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An application to the French urban public transport sector

Axel Gautier and Anne Yvrande-Billon

CORE

Voie du Roman Pays 34

B-1348 Louvain-la-Neuve, Belgium.

Tel (32 10) 47 43 04

Fax (32 10) 47 43 01

E-mail: corestat-library@uclouvain.be

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Contract renewal as an incentive device. An application to the French urban public transport sector

Axel GAUTIER¹ and Anne YVRANDE-BILLON²

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Abstract

In the French urban public transport industry, services are often delegated to a private firm by the mean of a fixed-term regulatory contract. This contract specifies the duties of the firm and a financial compensation. When it expires, a new contract is awarded, possibly to a different operator. Cost-plus and fixed-price (gross cost or net cost) contracts are commonly used to regulate the operators in the transport industry. In this paper, we analyse the incentives for the operator to reduce its cost. These incentives come from both the profit maximization during the current contract and the perspective of contract renewal. In our model, the amount of cost-reducing effort depends on the contract type and the time remaining till contract expiration. We use a sample of 124 French urban public transport networks covering the period 1995-2002 to test our predictions. Our proxy for the cost reducing effort is technical efficiency. The data largely confirm the importance of contract type on performances and the incentive effect of contract renewal.

Keywords: incentive regulation, urban transport, stochastic frontier analysis.

JEL Classification: L33, L51, L92

¹ Université de Liège, HEC, CREPP, B-4000 Liège, Belgium; Université catholique de Louvain, CORE, B-1348 Louvain-la-Neuve, Belgium. E-mail: agautier@ulg.ac.be

² University Paris 1, CES, Paris, France. E-mail: yvrande@univ-paris1.fr

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Introduction

Cost-plus and fixed-price contracts are commonly used to regulate firms in utilities industries. In a cost-plus contract, the regulator reimburses all costs and pays, in addition, a specified profit rate. In a fixed-price contract, the regulator transfers to the firm a fixed payment independently of its realized cost. The incentive regulation literature establishes that fixed-price contracts give more incentives to reduce costs than cost-plus contracts (Laffont and Tirole, 1986, 1993). In these models, the firm's cost depends on an exogenous technological parameter, specific to the firm, and on the post-contractual effort exerted by the contractor. Only the realized cost is observable and, therefore, the effort cannot be contracted upon. In a cost plus contract the firm's profit is independent of its realized cost. Hence, the firm has no incentive to engage in a costly post-contractual effort. By contrast, under a fixed-price contract, any cost increase or decrease amounts to a change in the firm's profit. The firm has then a lot of incentives to perform effort. Precisely, a firm regulated by a fixed-price contract chooses the efficient amount of effort i.e. the effort that minimizes the total cost. For this reason, the fixed-price contract is a *high-powered incentive scheme*, while the cost-plus contract is a *low-powered incentive scheme*.¹ Empirical evidence confirms that firms operating under a fixed-price contract are more efficient than firms operating under a cost plus contract (Mathias & Roger 1989, Gagnepain & Ivaldi 2002, Aubert & Reynaud 2005). But performance may not be the only criterion that determines the choice of a contractual form. For Bajari and Tadelis (2001), a cost plus contract allows more adaptation to unforeseen contingencies and despite providing less incentive, it may be optimally chosen in uncertain environments.

In this paper, we compare the incentives provided by cost plus and fixed-price contracts in a dynamic framework. We consider an industry where the regulator and the firm sign a contract that lasts for several periods and at each period the firm has an opportunity to engage in a cost reducing effort. Industries like water supply, waste collection or urban transportation, where public authorities delegate the provision of the service to operators,

¹ Yet, despite providing more incentives, a fixed-price contract may not be the regulator's preferred option. Thus for instance, as shown by Laffont and Tirole (1986), when information is asymmetric, the optimal contract is neither a cost-plus nor a fixed-price contract but a menu of linear contracts where, in addition to a fixed payment, a fraction of the cost is reimbursed.

share this feature. Our model studies the optimal allocation of effort during the whole contracting period. We first confirm that fixed-price contracts provide more incentives. Moreover we show that under a fixed-price contract effort decreases with time to expiration. To understand, consider an effort that reduces the operating cost by a given amount e . This effort has an undiscounted benefit (the cost saving for the remaining periods) of $e(T-t)$ where t , is the time at which effort is exerted and T , the date of contract expiration. Clearly, the marginal benefit of effort decreases during the contracting period (with t). Hence, in a fixed-price contract, the amount of effort decreases over time till the expiration date.

The contribution of the paper is not only to assess the optimal effort path but also to consider contract renewal as an incentive device. In a second step, we indeed incorporate in the model the possibility for firms to be renewed, consistently with what happens in most utilities industries where regulators periodically organize calls for tender. We show that the probability of being renewed impacts positively on effort, which confirms the incentive effect of competitive tendering.² The magnitude of this effect depends on the sensitivity of the probability of being renewed with respect to the operator's performance. Moreover, when the decision to renew or not a contract is based only on the relative performance of the incumbent's operator at the last period, operators have more incentives to exert effort when the contract renewal date approaches. The reason is simple, a given effort costs less when it is exerted later on because future profit flows are discounted.

To summarize, we identify two sources of incentives to undertake a costly cost-reducing effort: profits from the current contract and profit from a future renewed contract. Incentives coming from the current contract profit maximization only operate if the contract is a fixed-price contract. Moreover, they are stronger at the beginning of the contracting period. Incentives coming from contract renewal apply to both types of contract and they are greater when the contract approaches to its end. Then, for cost-plus contract, effort should decrease with time to expiration. For the fixed-price contract, effort can increase, decrease or be U-shaped with the remaining time till contract expiration depending on the relative importance of the two types of incentives.

² Like cost plus contract, sharecropping agreements have long been pointed for not providing enough incentives to perform effort. Indeed, in a sharecropping contract, the farmer does not capture the full marginal benefit of his labor and therefore he may undersupplies effort. However, Cheung (1969) shows that effort under provision may not be an issue in sharecropping since the landowner and the tenant have the choice of whether or not to renew the relation each year. The opportunity to continue the relationship is part of the incentive package offered to the farmer. Likewise, in the utility sector, contract renewal may act as an incentive device.

An additional contribution of our paper is to use a more sophisticated classification of contractual practices that better corresponds to the variety of arrangements observed in utilities industries. Indeed, in these sectors, there are two types of commonly used fixed-price contracts: gross cost and net cost contracts. In a net cost contract, the operator has two sources of income, the commercial receipts from the service and a fixed transfer from the regulator. In a gross cost contract, commercial receipts are collected by the regulator. Hence, for a public transport operator regulated by a net cost contract, any change in the traffic volume affects the operator's profit. And, since in the French public transport sector prices are regulated, traffic losses cannot be recovered by a tariff increase. By contrast, in a gross cost contract, the operator's sole source of income is the transfer which is independent of changes in commercial receipts.

In this paper, we argue that those firms that are regulated by a gross cost contract exert more effort than firms regulated by a net cost contract. Indeed, firms operating under a net cost contract have two possibilities to increase their profit: they can exert a productive effort to decrease their operating cost and they can perform a commercial effort to increase the number of journeys on their network, and thereby their income. On the other hand, firms operating under a gross cost contract do not increase their profit when traffic increases. Hence, we conjecture that gross cost contracts will outperform net cost contracts in terms of productive effort when commercial and productive efforts are substitutes, that is when either the commercial effort increases at the margin the cost of productive effort or commercial performance reduces at the margin the sensitivity of the renewal decision with respect to operating cost. In both cases, net cost contract operators will perform more commercial effort than gross cost contract operators and thereby less productive effort.

To test these predictions, we use an original panel data set covering 124 French urban transport networks over the period 1995-2002. The French urban transport sector is of particular interest because local regulators that delegate the operation of urban transport services to private operators can choose to regulate them under fixed-price (gross cost or net cost contracts) or cost plus contracts. In addition, local regulators are legally obliged to periodically launch calls for tender (usually every 6 years). These characteristics allow us to compare the performance of firms operating under fixed-price and cost plus contracts and to assess the role of contract renewal as an incentive device.

Using the stochastic production frontier methodology for panel data (Battese and Coelli 1995), we estimate the impact of contractual choice and time to expiration on operators' technical efficiency, our proxy for unobservable productive effort. The results of our estimations support the conjecture that firms operating under fixed-price contracts are more efficient than those operating under cost plus, consistently with the results obtained by Gagnepain and Ivaldi (2002) or Roy and Yvrande-Billon (2007). Moreover, we observe that firms operating under a gross cost contract have the highest technical efficiency. Our results also reveal that time to expiration has a positive impact on efficiency for firms operating under fixed-price contracts, i.e. these firms exert more effort at the beginning of the contracting period. On the contrary, according to our estimations, time to expiration does not appear as a significant determinant of the level of effort exerted by firms under cost plus contracts and we do not observe that firms operating under a cost-plus contract exert more effort when the expiration date approaches. Finally, we compare the efficiency of private and semi-private firms, the latter corresponding to hybrid organizational forms where the threat of termination is lower. We show that semi-private firms have a lower efficiency level than private ones, whether they operate under cost plus or fixed-price contracts. This confirms that contract renewal is indeed an incentive device although the lack of competition in the French UPT sector may limit the importance of its effect.

The paper is organized as follows. Section 1 presents our model of dynamic regulation and the propositions we intend to test. Section 2 presents the French urban public transport sector. Section 3 presents our methodology and data. Section 4 provides the results of our estimations.

1. The model

A. A simple dynamic model of regulation

We consider a regulated utility sector where the production of the utility good/service is delegated by a regulator to a private firm. The selected firm is chosen by the regulator after a competitive process.

We construct a continuous time model. At time $t=0$, the regulator and the firm sign a contract that lasts until time T . The contract stipulates the duties of the contractor and compensation scheme. We first consider two possible contracts: (1) a cost-plus contract where the regulator

pays at each time t , the contractor's cost $c(t)$ increased by a given amount p^{C+} and (2) a fixed-price contract where the regulator transfers p^{FP} to the firm at each time t irrespective of its realized cost $c(t)$. In our model, the contract type is exogenously given.

At time $t=0$, the firm has an initial cost $c(0)$. At each subsequent time t , the cost $c(t)$ of the contractor is observable.³ However, in line with the incentive regulation literature (Laffont and Tirole, 1993), we assume that by exerting an unobservable effort $a(t)$ at time t , the firm reduces its cost by an amount $a(t)$. That is $\dot{c} = -a(t)$ where \dot{c} is the time derivative of $c(t)$.

Hence, we have $c(t) = c(0) - \int_0^t a(\tau) d\tau$.

Effort is costly: when the firm exerts an effort $a(t)$, it incurs a cost $\psi(a(t))$. The function $\psi(\cdot)$ satisfies the following properties: $\psi' > 0$, $\psi'' > 0$, $\psi(0) = 0$, $\psi'(0) = 0$. There is no uncertainty in our model and, therefore, effort can be perfectly inferred from the observed cost. Hence, in principle, the firm can be perfectly compensated for its effort but this requires a more sophisticated contract than the fixed-price and cost-plus contracts we consider.

At each time t , the contractor realizes a profit equal to:

$$\pi(t) = \begin{cases} p^{C+} - \psi(a(t)) & \text{if the firm operates under a cost - plus contract} \\ p^{FP} - c(t) - \psi(a(t)) & \text{if the firm operates under a fixed - price contract} \end{cases}$$

Profits are discounted at rate ρ . The total discounted profit that the firm obtains from the contract is $\int_0^T e^{-\rho t} \pi(t) dt$. The firm accepts the initial contract if its total profit is at least equal to its outside opportunity.

We will first discuss the incentives to exert effort that come from profit maximization. In the next section, we will discuss the joint effect of profit maximization and contract renewal (which corresponds to the maximization of the expected profit from the renewed contract). Absent the possibility of contract renewal, the objective of the contracting firm is to maximize the sum of its total expected discounted profit flow. A firm operating under a fixed-price contract faces the following problem:

$$\max_{a(t)} \int_0^T e^{-\rho t} [p^{FP} - c(t) - \psi(a(t))] dt \quad \text{subject to } \dot{c} = -a(t), c(0) \text{ and } T \text{ given}$$

In other words, the firm must find the optimal effort path $a(t)$ that maximizes its discounted profit flow. The associated Hamiltonian function is:

$$H = e^{-\rho t} [p^{FP} - c(t) - \psi(a(t))] - \lambda(t)a(t)$$

³ Cost observability is a necessary condition for implementing a cost-plus contract.

The first order conditions read as follow:

$$\begin{aligned}
(1) \quad & \frac{\partial H}{\partial a(t)} = -e^{-\rho t} \psi'(a(t)) - \lambda(t) = 0 \\
(2) \quad & \dot{c} = -a(t) \\
(3) \quad & \dot{\lambda} = e^{-\rho t} \\
(4) \quad & \lambda(T) = 0
\end{aligned}$$

Combining (3) and (4), we have $\lambda(t) = -\frac{1}{\rho}(e^{-\rho t} - e^{-\rho T}) \leq 0$. Hence, the optimal effort path

for a firm operating under a fixed-price contract is (we use a hat to denote optimal values):

$$\hat{a}^{FP}(t) = \psi'^{-1}\left(\frac{1}{\rho}\left(1 - \frac{e^{-\rho T}}{e^{-\rho t}}\right)\right)$$

A firm operating under a cost-plus contract faces the following problem:

$$\max_{a(t)} \int_0^T e^{-\rho t} [p^{C+} - \psi(a(t))] dt \text{ subject to } \dot{c} = -a(t), c(0) \text{ and } T \text{ given}$$

The solution is immediate: $\hat{a}^{C+}(t) = 0$.

The results of our analysis can be summarized in the following propositions.

Proposition 1: For all $t < T$, $\hat{a}^{FP}(t) > \hat{a}^{C+}(t) = 0$.

Proposition 2: $\frac{\partial \hat{a}^{FP}(t)}{\partial t} < 0$.

Proposition 1 is standard. It confirms that firms under a cost-plus contract have no incentives to exert effort while a fixed-price contract provides incentives for effort (Laffont & Tirole 1993, Bajari and Tadelis, 2001).

Proposition 2 shows that the optimal effort path under fixed-price contracts decreases over time. This is due to the fact that marginal benefits of effort are decreasing over time so that, to maximize their profit flow, operators regulated by fixed-price contracts have more incentive to exert effort earlier. A given effort exerted at time t increases the profit from the current period to the expiration date while the cost is only incurred once. Therefore, the firm exerts more effort at the beginning of the contract than when its end approaches.

B. Contract renewal as an incentive device

In the utility sector, the continuity of the service is an important determinant of its quality. Therefore, at the expiration of the initial contract (at time T), the regulator awards a new contract for the period going from T to $T+\Delta T$.⁴ Regulators in utility sector periodically organize call for tender to attribute fixed-term contracts.

Importantly, the incumbent firm often participates in the competitive process leading to the attribution of the new contract. Therefore, the perspective of contract renewal might be an important source of incentive for the incumbent firm.

The role of contract renewal as an incentive device has long been recognized in the incentive regulation literature. Laffont and Tirole (1993) consider that the breakout rule (the choice of renewing or not a firm as a function of its realized cost at the end of the initial contract) is part of the regulatory contract. In this case, the regulator may bias the contract renewal to favour the incumbent or the entrant in order to provide more incentives.⁵ And such a bias proves to be optimal under asymmetric information. In this paper, unlike Laffont and Tirole, we do not explicitly model the process of contract renewal. Rather, we assume that, everything else being equal, a more efficient operator has a higher probability of being renewed, a property that holds in Laffont and Tirole's models. In the French urban transport sector, the authority cannot contract on the renewal procedure since it is stipulated by the law. However, contract attribution being based on the principle of '*intuitu personae*', we cannot exclude that some authorities might be biased in favour of one party, presumably the incumbent firm. We will discuss the consequence of that when we detail our results.

We will assume that the incumbent firm has a probability of being renewed which negatively depends on its realized cost at the end of the initial contract $c(T)$. Let us denote by $P(c(T))$, the probability of contract renewal for the incumbent when it achieves a cost $c(T)$ at time T .

We assume that the function $P(c(T))$ is continuous and differentiable and that

$$P' = \frac{\partial P(c(T))}{\partial c(T)} < 0. \quad \text{That is, a firm with a lower cost has a higher probability of being}$$

renewed.

For example, suppose that the incumbent firm competes for the contract with N other firms. Each competitor $i=1, \dots, N$ is characterized by a cost of providing the service c_i . The

⁴ Note that this new contract may differ from the initial one in many respects (length, type of compensation, duties of the firm...).

⁵ Similarly, Dalen et al. (2006) analyze a mechanism in which firms are ordered on the basis of the observed quality they provide and the firms that are relatively more successful are renewed, the others are not.

regulator observes the cost c_i as well as the incumbent cost $c(T)$ and selects the lowest cost provider. If the costs c_i are independently drawn from a common distribution function $f(c_i)$, the probability of being renewed with a cost $c(T)$ is equal to $P(c(T)) = [1 - F(c(T))]^N$, where $F(\cdot)$ is the cumulative distribution function associated with $f(\cdot)$. In this case, $P' < 0$.

If the contract of the incumbent firm is renewed for a period ΔT , the firm collects an additional profit flow. This profit must be at least equal to the firm outside opportunity. In the sequel, we will consider that the discounted profit flow for the incumbent coming from the renewed contract, denoted by $\bar{\pi}$, is independent of the contract type and of the realized cost $c(T)$. This, indeed, would be the case if the regulator observes the firm's cost.⁶

When the possibility of contract renewal is taken into account, the firm maximizes a (unweighted) sum of its current and expected future profit flows. That is the firm solves the following problem:

$$\max_{a(t)} \int_0^T e^{-\rho t} \pi(t) dt + P(c(T))\bar{\pi} \text{ subject to } \dot{c} = -a(t), c(0) \text{ and } T \text{ given.}$$

In the case of a fixed-price contract, the first order condition (4) of the above maximization problem must be replaced by:

$$(5) \quad \lambda(T) = \frac{\partial P(c(T))}{\partial c(T)} \bar{\pi}$$

Combining (3) and (5), we have $\lambda(t) = P' \bar{\pi} - \frac{1}{\rho} (e^{-\rho t} - e^{-\rho T}) \leq 0$. Hence, the optimal effort path is:

$$\hat{a}^{FP}(t) = \psi'^{-1} \left(-\frac{P' \bar{\pi}}{e^{-\rho t}} + \frac{1}{\rho} \left(1 - \frac{e^{-\rho T}}{e^{-\rho t}} \right) \right)$$

In the case of a cost-plus contract, the first order conditions of the maximization problem are (1), (2), (5) and

$$(6) \quad \dot{\lambda} = 0$$

Combining (5) and (6), we have $\lambda(t) = P' \bar{\pi}$. Hence, the optimal effort path is :

$$\hat{a}^{C+}(t) = \psi'^{-1} \left(-\frac{P' \bar{\pi}}{e^{-\rho t}} \right)$$

The results of our analysis can be summarized in the following propositions.

⁶ If, in the case the contract is renewed, more efficient firms have a lower profit flow, by exerting effort the operator increases its probability of contract renewal but it decreases the profit coming from contract renewal. Therefore, incentives coming from contract renewal are lower (a kind of ratchet effect).

Proposition 3: Considering the possibility of contract renewal, for all $t < T$, (i) $\hat{a}^{FP}(t) > \hat{a}^{FP}(t)$, (ii) $\hat{a}^{C+}(t) > \hat{a}^{C+}(t)$ and (iii) $\hat{a}^{FP}(t) > \hat{a}^{C+}(t) > 0$.

Proposition 4: $\frac{\partial \hat{a}^{C+}(t)}{\partial t} > 0$.

Proposition 3 establishes that, when contract renewal is taken into account, the level of effort exerted by operators increases. The possibility of contract renewal thus appears as an incentive device. The magnitude of this effect depends on the sensitivity of the probability of contract renewal with respect to the realized cost at the end of the contracting period. And, for a firm operating under a fixed-price contract, this incentive effect reinforces the one coming from profit maximization.

Proposition 4 shows that there is more effort exerted in a cost-plus contract as the end of the contract approaches. In other words, when taking into account contract renewal, the optimal effort path under cost-plus contracts increases over time. The reason is that only the total amount of effort together with the initial cost $c(0)$ matters for contract renewal. Hence firms exert more effort when it is cheaper, that is at the end of the contract.⁷

The impact of time to expiration on effort path is ambiguous in the case of fixed-price contract. On the one hand, incentives coming from the maximization of the profit flow calls for a decrease in $a(t)$ (Proposition 2). On the other hand, incentive for contract renewal calls for an increase in $a(t)$. Hence, the combined effect might be increasing, decreasing or U-shaped.

⁷ The result of proposition 4 would be affected if we introduce uncertainty in our model. If the cost has a stochastic component, effort would depend on the realized cost at each time t and the remaining time till contract expiration. In this case, the monotonicity of effort would not be guaranteed.

C. Gross cost and net cost contracts

In our analysis, we considered that the only source of income for the operator is the transfer paid by the regulator. This means that the receipts from the service are actually collected by the regulator. This is indeed the case for two contract types widely used in the utility sector, the cost-plus and the gross cost contracts. There is however a third popular contract type: the net cost contract, where the operator receives a fixed payment and collects the service revenues. Hence, the total income at period t for an operator regulated by a net cost contract is $\bar{p}x(t) + p^{NC}$ where p^{NC} is the transfer, \bar{p} is the price and $x(t)$ is the quantity sold. In the utility sectors, prices are often regulated and specified in the contract. Hence, the only way to increase the sales proceeds is to increase the quantity sold. We will consider that the demand for a service depends on its price, its quality and the commercial effort performed to promote the service. In the field of urban transport, this commercial effort includes all the initiatives to encourage the use public transport (e.g. information to potential customers, mobility plans, advertisement, provision of intermodal facilities).

We therefore distinguish productive and commercial efforts. Productive effort $a_1(t)$ aims at reducing the cost, commercial effort $a_2(t)$ aims at increasing the quantity sold. More specifically we assume that $\dot{c} = -a_1(t)$ and $\dot{x} = f(a_2(t))$ with $f' > 0$. The cost of effort is then $\psi(a_1(t), a_2(t))$. This function is increasing and convex in its two arguments.

In a competitive bidding for a fixed-price contract, the contract is awarded to the firm who ask for the lowest amount of subsidy. In the case of a gross cost contract, the lowest bidder is likely to be the firm with the lowest cost. In the case of a net cost contract, the lowest bidder is likely to be the firm that could achieve the lowest operating deficit⁸ ($= c(T) - \bar{p}x(T) \geq 0$). And, since a cost reduction of 1 euro has the same impact on the operating losses than an increase of 1 euro in the commercial receipts, the probability of contract renewal could be expressed as $P[c(T) - \bar{p}x(T)]$ with $P_c = dP/dc(T) = -\bar{p}P_x = -dP/dx(T) < 0$.

Suppose that the function $dP/dc(T)$ is the same whatever the type of fixed-price contract (gross cost or net cost contract). The operator will exert more productive effort in the gross

⁸ In the French urban transport, the commercial receipts account for less than half of the total costs.

cost case under the following assumptions: (A1) $\frac{\partial^2 \psi}{\partial a_1(t) \partial a_2(t)} \geq 0$ and (A2)

$$P_{cx} = \frac{\partial^2 P}{\partial c(T) \partial x(T)} \leq 0.$$

Assumption A1 means that productive and commercial efforts are substitutes. This recovers the idea that managerial resources are scarce and, therefore, more effort in one task makes, at the margin, effort more costly in the other. Assumption A2 states that the renewal probability is concave in the operator's own performance. The impact of effort on the probability of being renewed decreases with the operator's performance. Under assumptions A1 and A2, we can establish the following result (the proof is in the appendix).

Proposition 5: Firms operating under a gross cost contract exerts more productive effort than firms operating under a net cost contract.

According to proposition 5, a net cost contract provides less incentives for productive efficiency than a gross cost contract because commercial effort partially crowds out productive effort. More effort (in general) is more and more costly and its benefit in terms of renewal probability decreases. Hence, operators invest less productive effort because they do invest more in commercial effort. Indeed, the lower productive efficiency induced by the net cost contract is compensated by a higher level of commercial effort. Firms operating under a gross cost contract have no incentives to undertake commercial effort (unless the contract renewal decision is based on cost and traffic levels) while, under a net cost contract, commercial effort increases both the profit and the probability of continuing operations. Hence, net cost contracts induce a lower productive efficiency but a higher commercial efficiency. However, in our data, we are only able to test the first effect.

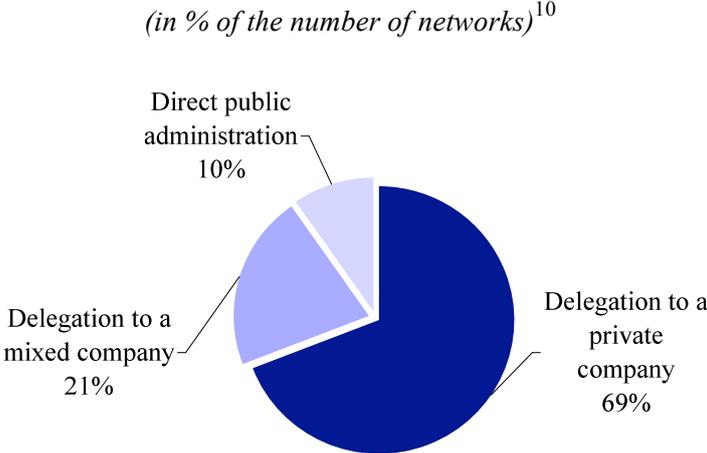
2. The French urban public transport sector

To test our propositions on the impact of regulatory schemes and time to contractual expiration on effort, we focus on the French urban public transport sector. With regard to the issue we are interested in, this case is a particularly rich domain since, in France, the local authorities in charge of regulating the procurement of urban public transport services can choose between various organizational modes.

First, they may choose between direct provision and outsourcing. In the former option, urban transport services are provided in-house by a public administration. In the latter case, service

provision is delegated to external contractors that can be either a semi-public firm⁹ or a private company. In such cases, local authorities are obliged to periodically organize a competitive tendering to select their provider (every 6 years in average). Thus contracts cannot be automatically renewed. Figure 1 shows the distribution of these modes of organizations in 2002.

Figure 1: Modes of organization of the French urban public transport in 2002-



The second interesting feature of this sector is that various contractual schemes are used to regulate external operators. Indeed, when service operation is delegated to a private or semi-public firm, the formal contract between local authorities and operators may be of three different types, depending on their degree of risk-sharing. Operators may be regulated by cost-plus contracts (called management contract), characterized by the full recovery of budget losses by local authorities. Under such scheme, operators bear neither industrial risk (on cost) nor commercial risk (on commercial revenues). A second type of regulatory schemes is gross cost contracts, where industrial risk is taken by the operator while commercial risk is borne by the local authority. At last, regulatory schemes in the French urban public transport sector may also take the form of net cost contracts, where both the industrial and the commercial risks are borne by the operator. This typology therefore echoes the traditional distinction between cost-plus and fixed-price contracts since the two last types of contracts (gross cost

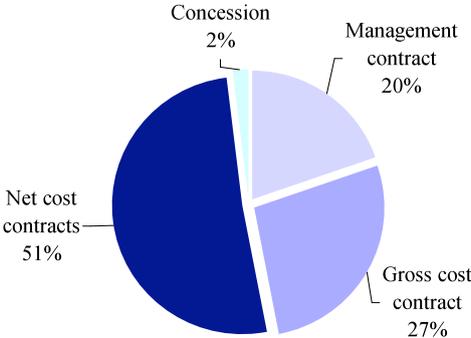
⁹ In this case, the majority of the capital stock (at least 51% and at most 82%) is under public control.

¹⁰ Source: our database of 165 local authorities out of a total of 241 existing local authorities in France. This dataset is described later on in the paper.

and net cost contracts) are variants of fixed-price contracts. Figure 2 reports the share of each contractual type in 2002¹¹.

Figure 2 : Modes of delegation of the French urban public transport in 2002

(in % of the number of networks)¹²



As already mentioned, under the French legal framework of the urban transport sector, the use of competitive tendering to select the service provider is compulsory and automatic renewal of contracts is forbidden. However, as emphasized by Yvrande-Billon (2006) and Amaral *et al.* (2008), this does not mean that competition for the market is intense. As illustrated in figure 3, the French urban public transport market is characterized by few bidders (1.6 in average over the period 1995-2002 which is the one we concentrate on) and a high proportion of tenders with only one bidder (50% in average). Additionally, out of the 99 bidding procedures we were able to record over the period 1995-2002, 87 % (85) have led to the renewal of the incumbent. Interestingly, we also observe that, when the incumbent is a semi-public company, he is renewed in 95.45% of the cases¹³, whereas a private incumbent has a probability of 83.12% of being renewed¹⁴.

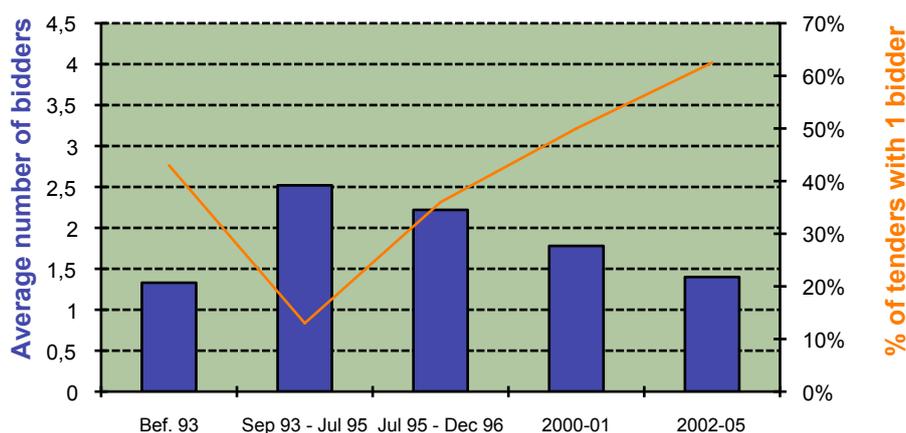
¹¹ As indicated on the figure, a fourth type of contract (concession contracts) is used to regulate private operators. With this type of regulatory scheme, operators bear the industrial and commercial risks, as in net cost contracts, but they are also in charge of the investments in dedicated infrastructure, equipment and rolling stock. This type of contract is therefore associated with longer duration but is rarely used in the French context.

¹² Source: our database of 165 local authorities.

¹³ Out of the 22 auctions with a semi-public incumbent, only 1 translated into a change of operator.

¹⁴ Out of the 77 auctions with a private incumbent, 13 translated into a change of operator.

Figure 3 : Number of bidders in France



Source: CERTU 1997, 1999, 2001, GART 2005 and authors' own calculation

These results need to be interpreted carefully. The decreasing and low number of bidders might obviously be related to the extent of the networks and to the resulting concentration of the transport industry. The market is dominated by three large companies which hold together more than 74% of the market shares in terms of numbers of networks. The potential for competition is therefore limited *de facto*. Furthermore, the rate of incumbents' renewal is likely to be a very imperfect indicator of competitive pressure. We can indeed consider that the incumbents have renewed most of their contracts by placing better bids than their competitors. In this sense, the high rate of incumbents' renewal that we observe in France would not indicate that competition for the market does not exist. However, given the very high proportion of calls for tender that received only one bid and considering that collusive practices in the sector were recently condemned by the French Competition Commission (Conseil de la Concurrence 2005), one can decently assert that the French urban public transport sector is characterized by a low level of competition. In addition, the lack of transparency of the selection procedure monitored by local authorities together with the magnitude of their discretionary power¹⁵ make the French system prone to favouritism.

With regard to our model, these characteristics of the French system of regulation in the urban public transport sector have an important implication. The low level of competitive intensity

and the potential for favouritism suggest that $P' = \frac{\partial P(c(T))}{\partial c(T)}$ might be relatively small, that is

¹⁵ See Yvrande-Billon (2006) for a detailed explanation of the procedure.

to say that the probability of contract renewal might be relatively insensitive to the realized cost of the last period. Moreover, consistently with our previous observations, one can expect P' to be even smaller in the case of semi-public companies, which are partly managed by local authorities. Indeed, for a semi-public company, the authority is both involved in the management of one potential bidder and responsible for allocating the contract. In such a situation, rival firms might be deterred to make counter-offers and incumbent's renewal is likely¹⁶.

3. Empirical methodology and data

To test our propositions, we use technical efficiency as a proxy for unobservable effort, as it has been done in various empirical contributions to the new theory of regulation (Aubert and Reynaud (2005), Piacenza (2006), Margari *et al.* (2007)). Technical efficiency refers to the degree to which service provision is maximised given the resources at hand¹⁷. In other words, technical inefficiency arises from an excessive use of inputs and its measurement involves a comparison between observed and optimal values of services (outputs) and resources (inputs). This performance indicator is intensively used in the empirical literature in transport economics (De Borger *et al.* 2002). Moreover as it is a measure of physical performance this indicator less suffers from problems of data availability and reliability. The information required to measure technical efficiency are the service and resource quantities, which are very often available at the firm level and are, most of the time, more reliable than financial or monetary data (like profits or costs for instance).

Several methods can be used to evaluate the technical efficiency of a given firm (Murillo-Zamarano 2004). Among the more common approaches¹⁸, the one we use in this paper is the stochastic frontier analysis (SFA). This frontier method is not strictly preferable to the others. On the one hand, compared to the non-parametric methods, this method allows taking account of random errors. On the other hand, its main disadvantage is that it assumes that the boundary of the production possibility set can be represented by a particular functional form

¹⁶ Such effects are highlighted by the local authorities: in recent interviews conducted by a trade organization (GART 2005), some of them declared that delegation to a semi-public company was a mode of organization that discourages potential entrants to submit bids.

¹⁷ Depending on the circumstances, efficiency can also be measured from the opposite orientation, as the degree to which resource consumption is minimized to satisfy service demand.

¹⁸ The three more common approaches are (1) parametric linear programming approach, (2) data envelopment analysis and (3) stochastic production frontier. For a description of these different approaches, see Coelli, Rao & Battese (1998) or Coelli, Estache, Perelman & Trujillo (2003).

with constant parameters. However, we consider that the fact that SFA imposes an explicit functional form and distribution assumption on data is less of an issue since our large database allows us to run a translog function, which is a very flexible functional form. Moreover, as our objective in this paper is not only to estimate a frontier and collect inefficiency scores but also and above all to analyse the determinants of technical inefficiency, the more relevant method seems to be the stochastic frontier analysis and more precisely, the panel model proposed by Battese and Coelli (1995).

The stochastic production frontier¹⁹ of firm i in time t is thus defined by:

$$y_{it} = f(x_{it}, z_{it}; \beta) + v_{it} - u_{it} \quad (1)$$

where y_{it} represents the production level of the i -th firm at date t ; x_{it} is a vector of inputs of the i -th firm at date t ; z_{it} is a vector of environmental variables for the i -th firm at date time t ; β is a vector of unknown parameter to be estimated. The v_{it} and u_{it} are random variables. More precisely, v_{it} is the idiosyncratic error component of the stochastic part. It corresponds to the usual disturbance introduced in regression models, and therefore represents all types of omitted or unobservable variables that have unbounded effects on output (such as weather uncertainty or measurement errors). u_{it} is the technical inefficiency component of the stochastic part. It is therefore supposed to be a non-negative valued random variable ($u_{it} \geq 0$) and it captures the technical and economic inefficiency under control of the operator.

The v_{it} are assumed to be *iid* $N(0, \sigma_v^2)$ random errors, independently distributed of the u_{it} . The u_{it} are assumed to be independently distributed as truncated normal $N(w_{it}\delta, \sigma_u^2)$, where w_{it} is a vector of explanatory variables that affect technical inefficiency of firms over time and δ is a vector of unknown coefficients.

The parameters β and α are estimated simultaneously with the method of maximum likelihood and the likelihood function is expressed in terms of the variance parameters, $\sigma^2 = \sigma_u^2 + \sigma_v^2$, $\sigma^2 = \sigma_u^2 + \sigma_v^2$ and $\gamma = \sigma_u^2 / (\sigma_u^2 + \sigma_v^2)$, $\gamma = \sigma_u^2 / (\sigma_u^2 + \sigma_v^2)$. γ measures the importance of the variance of production inefficiency relative to total variance. A value close to one indicates that productive inefficiency is important relative to the random noise term affecting production level (for a more detailed explanation of this method, see Kumbhakar & Knox Lovell, 2000).

¹⁹ The production frontier gives the maximum output that can be produced from a specified set of inputs, given the existing technology available or, put differently, the minimum resources employed for producing a certain level of output.

A first advantage of the Battese and Coelli's model is that it formulates a model for the technical inefficiency effects, which is not done in many studies estimating stochastic production frontiers. The second advantage is that it allows estimating simultaneously the parameters of the stochastic production frontier and the parameters of the inefficiency model. Therefore, this approach is statistically more relevant than the two-stage approach used in several studies which consists in predicting the technical inefficiency effects via the estimation of a stochastic production frontier and then regressing the inefficiency measures obtained in the first stage on some explanatory variables. Thus, in the first stage, inefficiency effects are assumed to be identically distributed whereas in the second stage these error terms are assumed to depend on some other variables. The model developed by Battese and Coelli allows avoiding this inconsistency (Dalen & Gomez-Lobo, 2002).

The database we use to confront our predictions and calculate technical efficiency assembles the results of two annual surveys conducted by an agency of the French Ministry of Transportation on the one hand and a trade organization that gathers most of the local authorities in charge of urban transport on the other hand. The data are available between 1995 and 2002 for a total of 165 networks (out of 241). But, for a purpose of homogeneity we have excluded the cities with at least one mass transit system (subway and tramway) which have obviously a different production function. We have also reduced our sample by excluding the smallest cities (under 30,000 inhabitants) that are also assumed to have a different production function²⁰. At last, as our propositions only deal with the performance differential of various delegation contracts, we have excluded from the original sample all the cities where service is provided by a public administration. The result is an unbalanced panel of 802 yearly observations covering 124 different urban transport networks over eight recent years (from 1995 to 2002 included).

Our output variable (y_{it}) is the number of vehicle-kilometres produced by the i -th firm during year t . The definition of output we retain is therefore supply-orientated, which is disputable (Berechman 1993). Ignoring demand may indeed lead to consider that the most efficient operators are those whose buses are empty. However, the main argument explaining our choice of a supply-orientated measure of output is that demand-related measures (such as

²⁰ As a consequence of these selections, the few networks operated by a company regulated by a concession contract were excluded.

passenger-trips) are not so much under the control of operators but are rather extremely dependent upon exogenous determinants such as the rates of unemployment and car ownership, which, furthermore, are unavailable at a disaggregated level in our database²¹. Consequently, what we call technical efficiency in our empirical analysis is the operators' technical capability to produce the maximum level of vehicle-kilometres given the underlying technology, i.e. given a specified set of inputs.

The inputs we consider are the most frequently used in the literature, namely capital, labour and energy. Capital (X^{CAP}) is measured by the number of vehicles (bus, trolleybus, minibus, etc...) used to provide the service. We could not have enough reliable financial data to create another indicator of capital expenses. However, although incomplete, our indicator takes into account the major part of capital, that is rolling stock. Labour (X^{LAB}) is measured by the number of employees including temporary work and subcontracting personnel with no distinction between driving labour and non-driving labour. The total number of employees is measured in equivalent full time and the quantity of labour in equivalent 'employee-year'. At last, energy (X^{ENE}) is measured in equivalent diesel m3.

In addition to these input variables, we introduce various control variables to take into account the characteristics of the networks and the quality of the rolling stock. Thus we take the number of inhabitants per kilometre of bus line as a proxy for the density of population in the area served by public transport ($Z^{DENSITY}$). The impact of this variable on the level of production is expected to be positive as the higher the population density the more vehicles-kilometres supplied by the operators. We also control for the average commercial speed of buses (Z^{SPEED}). This variable partly captures the environmental characteristics of the network such as the presence of natural barriers or the existence of traffic congestion that are expected to have a negative impact on commercial speed, hence a negative impact on technical efficiency. At last, we use the average age of rolling stock to control for the differences in the quality of capital (Z^{AGE}). We expect the level of production to be negatively related to the average age of the fleet.

Finally, to test our central propositions regarding the impact of regulatory schemes and time to expiration on effort, we introduce the following variables in the inefficiency model.

- *PRIVATE* is a dummy variable taking the value 1 if the operator in a particular year is a private company and 0 otherwise (that is if the operator is a semi-public company);

²¹ For other arguments as to why the majority of technical efficiency studies in urban transit uses pure supply indicators, see Kerstens (1996).

- *FP* is a dummy variable taking the value 1 if the operator is regulated by a fixed-price contract and 0 otherwise;
- *CPLUS* is a dummy variable taking the value 1 if the operator is regulated by a cost-plus contract and 0 otherwise;
- *GROSS* is a dummy variable taking the value 1 if the operator is regulated by a gross cost contract and 0 otherwise;
- *NET* is a dummy variable taking the value 1 if the operator is regulated by a net cost contract and 0 otherwise;
- *EXPIR_t* measures at year *t* the number of remaining years before contract expiration; hence *EXPIR_{it}*GROSS_{it}* for instance gives at year *t* the number of remaining years before the gross cost contract of operator *i* expires.

Descriptive statistics on our variables are provided in table 1.

Table 1: Sample descriptive statistics (124 networks, 8 periods)

Variable	Mean	Standard deviation	Minimum	Maximum
Vehicle-km (Y)	2,599,757	2,585,871	178,106	11,400,000
Labour (X ^{LAB})	151.721	164.719	8	958.749
Energy (X ^{ENE})	1,173.022	1,287.478	78	6,005.557
Capital (X ^{CAP})	67.488	65.001	6	365
Age (Z ^{AGE})	8.221	1.942	3.3	16.5
Speed (Z ^{SPEED})	16.271	2.483	11.4	30
Density (Z ^{DENSITY})	734.076	332.382	207.588	2,608.353
Private	0.728	0.445	0	1
FP	0.708	0.455	0	1
Gross	0.278	0.448	0	1
Net	0.430	0.495	0	1
Expir*Cplus	1.066	2.006	0	11
Expir*Gross	1.176	2.310	0	11.92
Expir*Net	2.060	2.954	0	15

4. Empirical results

To determine the inefficiency properties of the various regulatory schemes and of time to expiration, we estimate the following translogarithmic production frontier model²²:

$$\begin{aligned}
\ln Y_{it} = & \beta_0 + \beta_{LAB} \ln X_{it}^{LAB} + \beta_{ENE} \ln X_{it}^{ENE} + \beta_{CAP} \ln X_{it}^{CAP} \\
& + \beta_{DENSITY} \ln Z_{it}^{DENSITY} + \beta_{SPEED} \ln Z_{it}^{SPEED} + \beta_{AGE} \ln Z_{it}^{AGE} \\
& + \beta_{LAB,LAB} \ln X_{it}^{LAB} \ln X_{it}^{LAB} + \beta_{LAB,ENE} \ln X_{it}^{LAB} \ln X_{it}^{ENE} + \beta_{LAB,CAP} \ln X_{it}^{LAB} \ln X_{it}^{CAP} \\
& + \beta_{ENE,ENE} \ln X_{it}^{ENE} \ln X_{it}^{ENE} + \beta_{ENE,CAP} \ln X_{it}^{ENE} \ln X_{it}^{CAP} \\
& + \beta_{CAP,CAP} \ln X_{it}^{CAP} \ln X_{it}^{CAP} \\
& + v_{it} - u_{it}
\end{aligned}$$

with the technical inefficiency effects u_{it} assumed to be independently distributed as truncated normal $N(\delta w_{it}, \sigma_u^2)$ $N(\delta w_{it}, \sigma_u^2)$ where $w = \{PRIVATE; FP; GROSS; NET; EXPIR * CPLUS; EXPIR * GROSS; EXPIR * NET\}$

$$w = \{PRIVATE; FP; GROSS; NET; EXPIR * CPLUS; EXPIR * GROSS; EXPIR * NET; EXPIR^2 * GROSS; EXPIR^2 * NET\}$$

is a vector of firm specific variables that affect inefficiency across firms and δ is a vector of unknown coefficients. The various combinations of variables that were introduced in the vector w will be discussed below when the results are presented.

Before displaying and interpreting the results of our estimations, it is worth mentioning the testable propositions that can be derived from our theoretical model. We expect *FP*, *GROSS* and *NET* to have a positive impact on technical efficiency²³ as we conjecture that fixed-price contracts are more high-powered incentives contracts than cost-plus contracts (proposition 1). Additionally, according to proposition 5, we expect the variable *GROSS* to have a larger impact on technical efficiency than *NET*. According to proposition 3, *PRIVATE* is expected to have a positive impact on efficiency. Indeed, as we assume that the probability of contract renewal for semi-public operators is less sensitive to realized cost at the end of the contract, we expect private firms to perform better than semi-public operators. From proposition 4, *EXPIR * CPLUS* is expected to impact negatively on efficiency since we conjecture that operators under cost-plus regulatory schemes exert more effort at the end of the contracting

²² In order to reduce the number of parameters to be estimated, we omit the cross-products between the inputs X and the control variables Z .

²³ Note that our model is a technical inefficiency model so that, in the estimations, a negative sign means that the variable has a positive (negative) impact on efficiency (inefficiency). For commodity reasons, in the formulation of our testable propositions, we prefer to indicate the expected impact of our firm specific variables on efficiency.

period. At last, the expected signs of the coefficients of $EXPIR * GROSS$ and $EXPIR * NET$ are *a priori* unknown. Indeed, the theoretical model does not allow us to disentangle between the opposite effects of these variables on effort. On the one hand, incentives coming from profit maximization call for a positive impact of $EXPIR * GROSS$ and $EXPIR * NET$ on technical efficiency (proposition 2): the further from contract expiration, the higher the level of effort exerted by operators under fixed-price contracts. On the other hand, incentives coming from contract renewal call for a negative impact of these two variables on technical efficiency (proposition 4): the closer to the end of the contract, the higher the level of effort exerted by operators under fixed-price regulatory schemes.

Table 2. Production frontier estimation results

Parameter	Model 1	Model 2	Model 3	Model 4	Model 5
β_0	9.544*** (23.821)	9.562*** (27.254)	9.567*** (27.145)	9.480*** (26.703)	9.487*** (26.504)
β_{LAB}	1.620*** (5.858)	1.524*** (6.143)	1.541*** (6.117)	1.525*** (6.093)	1.531*** (6.034)
β_{ENE}	-0.535 (-1.570)	-0.550* (-1.894)	-0.556* (-1.905)	-0.501* (-1.703)	-0.506* (-1.698)
β_{CAP}	-0.045 (-0.198)	0.087 (0.392)	0.075 (0.339)	0.046 (0.206)	0.046 (0.206)
$\beta_{DENSITY}$	-0.009 (-1.272)	-0.009 (-1.277)	-0.009 (-1.353)	-0.008 (-1.152)	-0.008 (-1.148)
β_{SPEED}	0.127*** (6.004)	0.138*** (6.529)	0.138*** (6.513)	0.139*** (6.535)	0.139*** (6.464)
β_{AGE}	-0.041*** (-3.260)	-0.046*** (-3.719)	-0.046*** (-3.644)	-0.043*** (-3.314)	-0.043*** (-3.374)
$\beta_{LAB,LAB}$	0.255*** (4.390)	0.229*** (4.186)	0.237*** (4.183)	0.235*** (4.141)	0.234*** (4.077)
$\beta_{LAB,ENE}$	-0.601*** (-5.186)	-0.568*** (-5.441)	-0.577*** (-5.443)	-0.579*** (-5.487)	-0.582*** (-5.422)
$\beta_{LAB,CAP}$	0.037 (0.334)	0.071 (0.715)	0.062 (0.588)	0.076 (0.734)	0.080 (0.763)
$\beta_{ENE,ENE}$	0.274*** (3.535)	0.281*** (4.254)	0.283*** (4.255)	0.276*** (4.119)	0.277*** (4.072)
$\beta_{ENE,CAP}$	0.080 (0.762)	0.018 (0.182)	0.025 (0.257)	0.035 (0.354)	0.035 (0.353)
$\beta_{CAP,CAP}$	-0.060 (-0.892)	-0.044 (-0.681)	-0.044 (-0.655)	-0.057 (-0.854)	-0.059 (-0.880)
<i>Year dummies</i>	<i>NO</i>	<i>NO</i>	<i>YES</i>	<i>NO</i>	<i>YES</i>
δ_0	0.057*** (5.964)	0.018 (1.242)	0.025 (1.371)	0.068*** (3.369)	0.068*** (3.297)
$\delta_{PRIVATE}$	-0.048*** (-3.893)	-0.079*** (-5.329)	-0.077*** (-4.348)	-0.030*** (-1.929)	-0.031* (-1.914)
δ_{FP}	-0.080*** (-6.760)				
δ_{GROSS}		-0.582*** (-6.933)	-0.543*** (-5.299)		
δ_{NET}		-0.093*** (-6.055)	-0.085*** (-5.062)		
$\delta_{EXPIR*CPLUS}$				0.0007 (0.218)	0.0005 (0.151)
$\delta_{EXPIR*GROSS}$				-0.040* (-1.833)	-0.041* (-1.793)
$\delta_{EXPIR*NET}$				-0.008** (-2.164)	-0.009** (-2.158)
σ^2	0.006 (15.145)	0.011 (14.650)	0.011 (7.353)	0.008 (5.825)	0.008 (5.614)
γ	0.011 (17.930)	0.544 (11.952)	0.507 (4.326)	0.365 (2.446)	0.381 (2.600)
<i>LL function</i>	969.29	899.71	899.41	898.52	898.92
<i>LR test one sided errors</i>	195.49	56.31	55.01	53.93	54.05
<i>Nb of restrictions</i>	4	5	5	6	6

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$. t-ratios are in parentheses.

To facilitate the interpretation of the estimated first-order parameters in the translog production functions, we calculated the production elasticities at the sample means²⁴ and obtained the ratios presented in Table 3. As expected, the estimated production elasticities of our input variables (labour, energy, rolling stock) are positive, meaning that an increase in transit inputs results in a larger output. Furthermore, the obtained values are consistent with the results of other studies (Roy *et al.* 2007).

Table 3. Production elasticities

<i>Production elasticity at the sample means</i>	<i>Model 1</i>	<i>Model 2</i>	<i>Model 3</i>	<i>Model 4</i>	<i>Model 5</i>
Labour	0.090	0.109	0.105	0.113	0.105
Energy	0.657	0.645	0.652	0.636	0.634
Vehicles	0.201	0.200	0.192	0.195	0.198
Return to scale	0.947	0.954	0.949	0.944	0.937

Regarding the inefficiency models, it appears from model 1 that operators under fixed-price contracts are closer to the production frontier than operators under cost-plus contracts (δ_{FP} is negative). However, the parameter γ , although statistically different from 0, is low (0.011). If instead we split the variable *FP* into two categories (*GROSS*, *NET*) to take into account the existence of gross cost and net cost contracts, the quality of the estimation (models 2 and 3) largely improves (γ is equal to 0.544 and 0.507 respectively and is significantly different from 0). Both results therefore support our proposition 1 which conjectured that fixed-price contracts are superior regulatory schemes in term of technical efficiency. Moreover, our proposition 5 is corroborated as the coefficient of *GROSS* is significantly larger in absolute value than the coefficient of *NET*. As already emphasized by Roy and Yvrande-Billon (2007), gross cost contracts appear to induce the higher levels of technical efficiency.

The impact of contract renewal on effort is captured by the dummy variable *PRIVATE* which indicates whether the operator is a private company or a semi-public entity (the omitted case). In all models, the variable *PRIVATE* has a significant positive impact on efficiency (the parameters $\delta_{PRIVATE}$ are all significantly different from zero at 1%). Consistently with our proposition 3, private operators exhibit higher technical efficiency than semi-public firms. This might be due to the fact that private operators face more competition at the contract

²⁴ For instance, labour elasticity is calculated at the sample means with the following formula : $\varepsilon^{LAB} = (\partial \ln Y / \partial \ln X^{LAB}) = \beta_{LAB} + 2 \cdot \beta_{LAB,LAB} \ln \bar{x}^{LAB} + \beta_{LAB,ENE} \ln \bar{x}^{ENE} + \beta_{LAB,CAP} \ln \bar{x}^{CAP}$.

attribution stage than semi-public companies. In such case, this would confirm that contract renewal is indeed an incentive device.

Models 4 and 5 suggest that time to expiration has no consequence on the level of effort exerted by operators under cost-plus contracts since the coefficient $\delta_{EXPIR*CPLUS}$ is not statistically different from zero (no support for proposition 4). On the contrary, time to expiration appears as a significant determinant of technical efficiency for operators under fixed-price contracts (whether gross or net cost contracts). The coefficients $\delta_{EXPIR*GROSS}$ and $\delta_{EXPIR*NET}$ are negative and statistically different from zero. This result corroborates our proposition 2: fixed-price contracts induce more incentives at the beginning of the contracting period. Yet, the fact that $\delta_{EXPIR*GROSS}$ and $\delta_{EXPIR*NET}$ are low and that $\delta_{EXPIR*CPLUS}$ is not statistically significant may indicate that the impact of contract renewal on effort is limited. Lack of competition in the French UPT sector may explain the low level of the coefficients associated with the variable linked to contract renewal. But, except for the variable $\delta_{EXPIR*CPLUS}$, all the variables have the expected sign and are statistically significant. This confirms that contract renewal has a positive but limited impact on productive efficiency.

5. Conclusions

Incentive regulation theory has long recognized the role of contracting practices in explaining the performances of regulated firms. In this paper, we particularly focus on the link between contract types and performances in a dynamic model of regulation where firms care about their current profits and their future profits coming from contract renewal. We distinguish three types of regulatory contracts, net cost, gross cost and cost-plus contracts that are widely used in the utility sector. We consider a firm regulated by one of these contracts and this firm has the possibility to undertake a cost-reduction effort. The firm and the regulator have signed an initial contract that lasts for several periods and, when it expires, a new contract will be put to tender. Firms have then the opportunity to have their contract renewed which obviously leads to higher profits. The possibility of contract renewal is indeed a particular feature of the utility sectors where service continuity is often a must. We study the incentives created by profit maximization and contract renewal for each contract type. We are interested not only in the magnitude of the incentive effects but also in their timing during the contracting period.

Our predictions are confronted with a panel dataset of 124 regulatory contracts used in the French urban public transport sector over the period 1995-2002. We adopt a stochastic production frontier methodology and use technical efficiency as a proxy for the level of effort exerted by operators. Our conclusions can be summarized in three main points.

First, we largely confirm that high powered incentive schemes are associated with higher performances. Our focus in this paper is productive efficiency, and regarding this aspect, those operators who are responsible for the productive risk have a higher performance than those who are not. But the observed relation between risk and performance is not a linear one. Those operators who bear in addition the commercial risk have a lower productive efficiency. Our explanation is that operators under a net cost contract can exert both productive and commercial effort to improve their financial performances, and, if the two are substitutes, they will exert less productive effort but more commercial effort. In our data, we observe a lower technical efficiency for net cost contract operators compared to gross cost contracts operators that we interpret as a lower level of productive effort but, because we do not have appropriate data on commercial performances, we cannot test the second part of the proposition.

Second, we analyze the allocation of effort during the whole contracting period. We show that the incentives to exert effort vary with the remaining time till contract expiration. A cost-reducing effort not only increases the performances at the current period but also during the remaining years until contract expiration. Therefore, the benefits of a cost-reducing effort are higher when it is exerted earlier. The data confirm that, except for the operators regulated by a cost-plus contract, there is more effort at the beginning of the contracting period, this effect being stronger for gross cost contracts.

Third, we consider the impact of contract renewal on the incentives to exert effort. At the contract expiration date, incumbent operators with a higher performance, have, *ceteris paribus*, a higher probability of being reappointed and thereby collecting new profits. In the French urban transport sector, competition is not fierce and the incentive effect coming from the possibility of contract renewal is therefore limited. Despite that, our data show that competition for the market remains an important disciplining device and the incentives it creates differ from those coming from profit maximization.

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6. Appendices

6.1 Proof of proposition 5

1. The contract is a gross cost contract

The profit of the firm is $\pi(t) = p^{GC} - c(t) - \psi(a_1(t), a_2(t))$ and the firm's objective writes as follow $\max_{a_1(t), a_2(t)} \int_0^T e^{-\rho t} \pi(t) dt + P(c(T))\bar{\pi}$ subject to $\dot{c} = -a_1(t)$, $c(0)$ and T given. The solution to this problem is given by $a_1^{GC}(t) = \hat{a}^{FP}(t)$ and $a_2^{GC}(t) = 0$.

2. The contract is a net cost contract

The profit of the firm is $\pi(t) = p^{NC} + \bar{p}x(t) - c(t) - \psi(a_1(t), a_2(t))$ and the firm's objective writes as follow $\max_{a_1(t), a_2(t)} \int_0^T e^{-\rho t} \pi(t) dt + P[c(T) - \bar{p}x(T)]\bar{\pi}$ subject to $\dot{c} = -a_1(t)$, $\dot{x} = f(a_2(t))$, $c(0)$, $x(0)$ and T given.

To solve this optimisation program, we construct the associated Hamiltonian function:

$$H = e^{-\rho t} [p^{NC} + \bar{p}x(t) - c(t) - \psi(a_1(t), a_2(t))] - \lambda_1(t)a_1(t) + \lambda_2(t)f(a_2(t))$$

Taking the first order conditions, we obtain after manipulations:

$$(1) \quad \psi_{a_1} = \frac{-\lambda_1(t)}{e^{-\rho t}}$$

$$(2) \quad \psi_{a_2} = \frac{\lambda_2(t)f'(a_2)}{e^{-\rho t}}$$

$$(3) \quad \lambda_1(t) = -P_c\bar{\pi} + \frac{1}{\rho}[e^{-\rho T} - e^{-\rho t}] < 0$$

$$(4) \quad \lambda_2(t) = P_c\bar{\pi} - \frac{\bar{P}}{\rho}[e^{-\rho T} - e^{-\rho t}] > 0$$

Combining (1) and (3), we have that under assumptions A1 and A2 $a_1^{NC}(t) \leq a_1^{GC}(t)$ if $a_2^{NC}(t) \geq 0$. A sufficient condition for that is $f'(0) > 0$. In this case, $a_2^{NC}(t) \geq a_2^{GC}(t) = 0$.

6.2 Specification tests

Table 4. Specification Tests

<i>Null hypothesis</i>	<i>Test Statistic</i>	<i>Critical Value</i>	<i>Decision</i>
Model 1			
(1) No inefficiency effects $H_0: \gamma = \delta_0 = \delta_{PRIVATE} = \delta_{FP} = 0$	195.49	$\chi^2_{1\%}(4) = 13.277$	Reject H_0
(1') No impact of incentive schemes and competition on efficiency $H_0: \delta_{PRIVATE} = \delta_{FP} = 0$	195.26	$\chi^2_{1\%}(2) = 9.210$	Reject H_0
Model 2			
(2) No inefficiency effects $H_0: \gamma = \delta_0 = \delta_{PRIVATE} = \delta_{GROSS} = \delta_{NET} = 0$	56.31	$\chi^2_{1\%}(5) = 15.086$	Reject H_0
(2') No impact of incentive schemes and competition on efficiency $H_0: \delta_{PRIVATE} = \delta_{GROSS} = \delta_{NET} = 0$	56.1	$\chi^2_{1\%}(3) = 11.341$	Reject H_0
Model 3			
(3) No inefficiency effects $H_0: \gamma = \delta_0 = \delta_{PRIVATE} = \delta_{GROSS} = \delta_{NET} = 0$	55.01	$\chi^2_{1\%}(5) = 15.086$	Reject H_0
(3') No impact of incentive schemes and competition on efficiency $H_0: \delta_{PRIVATE} = \delta_{GROSS} = \delta_{NET} = 0$	55.5	$\chi^2_{1\%}(3) = 11.341$	Reject H_0
Model 4			
(4) No inefficiency effects $H_0: \gamma = \delta_0 = \delta_{PRIVATE} = \delta_{EXPIR * CPLUS} = \delta_{EXPIR * GROSS} = \delta_{EXPIR * NET} = 0$	53.93	$\chi^2_{1\%}(6) = 16.812$	Reject H_0
(4') No impact of incentive schemes and competition on efficiency $H_0: \delta_{PRIVATE} = \delta_{EXPIR * CPLUS} = \delta_{EXPIR * GROSS} = \delta_{EXPIR * NET} = 0$	53.72	$\chi^2_{1\%}(4) = 13.277$	Reject H_0
Model 5			
(5) No inefficiency effects $H_0: \gamma = \delta_0 = \delta_{PRIVATE} = \delta_{EXPIR * CPLUS} = \delta_{EXPIR * GROSS} = \delta_{EXPIR * NET} = 0$	54.05	$\chi^2_{1\%}(6) = 16.812$	Reject H_0
(5') No impact of incentive schemes and competition on efficiency $H_0: \delta_{PRIVATE} = \delta_{EXPIR * CPLUS} = \delta_{EXPIR * GROSS} = \delta_{EXPIR * NET} = 0$	54.52	$\chi^2_{1\%}(4) = 13.2770$	Reject H_0

The likelihood-ratio test statistic, $\lambda = -2\{\log[Likelihood(H_0)] - \log[Likelihood(H_1)]\}$, has approximately chi-square distribution with parameter equal to the number of parameters assumed to be zero in the null hypothesis, H_0 , provided H_0 is true.

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