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The Cost of Contract Renegotiation: Evidence from the Local Public Sector¹

Philippe Gagnepain,² Marc Ivaldi³ and David Martimort⁴

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Contract theory claims that renegotiation prevents from reaching the informationally constrained efficient solution that could have been obtained under full commitment. Assessing the cost of renegotiation compared to the full commitment scenario still 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 contracts for urban transport services. 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 are greater when a cost-plus contract was signed earlier on than following a fixed-price contract. We then 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.

Contract theory claims that, under a variety of circumstances, renegotiation imposes various transaction costs. Although renegotiation improves contracting *ex post*, it has also perverse effects on the parties' *ex ante* incentives.¹ Overall, those costs prevent those parties from reaching the informationally constrained efficient solution that could have been achieved under full commitment. Yet, an open issue from an empirical viewpoint remains to assess the welfare losses associated with renegotiation. Furthermore, another important question especially from a policy perspective is to evaluate the distribution of these losses among contracting parties.

Indeed, making progresses on these fronts is crucial, especially for practitioners who are eager to evaluate the performances of various contractual arrangements found in 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' (in a sense to be discussed later) every 5 years by public authorities in charge of regulating transport operators. Since then, practitioners 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 has often been considered as a justification of the operators' political activism.

Motivation. This paper has two main objectives. First, we construct and estimate a structural principal-agent model of contract renegotiation in the French urban trans-

¹Such 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.

port sector. A basic assumption of this model is that contracting takes place under asymmetric information: Operators are privately informed on their innate costs at the time of contracting with public authorities. Second, we use those estimates in a counterfactual experiment whose goal is to recover not only the welfare gains but also their distribution if full commitment were feasible. These gains are significant although unevenly distributed: Operators would be net winners whereas taxpayers/consumers would lose had contract length been extended.

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 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.² Of much importance from a practical point of view, these menus approximate quite well and sometimes replicate what more complex optimal 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 (i.e., one cost-plus and one fixed-price contracts) is enough 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 is revealed over time. This point is familiar from the agency literature on limited commitment.⁵ However, it is revisited here in an institutional context where

²In 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).

³Laffont and Tirole (1993, Chapter 1) showed that a convex optimal nonlinear cost reimbursement rule can be implemented with a menu of linear contracts. Wilson (1993) and McAfee (2002) demonstrated that such menus might already fare well even when restricted to a few items.

⁴More 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.

⁵Dewatripont (1989) and Laffont and Tirole (1993, Chapter 10) among others.

only menus with two options (fixed-price/cost-plus) are feasible. Whereas the existing theoretical literature on limited commitment has focused on discrete type models to derive fully optimal renegotiation-proof contracts but is often criticized for its lack of tractability, we import 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. In particular, it is a prerequisite to consider a continuum of types for evaluating a meaningful distribution of cost parameters in our empirical model and neatly characterize the probabilities of various contractual regimes (cost-plus, fixed-price, and moves over time from cost-plus to fixed-price contracts).

Empirical analysis. The theoretical model readily boils down to an econometric set-up whose parameters are estimated under a scenario where renegotiation takes place. To understand the source of 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. These efficiency gains also give more rents to the most efficient operators who enjoy 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 this 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 yields two main results. First, it provides an estimate of the congruence of objectives between the operator and the local government in charge of regulating the service. The operator's bargaining power when negotiating contracts depends on political preferences. Right-wing municipalities are more prone to favor private operators than left-wing ones.⁷

Second, using our estimates of the operator's innate cost distributions and other parameters of the model, we evaluate the welfare gains that would be obtained when

⁶The static analysis in Rogerson (2003) cannot cover the rich dynamic patterns observed in our data set, in particular the move towards fixed-price contracts as time passes.

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

moving to the full commitment solution. The intertemporal subsidies under full commitment are higher than under renegotiation, so that taxpayers are net losers from a hypothetical increase in contract length. However, the welfare gains are significant. Taxpayers bear an increase in tax burden of 8 million Euros whereas operators see their rent increase by roughly 8.2 million Euros. This provides a strong rationale for the operators' lobbying effort towards increasing 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 complex nonlinear 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 also such complex regulatory schemes to estimate costs and demand parameters of structural models. Other empirical studies have instead argued 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 face a 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 instead model contract design in a dynamic context.

In that respect, our paper is also related to Dionne and Doherty (1994). These authors focused on the car insurance industry in California and suggested that insurers may use long-term contracts to enhance efficiency and attract portfolios of low-risk drivers. Our empirical analysis shows the extent to which long-term contracts may benefit not only principals (hereafter public authorities) but also agents (operators).

Organization of the paper. Section 1 provides an overview of the French urban trans-

portation sector. Section 2 presents our theoretical model and characterizes the optimal menu of contracts (fixed-prices/cost-plus) both under full commitment and renegotiation. Section 3 develops our empirical method. Section 4 evaluates the welfare gains when moving to full commitment and their distribution between operators and taxpayers. Section 5 discusses other potential hypothesis explaining the pattern of subsidies observed in practice. Section 6 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. In each urban area of significant size endowed with a transport network, a local authority (a city, a group of cities or a district) contracts with a single operator to provide the transport service. Regulatory rules prevent the presence of several suppliers on the same network. A distinguishing feature of France compared to most other OECD countries is that, in 2002, 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 These companies, defined by 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 fully controlled by local governments.

1.1 Economic Environment

The 1982 Transportation Law establishes a decentralized decision-making process concerning the local transport policy and provides regulatory guidelines. 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 investment and ownership nature. The local authority may operate the network directly or it may rely on an operator. In this case, a formal contract defines the regulatory rules that the operator must follow as well as a cost-reimbursement scheme.¹⁰

⁸Proofs of the theoretical results are relegated to an Appendix.

⁹For 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).

¹⁰Since 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, very few networks

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 *Groupe des Autorités Responsables du Transport* (GART, Paris), a nationwide trade organization that gathers most of the local authorities in charge of a urban transport network. This rich source is a unique tool for comparing regulatory systems both across space and over time. 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 surveyed. Overall, the panel data set covers 49 different urban transport networks over the period 1987-2001. Note finally that we only focus on transport networks where the operator is a private entity. This rules out the so-called *Régies municipales* where the service is fully integrated within the city administration, like in Paris or Marseille, as these cases are not concerned with the principal-agent problem at the heart of our investigation.

have changed operators from one regulatory period to the other until recently. 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 which is 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.

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 stringent financial constraints, 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 and often point at their lack of expertise.¹¹ 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 the 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 naturally arises on top of the adverse selection problem. When compounded, those informational asymmetries play a crucial role in the design of contractual arrangements and financial objectives.^{12, 13}

¹¹The 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).

¹²Gagnepain 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.

¹³Three 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. 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 entail relatively predictable 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

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 contracts 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. In the same network, the regulatory scheme may switch from cost-plus to fixed-price or from fixed-price to cost-plus between two regulatory periods. We observe 20 changes of regulatory regimes, most of them (i.e., 17) being switches from cost-plus to fixed-price regimes. These changes occur because the same local authority may be willing to change regulatory rules, or because a new government is elected and changes the established rules. Note however that a change in the political preference of the local government does not necessarily imply an early renegotiation of the contract before its term. Newly elected 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 with a series of fixed-price schemes. 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, a dummy variable CF indicating whether the observed fixed-price contract is implemented after a cost-plus regime or not, and a set of firms fixed effects.¹⁴ The CF dummy is positive and significant at the 1% level. On average, subsidies paid under fixed-price after a cost-plus

¹⁴Estimation results are (392 observations, firms fixed effects included, standard errors in parenthesis):
 $\log Subsidy = 4.87 + 0.68 \log Rolling\ Stock + 0.23 \log network - 0.11 Right-Wing + 0.34 CF.$
(0.26) (0.05) (0.03) (0.03) (0.09)

are 40.9% higher than those observed in the case of a sequence of fixed-price regimes. The theoretical model below accounts for the features of the regulatory contracts used in the French urban transportation industry and provides a rationale for the dynamic patterns of subsidies.

2 Theoretical Model

The model adapts the lessons of the contracting literature under imperfect commitment to the regulatory contracts just described. First, operators choose between fixed-price or cost-plus contracts. Second, subsidies may increase over time. We argue below that such patterns arise when contracts are renegotiation-proof. This positive model is then compared to an hypothetical setting where regulators could commit but optimal subsidies would then remain constant over time.

Generalizing the objective functions used in Baron and Myerson (1982) and Laffont and Tirole (1993), the preferences of the local authority (the ‘principal’) are defined as:

$$W = S - (1 + \lambda)t(c) + \alpha U$$

where S is the gross surplus generated by the service and U is the profit of the operator.¹⁵ Subsidies $t(c)$ raised by means of a distortionary taxation entail some dead-weight loss that is captured by introducing a positive cost of public funds $\lambda > 0$.

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 .

Public authorities might differ in terms of the weights left to the operator’s profit 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 capture the firm’s bargaining power in tender offers and as such

¹⁵Implicitly, we consider a setting where the elasticity of demand is small which is a reasonable assumption in the case of transportation in the medium term horizons we are considering here. In other words, the surplus is basically constant. See Oum et al. (1992).

reflect the level of *ex ante* competition among potential operators.^{16,17} In view of our empirical study, we may also distinguish local governments according to their political preferences. Rightist (resp. leftist) local governments commend more (resp. less) rent for the private operator. This corresponds to higher values of α .

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 .¹⁸ 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 ($\psi' > 0$, $\psi'' > 0$) 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, $\dot{R}(\theta) > 0$ where $R(\theta) = \frac{F(\theta)}{f(\theta)}$ so that all optimization problems considered have quasi-concave objectives.¹⁹

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

$$U = t(c) - c - \psi(e).$$

¹⁶In this sector, *ex ante* competition is not so fierce. Indeed, operators from different groups mostly avoid head-to-head competition and generally bid 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 an ad hoc specification of the intensity of potential downstream competition comes from a better fit to the real-world practices while it fortunately eases the analysis of the contractual dynamics.

¹⁷Following 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.

¹⁸In accordance with the lack of expertise in practice, we assume that the public authority has no auditing capabilities and cannot check whether high costs are due to high innate inefficiency or to low efforts. Adding the possibility of audit would relax incentive problems and making higher power incentives (i.e., fixed-price contracts) more attractive (Baron and Besanko, 1984a, Laffont and Tirole, 1993-Chapter 12, and Khalil, 1997).

¹⁹For 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.

2.1 Full Commitment

Suppose that the local government offers a long-term contract which covers two contracting periods. 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 benchmark is attractive to later on 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.

Consider first a two-period fixed-price contract which entails the corresponding subsidies is $t_i(c) = b_i$ in each period i . With such fixed-price contracts, the principal passes 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 always reimbursed for his costs so that he exerts no effort and his payoff is zero.²⁰

Only the most efficient operators such that $\theta \leq \theta^*$ choose fixed-price contracts.²¹ 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 the fixed-price contract whereas inefficient ones go for the cost-plus. The marginal operator with type θ^* is just indifferent between those two options:

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

Only efficient operators such that $\theta \leq \theta^*$ who operate under a fixed-price contract earn an information rent worth $\theta^* - \theta$.²²

²⁰The 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.

²¹From an empirical point of view, the econometrician only observes the choices 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. Following the mechanism design tradition, this process is captured because principals offer menus among which operators with different types self-select.

²²The operator's choice between taking either a two-period fixed price contract or a cost-plus one

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. The subsidy b^F is constant over time: $b_1^F = b_2^F = b^F$ with*

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

The most efficient firms ($\theta \leq \theta^F = b^F + k$) choose this two-period fixed-price contract. The least efficient firms ($\theta \geq \theta^F = b^F + k$) 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 would ensure that the operator exerts the first-best effort whatever his innate technology. However, doing so also leaves too much information rent to the most efficient types and this is socially costly. A cost-plus contract nullifies this rent but also destroys incentives to reduce costs.

Under full commitment, the optimal contract is the twice-repeated version of the optimal static contract: a by-now standard result in the literature.²³ 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.²⁴ Such evidence thus suggests that the full commitment scenario is not followed.

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 command more rent.

2.2 Renegotiation

Overview and modeling choices. The full commitment assumption does not capture real-world practices as we explained above. Although the 1993 Law invites local au-

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.

²³See Baron and Besanko (1984b) and Laffont and Martimort (2002, Chapter 8).

²⁴This 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.

thorities 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 contemplating the possibility to contract with a new operator.

Contract 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 attractive.²⁵ The second paradigm considers instead that only short-term contracts can be enforced.²⁶ 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 recontracting is sufficiently credible. 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 is '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. Renegotiating towards a second-period fixed-price contract with a large subsidy allows operators who have revealed not to be very efficient earlier on by choosing a cost-plus contract in the first period to reap productivity gains later on. Such large subsidies might thus be viewed as *ex post* attractive from the principal's viewpoint. However, the second-period fixed-price contract may entail such a large subsidy that

²⁵Dewatripont (1989), Laffont and Tirole (1993, Chapter 10), Hart and Tirole (1988), Rey and Salanié (1996).

²⁶Guesnerie, Freixas and Tirole (1985), Laffont and Tirole (1993, Chapter 9).

even the most efficient operators may want to forego the gains of being under a fixed-price contract earlier on and wait for such attractive opportunities at the renegotiation stage. This important dynamic trade-off is at the core of our model.

Contracts. To build a model that fits with the contracting patterns which are actually found in our data set, we allow the principal to offer three possible options: A two-period fixed-price contract, a first-period cost-plus contract followed by a second-period fixed-price and a two-period cost-plus contract. Let us index by $j = G, I, B$, respectively these three scenarios. Let also denote by $C_1^0 = (b_1, b_2^0)$ the subsidies under scenario G , by $C_2^0 = (\theta, b_3^0)$ the payments under scenario I (where we take into account that effort is zero at date 1 so that realized costs and payments are then equal to θ), and finally $C_3^0 = (\theta, \theta)$ the payments under scenario B . We will use the more compact notation $C^0 = (b_1, b_2^0, b_3^0)$ to denote the overall menu of fixed prices and by $R^0 = (b_2^0, b_3^0)$ its continuation for date 2.

Operators choose different options depending on their types. We look for a cut-off equilibrium where the most efficient types that belong to a lower tail interval Θ_G follow history G , whereas intermediate and least efficient ones that belong respectively to the middle interval Θ_I and to the upper tail interval Θ_B follow histories I and B .

Let denote $\tilde{R} = (\tilde{C}_2, \tilde{C}_3) \equiv (\tilde{b}_2, \tilde{b}_3)$ a subsidy profile offered at the renegotiation stage following an initial offer C^0 .²⁷ Renegotiation takes place if those new subsidies increase the operator's payoff, i.e., if the following inequalities hold:

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

The first inequality in (2) says that types in Θ_G accept the renegotiation that takes place after the choice of an earlier fixed-price contract if it increases the subsidy above b_2^0 . The second inequality is similar for types in Θ_I who chose earlier on to operate with a cost-plus contract.

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 (either \tilde{b}_2 or \tilde{b}_3) is made once the principal has already updated his beliefs over the operator's type following his earlier

²⁷We omit the dependence of \tilde{R} on C^0 for notational simplicity.

choice to operate under a fixed-price or a cost-plus in the first-period.

• **Firm's strategy.** The firm anticipates (perfectly in equilibrium) the second period subsidies 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 $\Theta_G = \left[\underline{\theta}, b_1 + k + \frac{1-\beta}{\beta}(b_2 - b_3) \right]$ already adopt 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 a two-period fixed-price contracts with subsidies (b_1, b_2) and moving from a first-period cost-plus contract to a second-period fixed-price contract with subsidy b_3 .
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 operating under a cost-plus contract over both periods.
3. Types in $\Theta_B = [b_3 + k, \bar{\theta}]$ choose a two-period cost-plus contract C_3^0 anticipating that the renegotiated fixed prices won't be attractive for them anyway.

This pattern summarizes incentive compatibility in this dynamic context. To illustrate, if the cut-off type θ_1^* is just indifferent between adopting fixed prices in both periods or only at date 2, more efficient types, such that $\theta \leq \theta_1^*$, certainly also prefer to operate under fixed-price contracts.

'Almost' equilibrium and limited updating. Before renegotiation, the principal updates his beliefs using only the information that is revealed by the firm's first-period choice between operating under a fixed-price or a cost-plus contract. This is a slight departure away from full rationality to the extent that the principal could have updated his beliefs with the more precise information contained in the realized first-period costs if the firm had operated under a cost-plus contract. This justifies the use of the qualifier 'almost' for our notion of equilibrium.²⁸

²⁸Relying on such 'almost' rational principal is of course a methodological simplification. With this simplified view of updating, our model keeps then all the flavor of the dynamic rent/efficiency trade-off familiar from the theoretical literature on renegotiation without making the analysis non-tractable even though we consider here a model with a continuum of types.

Renegotiation-Proofness Principle. The theoretical literature has shown that focusing on renegotiation-proof mechanisms which come unchanged through the renegotiation process is without loss of generality.²⁹ Any long-term agreement which is renegotiated to some contract could be replaced by another long-term contract with a second-period continuation equal to this renegotiated offer. This continuation cannot be superseded by any other contract; otherwise, it would not have been optimal to renegotiate towards such offer in the first place. Our focus on renegotiation-proof profiles of subsidies follows this logic.³⁰

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

Proposition 2 *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:*

$$b_3 \geq \beta b_1 + (1 - \beta)b_2, \quad (3)$$

$$kf(b_3 + k) - \left(1 - \frac{\alpha}{1 + \lambda}\right) \left(F(b_3 + k) - F\left(b_1 + k + \frac{1 - \beta}{\beta}(b_2 - b_3)\right)\right) \leq 0. \quad (4)$$

Condition (3) 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 (4) expresses the fact that raising the second-period subsidy for those firms with intermediate types having taken contract C_2^0 is not found attractive by the principal at the renegotiation stage. For a renegotiation-proof profile of subsidies, the efficiency gains obtained by slightly increasing the subsidy b_3 to attract less efficient operators who initially thought about operating under C_3^0 should be less than the net cost of raising the rent of all inframarginal types who already chose C_2^0 and enjoy that increase in the subsidy. Indeed, when b_3 is increased by a small amount db , the marginal type θ_2^* , who is just indifferent between taking the two-period

²⁹Hart and Tirole (1988), Dewatripont (1989), Laffont and Tirole (1993, Chapter 10), Bester and Strausz (2001).

³⁰The theoretical literature on renegotiation focuses on discrete types distributions. Working with a continuum is necessary to take into account the significant heterogeneity in costs realizations that is found in our data set. It also allows us to divide the types space into three intervals Θ_G , Θ_I and Θ_B whose respective measures (obtained from the equilibrium behavior of cut-off types that define those intervals) can be matched with the empirical distribution of observed behaviors. 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 would not explain well our data set.

cost-plus contract and a fixed-price contract for the second period only, slightly moves up and an extra mass of less efficient types $f(b_3 + k)db$ brings efficiency gains of size k . On the other hand, information rents increase for all types in Θ_I and that cost is proportional to $(F(b_3 + k) - F(\theta_1^*)) db$.

Optimal renegotiation-proof menus of contracts. Optimizing the principal's expected intertemporal welfare subject to the renegotiation-proofness constraint (4), we find:

Proposition 3 *The optimal renegotiation-proof menu of contracts $C^R = (b_1^R, b_2^R, b_3^R)$ is such that the two-period fixed-price contract entails a constant subsidy, $b_1^R = b_2^R = \underline{b}^R$, which is lower than the subsidy $b_3^R = \bar{b}^R$ when a fixed-price contract is chosen for the second period only:*

$$\bar{b}^R > \underline{b}^R. \quad (5)$$

The renegotiation-proofness constraint (4) is binding:

$$kf(\bar{b}^R + k) = \left(1 - \frac{\alpha}{1 + \lambda}\right) \left(F(\bar{b}^R + k) - F\left(\underline{b}^R + k + \frac{1 - \beta}{\beta}(\underline{b}^R - \bar{b}^R)\right)\right). \quad (6)$$

To understand the intuition behind (5), notice that the renegotiation-proofness constraint (4) is relaxed when the probability of having a type in Θ_I (i.e. the difference $F(b_3 + k) - F\left(b_1 + k + \frac{1 - \beta}{\beta}(b_2 - b_3)\right)$) increases. Intuitively, if there are enough types in that middle interval, it becomes relatively costly to raise the subsidy \tilde{b}_3 at the renegotiation stage. Efficiency gains associated to such increase are then lower than the increase in the information rents distributed to all types in such interval Θ_I . Increasing the probability $F(b_3 + k) - F\left(b_1 + k + \frac{1 - \beta}{\beta}(b_2 - b_3)\right)$ is obtained by committing to a large b_3 and low b_1 and b_2 that are not renegotiated. Finally, because the cut-off type θ_1^* depends only on the discounted subsidy $b_1 + \frac{1 - \beta}{\beta}b_2$, b_1 and b_2 must be reduced by the same amount. Hence, with a two-period fixed-price contract, subsidies are constant over time.

Our model predicts thus an increasing profile 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 his 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 the efficiency parameter θ and the social value of effort k . Finally, we recover the missing elements that characterize the regulator's objective function. We focus at this stage on the optimality conditions induced by Proposition 3.

Before turning to the empirical model itself, we present in the next section our data and the different variables of interest. We explain as well throughout each step of the empirical analysis how we organize our dataset for the estimation. In particular, we 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 an 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 (measured in kilometers), the number of lines operated, the size of the rolling stock (measured by the number of vehicles), the share of the labor bill in total costs, the share of drivers or engineers in the total labor force, and the identity of the industrial group which owns the operator (Keolis, Transdev, Agir, or Connex). 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.

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 preference 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 preference 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.^{31, 32}

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

³¹To make our dataset consistent with our (two-period) theoretical model, we structure our sample in the following way: 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 sample which is considered for the estimation entails 117 contracts.

³²Note 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.

Hence, if the contractual arrangement is respectively

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

Estimation. We propose to recover the missing variables \bar{b}^{FF} , \underline{b}^{CF} , and \bar{b}^{CC} empirically. In municipality i , we expect subsidies to depend on a set Y of characteristics of the public authority, the operator, and the transportation service itself. We write:

$$\underline{b}_i^R = \underline{B}(Y_i, \tau) + \epsilon_i, \quad (7)$$

$$\bar{b}_i^R = \bar{B}(Y_i, \nu) + \varkappa_i, \quad (8)$$

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 ν , which have to be estimated. We thus expect to identify two distinct marginal impacts of a given characteristic on the choice of \underline{b}^R and \bar{b}^R . According to our theoretical model, we need to check that $\underline{b}_i^R < \bar{b}_i^R$. We verify *ex post*, i.e., on our estimates, that these inequalities hold.

The estimation procedure works 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 $\hat{\underline{b}}_i^{CF}$ 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 \bar{b}_i^R . Using observations Y_i^{CF} for these specific arrangements, we obtain maximum likelihood estimates of ν . We then derive the value $\hat{\bar{b}}_i^{FF}$ (resp. $\hat{\bar{b}}_i^{CC}$) using our estimates ν and a set of characteristics Y_i^{FF} (resp. Y_i^{CC}) if a FF (resp. CC) arrangement is considered.³³

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.

³³For ease of exposition, we omit the labels FF , CF , or CC in what follows.

Results. We assume a linear relationship between a subsidy level and a set of characteristics Y_i in equations (7) and (8). 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 zero otherwise, a dummy variable that takes value one if the operator belongs to the corporation Keolis and zero otherwise, a dummy variable that takes value one if the operator belongs to the corporation Agir and zero otherwise, and a dummy variable that takes value one if the operator belongs to the corporation Connex and zero 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 \bar{b}^R , while the second-period subsidy \bar{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. Likewise, the right-wing variable has a negative and significant sign,³⁴ 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 $\hat{\underline{b}}^R$ and $\hat{\bar{b}}^R$ for all contract-year of the reduced sample. A simple t-test confirms that both quantities are statistically different from each other. Moreover, $\hat{\underline{b}}^R < \hat{\bar{b}}^R$ 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

³⁴This 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.

distribution $F(\cdot, \nu_{lc}, \sigma_{lc})$ is normal with mean ν_{lc} , variance σ_{lc} and density $f(\cdot, \nu_{lc}, \sigma_{lc})$.³⁵

Data selection. To compute the distribution of θ , we use all contracts of our reduced dataset since we look for the probabilities of choosing one series of contracts among all possible arrangements. We thus consider 117 contracts, i.e., 579 contract-years.

Estimation. We assume that the θ_i s are independent draws from a normal distribution that is common across networks.³⁶ The operator accepts a fixed-price contract in both periods when $\theta_i \leq \theta_{1i}^* = \underline{b}_i^R + k + \frac{1-\beta}{\beta}(\underline{b}_i^R - \widehat{b}_i^R)$ so that the probability of accepting such fixed-price contract is:

$$\Pr(\theta_i \leq \theta_{1i}^*) = F\left(\underline{b}_i^R + k_i + \frac{1-\beta}{\beta}(\underline{b}_i^R - \widehat{b}_i^R), \nu_{lc}, \sigma_{lc}\right). \quad (9)$$

We consider here the pair $(\underline{b}_i^R, \widehat{b}_i^R)$ 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:

$$k_i = k(X_i, \varphi), \quad (10)$$

where φ is a vector of parameters to be estimated.

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

$$\Pr(\theta_{1i}^* \leq \theta_i \leq \theta_{2i}^*) = F(\bar{b}_i^R + k_i, \nu_{lc}, \sigma_{lc}) - F\left(\widehat{b}_i^R + k_i + \frac{1-\beta}{\beta}(\widehat{b}_i^R - \bar{b}_i^R), \nu_{lc}, \sigma_{lc}\right). \quad (11)$$

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

³⁵Our 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.

³⁶Attempts to identify fixed effect in our structural model through fixed-effect dummy variables have been unfruitful. Note however that our structural model heavily relies on k , the social value of effort, which itself depends on a set of explanatory variables, the operator's group identity, the size of the network, and the share of engineers in the labor force. The group identity variable is the group fixed effect while the two latter variables are quite stable over time and can therefore be reasonably expected to capture firms fixed effects.

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

$$\Pr(\theta_{2i}^* \leq \theta_i) = 1 - F\left(\widehat{b}_i^R + k_i, \nu_{lc}, \sigma_{lc}\right). \quad (12)$$

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

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

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

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

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

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 one if the operator belongs to the corporation Keolis and zero otherwise, a dummy variable worth one if the operator belongs to the corporation Agir and zero otherwise, and a dummy variable worth one if the operator belongs to the corporation Connex and zero 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 column (I), k depends on four dummy variables which account for the identity of the operator's group (Connex is the reference group). Only Transdev 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.³⁷ This result also suggests that Transdev has preferences for fixed-price contracts as an increase in k increases the probability to choose a fixed-price regime. This pattern is well known by transport regulators in France.³⁸

In column (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 column (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.

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.

³⁷The 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.

³⁸See the reports of the Groupement des Autorités Responsables de Transport (GART), <http://www.gart.org/S-informer/Publications-du-GART>.

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 $\Phi(\cdot)$ 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 $\hat{\nu}_{lc}$, $\hat{\sigma}_{lc}$, $\hat{\beta}$ and \hat{k}_i are obtained, we evaluate the regulator's preference parameter $\hat{\alpha}_i$. To do so, we use the renegotiation-proofness condition (6) rewritten now as:

$$\begin{aligned} & -k_i f\left(\bar{b}_i^R + k_i, \nu_{lc}, \sigma_{lc}\right) \\ & + \left(1 - \frac{\alpha_i}{1 + \lambda}\right) \left(F\left(\bar{b}_i^R + k_i, \nu_{lc}, \sigma_{lc}\right) - F\left(\underline{b}_i^R + k_i + \frac{1 - \beta}{\beta} \left(\underline{b}_i^R - \bar{b}_i^R\right), \nu_{lc}, \sigma_{lc}\right) \right) = 0, \quad i = 1, \dots, N. \end{aligned} \quad (13)$$

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

$$\alpha_i = \alpha(Z_i, \chi), \quad (14)$$

where χ is a vector of parameters to be estimated.

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 (6). We will thus let λ take several values which are consistent with the cost of an administration operating in a developed country.³⁹ We

³⁹Ballard, 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

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 3 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 (13) is rewritten as

$$J\left(\underline{b}^R, \bar{b}^R, k_i, \alpha_i, \lambda, \nu_{rp}, \sigma_{lc}, \xi_i\right) = 0, \quad (15)$$

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

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 preference.⁴⁰ 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 preference of the local government, casual evidence suggests that a right-wing local government is more eager to favor private operators. The estimate $\hat{\alpha}_i$ should thus be higher with a right-wing local government.⁴¹

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.

generally, distortions fall between 1.15 and 1.40 in countries with an efficient tax system. Gagnepain and Ivaldi (2002) obtained a similar result in their study of the French transportation sector.

⁴⁰When the local authority includes several cities, the political preference is that of the main municipality.

⁴¹This point is corroborated in Levin and Tadelis (2009).

A potential criticism of our three-step estimation procedure is that we may not fully account for the optimality conditions satisfied by \underline{b}^R and \bar{b}^R which are not part of the estimation process.⁴² An alternative estimation procedure could consist in recovering values of $(\underline{b}^R, \bar{b}^R)$ through the system made of those two optimality conditions plus the renegotiation-proofness constraint. Thus, $\underline{b}^R(\cdot)$ and $\bar{b}^R(\cdot)$ 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. Although attractive, this alternative procedure suffers from a serious drawback in that it does not use our data observations of $(\underline{b}^R, \bar{b}^R)$. Using directly the data observations of $(\underline{b}^R, \bar{b}^R)$ or recovering $(\underline{b}^R, \bar{b}^R)$ through a system of optimality conditions would probably yield a similar outcome if our theoretical model perfectly explained the data reality, which is probably excessive. We therefore prefer to use the data information on $(\underline{b}^R, \bar{b}^R)$. To convince the reader that our approach is reasonable, we propose an ex post test to check that our estimates $\hat{\nu}_{lc}$, $\hat{\sigma}_{lc}$, $\hat{\beta}$, \hat{k}_i , and $\hat{\alpha}_i$ verify the conditions expressed in (24) and (25). To do so, we replace μ in (24) by its expression from (25) in order to generate an equation (24'). Then, we compute a t -test to check whether the left-hand side of equation (24') 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.⁴³ We

⁴²See the proof of Proposition 3 in the Appendix for expressions of those conditions.

⁴³Remember 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.

proceed as follows.⁴⁴

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 $\hat{\alpha}^R > 0$. Once outliers are discarded, we obtain a subsample of 114 contract-years.

Step 1. Using our set of renegotiation-proof estimates $\Upsilon^R = (\hat{\nu}^R, \hat{\sigma}^R, \hat{k}^R, \hat{\alpha}^R, \hat{\beta}^R)$ 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 \hat{b}_i^F that would be paid under full commitment. To do so, we solve (1) with respect to \hat{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 \hat{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 4.⁴⁵

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 $\hat{T}_i^F > \hat{T}_i^R$, i.e., switching from limited to full commitment entails a higher intertemporal 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 in-

⁴⁴See the Appendix for details.

⁴⁵Note that the final welfare results do not vary in a significant manner if other values of k_i are chosen.

creases 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 Alternative Assumptions

Overall, the analysis above suggests that our structural model is a reasonable representation of the industry: We have provided a test which rejects a simple contract choice model with no asymmetric information parameters against our structural approach. The estimated parameters obtained from the empirical model are in general significant and have signs which go in the right direction. Moreover, although we do not impose any constraint on the estimation procedures, we do obtain estimates that are consistent with the assumptions of the theoretical model.

For the sake of completeness, this section nevertheless discusses alternative scenarios which could be relevant to explain our data, or which could be simulated using ingredients from our limited commitment model. Our goal here is to point out a few criticisms of those alternative explanations, to confirm the relevance of our focus on renegotiation as the main explanation of the contracting patterns found in the data set, and provide additional welfare measures for different contracting scenarios.

5.1 Evolving Bargaining Powers

The optimal subsidy given by (1) is greater when the operator's bargaining power α increases. This suggests that a pattern where greater subsidies are offered following an earlier cost-plus contract could also be replicated with the simpler assumption that bargaining power evolves over time. More precisely, suppose that only short-term contracts can be signed but that innate costs are independent draws from the same distribution in each period. Subsidies in each period are still given by (1) with the added feature that α is time-varying and increasing.

There are two issues with such model. The first one is that it is difficult to understand why changes in α would depend on the earlier history (fixed-price or cost-plus) and especially be more pronounced following a cost-plus contract as featured in our dataset. Indeed, economic theory suggests that changes in bargaining power could

result from a more pronounced collusion between operators and public authorities, or from more symmetric stands following earlier sunk investments by operator. However, both collusion and sunk investments are facilitated when rents are high; a feature of fixed-price contracts. So if anything, the operator's bargaining power should increase following fixed-price and not cost-plus contracts.

Second, we can construct a simple test of whether subsidies increase over time and whether this pattern is firm specific. If the bargaining power of an operator increased over time and affected subsidies, we should observe an increase in the subsidy levels of the successive fixed-price contracts signed after a cost-plus regime for this operator. We run a simple regression of the log subsidy paid on a set of covariates plus a dummy which measures whether the observed fixed-price contract is implemented after a cost-plus regime or not (CF), an interaction $Trend \times CF$, three interactions $Trend \times CF \times Firm_j$ where $Firm_j$ is a dummy variable that accounts for the identity of the company which owns the observed operator, and a set of firms fixed effects. None of the interactions has a significant impact on the observed subsidies, which suggests that an increase of the bargaining power over time is unlikely, or that, if the bargaining power of firms increases over time, it does not affect subsidies.⁴⁶

5.2 Short-Term Contracts

An alternative scenario, already investigated both in the theoretical and empirical literatures,⁴⁷ is the only feasible contracts are short-term. In the present context of the French transportation sector, we argued above that this scenario does not fit actual practices. Nevertheless, and for completeness, it is worth simulating the welfare impact of such stronger degree of contract incompleteness, much in spirit of Section 4. This allows us to compare welfare between full commitment, limited commitment, and no-commitment.

Let us briefly sketch how the contracting game unfolds with short-term contracts. In the first period, operators again select different contracts according to their innate

⁴⁶Estimation results are (392 observations, firms fixed effects included, standard errors in parenthesis):
 $\log Subsidy = 4.94 + 0.68 \log Rolling\ Stock + 0.22 \log network - 0.11 Right-Wing + 0.32 CF + 0.01$
(0.26) (0.05) (0.03) (0.03) (0.13) (0.01)
 $Trend \times CF - 0.01 Trend \times CF \times Keolis + 0.00 Trend \times CF \times Connex + 0.08 Trend \times CF \times Transdev.$
(0.01) (0.01) (0.07)

⁴⁷See respectively Laffont and Tirole (1993, Chapter 9) and Dionne and Doherty (1994).

costs. As before the most efficient firms choose a first-period fixed-price contract with subsidy b_1 whereas the least efficient ones operate under a cost-plus contract. Before re-contracting, the principal updates his beliefs on the operator's cost parameter according to whether a fixed-price or a cost-plus contract has been chosen.⁴⁸

To make comparison between the cases of short-term contracting and renegotiation more meaningful, we focus on equilibria with short-term contracts which generate the three patterns observed in our data: Fixed-price or cost-plus contracts over both periods, or a cost-plus followed by a fixed-price contract. Following our earlier notations, a profile of subsidies (b_1, b_2, b_3) is offered at the different points in time along the different histories. Of course, the principal chooses a first-period subsidy that determines the first-period cut-off with an eye on how it affects the continuation of the contracting game. In particular, following an earlier choice of a cost-plus contract and thus knowing that the operator's type is greater than θ_1^* , the optimal second-period subsidy b_3 must be conditionally optimal given the principal's updated beliefs:

$$kf(b_3 + k) = \left(1 - \frac{\alpha}{1 + \lambda}\right) (F(b_3 + k) - F(\theta_1^*)). \quad (16)$$

This 'conditional optimality'⁴⁹ just expresses the fact that, in choosing the second-period subsidy, the principal trades off the extra cost in terms of extra rents and the efficiency gains of offering a greater subsidy b_3 for a subset of types who operated earlier on under a cost-plus. This condition is very similar to the binding renegotiation-proofness constraint (4) up to a (possibly) different value for the first-period cut-off θ_1^* . The main difference between the no-commitment and the renegotiation-proof scenarios comes instead following the earlier choice of a fixed-price contract. The principal then knows that the firm is rather efficient and has thus incentives to cut down second-period subsidies; a well-known instance of the 'ratchet effect'. More formally, if type θ_1^* is indifferent between a fixed-price and a cost-plus contract in the first period and chooses a fixed-price, it will receive only a low subsidy b_2 such that $\theta_1^* = b_2 + k$ in the second period while choosing a cost-plus in the first period would have secured more rent later on through increased subsidies. This subsidy b_2 extracts all second-period rent from that cut-off type. The principal cannot make any credible promise to reward operators who choose earlier on a fixed-price contract with some extra rent later on. As

⁴⁸As in our main renegotiation scenario, we assume that, had a cost-plus been chosen, the exact realization of those costs would not be used to update the principal's beliefs.

⁴⁹The term was coined by Laffont and Tirole (1993, Chapter 10).

a result, subsidies are decreasing over time in the sense of $b_2 < b_1$.⁵⁰ This is in contrast with what we observe in our data and what a renegotiation-proof scenario predicts. In that case, the principal can smooth the rewards for choosing earlier to operate under a two-period fixed-price contract with subsidies which are constant over time.

Turning to the empirical analysis, we simulate the welfare obtained with this short-term contract scenario with our data. The empirical strategy is similar to the one presented in Section 4: Starting from our estimates of the various parameters of the model obtained from the renegotiation-proof scenario, we can reconstruct estimates of the cut-offs θ_1^* , θ_2^* , and θ_3^* that delineate the various first-period scenarios. The corresponding subsidies and the value of welfare are then easily computed. The empirical results suggest that moving to short-term contracts deteriorates welfare compared to limited commitment. For the average network, the welfare obtained under limited commitment represents 98% of the welfare obtained under full commitment while a scenario with short-term contracting captures only 93% of this full commitment welfare.⁵¹

6 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.

Our analysis, however, calls for a few remarks and 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, extending contract length might not favor the

⁵⁰See the Appendix for details.

⁵¹These simulations are computed with a smaller database than the one used in Section 4. For this reason, the welfare differentials presented here slightly depart from those presented in Table 6.

emergence of a more competitive playing field which may reduce 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 might 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. 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 approach might also be fruitful in other contexts where full-fledged theoretical models become non-tractable.

Even though our estimates are significant, we might be underestimating the welfare gains of commitment. Indeed, we have no ideas on how renegotiation weakens the operator's incentives to make relationship-specific investments except through informal talks with practitioners in the field. Introducing these considerations would reinforce our argument in favor of extending contract length. Longer contract durations would indeed 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. Reputation building might significantly relax 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. By putting reputation aside, we have thus analyzed a 'worst scenario' under renegotiation. More research both on the

theory side but 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. At this stage, we have no information on this issue.

Other weaknesses of our analysis could be improved in the future: Our cost function is quite basic; while it offers convenience and tractability to develop the theoretical model, it may reasonably raise concerns on the predictability of the estimated model. More flexible functional forms and/or non-parametric techniques could be investigated. Note also that our simulations of the full commitment or no-commitment cases assume that the current ingredients of the industry are unchanged. This assumption could be relaxed; we could for instance expect that the distribution of the innate costs is different under a full commitment scenario if new operators with different cost characteristics enter the market (knowing that regulatory rules are modified). We have currently no theoretical justification to offer to describe such changes but further investigation in this direction is indeed welcome. We have also noted that the industry has changed significantly after 2001. In particular, movements of operators from one network to another have been observed. Modeling the strategic behavior of operators in competitive tendering is an interesting topic that needs to be addressed as well.

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. Intertemporal welfare under full commitment is:

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

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 $F(\beta b_1 + (1 - \beta)b_2 + k)$ takes such contract. The term $\int_{\beta b_1 + (1 - \beta)b_2 + k}^{\bar{\theta}} \theta f(\theta) d\theta$ is 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 under full commitment can be rewritten as:

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

The monotone hazard rate property ensures quasi-concavity of this objective.⁵² The corresponding first-order conditions characterize the optimal subsidy in (1) which is constant over time. ■

Proof of Proposition 2. We first describe the timing of the game with the possibility of renegotiation. Proposition 4 then shows the validity of the Renegotiation-Proofness Principle in our context. We finally characterize renegotiation-proof profiles.

Timing.

- 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 taking into account whether a fixed-price or a cost-plus contract is chosen in the first period.
- Date 1.00: First-period costs and payments are realized.
- Date 1.25: If he wishes so, the principal offers a renegotiation with a new (fixed-price) subsidy. Let these new subsidies be \tilde{b}_2 and \tilde{b}_3 .

⁵²See for instance Bagnoli and Bergstrom (2005).

- Date 1.50: The firm chooses whether to accept the new offer or not and chooses the second-period effort accordingly. If the offer is refused, the initial contract is enforced. Otherwise, the renegotiated offer supersedes the initial contract.
- Date 2: Second-period costs and payments are realized.

Proposition 4 *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 conditions:*

$$\tilde{b}_2 \geq b_2 \quad \text{and} \quad \tilde{b}_3 \geq b_3. \quad (17)$$

Proof: Fix any initial contract C^0 and consider renegotiated offers $\tilde{R} = (\tilde{b}_2, \tilde{b}_3)$ 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 for date 2 becomes:

$$W_2(C^0, \tilde{R}, R) = \int_{\underline{\theta}}^{b_1+k+\frac{1-\beta}{\beta}(b_2-b_3)} \left(S - (1+\lambda)\tilde{b}_2 + \alpha(\tilde{b}_2 + k - \theta) \right) f(\theta) d\theta \quad (18)$$

$$+ \int_{b_1+k+\frac{1-\beta}{\beta}(b_2-b_3)}^{\tilde{b}_3+k} \left(S - (1+\lambda)\tilde{b}_3 + \alpha(\tilde{b}_3 + k - \theta) \right) f(\theta) d\theta \quad (19)$$

$$+ \int_{\tilde{b}_3+k}^{\bar{\theta}} (S - (1+\lambda)\theta) f(\theta) d\theta. \quad (20)$$

Note that this expression is 'unconditional', i.e., it is a weighted sum of the welfares following each possible first-period scenario with the weights being the corresponding probabilities $F\left(b_1 + k + \frac{1-\beta}{\beta}(b_2 - b_3)\right)$ of choosing the two-period fixed-price contract (i.e., C_1^0) earlier on and $1 - F\left(b_1 + k + \frac{1-\beta}{\beta}(b_2 - b_3)\right)$ of operating under a cost-plus contract in the first period (i.e., either C_2^0 or C_3^0).

The 'conditional' second-period welfares following the first-period choice to operate under either a fixed-price (following C_1^0) or a cost-plus (following either C_2^0 or C_3^0) contract are respectively

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

and

$$\begin{aligned} \mathcal{W}_2(C^0, \tilde{R}, R|CP) &= \int_{b_1+k+\frac{1-\beta}{\beta}(b_2-b_3)}^{\tilde{b}_3+k} \left(S - (1+\lambda)\tilde{b}_3 + \alpha(\tilde{b}_3+k-\theta) \right) \frac{f(\theta)}{1 - F\left(b_1+k+\frac{1-\beta}{\beta}(b_2-b_3)\right)} d\theta \\ &+ \int_{\tilde{b}_3+k}^{\bar{\theta}} (S - (1+\lambda)\theta) \frac{f(\theta)}{1 - F\left(b_1+k+\frac{1-\beta}{\beta}(b_2-b_3)\right)} d\theta. \end{aligned}$$

Maximizing $\mathcal{W}_2(C^0, \tilde{R}, R|FP)$ with respect to \tilde{b}_2 and $\mathcal{W}_2(C^0, \tilde{R}, R|CP)$ with respect to \tilde{b}_3 is clearly equivalent to maximizing $W_2(C^0, \tilde{R}, R)$ with respect to $\tilde{R} = (\tilde{b}_2, \tilde{b}_3)$. Because it is more compact, this latter ('unconditional') approach is privileged here.

The expression of $W_2(C^0, \tilde{R}, R)$ takes into account that operators with types in $\Theta_G = [\underline{\theta}, b_1+k+\frac{1-\beta}{\beta}(b_2-b_3)]$ are already committed to a two-period fixed-price contract anticipating second-period equilibrium subsidies. These operators nevertheless welcome any increase in the second-period subsidy \tilde{b}_2 above b_2 at the renegotiation stage. The principal's payoff from such deviation must be computed with this new subsidy. This yields a contribution to expected second period welfare equal to the first-term in (18).

Types in $\Theta_I = [b_1+k+\frac{1-\beta}{\beta}(b_2-b_3), b_3+k]$ are committed to operate under a fixed-price contract only in the second period. But increasing this second-period 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. The least efficient types in $[\tilde{b}_3+k, \bar{\theta}]$ remain on a cost-plus contract. This yields the expressions of the last two terms (19) and (20).

The principal 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:

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

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 choices 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 (17) implies

$$\tilde{b}_2 \geq b_2^0. \quad (21)$$

Similarly, that b_3 satisfies the second condition in (2) and \tilde{b}_3 satisfies the second condition in (17) implies

$$\tilde{b}_3 \geq b_3^0. \quad (22)$$

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:

$$W_2((b_1^0, R), R, R) \geq W_2((b_1^0, R), \tilde{R}, R). \quad (23)$$

This condition is true, in particular, for any $\tilde{R} = (\tilde{b}_2, \tilde{b}_3)$ that is feasible if R is offered at the renegotiation-stage. This shows that R comes unchanged through the renegotiation process, i.e., solves the following problem:

$$(\mathcal{R}) : \quad R = \arg \max_{\tilde{R}} W_2((b_1, R), \tilde{R}, R) \text{ subject to (17).}$$

This ends the proof of Proposition 4. ■

Turning now to problem (\mathcal{R}) , first note that $\alpha < 1 + \lambda$ implies that the maximum of the integral in (18) is obtained when (17) 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 operate 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 (4). ■

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

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

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

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

$$(\mathcal{P}^R) : \quad \max_C \mathcal{W}(C) \text{ subject to (3) and (4).}$$

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 (\mathcal{P}^R) is then straightforward. 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 account this fact and optimizing with respect to $(\underline{b}^R, \bar{b}^R)$ yields the following first-order conditions:

$$k = \left(1 - \frac{\alpha}{1 + \lambda}\right) \left(R \left(\underline{b}^R + k + \frac{1 - \beta}{\beta} (\underline{b}^R - \bar{b}^R) \right) + \frac{\mu}{\beta(1 + \lambda)} \right), \quad (24)$$

$$\begin{aligned} k = & \left(1 - \frac{\alpha}{1 + \lambda}\right) \left(\frac{F(\bar{b}^R + k) - F\left(\underline{b}^R + k + \frac{1 - \beta}{\beta} (\underline{b}^R - \bar{b}^R)\right)}{f(\bar{b}^R + k) - f\left(\underline{b}^R + k + \frac{1 - \beta}{\beta} (\underline{b}^R - \bar{b}^R)\right)} \right) \\ & - \mu \frac{\left(\left(1 - \frac{\alpha}{1 + \lambda}\right) \left(\frac{f(\bar{b}^R + k)}{1 - \beta} + \frac{f\left(\underline{b}^R + k + \frac{1 - \beta}{\beta} (\underline{b}^R - \bar{b}^R)\right)}{\beta} \right) - \frac{k f'(\bar{b}^R + k)}{1 - \beta} \right)}{(1 + \lambda) \left(f(\bar{b}^R + k) - f\left(\underline{b}^R + k + \frac{1 - \beta}{\beta} (\underline{b}^R - \bar{b}^R)\right) \right)} \end{aligned} \quad (25)$$

where $\mu > 0$ is the Lagrange multiplier of (4).

Moreover, (4) implies that

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

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

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

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

where

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

$$+ \int_{\bar{b}_i^R + \hat{k}_i^R}^{\bar{\theta}} \theta f(\theta) d\theta,$$

and

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

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

$$\mathcal{W}_i^F = S - (1 + \lambda) T_i^F + \hat{\alpha}_i^R U_i^F, \quad (27)$$

where

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

and

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

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

$$\Delta \mathcal{W}_i = \mathcal{W}_i^F - \mathcal{W}_i^R. \quad (28)$$

Similar definitions follow for ΔT_i and ΔU_i . ■

Short-Term Contracts. This Appendix characterizes an equilibrium sequence of short-term contracts. We are again looking for a partition equilibrium where, in the first period, types $\theta > \theta_1^*$ choose a cost-plus contract whereas types $\theta \leq \theta_1^*$ choose a fixed-price contract with subsidy b_1 . Continuation contracts depend on what happened in the first period. Again following any first-period history and after having updated beliefs accordingly, the principal offers the choice between a fixed-price and a cost-plus contract. We are first solving for such continuations before finding the equilibrium cut-off θ_1^* in the first period. To make the comparison between the case of short-term contracting and renegotiation relevant, we isolate below conditions under which three

patterns arise: fixed-price contracts in both periods, a cost-plus followed by a fixed-price contract and finally cost-plus contracts in both periods.

Second-period contracts. Suppose that a fixed-price contract has been chosen in the first period, the principal now offers a subsidy b_2 that again might split $[\underline{\theta}, \theta_1^*]$ into two sub-intervals. In the second period, types with a cost parameter $\theta \in [\underline{\theta}, \theta_2^*]$ (where $\theta_2^* \leq \theta_1^*$) choose this fixed-price contract whereas types $\theta \in [\theta_2^*, \theta_1^*]$ operate under a cost-plus contract. Of course, θ_2^* is again defined as $\theta_2^* = b_2 + k$. Following such history, the second-period welfare becomes:

$$\mathcal{W}_2(b_2|FP) = \int_{\underline{\theta}}^{b_2+k} (S - (1+\lambda)b_2 + \alpha(b_2 + k - \theta)) \frac{f(\theta)}{F(\theta_1^*)} d\theta + \int_{b_2+k}^{\theta_1^*} (S - (1+\lambda)\theta) \frac{f(\theta)}{F(\theta_1^*)} d\theta \quad (29)$$

Optimizing this expression, we find:

$$\theta_2^* = \min\{\theta^F, \theta_1^*\}. \quad (30)$$

When $\theta_1^* \leq \theta^F$, all types in $[\underline{\theta}, \theta_1^*]$ operate under a fixed-price contract also in the second period. The corresponding subsidy is thus:

$$\theta_1^* = b_2 + k.$$

This scenario replicates a segmentation of the types set which is similar to that arising in our renegotiation scenario. The difference is that of course the level of the second-period subsidy might change. It is lower with short-term contracts because the principal cannot make any commitment to a second-period subsidy in order to compensate the firm for an earlier choice of a fixed-price contract.

Following the choice of a cost-plus contract in the first period, the principal offers a subsidy b_3 that again splits the set $[\theta_1^*, \bar{\theta}]$ into two sub-intervals. Operators with a type $\theta \in [\theta_1^*, \theta_3^*]$ (where $\theta_3^* \geq \theta_1^*$) choose a fixed-price contract for the second period whereas those with a type $\theta \in [\theta_3^*, \bar{\theta}]$ still operate under a cost-plus contract. Again, we have $\theta_3^* = b_3 + k$. The second-period 'conditional' welfare becomes:

$$\mathcal{W}_2(b_3|CP) = \int_{\theta_1^*}^{b_3+k} (S - (1+\lambda)b_3 + \alpha(b_3 + k - \theta)) \frac{f(\theta)}{1 - F(\theta_1^*)} d\theta + \int_{b_3+k}^{\bar{\theta}} (S - (1+\lambda)\theta) \frac{f(\theta)}{1 - F(\theta_1^*)} d\theta. \quad (31)$$

Optimizing this expression yields the cut-off θ_3^* as

$$k = \left(1 - \frac{\alpha}{1+\lambda}\right) \frac{F(\theta_3^*) - F(\theta_1^*)}{f(\theta_3^*)} \quad (32)$$

which can be rewritten as (16).

Assuming that not only $R(\theta) = \frac{F(\theta)}{f(\theta)}$ but also $S(\theta) = \frac{F(\theta)-1}{f(\theta)}$ are increasing with θ , the right-hand side of (32) is proportional to $(1 - F(\theta_1^*))R(\theta_3^*) + F(\theta_1^*)S(\theta_3^*)$ which is also an increasing function of θ_3^* . Hence, (32) admits a unique solution $\theta_3^* \in (\theta_1^*, \bar{\theta})$ when:

$$k < \left(1 - \frac{\alpha}{1+\lambda}\right) \frac{1 - F(\theta_1^*)}{f(\bar{\theta})}.$$

Note also that (32) implies that $k < \left(1 - \frac{\alpha}{1+\lambda}\right) R(\theta_3^*)$ and thus $\theta_3^* > \theta^{FC}$.

The optimality condition (32) implies that, viewed as a function of θ_1^*, θ_3^* satisfies:

$$\frac{d\theta_3^*}{d\theta_1^*} = \frac{f(\theta_1^*)}{f(\theta_3^*) - \frac{k}{1-\frac{\alpha}{1+\lambda}} f'(\theta_3^*)}. \quad (33)$$

But $R'(\theta_3^*) > 0$ implies $\frac{f'(\theta_3^*)}{f(\theta_3^*)} < \frac{1}{R(\theta_3^*)}$ and thus $f(\theta_3^*) - \frac{k}{1-\frac{\alpha}{1+\lambda}} f'(\theta_3^*) > f(\theta_3^*) \left(1 - \frac{k}{(1-\frac{\alpha}{1+\lambda})R(\theta_3^*)}\right) > 0$ which holds since $\theta_3^* > \theta^{FC}$. Therefore, we have:

$$\frac{d\theta_3^*}{d\theta_1^*} > 0.$$

First-period subsidy. The cut-off type θ_1^* must be indifferent between choosing a first-period fixed-price contract b_1 followed by a second-period subsidy $b_2 + k = \theta_1^*$ that leaves no extra rent to that type or choosing a cost-plus contract followed by a fixed-price with subsidy b_3 . This leads to the indifference condition:

$$\beta(b_1 + k - \theta_1^*) = (1 - \beta)(b_3 + k - \theta_1^*)$$

or using the definition of θ_3^*

$$\beta(b_1 + k - \theta_1^*) = (1 - \beta)(\theta_3^* - \theta_1^*). \quad (34)$$

Conditions (32) and (34) define the pair (θ_1^*, θ_3^*) as a function of b_1 only. We shall make this dependence explicit in what follows. The same remark applies to the second-period subsidies that are also functions of b_1 only. We will thus have:

$$\theta_1^*(b_1) = b_2(b_1) + k \text{ and } \theta_3^*(b_1) = b_3(b_1) + k. \quad (35)$$

We deduce from the first of those conditions, taken together with (32) and (34) that:

$$\beta(b_1 - b_2(b_1)) = (1 - \beta)(\theta_3^* - \theta_1^*) > 0$$

and thus

$$b_2(b_1) < b_1.$$

The intertemporal welfare can be written as a function of b_1 also as:

$$\begin{aligned} \mathcal{W}(b_1) = & \beta \left(\int_{\theta_1^*(b_1)}^{\bar{\theta}} (S - (1 + \lambda)\theta) f(\theta) d\theta + \int_{\underline{\theta}}^{\theta_1^*(b_1)} (S - (1 + \lambda)b_1 + \alpha(b_1 + k - \theta)) f(\theta) d\theta \right) \\ & + (1 - \beta)(F(\theta_1^*(b_1))W_2(b_2(b_1)|FP) + (1 - F(\theta_1^*(b_1)))W_2(b_3(b_1)|CP)). \end{aligned} \quad (36)$$

Using the Envelope Theorem to simplify the impact of b_1 on the second period subsidy, we get:

$$\begin{aligned} \frac{d\mathcal{W}}{db_1}(b_1) = & \beta \left(\frac{d\theta_1^*}{db_1}(\alpha(b_1 + k - \theta_1^*(b_1)) - (1 + \lambda)(b_1 - \theta_1^*(b_1)))f(\theta_1^*(b_1)) + (\alpha - 1 - \lambda)F(\theta_1^*(b_1)) \right) \\ & + (1 - \beta)\frac{d\theta_1^*}{db_1}(((1 + \lambda)(b_3(b_1) - \theta_1^*(b_1)) - \alpha(b_3(b_1) + k - \theta_1^*(b_1)))f(\theta_1^*(b_1))). \end{aligned}$$

Simplifying further using (34) yields the following expression:

$$\frac{d\mathcal{W}}{db_1}(b_1) = \beta \left((\alpha - 1 - \lambda)F(\theta_1^*(b_1)) + (1 + \lambda)\frac{2\beta - 1}{\beta}\frac{d\theta_1^*}{db_1}f(\theta_1^*(b_1))k \right). \quad (37)$$

Assuming quasi-concavity of the objective, the optimal first-period subsidy is such that:

$$k = \frac{\beta}{2\beta - 1} \left(1 - \frac{\alpha}{1 + \lambda} \right) \frac{R(\theta_1^*(b_1))}{\frac{d\theta_1^*}{db_1}(b_1)}. \quad (38)$$

Differentiating (34) with respect to b_1 yields:

$$\frac{d\theta_1^*}{db_1} = \frac{1}{1 + \frac{1-\beta}{\beta} \left(\frac{d\theta_3^*}{d\theta_1^*} - 1 \right)}.$$

In particular, when $\beta \geq 1/2$ and since $\frac{d\theta_3^*}{d\theta_1^*} \geq 0$, the optimal cut-off $\theta_1^*(b_1)$ is such that $\theta_1^*(b_1) \leq \theta^{FC}$ as conjectured by our profile.

Note that altogether, (32), (33) and (38) define the cut-offs θ_1^* and θ_3^* . From (34) and (35), we finally get the expression of all subsidies. We can evaluate the probabilities of each different regimes. Inserting into (36) yields then the expression of the intertemporal welfare with short-term contracts. ■

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

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

Table 2: Estimated Subsidies I

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

Table 3: Estimated Subsidies II

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

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

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

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

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