteristics of contracts and institutional practices 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 alleys for further investigation. First, we have deliberately restrained the general features of theoretical models used in the renegotiation literature 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 challenge) and then 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 menus which, although sub-

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<sup>40</sup>Note that the final welfare results do not vary in a significant manner if other values of  $k_i$  are chosen.

optimal, brings tractability. 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, and more specifically to our analysis of the transportation sector, note that 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 push even further towards an increase in contract length that could secure investments and avoid hold-up effects.

Third, a more complete analysis of the renegotiation process should incorporate the possibility that public authorities build reputations for being tough on renegotiation. Indeed, such reputation would be beneficial in relaxing renegotiation-proofness constraints. In other words, an omitted variable of our analysis is the amount of reputational capital available to the contracting parties. That capital may be much easier to build in political contexts where public authorities are likely to be reelected in the future and still in charge with regulating the service in subsequent periods. Our theoretical model has put aside those reputation issues and has thus analyzed a “worst scenario” under renegotiation. More research both on the theory side and also in building data sets which could account for that reputational capital is certainly called for.

Fourth, 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, the management practices and incentive structures of those 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. This would help us to address whether major sources of benefits in contract design come from better institutional design improving thereby commitment or from better designing more “complex” cost reimbursement rules: an important issue for practitioners.

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

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## Appendix (NOT FOR PUBLICATION)

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

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

The monotone hazard rate property ensures quasi-concavity of this objective.<sup>41</sup> The corresponding first-order conditions characterize the optimal subsidy in (1). ■

**Proof of Proposition 2.** Take any initial contract offer  $C^0 = (b_1, R^0)$  and define  $R$  as the solution to  $(\mathcal{R}^0)$ . Consider now the new contract  $C = (b_1, R)$ . We want to prove that the history of the firm's types self-selection and the principal's second-period payoff are both unchanged with this new offer. Several observations lead to that result.

1. Since the agent's perfectly anticipates the issue of renegotiation and makes his first-period accordingly, self-selection among the three different options takes place exactly in the same way with  $C$  as when  $C^0$  is initially offered.
2. By definition, any offer  $\tilde{R} = (\tilde{b}_2, \tilde{b}_3)$  that is feasible at the renegotiation-stage given  $R$  is feasible given  $R^0$ . Indeed, that  $b_2$  satisfies the first condition in (2) and  $\tilde{b}_2$  satisfies the first condition in (6) imply

$$\tilde{b}_2 \geq b_2^0. \tag{22}$$

Similarly, that  $b_3$  satisfies the second condition in (2) and  $\tilde{b}_3$  satisfies the second condition in (6) imply

$$\tilde{b}_3 \geq b_3^0. \tag{23}$$

3. By definition,  $R$  solves  $(\mathcal{R}^0)$  and thus for any  $\tilde{R} = (\tilde{b}_2, \tilde{b}_3)$  that is feasible given  $R^0$ , we have:

$$W_2((b_1^0, R), R, R) \geq W_2((b_1^0, R), \tilde{R}, R). \tag{24}$$

This condition is true, in particular, for any  $\tilde{R} = (\tilde{b}_2, \tilde{b}_3)$  that is feasible at the renegotiation-stage following the offer of  $R$ . This shows that  $R$  solves also  $(\mathcal{R})$ .

This ends the proof of Proposition 2. ■

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<sup>41</sup>See for instance Bagnoli and Bergstrom (2005).

**Proof of Proposition 3.** First, note that  $\alpha < 1 + \lambda$  implies that the maximum of the first integral in (5) is obtained when (6) is binding.

Second, consider (unexpected) renegotiation offers with  $\tilde{b}_3 \geq b_3$ . Types in  $[b_3 + k, \tilde{b}_3 + k]$  which were anticipating to work on a second-period cost-plus contract are now adopting the fixed-price contract with the new greater subsidy  $\tilde{b}_3$  at the renegotiation stage. Optimizing  $(\mathcal{R})$  which is quasi-concave in  $\tilde{b}_3$  and taking into account that  $b_3$  must be the solution yields condition (8). ■

**Proof of Proposition 4.** Assuming quasi-concavity in  $(b_1, b_2, b_3)$  of the Lagrangean corresponding to the optimization problem, the first-order optimality conditions for  $b_1^R$  and  $b_2^R$  are the same so that, it is optimal to set  $b_1^R = b_2^R = \underline{b}^R$ . Taking into this fact and optimizing with respect to  $(\underline{b}^R, \bar{b}^R)$  yields the first-order conditions (9) and (10).

Moreover, (8) implies that

$$F(\bar{b}^R + k) - F\left(\underline{b}^R + k + \frac{(1 - \beta)}{\beta}(\underline{b}^R - \bar{b}^R)\right) > 0$$

which itself implies  $\underline{b}^R < \bar{b}^R$ . ■

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

$$\mathcal{W}_i^R = S - (1 + \lambda) T_i^R + \hat{\alpha}_i^R U_i^R, \quad (25)$$

where

$$\begin{aligned} T_i^R = & \int_{\underline{\theta}}^{\underline{b}_i^R + \hat{k}_i^R + \frac{1-\hat{\beta}}{\hat{\beta}}(\underline{b}_i^R - \bar{b}_i^R)} \underline{b}_i^R f(\theta) d\theta + \int_{\underline{b}_i^R + \hat{k}_i^R + \frac{1-\hat{\beta}}{\hat{\beta}}(\underline{b}_i^R - \bar{b}_i^R)}^{\bar{b}_i^R + \hat{k}_i^R} (\hat{\beta}\theta + (1 - \hat{\beta})\bar{b}_i^R) f(\theta) d\theta \\ & + \int_{\bar{b}_i^R + \hat{k}_i^R}^{\bar{\theta}} \theta f(\theta) d\theta, \end{aligned}$$

and

$$U_i^R = \int_{\underline{\theta}}^{\underline{b}_i^R + \hat{k}_i^R + \frac{1-\hat{\beta}}{\hat{\beta}}(\underline{b}_i^R - \bar{b}_i^R)} (\underline{b}_i^R + \hat{k}_i^R - \theta) f(\theta) d\theta + \int_{\underline{b}_i^R + \hat{k}_i^R + \frac{1-\hat{\beta}}{\hat{\beta}}(\underline{b}_i^R - \bar{b}_i^R)}^{\bar{b}_i^R + \hat{k}_i^R} (1 - \hat{\beta})(\bar{b}_i^R + \hat{k}_i^R - \theta) f(\theta) d\theta.$$

Likewise, from our full commitment program, 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  $\hat{\alpha}_i^R$ :

$$\mathcal{W}_i^F = S - (1 + \lambda)T_i^F + \widehat{\alpha}_i^R U_i^F, \quad (26)$$

where

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

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  $\mathcal{W}_i^R$  and  $\mathcal{W}_i^F$ . Hence, we evaluate the welfare differential between both renegotiation-proof and perfect commitment situations as

$$\Delta \mathcal{W}_i = \mathcal{W}_i^F - \mathcal{W}_i^R. \quad (27)$$

Similar definitions follow for  $\Delta T_i$  and  $\Delta U_i$ . ■

<b>Variables</b>	<b>Mean</b>	<b>Stand. Dev.</b>
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 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 1: Data

Variables	$\underline{b}$		$\bar{b}$	
	I	II	I	II
Constant	6.17*** (0.38)	6.39*** (0.29)	7.15*** (0.30)	7.49*** (0.33)
Rolling Stock	0.54*** (0.07)	0.52*** (0.06)	0.61*** (0.05)	0.61*** (0.05)
Network Size	0.24*** (0.04)	0.23*** (0.03)	0.07* (0.04)	0.07* (0.04)
Right-Wing	-0.06** (0.03)	-0.07** (0.03)	-0.16*** (0.05)	-0.16*** (0.05)
Labor Share	-1.11*** (0.19)	-1.13*** (0.19)	-1.35*** (0.17)	-1.35*** (0.17)
Connex		0.07 (1.15)		-0.15 (3.02)
Agir		-0.7*** (0.08)		-0.37*** (0.07)
Keolis		0.8*** (0.04)		-0.33*** (0.06)
Error Sd. Dev.	0.11*** (0.004)	0.11*** (0.004)	0.05*** (0.003)	0.05*** (0.003)
Firms Fixed effects	Yes	Yes	Yes	Yes
# of Observations	300	300	93	93

Table 2: Estimated Subsidies I

	$\hat{\underline{b}}$	$\hat{\bar{b}}$
Average (1000 Euros)	13487** (6436)	16490** (7249)
# of Observations	579	579

Table 3: Estimated Subsidies II

Variables	Social value of effort $k$		
	I	II	III
Agir	-0.05 (0.05)	-1.05** (0.41)	1.00*** (0.25)
Keolis	0.06 (0.04)	-0.03 (0.10)	0.29** (0.11)
Transdev	0.45*** (0.10)	0.37* (0.19)	-0.94*** (0.37)
Agir $\times$ size		4.08*** (1.58)	
Keolis $\times$ size		0.46 (0.39)	
Transdev $\times$ size		1.17 (0.78)	
Agir $\times$ Engineers			-3.80*** (0.92)
Keolis $\times$ Engineers			-0.89** (0.39)
Transdev $\times$ Engineers			5.01*** (1.57)
First Period Weight $\beta$	0.39*** (0.06)	0.25*** (0.08)	0.41*** (0.06)
Mean $\theta$ ( $\times 10000$ )	0.15*** (0.03)	0.14*** (0.04)	0.15*** (0.03)
Stand. Dev. $\theta$ ( $\times 10000$ )	0.29*** (0.05)	0.43*** (0.14)	0.25*** (0.04)
# of Observations		579	

Table 4: Renegotiation-proof: Inefficiency distribution and social value of effort

$\lambda$	$\alpha \times$ right wing		
	I	II	III
0.3	1.20*** (0.11)	1.22*** (0.10)	1.21*** (0.11)
# of Observations		392	

Table 5: Renegotiation-proof: Parameters of interest in Proposition 2

<b>Welfare Items</b>	<b>Total (in Million Euros)</b>
Subsidy	
- Full commitment	33.6
- Renegotiation-proof	27.5
Differential	+6.1
Social cost	
- Renegotiation-proof	35.7
- Full commitment	43.7
Differential	+8.0
Rent operator	
- Renegotiation-proof	71.3
- Full commitment	79.5
Differential	+8.2
Total welfare	
- Renegotiation-proof	50.9
- Full commitment	53.0
Differential	+2.1
# of observations	114

Table 6: Welfare differentials for the average network