The Cost of Contract Renegotiation: Evidence from the Local Public Sector[1]

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The renegotiation of regulatory contracts is known to prevent regulators from achieving the full commitment efficient outcome in dynamic contexts. However, assessing the cost of such 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, only two types of contracts are used in practice (fixed-price and cost-plus). Second, subsidies increase over time. We compare a scenario with renegotiation and a hypothetical situation with full commitment. We conclude that the welfare gains from improving commitment would be significant but would 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 are renegotiated over time, the empirical literature on those issues lags much behind both in terms of volume and scope.

Is is by now well-known that renegotiation imposes various transaction costs on contracting. Although renegotiation improves contracting *ex post*, it has also perverse effects on the contractual parties' *ex ante* incentives.[1] Overall, those costs prevent contracting parties from achieving the informationally constrained efficient solution that could have been reached under full commitment. However, an open issue from an empirical viewpoint remains to assess the welfare losses associated with such renegotiation. Furthermore, another important question is to understand how those losses are distributed between contracting parties.

Making progresses on this front is crucial, especially for practitioners who are eager to evaluate the performances of various contractual arrangements found in their real-world 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 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 duration 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

[1] Such perverse incentives arise in at least three occasions. First, information may be incorporated in contract design only at a slow pace as in the literature on adverse-selection under imperfect commitment (Dewatripont, 1989, Hart and Tirole, 1988, Laffont and Tirole, 1993, Chapter 10, Rey and Salanié, 1996, Laffont and Martimort, 2002, Chapter 9, among others). Second, the threat of regulatory hold-up may impede specific investments which requires costly governance and various safeguards (Williamson, 1985). Finally optimal risk-sharing arrangements may be disrupted (Fudenberg and Tirole, 1990). Only the first of these impediments to contracting will be investigated in this paper.

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 menus of linear contracts might facilitate self-selection of operators according to innate costs.[2] Of much importance from a practical point of view, such menus approximate quite well the optimal contract and are sometimes even able to achieve what more complex nonlinear contracts would do.[3] In that respect, Rogerson (2003) pointed out that, in most real-world procurement contexts, a menu with only two items (cost-plus/fixed-price) may actually suffice to achieve much of the gains from trade, even under asymmetric information.[4]

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 patterns. Increasing subsidies result from the local authorities' limited ability to commit and the fact that information on the operator's cost structure gets revealed over time. This point is familiar from the agency literature on limited commitment.[5] However, it is revisited here in a specific institutional context where two-item menus (fixed-price/cost-plus) are the only feasible contracts. Whereas

[2]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).

[3]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.

[4]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.

[5]Dewatripont (1989), Laffont and Tirole (1993, Chapter 10) and Laffont and Martimort (2002, Chapter 9) among others.

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 (2003)'s model into a dynamic framework where contracts are renegotiated over time.[6] So doing, we look for a theoretical modeling consistent with our data set. Considering a continuum of types is indeed 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 provide a structural estimation of the model parameters under a scenario assuming that renegotiation is a concern for the parties. To understand the estimation bias that would arise had we wrongly assumed full commitment, it is useful to come back on the basic intuition underlying the trade-off between *ex post* efficiency and *ex ante* incentives that appears under renegotiation. To be acceptable, renegotiation must raise subsidies so that even operators which are only mildly efficient may end up choosing fixed-price contracts. Those efficiency gains give also more rents to the most efficient operators who enjoy such increased subsidies. From a welfare point of view, renegotiation is thus more attractive when the social value of the operators' effort in cutting costs is greater. Only in that case, the efficiency gains from renegotiation dominate its costs in terms of extra rents. Wrongly assuming full commitment when analyzing our data would thus amount to underestimate the social value of effort and overestimate information rents.

Our empirical analysis also provide estimate of the congruence of objectives between the operator and the local government in charge of regulating the service. The weight of the operator's profit in the regulator's objective depends on the political color. Right-wing municipalities are more prone to favor private operators than left-wing ones.[7]

Finally, using our estimates of the operator's innate cost distributions and other

[6] Rogerson (2003)'s analysis is static and thus cannot cover 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 passes.

[7] Kalt and Zupan (1984, 1990) provided evidence on the fact that policymakers' ideology may have a significant impact on regulatory outcome.

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 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 justifies the operators' political activism in pushing for an increase in contract duration.

Literature review. Our model belongs to the recent empirical literature on regulatory contracts. First, as already explained, this paper contributes to the ongoing empirical debate on the value of using simple menus of contracts. 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 that costs are observable 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 models. Other empirical studies argue instead that such complex mechanisms might not be so useful. Bajari and Tadelis (2001) focused on the private construction industry in the U.S. and noticed 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 menus with only 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 with more complex mechanisms. We improve upon Gagnepain and Ivaldi (2002) by modeling contract design and giving more attention to the dynamics of contracts.

In that respect, our paper is also related to Dionne and Doherty (1994). They 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 the extent to which long-term contracts may benefit not only principals (hereafter public authorities) but also their agents (operators).

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 when renegotiation matters. Section 3 develops our empirical method. Section 4 evaluates the magnitude of the welfare gains when moving to full commitment and their distribution between operators and taxpayers. Section 5 highlights alleys for further research.[8]

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.[9] In 2002, these companies, with their respective ownership structures and market shares (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 the control of local governments.

1.1 Economic Environment

The 1982 Transportation 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 route and fare structures, capacity, quality of service, conditions for subsidizing the service, levels of

[8]Proofs of the theoretical model are provided in an Appendix.

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

investment and ownership nature. 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 a cost-reimbursement scheme.

Since 1993, "beauty contests" are required to allocate the building and management of new infrastructures for urban transportation when the date for contract renewal 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 foster ex ante competition since most local authorities usually receive bids from only one firm, namely the operator already in charge. Several reasons might 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 operators in France are located on specific geographical areas which restricts competition. Finally, 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 must 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).

Undertaking 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 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 has 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.[10] 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 arises quite naturally on top of the adverse selection problem. When compounded, those informational asymmetries

[10] 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).

play a crucial role in the design of contractual arrangements and financial objectives.[11]

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 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 but, 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. Fixed-price regimes are high-powered incentive schemes, while cost-plus regimes do not provide any incentives for cost reduction. Over the period of observation, fixed-price contracts are employed in 55.5% of the cases.

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 and 94 are given from their starting point. 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

[11]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.

to change regulatory rules, or because a new government is elected and changes the established rules. Note however that a change in the political color of the local government does not necessarily imply an early renegotiation of the contract before its term. New local governments are indeed committed to the contracts signed by their predecessors. 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. Indeed, 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 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.[12] 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. 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 instead of cost-plus contracts.

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 accordingly. First, operators choose between either a fixed-price or a cost-plus contract. Second, contracts entail increasing subsidies over time. We will argue below that such patterns arise when contracts are "renegotiation-proof."

[12]Estimation results are (392 observations, firms' fixed effects included, standard errors in parenthesis): $\log Subsidy = \underset{(0.26)}{4.87} + \underset{(0.05)}{0.68} \log Rolling\ Stock + \underset{(0.03)}{0.23} \log network - \underset{(0.03)}{0.11}\ Right\text{-}Wing + \underset{(0.09)}{0.34}\ CF.$

This positive model is then compared to an hypothetical setting where regulators could commit but optimal subsidies would then remain constant over time.

Consider a local authority (the "principal"). Generalizing the objective functions used in Baron and Myerson (1982) and Laffont and Tirole (1993), the preferences of this principal are defined as:

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

where S is the gross surplus generated by the service.[13]

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 firm's cost c and $t(c) \equiv c$ for all c. Raising subsidies from the local budget with distortionary taxation entails some dead-weight loss that is captured by introducing a positive 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 might justify such preferences of local governments. The parameter α might for instance capture the firm's bargaining power at the time of awarding franchises and as such reflect the level of *ex ante* competition among potential operators.[14,15] In view of our empirical study, we may also distinguish local governments according to their political preferences. We define rightist (resp. leftist) local governments as those which commend more (resp. less) rent for the private operator. This corresponds to higher values of α.[16]

[13] 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. See Oum et al. (1992).

[14] In this sector, *ex ante* competition is not so fierce. Indeed, different operators mostly avoid head-to-head competition and generally make tenders for markets in distinct urban areas. The decision n^0 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 α. 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.

[15] Following the insights of Baron (1989), Laffont (1996) and Faure-Grimaud and Martimort (2003), these preferences might also result from a political equilibrium among various forces at the local level.

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

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

$$c = \theta - e.$$

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 θ 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.[17]

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 and can reach thereby the highest possible intertemporal payoff. This gives us an attractive benchmark against which to assess the alternative model with limited commitment and renegotiation. This benchmark is also useful when we move to our empirical analysis and evaluate the costs of renegotiation.

Let δ be the discount factor and let us normalize the length of the first-period accounting period so that first-period welfare and profits receive the weight $\beta = \frac{1}{1+\delta}$ when computing net present values of those quantities.

[17] For the sake of our empirical analysis, it is worth noticing that the same operator could have different realizations of its innate cost on two different markets. This assumption captures the fact that costs on a given network are to a large extent idiosyncratic.

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. This long-term contract yields to the firm the (normalized) intertemporal payoff

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

Instead, with a cost-plus contract covering both periods, the operator is reimbursed for his costs so that he exerts no effort and his payoff is zero.[18]

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, more efficient types also do so. The types interval is thus split into two subsets. Efficient operators take fixed-price contracts whereas inefficient ones are on cost-plus. The marginal operator with type θ^* is just indifferent between choosing cost-plus or fixed-price long-term contracts where θ^* satisfies:

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

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.[19]

Although the public authority offers a menu of two possible long-term contracts with either fixed-price or cost-plus over both periods, the operator only selects one item within this menu. From an empirical point of view, the econometrician is only able to observe the choice made by operators, i.e., a single item (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. Following the mechanism design tradition, this process is captured in our theoretical model by having principals offering not a single offer but instead menus among which operators with different types self-select.

[18]The operator focuses on cost-reducing effort only and is not responsible for improving the quality of the service. Quality entails various dimensions 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 which are indeed observable and regulated by contract.

[19]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 θ^* 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 optimal subsidies under full commitment are given in the next proposition.

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

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

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 $\theta \geq \theta^F = b^F + k$ operate under a cost-plus contract for both periods.

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 it is socially costly. Offering instead only a cost-plus contract nullifies this rent but it also destroys incentives to exert effort.

Under full commitment, the optimal contract is the twice-repeated version of the optimal static contract: a by-now standard result in the dynamic contracting literature.[20] Given that the economic environment is stationary, the trade-off between rent extraction and efficiency remains the same in both periods. Hence, there is no reason to move from a cost-plus to a fixed-price contract over time. This justifies our initial focus on the binary choice between a long-term fixed-price and a long-term cost-plus contract and explains why we did not consider more complex patterns with cost-plus contracts followed by fixed-prices for instance. Such profiles are suboptimal under full commitment although they will be attractive under limited commitment.

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^* in both periods. This yields an expected social benefit $(1+\lambda)kf(b+k)db$. On the other hand, raising the subsidy entails a budgetary cost worth $(1+\lambda)F(b+k)db$ since even firms with infra-marginal types enjoy such higher subsidies. This nevertheless also raises the social value of the rent left to the most efficient firms by a quantity

[20]See Baron and Besanko (1984) and Laffont and Martimort (2002, Chapter 8).

$\alpha F(b+k)db$. 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).

The optimal subsidy b^F increases with k and α. Intuitively, when effort has a greater social value or when the operator's rent has more weight in the public authority's objectives, the optimal subsidy under a fixed-price contract must be raised to induce more firms to operate under higher powered incentives which commands more rent.

2.2 Renegotiation

Overview and modeling choices. The full commitment assumption used in Section 2.1 does not represent real-world practices as we explained above. Although the 1993 Law invites local authorities to re-auction concession contracts 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 "opérateur historique") 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 allows for long-term contracts which can be renegotiated if parties find it mutually attractive.[21] The second paradigm considers instead short-term contracts; only spot contracts for the current period can be enforced.[22] 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 "opérateur historique". 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, the promise of future rounds of contracting between the public authority

[21]Dewatripont (1989), Laffont and Tirole (1993, Chapter 10), Hart and Tirole (1988) and Rey and Salanié (1996) in adverse selection contexts.

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

and the incumbent is sufficiently credible. In other words, although no long-term contracts really bind parties together, everything happens as if the public authority could 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. Choosing a fixed-price contract is interpreted by the principal as being "good news" since it signals that the firm's innate efficiency parameter θ is low enough. Instead, choosing a cost-plus contract brings "bad news." In a dynamic environment, information on costs is revealed over time and the principal would like to draft new agreements that incorporate such information. In particular, an increase over time in the subsidies specified in fixed-price contracts allows operators who have revealed themselves as being not very efficient earlier on to achieve productivity gains later on. Such greater 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 because the most efficient firms may only move to fixed-price contracts later on to pocket greater subsidies. Overall, renegotiation is costly from the principal's viewpoint. 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.

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".

Operators with different types might choose different options. We will look for an equilibrium where the most efficient types that belong to an interval Θ_G follows history G, whereas intermediate and least efficient ones that belong respectively to the interval

Θ_I and Θ_B follow respectively histories I and B.

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 subsidies 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 but 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 θ.

• 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 subsidies following each of those paths are respectively denoted 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 a 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 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 an initial offer C^0.[23] A profile of renegotiated offers $\tilde{R} = (\tilde{b}_2, \tilde{b}_3)$ is accepted at the renegotiation stage, if subsidies satisfy the following constraints:

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

[23] We omit the dependence of $\tilde{R}$ on C^0 for notational simplicity.

The first inequality in (2) stipulates that types in Θ_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 Θ_I.

Equilibrium concept. 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 propose a renegotiation $\tilde{R}$ at date 2. This second-period offer is made once the principal has already updated his beliefs over the firm's type following its first-period decision.

• **Firm's strategy.** The firm anticipates (perfectly in equilibrium) what the second period subsidies are following renegotiation. Let denote those anticipated subsidies by $R = (b_2, b_3)$.

The firm follows a cut-off strategy that yields the following contracting pattern.

1. Types in $\Theta_G = \left[\underline{\theta}, b_1 + k + \frac{1-\beta}{\beta}(b_2 - b_3)\right]$ adopt already contract C_1^0 anticipating that b_2^0 and b_3^0 will be respectively renegotiated 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 choosing fixed-price contracts in each period with subsidies (b_1, b_2) and moving from a cost-plus contract to a fixed-price with subsidy b_3 in the second period.

2. Types in $\Theta_I = [b_1 + k + \frac{1-\beta}{\beta}(b_2 - b_3), b_3 + k]$ choose contract C_2^0 with the same expectations than above. The cut-off type $\theta_2^* = b_3 + k$ is just indifferent between moving from a cost-plus to a fixed-price contract with subsidy b_3 and taking a cost-plus contract over both periods.

3. Types in $\Theta_B = [b_3 + k, \bar{\theta}]$ choose contract C_3^0 anticipating the renegotiated fixed-price offer won't be attractive for them anyway.

This pattern summarizes incentive compatibility in this dynamic environment. For instance, if the cut-off type θ_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 Θ_G.

"Almost" equilibrium and limited updating. Note that the principal only updates his beliefs at date 0.50 before making a renegotiation 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 from observing first-period costs if the firm had chosen a cost-plus contract for that period and has indeed been reimbursed for those costs. This justifies the use of the qualifier "almost" for our notion of equilibrium.[24]

Renegotiation-Proofness Principle. 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.[25] 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 contract for the second period because, otherwise, it 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.

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 $R = (b_2, b_3)$ maximizes the principal's second period welfare subject to the following acceptance condition*

$$\tilde{b}_2 \geq b_2 \text{ and } \tilde{b}_3 \geq b_3. \quad (3)$$

[24]Let instead assume that the principal is fully rational and updates his beliefs following any possible realization of first-period cost. Inefficient firms under a cost-plus in the first period would certainly not fully reveal their type at this stage and, anticipating future renegotiation, 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 second-period contracting. Suppose instead that a firm with innate cost θ adopts a more naive first-period behavior and reveals 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. For the second period, the principal would ask the 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 mass points are found. Moreover, assuming that regulators have limited rationality is fair given their poor expertise, 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 due to our assumption of having a continuum of types. It also makes the theoretical model as close as possible to the existing data set.

[25]Hart and Tirole (1988), Dewatripont (1989), and Laffont and Tirole (1993, Chapter 10), Bester and Strausz (2001).

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 necessary to take into account the significant heterogeneity in the firm's realized costs that is found in our data set. Our focus on a continuum provides a nice division of the types space into three intervals Θ_G, Θ_I and Θ_B 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.[26]

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 following two conditions hold:*

$$b_3 \geq \beta b_1 + (1-\beta) b_2, \tag{4}$$

$$kf(b_3+k) - \left(1 - \frac{\alpha}{1+\lambda}\right)\left(F(b_3+k) - F\left(b_1 + k + \frac{1-\beta}{\beta}(b_2 - b_3)\right)\right) \leq 0. \tag{5}$$

Condition (4) ensures that the interval Θ_I is non-empty. It is just a feasibility condition on the possible subsidies profiles that are relevant to generate the pattern of histories found in our data set. Condition (5) 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 attractive 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 θ_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 increased subsidy. That cost is worth $(1+\lambda-\alpha)\left(F(b_3+k) - F(\theta_1^*)\right) db$.[27]

[26] 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. Indeed, mass points in the distribution of realized costs are not found in our data.

[27] 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 (5). 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.

Optimal renegotiation-proof menus of contracts. Optimizing the principal's expected intertemporal welfare subject to the renegotiation-proofness constraint (5), we find:

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*

$$k = \left(1 - \frac{\alpha}{1+\lambda}\right)\left(R\left(\underline{b}^R + k + \frac{1-\beta}{\beta}(\underline{b}^R - \bar{b}^R)\right) + \frac{\mu}{\beta(1+\lambda)}\right), \tag{6}$$

$$k = \left(1 - \frac{\alpha}{1+\lambda}\right)\left(\frac{F(\bar{b}^R + k) - F\left(\underline{b}^R + k + \frac{1-\beta}{\beta}(\underline{b}^R - \bar{b}^R)\right)}{f(\bar{b}^R + k) - f\left(\underline{b}^R + k + \frac{1-\beta}{\beta}(\underline{b}^R - \bar{b}^R)\right)}\right)$$
$$-\mu\frac{\left(\left(1 - \frac{\alpha}{1+\lambda}\right)\left(\frac{f(\bar{b}^R+k)}{1-\beta} + \frac{f\left(\underline{b}^R+k+\frac{1-\beta}{\beta}(\underline{b}^R-\bar{b}^R)\right)}{\beta}\right) - \frac{kf'(\bar{b}^R+k)}{1-\beta}\right)}{(1+\lambda)\left(f(\bar{b}^R+k) - f\left(\underline{b}^R + k + \frac{1-\beta}{\beta}(\underline{b}^R - \bar{b}^R)\right)\right)} \tag{7}$$

  where $\mu > 0$ is the Lagrange multiplier of (5).

- *Subsidies are increasing*

$$\bar{b}^R > \underline{b}^R. \tag{8}$$

- *The renegotiation-proofness constraint (5) holds as an equality*

$$kf(\bar{b}^R + k) = \left(1 - \frac{\alpha}{1+\lambda}\right)\left(F(\bar{b}^R + k) - F\left(\underline{b}^R + k + \frac{1-\beta}{\beta}(\underline{b}^R - \bar{b}^R)\right)\right). \tag{9}$$

Our model of limited commitment predicts thus increasing profiles of subsidies in the following sense: types who choose only a fixed-price contract for the second period 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 instead commit to long-term contracts. To do so, we need to simulate an hypothetical situation of perfect commitment, conditional on the current ingredients of the regulation of the French public transportation industry under limited commitment. These ingredients are unknown to the econometrician and need to be estimated. We explain in this section how we recover these ingredients and present the estimated values.

The estimation strategy is organized as a three-step procedure. We first focus on the menus of contracts faced by the operators. As we only observe the subsidies paid to the firms, we miss at least one item of the menu ($\underline{b}^R$, $\bar{b}^R$ or both, depending on which contractual arrangement is observed). The missing items need therefore to be recovered. In a second step, we estimate the ingredients of the model which are specific to the operator. Given the menu of contracts, the operator chooses the contract that maximizes its payoff. We use information on the contract choice, on the observed and estimated subsidies, as well as several characteristics of the operator obtained from our database to identify the distribution of efficiency parameter θ and the social value of effort k. Finally, we recover the missing ingredients related to the regulator. We focus at this stage on the optimality conditions induced by Proposition 4.

Before turning to the empirical model itself, we present in the next section our data and the different variables of interest. We will explain as well throughout each step of the empirical analysis how we organize our dataset for the estimation. In particular, we will define precisely which period and which network are selected in each case.

3.1 Data

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 contracts).

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 when 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.

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, we observe series of 3 contracts per network in most cases. Hence, our initial database contains 136 contracts in total.

In order to make our dataset consistent with our (two-period) theoretical model, we need to reduce slightly the size of the initial sample. We proceed as follows: If a series of fixed-price regimes or a series of cost-plus regimes is considered, we keep all the contractual periods under scrutiny for our empirical analysis, given that the subsidies are constant from one period to another; hence, we may use series of three or more contracts in this case. Now, when considering series where a fixed-price regime is implemented after a cost-plus, we restrict our attention to contractual arrangements which start after the arrival of a new local government. In this case, a cost-plus is followed by one fixed-price or a series of fixed-price contracts. As a result, the reduced sample which is considered for the estimation entails 117 contracts.

Note that one contract in one network should in principle correspond to a unique observation in our empirical model, i.e., the contract items should remain constant over the - say - 5 years of a contract length. 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, and 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 pertain to 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 (579) is much larger in practice than the number of contracts.

3.2 Step 1. Menus of contracts: Recovering Missing subsidies

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

• A series FF of fixed-price contracts over several contracting periods. The operator is rather efficient ($\theta \leq \theta_1^* = \underline{b}^R + k + \frac{1-\beta}{\beta}(\underline{b}^R - \overline{b}^R)$).

• A cost-plus contract followed by a fixed-price contract (CF herein). The operator is only mildly efficient ($\theta_1^* \leq \theta \leq \theta_2^* = \overline{b}^R + k$).

• A series of cost-plus contracts (CC herein). The operator is rather inefficient ($\theta \geq \theta_2^*$).

To exploit the two cut-offs θ_1^* and θ_2^* and recover the distribution of θ, we need to observe the subsidies ($\underline{b}^R$ and $\overline{b}^R$) specified in the optimal menu of contracts. Unfortunately, our data do not allow us to observe all subsidies included into a renegotiation-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 $\overline{b}^{FF}$,

• CF, we observe $\overline{b}^{CF}$ directly in the data and we need to recover $\underline{b}^{CF}$,

• CC, we need to recover $\overline{b}^{CC}$.

Estimation. We propose to recover the missing variables $\overline{b}^{FF}$, $\underline{b}^{CF}$, and $\overline{b}^{CC}$ 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

$$\underline{b}_i^R = \underline{B}\left(Y_i, \tau\right) + \epsilon_i, \tag{10}$$

$$\overline{b}_i^R = \overline{B}\left(Y_i, \upsilon\right) + \varkappa_i, \tag{11}$$

where ϵ_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 τ and υ, 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 $\overline{b}^R$. According to our theoretical model, we need to check that $\underline{b}_i^R < \overline{b}_i^R$. We verify *ex post*, i.e., on our estimates, that these inequalities hold.

The estimation procedure works 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 τ. We then derive the value $\widehat{\underline{b}}_i^{CF}$ using our estimates τ and a set of characteristics Y_i^{CF} if a CF arrangement is instead considered. (*ii*) Likewise, if we select in our dataset the fixed-price contracts of the CF arrangements only, the observed subsidies are the $\overline{b}_i^R$. Using observations Y_i^{CF} for these specific arrangements, we obtain maximum likelihood estimates of $\varkappa$. We then derive the value $\widehat{\overline{b}}_i^{FF}$ (resp. $\widehat{\overline{b}}_i^{CC}$) using our estimates $\varkappa$ and a set of characteristics Y_i^{FF} (resp. Y_i^{CC}) if a FF (resp. CC) arrangement is considered.[28]

Data selection. From the reduced sample, selecting FF arrangements only yields a subsample of 54 fixed-price contracts, i.e., 300 contract-years. Likewise, when keeping the fixed-price contracts of the CF arrangements only, we obtain a subsample of 23 fixed-price contracts, i.e., 93 contract-years.

Results. We assume a linear relationship between a subsidy level and a set of characteristics Y_i in equations (10) and (11). 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 given that several contract-years are observed for the same operator.

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 first-period subsidy $\underline{b}^R$, compared to $\overline{b}^R$, while the second-period subsidy $\overline{b}^R$ seems to be more sensitive to fluctuations in the rolling stock. Subsidies decrease if the share of labor in total operating expenses increases.

[28]For ease of exposition, we omit the labels FF, CF, or CC in what follows.

Likewise, the right-wing variable has a negative and significant sign;[29] note 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 group 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 value and the standard deviation of the estimated $\widehat{\bar{b}}^R$ and $\widehat{\underline{b}}^R$ for all contract-year of the reduced sample. A simple t-test confirms that both quantities are statistically different from each other. Moreover, $\widehat{\underline{b}}^R < \widehat{\bar{b}}^R$ as expected.

3.3 Step 2. Contract choice

We recover now the distribution of types by matching the theoretical probabilities of the three observed contractual regimes FF, CF and CC being chosen with their empirical probabilities. To do so, we take a parametric approach and assume that the distribution $F(\cdot, \nu_{lc}, \sigma_{lc})$ is normal with mean ν_{lc}, variance σ_{lc} and density $f(\cdot, \nu_{lc}, \sigma_{lc})$.[30]

Data selection. In order to compute the distribution of θ, we use all the contracts of our reduced dataset since we are interested in the probabilities of choosing one series of contracts among all the possible arrangements. We therefore consider 117 contracts, i.e., 579 contract-years.

Estimation. We assume that the θ_is are independent draws from a normal distribution that is common across networks. The operator accepts a fixed-price contract in both periods when $\theta_i \leq \theta^*_{1i} = \underline{b}^R_i + k + \frac{1-\beta}{\beta}(\underline{b}^R_i - \widehat{\bar{b}}^R_i)$ so that the probability of accepting such fixed-price contract is:

$$\Pr(\theta_i \leq \theta^*_{1i}) = F\left(\underline{b}^R_i + k_i + \frac{1-\beta}{\beta}(\underline{b}^R_i - \widehat{\bar{b}}^R_i), \nu_{lc}, \sigma_{lc}\right). \tag{12}$$

[29] This outcome is ambiguous since it is difficult to disentangle the right-wing effect from other factors which are proper to right-wing governments; in particular, right-wing municipalities have a significant preference for fixed-price contracts and this may explain why subsidies are lower in this case.

[30] 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 distribution ensures that our estimated distribution has short flat tails, i.e., a very small share of the operators lies in the tails of the probability distribution. Using distributions on bounded intervals, such as the Beta or the truncated normal, may be problematic. 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 our data.

We consider here the pair $\left(\underline{b}_i^R, \widehat{\overline{b}}_i^R\right)$ since the observed arrangement is FF. We allow the unobserved social value of effort k to vary across networks; it depends on a set of explanatory variables X_i which account for the characteristics of the operator:

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

where φ is a vector of parameters to be estimated.

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

$$\Pr\left(\theta_{1i}^* \leq \theta_i \leq \theta_{2i}^*\right) = F\left(\overline{b}_i^R + k_i, \nu_{lc}, \sigma_{lc}\right) - F\left(\widehat{\underline{b}}_i^R + k_i + \frac{1-\beta}{\beta}(\widehat{\underline{b}}_i^R - \overline{b}_i^R), \nu_{lc}, \sigma_{lc}\right). \tag{14}$$

We consider here the pair of subsidies $\left(\widehat{\underline{b}}_i^R, \overline{b}_i^R\right)$ given a CF history.

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

$$\Pr\left(\theta_{2i}^* \leq \theta_i\right) = 1 - F\left(\widehat{\overline{b}}_i^R + k_i, \nu_{lc}, \sigma_{lc}\right). \tag{15}$$

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

$$L_i\left(\nu_{lc}, \sigma_{lc}\right) = \Delta_i log\left(F\left(\underline{b}_i^R + k_i + \frac{1-\beta}{\beta}(\underline{b}_i^R - \widehat{\overline{b}}_i^R), \nu_{lc}, \sigma_{lc}\right)\right) +$$
$$\Pi_i log\left(F\left(\overline{b}_i^R + k_i, \nu_{lc}, \sigma_{lc}\right) - F\left(\widehat{\underline{b}}^R{}_i + k_i + \frac{1-\beta}{\beta}(\widehat{\underline{b}}^R{}_i - \overline{b}_i^R), \nu_{lc}, \sigma_{lc}\right)\right)$$
$$+\Sigma_i log\left(1 - F\left(\widehat{\overline{b}}^R{}_i + k_i, \nu_{lc}, \sigma_{rp}\right)\right),$$

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:

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

Results. To estimate $F(\cdot)$, we need to determine which variables X affect the social value of effort k. Explanatory variables are related to the operator's characteristics (its skills and managerial ability, its effort technology). These variables are a constant, 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 worth 1 if the operator belongs to the corporation Keolis and 0 otherwise, a dummy variable worth 1 if the operator belongs to the corporation Agir and 0 otherwise, and a dummy variable worth 1 if the operator belongs to the corporation Connex and 0 otherwise.

Results are presented in Table 4. During the estimation, we realized that explanations for the social value of effort highly differ from one network to the other, 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 operator's group (Connex is the reference group). Only Trandev has a significant and positive effect on k, suggesting that an operator belonging to Transdev may guarantee a higher social return on effort compared to operators from other groups.[31]

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 may illustrate 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.

[31] The social value of effort is negatively 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 in that firm but we did not have access to such 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 given significant results. The three estimation procedures yield very similar estimates of ν_{lc} and σ_{lc}, the mean and standard deviation of θ's normal distribution respectively. Our results are strongly significant and suggest that the average innate cost θ varies between 14 and 15 millions Euros.

We also obtain a direct estimate of the intertemporal weight β. Values are between 0.25 and 0.41, indicating that the second period is perceived as more important.

Finally, it is of interest to test whether our structural model for contract selection is useful and appropriate. To do so, we test our model against a simple ordered probit specification where the three contractual arrangements are chosen with probabilities $\Pr(FF) = \Phi(-\delta X)$, $\Pr(CF) = \Phi(\mu - \delta X) - \Phi(-\delta X)$, and $\Pr(CC) = 1 - \Phi(\mu - \delta X)$; δ being a vector of parameters to be estimated together with μ, X being the set of the operator's characteristics described above, and $\Phi(.)$ being the c.d.f. of the normal distribution. Since the two models are non-nested, we use a test proposed by Vuong (1989). The null hypothesis is that both models are equally far from the true data generating process in terms of Kullback-Liebler distances. The alternative hypothesis is that one of the two models is closer to the true data generating process. When the Vuong statistics is less than 2 in absolute value, the test does not favor one model against the other. Here, the statistics of our structural model versus the ordered probit is 4.7. This strongly supports the structural approach presented in this paper.

3.4 Step 3. Political preferences

Once estimates $\widehat{\nu}_{lc}$, $\widehat{\sigma}_{lc}$, $\widehat{\beta}$ and $\widehat{k}_i$ are obtained, we evaluate the regulator's preference parameter $\widehat{\alpha}_i$. To do so, we use the renegotiation-proofness condition (9) which is now rewritten as:

$$-k_i\, f\left(\bar{b}_i^R + k_i, \nu_{lc}, \sigma_{lc}\right) + \left(1 - \frac{\alpha_i}{1+\lambda}\right)\left(F\left(\bar{b}_i^R + k_i, \nu_{lc}, \sigma_{lc}\right) - F\left(\underline{b}_i^R + k_i + \frac{1-\beta}{\beta}\left(\underline{b}_i^R - \bar{b}_i^R\right), \nu_{lc}, \sigma_{lc}\right)\right) = 0, \quad i = 1, .., N. \tag{16}$$

The weight α_i varies across cities. It depends on a set of explanatory variables Z_i which characterize the local authority:

$$\alpha_i = \alpha\left(Z_i, \chi\right), \tag{17}$$

where χ is a vector of parameters to be estimated.

Note that we cannot identify separately the weight α and the cost of public funds λ since only the ratio $\frac{\alpha}{1+\lambda}$ matters in Equation (9). We will thus let λ take several values which are consistent with the cost of an administration operating in a developed country.[32] We only present estimation results when $\lambda = 0.3$. Alternative estimates of α can easily be calculated when $\lambda \neq 0.3$.

Data selection. We restrict the reduced sample to fixed-price contracts only given that Proposition 4 is about short-term (the fixed-price contracts belong to a CF arrangement) and long-term (the fixed-price contracts belong to a FF arrangement) fixed-price regimes. This yields a subsample of 77 contracts, i.e., 393 contract-years.

Estimation. To obtain maximum likelihood estimates, Equation (16) is rewritten as

$$J\left(\underline{b}^R, \overline{b}^R, k_i, \alpha_i, \lambda, \nu_{rp}, \sigma_{lc}, \xi_i\right) = 0, \tag{18}$$

where ξ_i is an error term. We need again do distinguish between the observed and the estimated $\left(\underline{b}^R, \overline{b}^R\right)$. If the observed fixed-price contract is extracted from a CF arrangement, we consider the pair $\left(\widehat{\underline{b}}_i^R, \overline{b}_i^R\right)$. Otherwise, If the observed fixed-price contract belongs to a FF arrangement, we consider the pair $\left(\underline{b}_i^R, \widehat{\overline{b}}_i^R\right)$.

Results. 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.[33] 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 $\widehat{\alpha}_i$ should thus be higher with a right-wing local government.[34]

[32]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 between 1.15 and 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.

[33]When the local authority includes several cities, the political color is that of the main municipality.

[34]This point is corroborated in Levin and Tadelis (2009).

Results are presented in Table 5. First, the number of cities constituting the local authority and population size were not significant and have been discarded. Second, whether the government is right-wing or not has a positive and very significant impact on α, confirming thereby our prior intuition. In this case, α takes value 0 for left-wing local 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.

A potential criticism of our three-step estimation procedure is that we may not fully account for the optimality constraints of Proposition 4 in the sense that (6) and (7) are not part of the estimation process. An alternative estimation procedure could consist in recovering values of $\left(\underline{b}^R, \overline{b}^R\right)$ through the system (6), (7) and (9). Thus, $\underline{b}^R(.)$ and $\overline{b}^R(.)$ would be two functions of a set of variables and parameters to be estimated which we could use to write the log-likelihood of observing one specific contractual arrangement in a similar fashion as in Step 2. This alternative procedure has the attractive feature of accounting explicitly for the optimality conditions for the regulator's problem. However, it suffers from a serious drawback in that it does not use our data observations of $\left(\underline{b}^R, \overline{b}^R\right)$. We argue that this alternative procedure and our methodology are similar, conditional on the fact that our theoretical model perfectly explains the data reality. Expecting that our model provides a perfect fit is probably excessive. We therefore prefer to use the data information on $\left(\underline{b}^R, \overline{b}^R\right)$. To convince the reader that our approach is reasonable, we propose an ex-post test to check that our estimates $\widehat{\nu}_{lc}$, $\widehat{\sigma}_{lc}$, $\widehat{\beta}$, $\widehat{k}_i$, and $\widehat{\alpha}_i$ verify the conditions expressed in (6) and (7). To do so, we replace μ in (6) by its expression from (7) in order to generate an equation (6′). Then, we compute a t-test to check whether the left-hand side of equation (6′) 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 renegotiation-proof scenario, we can reconstruct estimates of the average social cost of subsidies and the average rent left to operators under full commitment.[35] We proceed as follows.[36]

Data selection. We restrict the reduced sample to FF arrangements only given that proposition 1 is about long-term fixed-price contracts. Moreover, we focus on right-wing networks only since we need $\widehat{\alpha}^R > 0$. Once outliers are discarded, we obtain a subsample of 114 contract-years.

Step 1. Using our set of renegotiation-proof estimates $\Upsilon^R = \left(\widehat{\nu}^R, \widehat{\sigma}^R, \widehat{k}^R, \widehat{\alpha}^R, \widehat{\beta}^R\right)$ conditional on λ and its expression from the maximand in a scenario with limited commitment, we compute expected welfare levels $\mathcal{W}_i^R$ for each network of our subsample. 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 Υ^R give to the econometrician some information on the operator's and public authority's true characteristics.

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

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

We compute the total welfare gains as well as the gains for taxpayers and operators from commitment by considering an average network of the subsample, using estimates Υ^R conditional on $\lambda = 0.3$ and k_i specified as in (II) in Table 4.[37]

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. The important question is actually to determine how welfare gains of commitment are distributed between the parties. It turns out that $\widehat{T}_i^F > \widehat{T}_i^R$, i.e., switching from limited to full commitment entails a higher in-

[35] 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.

[36] See the Appendix for details.

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

tertemporal subsidy. 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 (+22.4%) on average.

Turning now to operators, our estimates show that their intertemporal rent increases when moving to full commitment by 8.2 million Euros (+11.5%). This is a significant gain that explains why operators are pushing to increase contracts length.

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. The welfare gains from extending contract length are significant but mostly accrue to operators.

In this conclusion, we would like to make a few remarks on our approach and suggest alleys for further investigation.

First, our result on the significant welfare gains of extending contract length should be taken with some words of caution. Indeed, it starts from the premise that, in this sector, competition is almost absent at the bidding stage. We are thus examining the benefits of such reform in a monopolistic setting where more competition could even bring higher welfare gains. However, one can also argue that extending contract length would not favor the emergence of a more competitive playing field which may have a negative impact on long-run welfare.

By focusing on menus with only two items (fixed-price and cost-plus contracts) whereas a model with a continuum of types would invite more complex menus and by simplifying the procedure for updating beliefs, we have significantly simplified our theoretical model. The benefit is that we were able to bring the lessons of the renegotiation literature 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 painful project. Taking data and institutional constraints seriously forced us instead to focus on the case of simple menus which, although suboptimal, brings also some tractability. This procedure seems to us extremely promising in areas where a purely theoretical approach would either produce untractable models or make progresses at the cost of imposing heroic assumptions on the underlying type distribution (assuming typically discrete types), assumptions that might hardly be corroborated by data. Our "midway" approach could certainly be fruitful also for other industries and contractual environments.

Even though our estimates show that welfare gains of commitment are significant, we might be underestimating those gains. 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 these considerations would reinforce our argument in favor of extending contract length. This would indeed help to secure specific investments and avoid hold-ups.

On the other hand, one could also argue that even writing a long-term contract may entail significant transaction costs, especially when future contingencies cannot be perfectly foreseen ex ante. In our model, such transaction costs have deliberately been omitted since we focused on stationary environments where efficiency parameters are drawn once for all. Introducing the possibility of writing more flexible contracts as uncertainty gets resolved would unveil some interesting benefits of renegotiation. On top, the need for drafting flexible arrangements may also favor fixed-price contracts since those contracts make operators more reactive to shocks affecting their costs. Yet, it is unclear to us whether those theoretical arguments in favor of some kind of limited commitment matter in the transportation sector under scrutiny.

A more complete analysis of the renegotiation process should incorporate the possibility that public authorities build reputations for being tough at the renegotiation stage to avoid thereby giving larger subsidies to operators. Such reputations might potentially relax significantly renegotiation-proofness constraints. In other words, an omitted variable of our analysis is the amount of reputational capital available to the contracting parties involved in those repeated negotiations. Our theoretical model has put aside 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.

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 matters even in a static context. Echoing the theoretical works of Rogerson (2003) and Chu and Sappington (2007), we could indeed ask whether simple two-item menus fare well compared with more complex menus given our estimate of the types distribution. Such investigation would help us to unveil whether the major sources of benefits in contract design come either from extending contract length or from better designing cost reimbursement rules in any given period. This last issue is high on practitioners' agenda.

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

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Appendix

Proof of Proposition 1. 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 types 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.

The principal's problem can be rewritten as:

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

The monotone hazard rate property ensures quasi-concavity of this objective.[38] The corresponding first-order conditions characterize the optimal subsidy in (1). ■

Proof of Proposition 2. Fix any initial contract C^0 and consider a renegotiated offer $\tilde R=(\tilde b_2,\tilde b_3)$ 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:

$$W_2(C^0,\tilde R,R)=\int_{\underline{\theta}}^{b_1+k+\frac{1-\beta}{\beta}(b_2-b_3)}\left(S-(1+\lambda)\tilde b_2+\alpha(\tilde b_2+k-\theta)\right)f(\theta)d\theta \tag{19}$$
$$+\int_{b_1+k+\frac{1-\beta}{\beta}(b_2-b_3)}^{\tilde b_3+k}\left(S-(1+\lambda)\tilde b_3+\alpha(\tilde b_3+k-\theta)\right)f(\theta)d\theta \tag{20}$$
$$+\int_{\tilde b_3+k}^{\bar\theta}\left(S-(1+\lambda)\theta\right)f(\theta)d\theta. \tag{21}$$

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

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

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 (19).

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 (20) and (21).

At date 1.25, the principal looks for a menu that maximizes the second-period welfare $W_2(C^0,\tilde{R},R)$ subject to the acceptance condition (2). The renegotiated offers $R=(b_2,b_3)$ must solve the following problem:

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

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 (3) implies

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

Similarly, that b_3 satisfies the second condition in (2) and $\tilde{b}_3$ satisfies the second condition in (3) altogether 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 comes unchanged through the renegotiation process, i.e., solves the following problem:

$$(\mathcal{R}): \quad R = \arg\max_{\tilde{R}} W_2((b_1, R), \tilde{R}, R) \text{ subject to (3).}$$

This ends the proof of Proposition 2. ■

Proof of Proposition 3. Define the principal's intertemporal welfare when offering $C = (b_1, b_2, b_3)$ as:

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

$$+ \int_{b_1+k+\frac{1-\beta}{\beta}(b_2-b_3)}^{b_3+k} (S - (1+\lambda)(\beta\theta + (1-\beta)b_3) + \alpha(1-\beta)(b_3 + k - \theta))\, f(\theta)d\theta$$

$$+ \int_{b_3+k}^{\bar{\theta}} (S - (1+\lambda)\theta)\, f(\theta)d\theta.$$

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

$$(\mathcal{P}^R): \quad \max_{C} \mathcal{W}(C) \text{ subject to (4) and (5).}$$

We shall assume quasi-concavity in (b_1, b_2, b_3) of the corresponding Lagrangean. The solution $C^R = (b_1^R, b_2^R, b_3^R)$ to problem (P^R) is then straightforward.

First, note that $\alpha < 1 + \lambda$ implies that the maximum of the first integral in (21) is obtained when (3) 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 expecting 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 (5). ■

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 (6) and (7).

Moreover, (5) 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:

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

where

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

and

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

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 $\widehat{\alpha}_i^R$:

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

where

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

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 when one computes 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

$$\Delta\mathcal{W}_i = \mathcal{W}_i^F - \mathcal{W}_i^R. \tag{27}$$

Similar definitions follow for ΔT_i and ΔU_i. ■

Variables	Mean	Stand. Dev.
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

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

Table 2: Estimated Subsidies I

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

Table 3: Estimated Subsidies II

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

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

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

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

Welfare Items	**Total (in Million Euros)**
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