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ESSENTIAL FACILITY FINANCING
AND MARKET STRUCTURE

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ABSTRACT

Essential Facility Financing and Market Structure*

The Paper analyses the funding of an infrastructure project (high speed train line, platform, tunnel, harbor, regional airport, fibre-to-the-home network, etc.) in a situation in which an incumbent operator has private information about market profitability (demand, cost) and the infrastructure owner is subject to a budget constraint, either on a per project basis or over the entire infrastructure. An open access policy raises welfare, but may make the project unviable since funding must be provided by capital contributions and access charges.

The infrastructure owner can ask the incumbent for a higher capital contribution if the latter insists on an exclusive use. Yet, such screening is at odds with social goals; the higher the demand (the lower the cost), the more the incumbent is willing to pay for exclusivity: that is precisely when competition yields the highest benefits. At the optimum, the incumbent's information impacts the decision of whether to build the infrastructure, but is not used to determine market structure.

The Paper further shows that an absence of long-term licencing favours monopoly franchising, while a threat of regulatory capture creates an open access presumption.

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NON-TECHNICAL SUMMARY

Economic regulation nowadays focuses mostly on infrastructure facilities characterized by significant returns to scale, large sunk costs or network externalities. Examples of such facilities that have been treated as essential include electric transmission grids, narrow-and-broadband copper local loops, harbours, airports, pipelines, railway tracks and stations, and Eurotunnel.

This Paper studies investment and funding of an infrastructure project when the infrastructure is subject to a budget constraint (either on a per project basis or over the entire network). Consider a situation of vertical separation between the infrastructure and operations on the downstream market, with the downstream segment consisting of an incumbent and potential entrants (the theory also applies to the case of a vertically integrated industry, in which the infrastructure provider is also present on the potentially competitive segment). The regulator can cut special deals to limit competition if that is what it takes to make the project financially viable. Since expected revenues drive investment profitability from charging for access, the incentives to invest in infrastructure are related to market design at the downstream level. A fully informed infrastructure owner would implement the project under a policy that opens access to all operators, provided it generates sufficiently high revenues through access charges (or investment contributions) to balance the budget; otherwise, it would grant a monopoly franchise to the incumbent to ensure project viability, or even not invest at all.

When the infrastructure owner has imperfect information about the demand for services enabled by the project or about operating costs, it must elicit information held by the downstream industry, and more precisely by the incumbent operator, assuming that the latter has private information on infrastructure viability. The screening instrument is the stake (investment contribution, access charge) taken by the incumbent. Unfortunately, private incentives conflict with the socially desirable policy of opening the market to competition when demand is high; that is when the benefits of competition are the highest: for, it is precisely when demand is high that the incumbent is most eager to preserve its monopoly position.

The policy implication of this observation is that the infrastructure owner should not try to screen the incumbent operator by demanding a basic (open access) contribution with the option of a higher investment contribution in exchange for an exclusive right. Rather, it should conduct its own in-depth marketing studies; it should also encourage the acquisition by potential entrants of information about cost or demand, so they can challenge undue claims made by the incumbent that demand is low and project viability requires an exclusive franchise.

Still, regulators will always have limited information about project viability. We solve for the optimal regulatory policy under imperfect information. Given the limited scope for screening noted above, the optimal policy takes the form of either an open access policy (with a relatively low contribution by the incumbent) or an exclusive franchise (with a higher contribution), in either case chosen on a priori grounds. (The optimal policy can also take the intermediate form of a 'moderation of competition', with a fixed number of years of an exclusive franchise followed by an opening of access.)

Several extensions of the basic framework are explored in the Paper, among which two are particularly worth mentioning. First, we investigate dynamics and show that monopoly franchises are immune to the ratchet effect, while the incumbent has an incentive to signal a low profitability of the segment by turning down an open access license. Second, we prove that a concern about regulatory capture may make open access the default rule and thus put the burden of proof on the monopoly franchising option.

Finally, although our analysis is primarily motivated by infrastructure investment in regulated sectors, it also sheds light on the twin issue of the treatment of essential facilities in antitrust law. Competition authorities face *ex post* the same dilemma as the regulators in regulated industries do *ex ante*: More competition increases welfare once the facility is built, but may result in a lower quality facility or in no facility at all.

1 Introduction

Scope of the analysis

The last twenty years have witnessed the large scale deregulation of sectors such as telecommunications, transportation and energy.[4] Activities with no significant returns to scale have been opened to competition and are now subject only to light regulation. In contrast, the other, "infrastructure" activities with significant returns to scale, large sunk costs and network externalities (e.g. cable, narrow-and-broadband copper local loops, transmission grids, harbors, regional airports, pipelines, intermodal platforms, high-speed train lines, Eurotunnel), are deemed to be essential facilities and are often regulated as public utilities or awarded exclusive franchising contracts.[5]

This paper studies investment and funding of an infrastructure project when the infrastructure is subject to a budget constraint either on a per-project basis or over the entire infrastructure. For example, a regulated railroad infrastructure owner may be required to invest only in projects that generate enough maintenance cost savings or raise enough access revenues to be financially viable,[6] or else to break even over its entire network. The downstream segment is populated by one incumbent and one (or several) entrant. In our model, the incumbent operator and the infrastructure owner will be taken to be separate entities, but they can indifferently be a single actor, which allows for a wide range of applications. For example, while incumbent railroad operators in Europe (respectively, electricity generators in the US) have been forced to divest the essential facilities, they are still vertically integrated in the US (respectively, in Europe).

The downstream market is potentially competitive, but the regulator can cut special deals to limit competition if that is what it takes to make the infrastructure financially viable.[7] Since investment profitability is driven by expected future revenues from charging

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[4]See, e.g., Armstrong-Cowan-Vickers 1994, and Laffont-Tirole 1999.

[5]The reader will find useful material on franchises in the transportation sector in several World Bank reports (Campos-Cantos (1999), Estache (1999) and Kerf *et al* (1998)).

[6]As is the case in France for RFF, the infrastructure owner (Article 4, Order 97-444).

[7]To think about the link between downstream market design and upstream investment financing, two examples related to railways are worth keeping in mind. First, most of the new tracks that have been

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for access, the incentives to invest in infrastructure are related to market design at the downstream level. The static vision of access policies is thus put into a new perspective, as possibly resulting from an ex ante optimal arrangement to finance, build and operate infrastructure projects.[8]

Although our analysis is primarily motivated by infrastructure investment in regulated sectors (transportation, energy, telecommunications), it also sheds light on the twin issue of the treatment of essential facilities in antitrust law. Essential facilities have been defined by American and European competition authorities as facilities the access to which is essential (and not just cheaper than the alternative) in order to compete on the downstream market, and whose owner is dominant and has no valid reason (lack of capacity, cost of achieving interoperability, protection of IP rights, ...) to deny access. Competition authorities often face a dilemma between granting generous access to the essential facility and thereby generating substantial social benefits from competition, and letting the facility owner recoup its investment. Indeed, competition authorities usually exclude patented innovations from the scope of application of the essential facility doctrine even though such innovations often meet the essential facility criteria, on the grounds that the patentees' freedom to choose their licensees and licensing fees encourages innovation. Competition authorities face "ex post" the same dilemma as the regulators in regulated industries do "ex ante": More competition increases welfare once the facility is built, but

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installed lately in France are high-speed tracks, that meet mechanical and safety standards to allow the French high-speed train TGV to run at maximum efficiency. These tracks are specifically reserved to TGV traffic, although ordinary long-distance trains could run on them as well and compete with the TGV. Furthermore, the technical specifications of railbeds were selected so as to be incompatible with the German high-speed train. Such decisions involve a monopolistic market design.

The second example is Eurotunnel. Financing the tunnel was complex, and negotiations ended up with the following arrangement for access. Half of the slots were reserved to the Shuttle (operated by Eurotunnel), the other half was allocated to the British and French incumbent operators. This controversial policy was relaxed by European competition authorities, which imposed the release of slots for potential entrants.

We do not pretend that our analysis rationalizes or invalidates these decisions, all the more as these policies date back to the pre-liberalization epoch. It proposes, however, a basic formulation of the potential trade-offs that can help us think about future infrastructure projects.

[8] Along similar lines, Campos and Cantos (1999) argue that the allocation of exclusivity rights in mixed concession contracts (as in Argentina or Burkina-Faso and Côte d'Ivoire) reflects a balance between the benefits of allowing competitive access and the private operator's greater profit stream under a monopoly regime.

may result in a lower-quality facility or in no facility at all.

Eliciting project viability

We assume that the regulator has imperfect information about the future demand for (or future cost of providing) the services enabled by the infrastructure. Typically, the demand for a new platform, a tunnel, a highway or fiber-to-the-home bandwidth is hard to forecast. In this respect, operating companies', in particular incumbent ones', superior marketing expertise and production experience put them in a better position to assess the value of infrastructure investments. This observation suggests that the regulator should elicit the information about infrastructure viability held by the downstream industry. In this paper, we are mainly interested in situations in which one incumbent operator has private information about the demand for (or the cost of operating) the segment; we will also briefly discuss the possibility that entrants also have private information about the segment's profitability.

Because competition destroys profits, a restrictive access policy granting exclusive access to the incumbent generates higher financial returns than a more liberal one that opens access to entrants. The regulator is therefore more likely to extract high access charges for exclusive access, which helps finance the project. On the other hand, social welfare is maximized by a more competitive market structure. A fully informed regulator would implement the project under open access provided that competition is compatible with access charges that are high enough to balance the budget; otherwise, the regulator would grant a monopoly franchise to the incumbent operator, or even not invest at all.

When the incumbent operator has superior information about the value of the project, the regulator must elicit this information in an incentive compatible way. The screening instrument is the stake taken by the incumbent. The incumbent operator must contribute in order to have the new infrastructure built; furthermore, it must participate more to the financing if it is to demand exclusivity. Alas, private incentives conflict with the socially desirable policy of opening the market to competition when demand is high; for, it is precisely when demand is high that the incumbent is most eager to preserve its

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monopoly position. That is, the incumbent is more eager to bear a high fraction of the investment cost to secure an exclusive right when demand is high. The reader familiar with incentive theory will recognize here a situation of "non-responsiveness,"[9] in which incentive compatibility imposes a monotonicity of policy with respect to the agent's private information that is opposite to the one desired by the principal.

The policy implication of this theoretical result is that the infrastructure owner should not try to screen the incumbent operator by demanding a basic open access contribution with the option of a higher investment contribution in exchange of an exclusive right. Rather, the infrastructure owner should conduct its own in-depth marketing studies; it should also encourage the acquisition by potential entrants of information about demand, so that they can challenge undue claims made by the incumbent that demand is low and project viability requires an exclusive franchise.

Outline

The paper is organized as follows. Section 2 lays out a simple model of infrastructure financing with a per-project break-even constraint. Section 3 analyzes the perfect information benchmark. Section 4 identifies the fundamental departure from the benchmark induced by asymmetric information and derives the optimal policy. Extensions of the model are explored in the following sections.

In Section 5, the regulator is allowed to break even over the entire network rather than on a per-project basis. Section 5 shows that, whether the incumbent is the same or differs across projects, open access segments should be cross subsidized by monopoly franchises. It is still the case, though, that due to incomplete information, the most profitable segments are operated under a monopoly franchise. Section 6 investigates dynamics and shows that monopoly franchises are immune to the ratchet effect, while the incumbent has an incentive to signal a low profitability of the segment by turning down an open access license. Section 7 shows that a concern about regulatory capture may make open access the default rule and thus put the burden of proof on the monopoly

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[9]See Guesnerie-Laffont (1984) and Caillaud et al (1988).

franchising option. Section 8 investigates two further extensions of the model, associated with the possibility of replacing the incumbent, and the observability of profits. Section 9 concludes.

Relationship to the literature

This paper belongs to a small, but growing literature on endogenous market structures. In Auriol-Laffont (1992) and Dana-Spier (1994), a regulator trades off the costs of duplication with the benefits of competition in a private value environment that is, in a situation in which operators have private information about their own production costs. Our research differs from theirs in two respects. First, the cost of competition is in terms of the viability of financing rather than duplication. Second, we consider a common value environment where the incumbent has private information about industry-wide parameters such as demand or cost. This departure turns out not to be innocuous: in a private value environment, the regulator is more willing to grant an exclusive franchise to an efficient firm, and conversely an efficient firm is willing to pay more than an inefficient one for the right to be the sole producer. Thus, the non-responsiveness that is central to our paper does not arise in Auriol-Laffont and Dana-Spier. Endogenous market structure determination also arises in the literature on universal service obligations (Milgrom 1996, Laffont-Tirole 1999), but this literature also focuses on private values and the set of issues considered there is rather different from those analyzed here.

2 Model

Consider an industry characterized by vertical separation between an upstream infrastructure and downstream service provision. The regulator, who in this version is also the upstream monopoly provider of infrastructure services, has to decide whether to build a new piece of infrastructure / realize a new project (equivalently, it could decide whether to keep an existing infrastructure in operation). The project involves investment cost I. Two operators can provide services over the infrastructure. The incumbent operator, firm

1, is already active in this market (or related segments, in the case of a new infrastructure) and has private information about the demand for and/or the cost of providing services. A potential entrant, firm 2, can enter the market and provide competitive services. The potential entrant, however, does not have access to the incumbent's information on market profitability before entry; it learns all relevant information about demand and cost only after it has entered and started operating services.[10] The regulator chooses whether to invest, and, in case of investment, whether the incumbent keeps a monopoly situation or the entrant is allowed to enter.

A parameter $\theta \in [\theta_L, \theta_H]$ characterizes the value of the project, both with respect to private profitability and to social welfare. To fix ideas, we will interpret it to be a downstream demand parameter, but it could also summarize common value aspects of the cost of providing services over the infrastructure. If the infrastructure is built, $\pi_M(\theta)$, $\pi_1(\theta)$ and $\pi_2(\theta)$ denote the (expected) profits made respectively, by an incumbent monopolist, and by the incumbent and the entrant in a duopoly. Similarly, let $W_M(\theta)$ and $W_D(\theta)$ denote social welfare, i.e. the sum of operators' profits and consumers' net surplus ($S_M(\theta)$ and $S_D(\theta)$) under monopoly and duopoly, respectively.

Let us spell out the information structure in more detail:

1. The incumbent operator knows θ. The regulator and the potential entrant do not; they share prior beliefs summarized by an absolutely continuous c.d.f. $F(.)$, with density $f(.)$. This assumption, while extreme, reflects the informational advantage that historical operators have over potential competitors and regulatory authorities. It could be relaxed by allowing the entrant to have some independent private information about market profitability.[11]

2. Profits (or social welfare levels) are not observable so that profit-based regulatory contracts, such as profit-sharing or profit-contingent fees, are not feasible. This

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[10]In Section 6.2 we look at a two-period situation where the entrant learns by operating.

[11]Private information shared by the incumbent and the entrant could be costlessly elicited using a Maskin-type mechanism (Maskin (1999)); hence, only independent information induces inefficiencies of the type described in our paper.

assumption is motivated by the possibility of transfers across product lines or by moral hazard considerations: see section 8.2.

3. Price regulation is ruled out. This restriction can also be motivated by moral hazard considerations. For example, quality aspects of services cannot be perfectly assessed by regulatory authorities. The fine structure of prices under price discrimination for various categories of consumers might also be difficult to regulate. We could of course allow price regulation on some basic services (as is done for example for railroad franchises in the UK) as long as the incumbent has private information about the cost of the demand for these services or enhanced services.

We make the following assumptions:

A.1: The surplus and profit functions are increasing in the demand parameter θ.

A.2: For all θ, $\pi_M(\theta) \geq \pi_1(\theta) + \pi_2(\theta)$: competition reduces industry profit. To avoid corner solutions, we will further assume that: $\pi_M(\theta_L) < I < \pi_1(\theta_H) + \pi_2(\theta_H)$.

A.3: For all θ, $0 < W_M(\theta) \equiv S_M(\theta) + \pi_M(\theta) < W_D(\theta) \equiv S_D(\theta) + \pi_1(\theta) + \pi_2(\theta)$: social welfare is larger under duopoly than under monopoly.

A.4: For all θ, $\dot{\pi}_M(\theta) > \dot{\pi}_1(\theta)$: a monopolist captures a higher share from an increase in demand (as measured by an increase in θ) than the same firm operating as a duopolist.

Assumptions A.2 (competition reduces industry profit) and A.3 (competition increases welfare) are standard in industrial organization. If the services supplied by both operators are perfect or close substitutes, assumption A.2 is satisfied by standard models of imperfect competition. If, however, both operators propose significantly differentiated services, or if there were complementarities between the two operators, assumption A.2 might not hold, but presumably open access would then not be contentious. Assumption A.3 is likely to hold as long as there are limited returns to scale at the downstream level: then, increasing the number of operators does not involve production inefficiencies, e.g., fixed

cost duplication, and more competition is unambiguously socially preferable. Again, open access is an issue only if there are benefits to competition. Assumption A.4, a sorting or Spence-Mirrlees condition, is central to the incentive analysis. It is quite natural, provided that competition is not profoundly altered when demand conditions, as measured by θ, change. For example, this set of assumptions is satisfied when the firms wage Bertrand-like price competition or when demand is linear with intercept θ and Cournot competition prevails after entry.[12]

The regulator maximizes aggregate social welfare, that is the sum of consumers' net surplus and producers' profits, under a balanced budget constraint. The regulator has two instruments: the market structure and investment contributions / access charges paid by the operators. First, the regulator can either grant a monopoly franchise to the incumbent, or give access to the infrastructure to both the incumbent and the entrant (or simply not build the infrastructure). In a first step, we rule out the possibility that the regulator grants a monopoly franchise to the entrant. We relax this assumption later on. Second, the regulator specifies the access charges paid by operating companies to use the infrastructure. In this model there is no difference between a contribution to the investment outlay and an access charge. Let a_M, a_1 and a_2 denote the access charges paid by firm 1 when it is a monopoly, and by firm 1 and firm 2 in case of a duopoly, respectively.

The financial constraint that forbids to invest without securing sufficient resources to match the investment spending can take different forms. A strong budget constraint requires that any project, characterized by its own θ, be fully financed by access charges: we call this an ex post budget balance constraint. A weaker constraint simply requires that the regulator balances the budget on average over all projects, so that the budget constraint is considered ex ante. Sections 3 and 4 consider the strong form, under which the regulator secures the funding for the individual project at the investment date. Section

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[12]Normalizing operating costs to zero and assuming perfect information about θ after entry, profit and surplus functions are given by $\pi_M(\theta) = \theta^2/4$ and $S_M(\theta) = \theta^2/8$, under monopoly, and by $\pi_1(\theta) = \pi_2(\theta) = \theta^2/9$ and $S_D(\theta) = 2\theta^2/9$ after entry.

5 analyzes the weaker form.

Note that we ignore the contract renegotiation concerns that are so pervasive for instance for fixed-price concession contracts.[13] While the parameter θ represents the best forecast of demand at the investment date, the realized demand is affected by ulterior shocks (thus, our profit and welfare functions, which are contingent on θ, are already expectations taken over post-investment realizations of uncertainty). Although our theory could be generalized to allow for future renegotiations (in which case the functions $\pi.(\cdot)$ and $W.(\cdot)$ would embody the future renegotiation), the model as it stands assumes that the payment of the access charges is made credible by the posting of bonds or else that access charges take the form of upfront investment contributions granting future usage rights to the operators.

Remark: As announced in the introduction, the model applies without any modification to the vertically integrated case, in which the incumbent operator owns the infrastructure (the regulator is then necessarily a separate entity). The only difference relates to accounting: The incumbent receives $\pi_M(\theta) - I$ in case of monopoly franchise, and $\pi_1(\theta) + a_2 - I$ in case of open access.

3 Perfect information benchmark: the conflict between competition and viability

Suppose first that demand is commonly known.[14] The regulator is subject to the strong balanced-budget requirement and must then compare three policies:

- Not building the infrastructure yields no additional welfare.

- Building the infrastructure and granting a monopoly franchise to the incumbent

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[13] See e.g. Engel et al (1997, 1998).

[14] We maintain throughout the assumption that profits and prices are unobservable, hence cannot be regulated.

with access charge $a_M(\theta)$ yields additional welfare equal to $W_M(\theta)$ provided budget is balanced: $a_M(\theta) \geq I$, and the incumbent breaks even: $\pi_M(\theta) - a_M(\theta) \geq 0$. In this case, it is clear that any access charge within $[I, \pi_M(\theta)]$ is feasible, provided that:

$$\pi_M(\theta) \geq I \tag{1}$$

that is, provided that:

$$\theta \geq \theta_M \equiv \pi_M^{-1}(I) \tag{2}$$

where $\theta_L < \theta_M < \theta_H$ from assumption A.2.

- Building the infrastructure and allowing competition with access charges $a_1(\theta)$ and $a_2(\theta)$ yields additional welfare equal to $W_D(\theta)$ provided the regulator balances her budget: $a_1(\theta) + a_2(\theta) \geq I$, and the two operating companies break even: $\pi_i(\theta) \geq a_i(\theta)$ for $i = 1, 2$. Again, many pairs of access charges are feasible provided that:

$$\pi_1(\theta) + \pi_2(\theta) \geq I \tag{3}$$

that is, provided that:

$$\theta \geq \theta_D^{SI} \equiv (\pi_1 + \pi_2)^{-1}(I) \tag{4}$$

where "SI" stands for "Symmetric Information", and where $\theta_M < \theta_D^{SI} < \theta_H$ from assumption A.2.

We have assumed that social welfare is higher under a duopolistic market structure. The infrastructure income generated by a duopolistic structure may, however, not be sufficient to finance the investment. Because competition reduces industry profit, the

budget balance requirement may force the regulator to grant a monopoly franchise to the incumbent operator, a second-best solution. This is summarized in the following and very intuitive proposition.

Proposition 1 : *The optimal full-information investment and market design are given by:*

- *for $\theta \in [\theta_L, \theta_M)$, the infrastructure is not built,*

- *for $\theta \in (\theta_M, \theta_D^{SI})$, the infrastructure is built and a monopoly franchise is granted to the incumbent,*

- *for $\theta \in (\theta_D^{SI}, \theta_H]$, the infrastructure is built and operated under open access.*

An infrastructure project that generates competitive operating profits in excess of the investment cost should be implemented under open access. We noted that in this case, the access fees charged to the incumbent and to the entrant are indeterminate. There may be scope for negotiation about the relative magnitude of these charges. The investment decision and the market structure in contrast are unambiguous.

Open access however, jeopardizes operating profits. In the absence of adequate financing by customers, or other stakeholders who benefit from the project, a monopoly franchise may have to be granted to the incumbent operator, whose operating profit can then be partially captured by the regulator to cover the investment cost.

4   Incomplete information

We now turn to the more realistic framework where the incumbent operator, due to his experience in serving the market or similar markets, has private information about the demand (or cost) parameter θ, while the regulator and the entrant only have prior distribution $F(.)$ over this parameter.

Following the standard mechanism design approach, the regulator proposes a menu of decisions about investment, market design and access charges with ex post balanced budget, among which the incumbent chooses one. Decisions, in particular access charges, must guarantee the potential entrant non-negative net expected profits.[15] The mechanism can w.l.o.g. be restricted to be a revelation mechanism. The investment and market design decisions can take value within $\{0, M, D\}$,[16] where we let M denote the decision to build the project under franchised monopoly, D the decision to build the project under open access and 0, the decision not to build the project. Let $a_I(.)$ and $a_E(.)$ denote the charges paid by the incumbent and the entrant, conditional on the incumbent's announcement.

4.1   Incentive-compatible franchises

The technical analysis that follows is standard (see e.g. Guesnerie-Laffont [1984]). The first lemma shows that incentive compatibility severely constrains feasible allocations:

Lemma 2 : *For any (deterministic) incentive compatible mechanism, there exist at most two threshold levels, θ_* and θ^*, with $\theta_L \leq \theta_* \leq \theta^* \leq \theta_H$, such that:*

- *if $\theta \in [\theta_L, \theta_*)$, the infrastructure is not built;*

- *if $\theta \in (\theta_*, \theta^*)$, the infrastructure is built and operated under open access;*

- *if $\theta \in (\theta^*, \theta_H]$, the infrastructure is built and operated under a monopoly franchise.*

Proof. Suppose that for θ the infrastructure is built under a monopoly franchise while for $\theta' > \theta$, it is built under open access. Then incentive compatibility requires that:

$$\pi_M(\theta) - a_I(\theta) \geq \pi_1(\theta) - a_I(\theta')$$
$$\pi_1(\theta') - a_I(\theta') \geq \pi_M(\theta') - a_I(\theta),$$

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[15]So, we assume that the entrant has to apply for access ex ante, before the mechanism takes place. Later, we show that the optimal (deterministic) mechanism is valid even if the entrant applies for entry after the incumbent's choice. So our assumption involves no loss of generality.

[16]So, we rule out stochastic mechanisms for the moment; see more on this below and in the appendix.

Summing up both inequalities yields:

$$\pi_1(\theta') - \pi_1(\theta) \geq \pi_M(\theta') - \pi_M(\theta), \tag{5}$$

which contradicts A.4. The comparisons with the decision not to build follows similar lines and relies on A.1. ∎

When the incumbent has private knowledge about the profitability of the project, there is no way to make him forego a monopoly position as its information about profitability improves. If the regulator is ready to grant a monopoly franchise for some θ, she must also grant the monopoly franchise for higher values $\theta' > \theta$. So, the full information policy is not incentive compatible.

As is standard in the theory of mechanism design, once the decision function is fixed, the access charge $a_I(.)$ for the incumbent is completely determined up to a constant. This access charge is necessarily a step function, characterized by (a_0, a_1, a_M), depending on whether the decision is $0, D$ or M. Obviously $a_0 = 0$.

Conditionally on the infrastructure being built, the only menu the regulator can offer consists of two options. If the incumbent selects a "base contribution" a_1, then the infrastructure is built and access is opened to competition. If in contrast, the incumbent is willing to contribute $a_M > a_1$, then he is awarded an exclusive right. Moreover, given the previous lemma, the incumbent chooses the base contribution for $\theta \in (\theta_*, \theta^*)$, while he opts for exclusivity for $\theta > \theta^*$. We call this menu an *exclusive-franchise-premium policy*, the premium for exclusivity being $a_M - a_1$.

4.2 Optimal franchising

Our second lemma characterizes the fundamental tension between efficiency and incentive compatibility: the market structure is optimally designed without eliciting the incumbent's private information.

Lemma 3 : *Exclusive-franchise-premium policies (menus) are suboptimal.*

Proof. Consider an exclusive-franchise-premium policy characterized by $(a_1, a_M, a_2(.))$ or alternatively by θ_* and θ^* with $\theta_L \leq \theta_* < \theta^* < \theta_H$ such that the following indifference equations hold for the incumbent:

$$\pi_1(\theta_*) - a_1 = 0$$
$$\pi_M(\theta^*) - a_M = \pi_1(\theta^*) - a_1$$

that is, $a_1 = \pi_1(\theta_*)$ and $a_M = \pi_M(\theta^*) + \pi_1(\theta_*) - \pi_1(\theta^*)$. Applying for entry must be individually rational for the entrant, so $a_2(.)$ must satisfy:

$$\int_{\theta_*}^{\theta^*} [\pi_2(\theta) - a_2(\theta)] \, dF(\theta) \geq 0,$$

as well as the budget constraint: for all $\theta \in (\theta_*, \theta^*)$, $a_1 + a_2(\theta) \geq I$ and $a_M \geq I$.

Consider now the policy such that the infrastructure is not built if $\theta < \theta_*$ and it is built and operated under open access if $\theta \in (\theta_*, \theta_H]$. This is obtained by maintaining $a_1 = \pi_1(\theta_*)$ and increasing a_M above $\pi_M(\theta_H)$. Moreover, fix the entrant's access charge so that $a_2 = \min_{\theta \in (\theta_*, \theta^*)} a_2(\theta)$. In the new mechanism, the incumbent ranks decisions 0 and D as before, depending on θ, and has no incentive to ask for an exclusive franchise: so incentive compatibility and individual rationality hold for the incumbent.

Since for θ in (θ^*, θ_H), $W_M(\theta)$ is replaced by $W_D(\theta)$, expected social welfare is unambiguously increased. The budget is balanced since it was for all $\theta \in (\theta_*, \theta^*)$ in the original mechanism. Finally, it is individually rational for the entrant to apply for entry since:

$$\int_{\theta_*}^{\theta^*} [\pi_2(\theta) - a_2] \, dF(\theta) \geq \int_{\theta_*}^{\theta^*} [\pi_2(\theta) - a_2(\theta)] \, dF(\theta) \geq 0.$$

Therefore, the new mechanism satisfies all requirements and yields higher social welfare. ∎

The regulator then need not rely on the incumbent's information to select a market structure at the optimum. She can restrict attention to two possible classes of policies.

(1) In the class of *no-competition policies*, the infrastructure is built if and only if $\theta \geq \theta^*$, and in this case it is operated under a monopoly franchise. The highest contribution that can be demanded from the incumbent is: $a_M = \pi_M(\theta^*)$. The optimal no-competition policy is therefore characterized by $\theta^* = \theta_M$, that is the infrastructure is built under monopoly franchise as long as it is financially viable.

(2) In the class of *no-exclusive-franchise policies*, the infrastructure is built if and only if $\theta \geq \theta_*$ and it is then operated under open access. The highest contribution that can be demanded from the incumbent is $\pi_1(\theta_*)$. An argument similar to the one in the proof of the previous lemma shows that the entrant's access charge can be chosen constant and equal to $\mathbb{E}\left[\pi_2(\theta) \mid \theta \geq \theta_*\right] = \int_{\theta_*}^{\theta_H} \frac{\pi_2(\theta)}{1-F(\theta_*)} dF(\theta)$. Let the function $a_D(.)$ be defined by:

$$a_D(\theta) = \pi_1(\theta) + \mathbb{E}\left[\pi_2(z) \mid z \geq \theta\right]$$

and note that it is increasing in θ. Let θ_D be the unique solution of $a_D(\theta) = I$, i.e. $\theta_D \equiv a_D^{-1}(I)$ or $\theta_D = \theta_L$ if $a_D(\theta) < I$ for all θ. The optimal no-exclusive-franchise policy is characterized by $\theta_* = \theta_D$, with entry fees $a_1 = \pi_1(\theta_D)$ and $a_2 = I - a_1$.

The implementation of this no-exclusive-franchise policy consists in asking the incumbent whether the project should be undertaken or not given his fee $a_1 = \pi_1(\theta_D)$, and in case it should, the entrant is invited to enter for a fee $a_2 = \mathbb{E}\left[\pi_2(\theta) \mid \theta \geq \theta_D\right]$. In this procedure, after the incumbent agrees on the project, the entrant should update his beliefs on θ given that $\theta \geq \theta_D$. Given the value of a_2, his decision to enter is then still rational and the policy is robust to this alternative timing of the entrant's decision.

The next proposition summarizes the analysis and states the optimal mechanism:

Proposition 4 : *It is never optimal to give the incumbent a choice between competition with a base contribution and an exclusive franchise for a premium over this base contribution.*

(a) If

$$\int_{\theta_M}^{\theta_H} W_M(\theta) dF(\theta) > \int_{\theta_D}^{\theta_H} W_D(\theta) dF(\theta); \tag{6}$$

the optimal regulatory policy under incomplete information grants the incumbent a monopoly franchise provided the latter is willing to finance the entire investment I. Otherwise, the infrastructure is not built.

(b) If (6) does not hold, the infrastructure is built if and only if the incumbent is willing to contribute $a_1 = \pi_1(\theta_D)$. The entrant then obtains access at $a_2 = \mathbb{E}\left[\pi_2(\theta) \mid \theta \geq \theta_D\right]$.

In a nutshell, the regulator cannot screen the incumbent operator to obtain a more competitive structure as demand improves; she must rely on her prior information only. The technically oriented reader will here recognize an instance of non-responsiveness (Guesnerie-Laffont (1984) and Caillaud & al (1988)). Bunching, i.e., the absence of extraction of the agent's information, arises when full information efficiency and incentive constraints require the market structure to move in opposite directions with θ.

Access charges: The definition of θ_D shows that provided open access is optimal, open access is more widespread than under perfect information: $\theta_D < \theta_D^{SI}$, since

$$I = \pi_1(\theta_D^{SI}) + \pi_2(\theta_D^{SI}) < \pi_1(\theta_D^{SI}) + \mathbb{E}\left[\pi_2(\theta) \mid \theta \geq \theta_D^{SI}\right].$$

Assumption A.2 implies that $\pi_M(\theta) \geq \pi_1(\theta) + \pi_2(\theta)$ but it does not imply that $\pi_M(\theta) \geq a_D(\theta)$. So, it is possible that $\theta_D < \theta_M$. In this case, (6) does not hold and the no-exclusive franchise policy is optimal under incomplete information. Then, the infrastructure is built more often than under perfect information and expected welfare is clearly higher than under perfect information. The explanation is obviously that the regulator extracts the entrant's expected profits, which may be higher than the realized profits if market profitability is barely above the threshold level. Entry may then occur only because the

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entrant is optimistic about θ, while under perfect information the entrant knows θ and is less willing to enter for low θ. As this looks like a pathological situation, we rule it out in the following by assuming:

A.5: Even under incomplete information, competition does not facilitate financing: $a_D(\theta) < \pi_M(\theta)$ for all θ.

Assumption A.5 is for example satisfied when competition in the market is intense, or when the uncertainty about demand is not too large.

Under a no-exclusive-franchise policy, the incumbent and the entrant do not pay the same access charge, even when both firms are technological and commercial equals (so $\pi_1(.) = \pi_2(.) = \pi(.)$), since

$$a_2 = \mathbb{E}\left[\pi(\theta) \mid \theta \geq \theta_D\right] > \frac{I}{2} > \pi(\theta_D) = a_1.$$

There is price discrimination with respect to access. This is no surprise since the incumbent knows θ and earns an informational rent from this knowledge, while the entrant only considers expected profits and gets no expected rent; even though they are technologically similar, both firms are informationally differentiated and should be treated differently.

Remark: It is worth investigating the nature of the optimal access policy when, for exogenous reasons, a non-discrimination constraint were imposed on the infrastructure manager. So, consider a symmetric model where $\pi_1(.) = \pi_2(.) = \pi(.)$ and suppose access must be granted on demand with a nondiscriminatory charge $\hat{a}$. If the access charge is fixed at $\hat{a} = I/2$, then there exists an equilibrium where the incumbent demands access if and only $\theta \geq \hat{\theta}$, where $\hat{\theta}$ is the unique solution of $\pi(\theta) = I/2$ (or equals θ_L), and where entry occurs if and only if the incumbent demands access. This nondiscrimination policy benefits the entrant and hurts the incumbent, but may jeopardize the financing of the infrastructure since $\hat{\theta} > \theta_D$.

4.3 Moderation of competition

Finally, we explore the possibility of moderation of competition that is, of a monopoly-franchise period followed by open access.

Such a possibility is suggested by the World Bank's experience in helping design and structure concession contracts for railways in various countries. For example, for the international link between Abidjan (Côte d'Ivoire) and Ouagadougou (Burkina Faso), a fifteen year concession was set up with a seven year period of exclusivity followed by a period of open access to another operator, after approval by the regulator, for an access fee that was agreed upon at the initial stage (see Campos-Cantos [1999]). Neglecting the (irrelevant) feature that the exclusivity period comes first, this market design can be viewed as a compromise between the two regimes that have been discussed previously, that is a mix between an open access policy and an exclusive franchise policy.

A similar mixed market structure could alternatively be obtained by reserving some rail trackage rights for the exclusive use of an incumbent operator while opening other rights to open access. In Argentina and Brazil, rail concessions have been set up that grant the operator an exclusive right except on certain track segments that are subject to open access.

Technically, our analysis so far has focused on deterministic policies, and we now generalize it to random policies, where the randomness can without loss of generality be interpreted as a temporal switch in the franchising regime.[17]

In a stochastic mechanism, the market structure is determined, conditionally on the infrastructure being built, according to a pre-specified probabilistic decision rule where $x(\tilde{\theta})$ is the probability that a monopoly franchise be granted when the incumbent announces market profitability $\tilde{\theta}$ (and $1 - x(\tilde{\theta})$ the probability that open access obtains).[18] The basic conclusion of Lemma 2 extends to stochastic regulatory policies. Condition-

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[17] If T is the length of the monopoly franchise and r the rate of interest, then $x = \left(1 - e^{-rT}\right)$ and $1 - x = e^{-rT}$ are the probabilities in the equivalent stochastic mechanism.

[18] Actually, a fully stochastic mechanism would also imply some randomization about the decision to build the infrastructure or not. We do not consider this possibility.

ally on building the infrastructure, the incumbent's expected utility as a function of his expected access charge $a_I(\tilde{\theta})$, his announcement $\tilde{\theta}$ and of the true market profitability θ is:

$$U(\tilde{\theta}, \theta) = [\pi_M(\theta) - \pi_1(\theta)] x(\tilde{\theta}) + \pi_1(\theta) - a_I(\tilde{\theta}).$$

Standard techniques show that $x(.)$ must be nondecreasing. Thus, the share of access rights reserved for the exclusive use of the incumbent, or the time duration of the exclusive franchise, must increase when market profitability improves. The tension between efficiency and incentive compatibility carries over to stochastic schemes.

As a consequence, there may be a first natural way to try to improve on the optimal deterministic regulatory policy characterized in Proposition 4, namely to propose an open access policy with moderation of competition, corresponding to a mechanism with a constant probability $x \in [0, 1]$ on some interval $[\theta_*, \theta_H]$ where the project is realized. The optimal policy in this class must trade off the social desirability of introducing as much competition as possible with the financial viability constraint that requires to take into account that the sum of the maximal access fee that can be demanded from the incumbent, namely $\{x\pi_M(\theta_*) + (1 - x)\pi_1(\theta_*)\}$, and of the maximal entry fee that can be imposed on the entrant, namely $(1 - x)\mathbb{E}[\pi_2(z) \mid z \geq \theta_*]$, must cover the investment cost; that is, it solves the following program:

$$\max_{\{x, \theta_*\}} \int_{\theta_*}^{\theta_H} [xW_M(\theta) + (1 - x)W_D(\theta)] \, dF(\theta)$$
$$\text{s.t.} \quad : \quad x\pi_M(\theta_*) + (1 - x)a_D(\theta_*) \geq I.$$

While Proposition 4 compares the polar cases $x = 0$ and $x = 1$, the Appendix shows that the solution of this program may be interior, with $x_* \in (0, 1)$. Proposition 5 summarizes the analysis (see the Appendix for further developments). Part (i) refers to arbitrary stochastic mechanisms, while part (ii) uses constant probability mechanisms.

Proposition 5 *: (i) Any stochastic incentive compatible mechanism is characterized by a threshold level θ_* and a nondecreasing probability of granting exclusivity rights $x(.)$ such that:*

- *if $\theta \in [\theta_L, \theta_*)$, the infrastructure is not built;*

- *if $\theta \in (\theta_*, \theta_H]$, the infrastructure is built and operated under a monopoly franchise with probability $x(\theta)$ and under open access with probability $1 - x(\theta)$.*

(ii) In certain environments, it is possible to improve upon an indefinite monopoly franchise or an indefinite open access policy through the use of moderation of competition.

The general message is clear: eliciting information from the incumbent is of little help in designing the optimal market structure and the optimal degree of competition. We return to deterministic mechanisms in the rest of the paper. The insights derived in this section would apply to the next sections as well.

5 Overall budget constraint and cross-subsidies among investment projects

We have assumed that the regulator is instructed to fully fund the investment cost *of any given project*. This section shows that the result that incomplete information drastically impacts the downstream market design is robust to different formalizations of the regulatory mandate. Ex post budget balance, defined on a project by project basis, is a strong and restrictive rule. While in the railroad industry this mandate applies to RFF in France, and to a certain extent in Germany, we must consider alternative regulatory mandates and their impact on downstream market design under incomplete information.

This section assumes that the regulator must cover the costs of its investments *on average* over its various investment projects. Thus the regulator is allowed to subsidize

some projects as long as the shortfall is covered by surpluses on other projects. There is a large number (technically a continuum of mass one) of projects, indexed by $\theta \in [\theta_L, \theta_H]$, where θ characterizes the value of an individual project. Each individual project involves investment cost I. The regulator cannot tell the projects apart, and simply knows the distribution of projects, summarized by the c.d.f. $F(.)$. Each project is as described earlier, with an incumbent who knows the parameter θ, and a potential entrant. As earlier, the regulator can select information contingent decision rule $\delta(\theta) \in \{O, M, D\}$ and access charges.

5.1 Same incumbent on all segments: the rotten segments curse and optimal cross-subsidies

When the incumbent operator is the same in all markets, by the law of large number, the incumbent cannot fool the regulator over the aggregate distribution of the demand parameters.[19] The incumbent therefore enjoys no rent. The regulator fixes the relative proportions of the various market structures. Formally, it may specify the fraction of projects m_0 that will be rejected, the fraction of projects m_D that will be implemented under open access and the fraction of projects m_M that will be implemented under a monopoly franchise, with $m_0 + m_D + m_M = 1$.

While the incumbent has no private information about the distribution of projects, he has superior information about each particular project. Given a *total* access charge A over all segments, he selects which investments are made under a monopoly franchise, which are made under open access, and which are let down:

$$\max_{\{\Theta_D \Theta_M\}} \left[\int_{\Theta_D} \pi_1(\theta) dF(\theta) + \int_{\Theta_M} \pi_M(\theta) dF(\theta) - A \right] \tag{7}$$

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[19]This would not be so if the incumbent had private information about the distribution, and not only about the value of individual projects.

s.t.

$$\int_{\Theta_D} dF(\theta) = m_D \quad \text{and} \quad \int_{\Theta_M} dF(\theta) = m_M \ ,$$

where Θ_D is the set of types of projects that the incumbent chooses to have implemented under open access, and Θ_M the set over which he chooses to enjoy operating monopoly. The incumbent chooses the monopoly regime for the most profitable projects, in the limit of a fraction m_M of projects, and then the next profitable projects under open access, in the limit of a fraction m_D of projects; he rejects the remaining, lowest profitability projects. More formally, $\Theta_M = (\theta^+, \theta_H)$, $m_M = 1 - F(\theta^+)$ and $\Theta_D = (\theta_-, \theta^+)$, and $m_D = F(\theta^+) - F(\theta_-)$. The choice of (m_D, m_M) is then equivalent for the regulator to the choice of two threshold levels as in previous sections and incentive compatibility has the same implications as earlier: high profitability projects are built under a monopoly franchise while intermediate profitability projects are built under open access. This we call the "rotten segments curse", since the regulator is very constrained in creating competition on the most profitable segments.

The incumbent's access charge can be determined only on a global basis, and leaves the incumbent with no rent:

$$A = \int_{\theta_-}^{\theta^+} \pi_1(\theta) dF(\theta) + \int_{\theta^+}^{\theta_H} \pi_M(\theta) dF(\theta),$$

and so the average budget constraint over all projects takes the simple form:

$$\int_{\theta_-}^{\theta^+} (\pi_1(\theta) + \pi_2(\theta) - I) \, dF(\theta) + \int_{\theta^+}^{\theta_H} (\pi_M(\theta) - I) dF(\theta) \geq 0. \tag{8}$$

The regulator maximizes (average) social welfare,

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$$\int_{\theta_-}^{\theta^+} W_D(\theta)dF(\theta) + \int_{\theta^+}^{\theta_H} W_M(\theta)dF(\theta)$$

subject to (8).

Note that this program is formally equivalent to the program that would obtain if the regulator did not impose an average budget constraint but could implement transfers from taxpayers to the regulator with a cost of public funds λ. The only difference is that λ would then be a given characteristics of the whole economy, while it is here the endogenous Lagrange multiplier associated with the budget constraint.

Letting λ denote the shadow price of the budget constraint and assuming interior solutions, the first-order necessary conditions are:

$$W_D(\theta_-) = \lambda[I - \pi_1(\theta_-) - \pi_2(\theta_-)], \tag{9}$$

and

$$W_D(\theta^+) - W_M(\theta^+) = \lambda[\pi_M(\theta^+) - \pi_1(\theta^+) - \pi_2(\theta^+)]. \tag{10}$$

The interpretation of these conditions is straightforward. Accepting more projects (reducing θ_-) creates a deficit with shadow cost $\lambda[I - \pi_1(\theta_-) - \pi_2(\theta_-)]$ but generates welfare $W_D(\theta_-)$. And similarly, an expansion of the monopoly region (a reduction of θ^+) generates a budget surplus with shadow value $\lambda[\pi_M(\theta^+) - -\pi_1(\theta^+) - \pi_2(\theta^+)]$, but reduces welfare by $W_D(\theta^+) - W_M(\theta^+)$.

Proposition 6 : *Suppose that the regulator must break even only over its entire network, that the incumbent is the same on all segments, and that the incumbent has information*

about market demand on each segment. Then the most profitable segments are served under a monopoly franchise. The segments under a monopoly franchise cross-subsidize those operated under open access. And some open access investments are made that do not break even on an individual basis.

5.2 Multiple incumbents

Let us now entertain the opposite hypothesis that each segment is initially served by a segment-specific incumbent (so, technically, there is a "continuum of incumbents"). The essential difference with the single-incumbent case is that each incumbent's utility is unknown, so that the incumbents enjoy rents. The analysis on the incumbents' side is identical to that of sections 3 and 4. The new feature relative to these sections is again that the regulator can lose money on some investments and recoup it on others.

Would the regulator want to treat otherwise identical segments differently? Let m_D (respectively, m_M) denote the fraction of segments for which the regulator offers open access (respectively, a monopoly franchise), where, without loss of generality,

$$m_D + m_M = 1.$$

Let $\hat{\theta}_D$ and $\hat{\theta}_M$ denote the lowest types for which the investment is made for a segment designated as an open access (respectively, a monopoly franchise) segment. The access charges on the two types of segments are therefore $\pi_1(\hat{\theta}_D)$ and $\pi_M(\hat{\theta}_M)$.

The regulator's program is

$$\max_{\{\hat{\theta}_M, \hat{\theta}_D\}} \left\{ m_M \int_{\hat{\theta}_M}^{\theta_H} W_M(\theta) dF(\theta) + m_D \int_{\hat{\theta}_D}^{\theta_H} W_D(\theta) dF(\theta) \right\}$$

s.t.

$$m_M \left[1 - F(\hat{\theta}_M) \right] \left[\pi_M(\hat{\theta}_M) - I \right] + m_D \left[1 - F(\hat{\theta}_D) \right] \left[a_D(\hat{\theta}_D) - I \right] \geq 0. \qquad (11)$$

Let us now make:[20]

A.6 $\quad \frac{\dot{\pi}_M(\hat{\theta}_M)}{W_M(\hat{\theta}_M)} \geq \frac{\dot{a}_D(\hat{\theta}_D)}{W_D(\hat{\theta}_D)}$ *whenever* $\hat{\theta}_D \geq \hat{\theta}_M$.

Assumption A.6 is a relatively mild assumption. Noting that $W_M(\hat{\theta}_M) \leq W_D(\hat{\theta}_D)$, then $\dot{\pi}_M(\hat{\theta}_M) \geq \dot{a}_D(\hat{\theta}_D)$ is sufficient for A.6 to hold. Since a_D is closely related to total duopoly profit, this sufficient condition *roughly* means that increases in demand lead to higher increases in profit under monopoly. It is satisfied for example in the standard Hotelling model,[21] or when uncertainty about θ is small and monopoly profit increases faster with demand than duopoly profit (which it does in standard models). The following proposition is demonstrated in the Appendix:

Proposition 7 : *Suppose that the budget constraint is over the entire network, that segments are served by different incumbents who know the demand on their own market, that A.6 holds, and that, in the single-segment context, the two institutions (open access, monopoly franchise) deliver roughly equivalent welfares. Then,*

(i) it is optimal to discriminate among otherwise identical segments and to operate some under open access and others under a monopoly franchise;

(ii) the monopoly segments cross-subsidize open access ones $(\pi_M(\hat{\theta}_M) - I > 0 > a_D(\hat{\theta}_D) - I)$.

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[20]Assumption A.6 is essentially an assumption about the shape of the distribution function $F(.)$ and the rate of increase of π_2. It is easy to see that:

$$\dot{a}_D(\theta) = \dot{\pi}_1(\theta) + \frac{f(\theta)}{1 - F(\theta)} \cdot \int_\theta^{\theta_H} \frac{[1 - F(s)]}{[1 - F(\theta)]} \dot{\pi}_2(s) ds.$$

So, A.6 is satisfied if both π_2 and the hazard rate are relatively insensitive to variations in θ.

[21]Let θ denote the uniform mass of consumers along the interval $[0, 1]$ and let there be two products at the two extremes of the segment. Assuming the market is covered and letting v, t and c denote consumer valuation, transportation cost and marginal cost, $\pi_M(\theta) = \theta \left(v - \frac{t}{2} - c \right)$ and $a_D(\theta) = \frac{\theta t}{2} + \frac{\theta + \theta_H}{2} \frac{t}{2}$. Since $v - \frac{t}{2} - c > t > \frac{3t}{4}$, the assumption is satisfied.

6 Dynamics

Let us now extend the basic model in yet another direction, that of repeated licensing. We consider the single-project context in a two-period setup $(t = 1, 2)$ and assume that the relationship between regulator and the operator(s) is run by short-term licenses; we will analyze the potential gains from long-term contracting. We also assume that the project must break even each period.

Two issues are worth of study. First, the incumbent's realization that his current acceptance impacts the regulator's beliefs about demand[22] and therefore the latter's future policy may lead him to modify his strategy. This ratchet effect has been analyzed extensively,[23] but its implications for the particular context at hand haven't been derived. Second, current entry may allow future "benchmarking" by allowing another operator to acquire information about market demand.

6.1 Ratcheting

To separate the two issues, let us first assume that if there is entry at date 1, the entrant doesn't learn demand before date 2.[24] So, even in case of open access at date 1, the incumbent still has an informational advantage at the beginning of date 2, and so entry does not bring about any benchmarking benefit.

In this setup, it is well-known[25] that the optimal long-term contract is the repetition of the optimal static contract, here described in proposition 4. This implies that if the incumbent finds it optimal not to strategically alter its behavior when facing a short-term

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[22]We maintain our assumption that the regulator does not observe profits. Were the regulator to regulate the incumbent's profit on this segment (which, recall, may not be an easy task due to potential cross-subsidies with the incumbent's other activities), the incumbent would further have an incentive for underprovision of effort at date 1 or for delaying income recognition (either through accounting methods or by investing in customer lock in) in order to signal a low demand on this particular segment.

[23]See, e.g., Freixas et al (1985) and Laffont-Tirole (1988).

[24]This obviously is a very strong assumption. On the other hand, it is reasonable to assume that the entrant's informational handicap does not vanish instantaneously after entry. This can be justified either by the presence of noise or by delays in income recognition.

[25]See, e.g., Baron-Besanko (1984) and Caillaud et al (1988).

contract of open access or monopoly franchise, then the lack of commitment imposes no cost. Let us recall that under assumption A.5, $\theta_M \leq \theta_D$ and consider the two cases envisioned in proposition 4:

(a) *Monopoly franchise is optimal in the static context.*

Suppose the regulator offers the optimal static contract at date 1, that is, proposes a short-term monopoly franchise at fee $a_M = \pi_M(\theta_M) = I$ to the incumbent. We claim that the dynamic perspective does not alter the incumbent's behavior, and that the regulator offers at date 2 to renew the monopoly franchise at the same fee a_M.[26] From a myopic viewpoint, the incumbent should accept the franchise if and only if $\theta \geq \theta_M$. Then, the regulator's posterior beliefs when the incumbent has accepted the franchise is the truncated distribution $f(\theta) / [1 - F(\theta_M)]$ on $[\theta_M, \theta_H]$. The regulator therefore offers the same monopoly franchise at date 2. And since the second-period fee must be at least equal to I, the incumbent will never be able to get better conditions in period 2.

We therefore conclude that monopoly franchising is immune to the ratchet effect. We now show that the same is not true for open access.

(b) *Open access is optimal in the static context.*

Suppose that at date 1 the regulator offers open access at access charge $a_1 = \pi_1(\theta_D)$ to the incumbent, and that, if the incumbent accepts, the regulator offers the same open-access-at-access-charge a_1 license at date 2. The hypothesized property that the open access policy is immune to the ratchet effect means that the incumbent accepts the duopoly franchise at date 1 if and only if $\theta = \theta_D$. Note in particular that type $\theta = \theta_D$ obtains no rent in either period.

Suppose now that the incumbent refuses the franchise at date 1. Then the regulator learns that $\theta < \theta_D$, and therefore offers the monopoly franchise at fee $a_M = \pi_M(\theta_M)$ at date 2, resulting in particular in a rent $\delta [\pi_M(\theta_D) - \pi_M(\theta_M)] > 0$ for type θ_D, where δ is the discount factor.

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[26]Provided the incumbent has accepted the monopoly franchise at date 1. Otherwise, the regulator learns that $\theta < \theta_M$ and therefore offers no contract at date 2 (or could, alternatively and without modification, offer the monopoly franchise at fee a_M).

We therefore conclude that the incumbent may have an incentive to convince the regulator that the demand forecast was too optimistic and that this market is a natural monopoly. The open access policy is not immune to the ratchet effect.

To analyze equilibrium behavior when open access is offered at date 1, let us assume that the discount factor is not large:

A.7 : $\qquad \dot{\pi}_1(\theta) > \delta \dot{\pi}_M(\theta) \quad$ for all $\quad \theta.$

Assumption A.7 means that discounting is large enough that as demand grows an open access license today matters more and more to the incumbent relative to a monopoly franchise tomorrow.

Suppose that at date 1 the regulator offers open access at access charges a_1 and a_2 for the incumbent and the entrant. Assumption A.7 implies that in equilibrium, the incumbent accepts the open access license if and only if $\theta \geq \widehat{\theta}$ for some $\widehat{\theta}$ to be determined. The open access financing condition therefore becomes:

$$a_1 + \mathbb{E}\left[\pi_2(\theta) \mid \theta \geq \widehat{\theta}\right] \geq I. \tag{12}$$

Because accepting the license signals high realizations of demand and therefore can only reduce the incumbent's date-2 welfare, necessarily

$$a_1 \leq \pi_1(\widehat{\theta}),$$

and so

$$\widehat{\theta} \geq \theta_D.$$

To simplify the analysis without loss of insights, let us assume that (6) is satisfied with equality, so a monopoly franchise and open access are equivalent in the single-project static context. Then a rejection of the open access license induces a monopoly franchise offer (at fee a_M) at date 2, while an acceptance leads to a new open source license at fee $\pi_1(\widehat{\theta})$ for the incumbent, implying that type $\widehat{\theta}$ does not obtain any second-period rent.[27] Therefore

$$\pi_1(\widehat{\theta}) - a_1 = \delta \left[\pi_M(\widehat{\theta}) - \pi_M(\theta_M) \right]. \tag{13}$$

The break-even condition under open access therefore becomes more stringent as δ grows:

$$a_1 + \mathbb{E}\left[\pi_2(\theta) \mid \pi_1(\theta) - \delta\left[\pi_M(\theta) - \pi_M(\theta_M)\right] \geq a_1\right] = I. \tag{14}$$

As the discount factor grows, the open-access cutoff $\widehat{\theta}$ increases. This reduces welfare at date 1 (lack of production on $[\theta_D, \widehat{\theta})$) and at date 2 (lack of competition on the same interval).

We can summarize our analysis in

Proposition 8 : *(i) The monopoly franchise is immune to the ratchet effect (ii) In contrast, an absence of long-term commitment makes the open access policy less attractive, as the incumbent attempts to signal a low profitability of the segment. Under assumption A.7, the incumbent accepts the open access license if and only if $\theta \geq \widehat{\theta}$, where $\widehat{\theta} > \theta_D$ increases with the discount factor.*

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[27] After acceptance by the incumbent, the regulator has in fact some discretion in the choice of access fees for the incumbent and the entrant, since $\widehat{\theta} > \theta_D$ implies that $a_D(\widehat{\theta}) > I$. We assume the regulator chooses the largest access charge that is acceptable by the incumbent in period 2.

6.2   Future benchmarking benefits of open access

Section 6.1 showed that, in the absence of benchmarking benefit, repeated interaction strengthens the case for a monopoly franchise. We investigate whether this conclusion is affected by the introduction of benchmarking benefits. Let us therefore entertain the polar assumption that in case of date 1 competition the entrant learns the state of demand at the end of date 1. The regulator can then fully extract rents at date 2.[28]   Maintaining assumption A.7, we see that the incumbent accepts the open access license if and only if $\theta \geq \widehat{\theta}$, where $\widehat{\theta}$ is still given by (13). The analysis of section 6.1 therefore remains valid.

Proposition 9 *: In the single-project context, proposition 8 still holds when the entrant learns the state of demand perfectly at date 1: There is no benchmarking benefit of open access.*

Proposition 9 hinges on our assumption that the regulator attaches no intrinsic value to extracting the incumbent's rent. It does not carry over to the case of multiple projects, multiple incumbents and a network-wide budget constraint (see section 5.2). Then, extracting the rent created by favorable realizations of demand generates a budget surplus which can be used fruitfully to cross-subsidize other projects. Open access may then become more, rather than less, attractive in a dynamic context.

7   Capture and the open access presumption

We have assumed non-cooperative behavior from all actors, in particular that the regulator does not collude with the operators. Let us now relax this assumption. As argued in Laffont-Tirole (1991), regulatory capture is associated with private information and the

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[28]This results from Maskin (1999). The benefits of benchmarking in a regulatory context have been studied by Caillaud (1990) and Shleifer (1985).

existence of potential rents. This implies here that regulatory capture, if it occurs, is capture by the incumbent. The interesting question is whether the concern about regulatory capture favors open access or monopoly franchising.

Suppose the regulator is only concerned about its self-financing mandate and that there is some uncertainty about the benefits of competition. The regulator may have some information about these benefits, on which it would be socially valuable to base the market design decision. The incumbent may however prefer this information not to be disclosed if it is detrimental to him, hence the possibility of capture and the necessity to curb it. More specifically, suppose there are two states of nature: in state $\omega = D$, which occurs with probability α, welfare under competition is higher than in the other state $\omega = d$: $W_D(\theta) \geq W_d(\theta)$ for all θ.

The state of nature could be due to uncertainty about the intensity of competition in duopoly (how likely it is that the firms will engage in tacit collusion) or about the entrant's entry cost (which could be the same as the incumbent's, except that the latter is already sunk). Let us follow this second interpretation so that the state of nature does not affect the incumbent's profits (under either regime); for the entrant, $\pi_{2D}(\theta) > \pi_{2d}(\theta)$ for all θ, the difference being equal to the difference in sunk costs. Following Proposition 4, let θ_D and θ_E be the optimal cut-off points when there is evidence that $\omega = D$ and when there is no evidence on ω:

$$\pi_1(\theta_D) + \mathbb{E}\left[\pi_{2D}(y) \mid y \geq \theta_D\right] = I$$

$$\pi_1(\theta_E) + \mathbb{E}\left[\alpha\pi_{2D}(y) + (1 - \alpha)\pi_{2d}(y) \mid y \geq \theta_E\right] = I.$$

It follows that $\theta_D < \theta_E$ and correspondingly, the incumbent's access charge under com-

petition satisfies:

$$a_{1D} \equiv \pi_1(\theta_D) < a_{1E} \equiv \pi_1(\theta_E).$$

Finally, let us also assume that Assumption A5 still holds so that $\theta_M < \theta_D$.

With probability ξ, the regulator has perfect information about the increase in consumer surplus brought about by competition. When the regulator has such information, this information is hard (may be disclosed), and it is shared by the incumbent. The entrant, however, is never informed about the state of nature. To make things interesting, let us assume that open access is optimal (when the signal is common knowledge, that is in the sense of proposition 4) in state D, while a monopoly franchise is optimal in state d.

Suppose, first, that in the absence of signal and when there is no threat of collusion, a duopoly franchise is optimal. Then capture is not an issue: Open access will prevail unless the regulator offers evidence that $\omega = d$, in which case a monopoly franchise is granted to the incumbent.[29] Because the default option in the absence of disclosure is open access, the incumbent has no incentive to capture the regulator.

The interesting case is then when absent any signal society would prefer a monopoly franchise. Intuitively, the incumbent is then eager to capture the regulator in case of a pro-competitive signal (D), since the regulator is indifferent between disclosing or hiding the signal D provided the project is fully funded, while the incumbent's informational rent is larger when the signal D is not disclosed. The incumbent's gain from hiding the signal D is given by:

$$\Delta(\theta) = [\pi_M(\theta) - \pi_M(\theta_M)] - \sup\{\pi_1(\theta) - \pi_1(\theta_D); 0\} > 0.$$

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[29] More precisely, the default option is open access with access charges a_{1E} and $a_{2E} = I - a_{1E}$. If evidence is provided that $\omega = D$, then open access still prevails, but with access charges a_{1D} and $a_{2D} = I - a_{1D}$.

Thus, the policy that is optimal under a public signal always induces monopoly franchising when the benefits of competition is private knowledge.

To prevent capture, two options are open.[30] First, and least realistically, the regulator may be rewarded for creating open access by making a convincing case for it (revealing D). The policy that can be implemented then coincides with the optimal policy with public signal, but welfare is reduced by an additional cost of $\xi\alpha\Delta(\theta_H)$ (in expected terms), that corresponds to the regulator's reward.[31] The regime is then not affected by the threat of capture.[32]

Second, one may eliminate the stake in collusion by giving the benefit of the doubt to competition. That is, the regulator is required to offer open access unless he makes a convincing case in favor of monopoly.[33] (or in favor of open access with access charges a_{iD}). In technical terms, open access prevails in the absence of signal (even though a monopoly franchise is then optimal in the absence of potential capture), and a monopoly franchise is granted only when the regulator reveals evidence that $\omega = d$. There is no scope for collusion anymore, but expected welfare is reduced, compared to the case of public signal, by the fact that monopoly franchise is chosen when the regulator does not get information, while open access would be preferable.

If ξ approaches 1, however, this social cost vanishes since it is unlikely that the regulator does not get information about ω. On the other hand, capture involves a non-negligeable social cost since a monopoly franchise is decided in all occurrences where the regulator has evidence that open access would be optimal (with probability $\xi\alpha$). Simi-

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[30] In this intuitive argument, we restrict attention to capture-proof policies that is, to policies that prevent collusion for sure. But the insight holds more generally.

[31] One can formulate alternative assumptions as to whether this cost enters the budget constraint. Because this case is not the focus of the section, we will not expand on this further.

[32] Note that preventing collusion with probability one, that is for all realizations of θ, might be excessively costly, depending upon the form of the welfare and profit functions. It might be socially preferable to adopt a policy that allows collusion to develop when it is too costly to fight. For instance, fixing a level of reward s for the infrastructure owner such that $\Delta(\hat{\theta}) = s$ will deter collusion except for $\theta > \hat{\theta}$, in which case an exclusive franchise will be recommended by the infrastructure owner while open access would be preferable.

[33] Again, the default option is open access with access charges a_{iE}, and if evidence is provided that $\omega = D$, access charges are a_{iD}.

larly, the social cost of rewarding the regulator is non-negligeable (proportional to $\xi\alpha$). We summarize this discussion in the following proposition.

Proposition 10 : *When the possibility of capture is a concern and the regulator is likely to be informed about consumer benefits (that is when ξ is large enough), the optimal capture-proof policy is to impose open access whenever no clear evidence is provided in favor of exclusivity.*

Note that, as is often the case when the institutional response to the threat of capture is accounted for, the incumbent is actually hurt by the suspicion that he might attempt to capture the regulator. The general message is that the concern about regulatory capture can only improve the case in favor of no-exclusive-franchise policies.

This conclusion does not depend upon the specific assumption that uncertainty concerns the entrant's fixed cost of entry. Taking the alternative interpretation in terms of intensity of competition would lead us to assume that $\pi_{iD}(\theta) < \pi_{id}(\theta)$ for $i = 1, 2$ and all θ. Assuming that A.5 holds for all ω, the incumbent would still try to prevent disclosure of signal D to benefit from a monopoly franchise. The additional difficulty comes from the fact that it is possible that the incumbent's access fee under the no-exclusive-franchise policy is larger when there is evidence about D than when no evidence is available. In such a case, the incumbent prefers to prevent disclosure of signal D even if the default option is open access, as this enables him to pay a smaller access charge under a duopoly regime. The conclusion of the previous proposition is still valid, namely that market design should be biased toward open access to fight capture, but it may be that capture to manipulate the access charges has to be deterred through additional instruments.

8 Further extensions

8.1 Transfer of the monopoly franchise

So far, we have ruled out the possibility that the regulator removes the incumbent and grants a monopoly franchise to the entrant. This section extends the model to deal with the possibility of franchise transfer.

To analyze the possibility of replacing the incumbent, consider the setting of Sections 3 and 4, with ex post budget balance. Let $\pi_E(\theta)$ denote the entrants profit as a newly franchised monopoly, and $W_E(\theta)$ the corresponding social welfare. To fix ideas, suppose that the incumbent has some special know-how or experience, or that the transfer of the franchise involves transaction/moral hazard costs, or else that consumer brand recognition is lost in the process of transferring the license, so that first-best efficiency as well as monopoly profits are higher when the incumbent, rather than the entrant, is the franchised monopoly. Formally, for all θ,

$$\pi_1(\theta) + \pi_2(\theta) < \pi_E(\theta) < \pi_M(\theta)$$

$$W_E(\theta) < W_M(\theta) < W_D(\theta).$$

We naturally assume that: $\dot{\pi}_E(\theta) > 0$. The model of sections 3 and 4 can be viewed as a special case of this more general model, in which $W_E(\theta)$ is negative.

The perfect information optimal policy is the same as in Section 3. Open access is optimal provided it allows self financing $(\theta > \theta_D^{SI})$, that is for high value projects. When $\theta < \theta_D^{SI}$, it is socially preferable to let the incumbent, rather than the entrant, be the monopolist because allocating the franchise to the incumbent both yields a higher social welfare and facilitates financing. So, there is no franchise transfer and the incumbent is

never replaced.

Under incomplete information, the incentive analysis is very similar to the one performed in section 4, except that we can now introduce an access fee a_E for the entrant under monopoly and some compensation payment $T \geq 0$ for the incumbent in case of franchise transfer. The incumbent monopolist must now take into account the possibility of transferring the franchise to the entrant, which yields him T. Assuming that the infrastructure is not built for low realizations of demand, necessarily $T = 0$.

The analysis in Section 4 is not modified if the regulator chooses the monopoly franchise, since for all $\theta < \theta_M$, $\pi_E(\theta) < \pi_M(\theta) \leq I$. More generally, however, if the regulator does not give a monopoly franchise to the incumbent, the possibility of granting a franchise to the entrant should be taken into account on some range (θ_E, θ_*) with $a_E = E[\pi_E(\theta) \mid \theta \in (\theta_E, \theta_*)]$ provided this is larger than I. Following the analysis in Section 4, the infrastructure is built and operated under open access for $\theta \in [\theta_*, \theta_H]$. Then, if $\pi_E(\theta_D) > I$, there exists a unique threshold θ_E, such that $\theta_L \leq \theta_E < \theta_D$ and

$$\mathbb{E}[\pi_E(\theta) \mid \theta_E \leq \theta \leq \theta_D] = I. \tag{15}$$

The range of operations can then be extended to $[\theta_E, \theta_H] \supseteq [\theta_D, \theta_H]$ while meeting the budget constraint thanks to the entrant's monopoly profits. But it may be optimal to let $\theta_* > \theta_D$. While this reduces welfare for $\theta \in (\theta_*, \theta_D)$, this policy may allow an extension of operations in the lower end of the distribution of the demand parameter.

The franchise transfer policy is straightforward to understand. It has one important consequence, in terms of policy. It is now possible that an intermediate value project be realized under monopoly franchise, as under perfect information; but then, the franchise should be granted to the entrant, not to the incumbent. The franchise transfer policy has also one important weakness: the regulator must trust the incumbent to cooperate when he exits the market, even though he has no strict incentive to reveal that the infrastructure should be operated under an entrant franchise versus not be built at all. It

would be worth developing a model where the incumbent is not indifferent between these two alternatives (transfer the monopoly franchise or let go the project).

8.2 Profit observability

Our assumption that the profit on the competitive segment is not regulated is fine for some concessions and regulated industries, but not for others. The regulator's ability to observe profit calls for earnings sharing schemes, in which some of the incumbent's profit is passed through to consumers. The extent of passthrough depends on the extent of moral hazard, broadly construed to include both X-inefficiency and cost-padding or more generally cost manipulations. For example, only limited amounts of passthrough are feasible and our analysis extends without modifications if the incumbent can easily transfer income or resources between the regulated segment and the unregulated activities (or segments regulated by other authorities, as in the case of water concessions awarded at the local level).

More generally, the key robustness issue is whether, under profit sharing, the incumbent still finds it relatively more profitable to obtain an exclusive franchise for high demand (or low cost). The "rotten segment curse" might no longer obtain if incentives were designed so as to be high-powered (involve low passthrough) in the open access region and low-powered (involve high passthrough) in the exclusive franchise region. Then, an increase in demand would be more profitable under open access than under an exclusive franchise, reversing assumption A.4 and substantially complicating the analysis. Again, it is feasible to find sufficient conditions for this reversal not to happen and therefore for the analysis of this paper to carry over to profit observability. For example, it suffices that moral hazard be socially very costly (profit sharing leads to a sharp increase in cost); or that uncertainty about θ be low enough; or else, that product market competition under open access be very intensive (close to Bertrand competition), so that $\pi_1(\theta)$ grows slowly with θ and so, offsetting the basic effect embodied in assumption A.4 requires completely

destroying incentives under exclusive franchising.

9   Conclusion

Infrastructure projects are often confronted with large uncertainty about market demand and possibly operating cost. Authorities in principle can attempt at eliciting incumbent firms' information on this aspect by offering a basic open access package combined with an exclusivity option in exchange of a higher investment contribution. Alas, the incumbent firm will demand exclusivity precisely when competition is socially most desirable. Authorities therefore cannot screen incumbents to select among open access, a monopoly franchise, or a moderation of competition.

Building on this basic insight, we showed that with multiple projects, segments operated under a monopoly franchise must cross-subsidize open access segments. We then showed that monopoly franchising is immune to the ratchet effect while open access is not; and that a concern for capture makes open access a more appealing default rule.

Needless to say, this first investigation of endogenous market structure with common values leaves scope for future theoretical inquiry. Furthermore, the implications of the present inquiry in different contexts are definitely worth drawing. As we noted in the introduction, competition authorities in their application of the essential facility doctrine confront a similar financing-vs-competition trade-off and lack of information about market viability as regulators of telecommunications, energy or transportation services. The influence of "ex post intervention" rather than "ex ante regulation" is worth thinking about. Similarly, our analysis could be useful when thinking about more sophisticated patent systems in which innovators would pay a premium for increased protection from competition (increased patent length, patent breadth, or freedom in licensing). These topics and others are left for future research.

References

[1] Armstrong, M., Cowan, S., and J. Vickers (1994) *Regulatory Reform: Economic Analysis and British Experience*, Cambridge: MIT Press.

[2] Auriol, E., and J.J. Laffont (1992) "Regulation by Duopoly," *Journal of Economics and Management Strategy*, 1: 507–533.

[3] Baron, D., and D. Besanko (1984) "Regulation and Information in a Continuing Relationship," *Information Economics and Policy*, 1:447–470.

[4] Caillaud, B. (1990) "Regulation, Competition and Asymmetric Information," *Journal of Economic Theory*, 52: 87–110.

[5] Caillaud, B., Guesnerie, R., Rey, P., and J. Tirole (1988) "Government Intervention in Production: A Review of Recent Contributions," *Rand Journal of Economics*, 19: 1–26.

[6] Campos, J. and P.Cantos, (1999) "Regulating Privatized Rail Transport", Worldbank Policy Research WP 2064.

[7] Dana, J., and K. Spier (1994) "Designing a Private Industry: Government Auctions with Endogenous Market Structure," *Journal of Public Economics*, 53(1): 127–47.

[8] Engel, E., Fischer, R., and A. Galetovic (1997) "Highway Franchising: Pitfalls and Opportunities," *American Economic Review, Papers and Proceedings*, 87: 68–72.

[9] —— (1998) "Least-Present-Value-of-Revenue Auctions and Highway Franchising," mimeo, University of Chile.

[10] Estache, A. (1999), "Privatization and Regulation of Transport Infrastructure in the 1990s", World Bank Policy Research WP 2248.

[11] Freixas, X., Guesnerie, R., and J. Tirole (1985) "Planning under Incomplete Information and the Ratchet Effect," *Review of Economic Studies*, 52: 173–192.

[12] Guesnerie, R., and J.J. Laffont (1984) "A Complete Solution to a Class of Principal-Agent Problems with an Application to the Control of a Self-Managed Firm," *Journal of Public Economics*, 25: 329–369.

[13] Kerf, M., D.Gray, T.Irwin, C.Levesque and R.Taylor (1998) "Concessions for Infrastructure", *World Bank Technical Paper N°399.*

[14] Laffont, J.J., and J.Tirole (1988) "The Dynamics of Incentive Contracts," *Econometrica*, 56: 1153–1175.

[15] —— (1991) "The Politics of Government Decision-Making: A Theory of Regulatory Capture," *Quarterly Journal of Economics*, 106: 1089–127.

[16] —— (1993) *A Theory of Incentives in Procurement and Regulation,* Cambridge: MIT Press.

[17] —— (1999) *Competition in Telecommunications*, Cambridge: MIT Press.

[18] Maskin, E. (1999) "Nash Equilibrium and Welfare Optimality," *Review of Economic Studies*, 66(1): 23–38.

[19] Milgrom, P. (1996) "Procuring Universal Service: Putting Auction Theory to Work," lecture at the Royal Swedish Academy of Sciences, Dec. 9.

[20] Shleifer A. (1985) "A Theory of Yardstick Competition," *Rand Journal of Economics*, 16: 319–327.

A   Appendix 1: Stochastic mechanisms

This appendix offers a technical discussion of the stochastic mechanisms considered in section 4.3.

An incentive compatible mechanism is characterized by $(x(.), \theta_*)$ such that $x(.)$ is non-decreasing. The full description of a mechanism involves access charges: $a_M(.)$ and $a_1(.)$ for the incumbent under respectively exclusivity and open access and $a_2(.)$ for the entrant (under open access, obviously). The integral form of the incentive constraint implies that for all $\theta \geq \theta_*$,

$$x(\theta)a_M(\theta) + (1 - x(\theta))a_1(\theta) = x(\theta)\pi_M(\theta) + (1 - x(\theta))\pi_1(\theta) - \int_{\theta_*}^{\theta} x(t) \left[\dot{\pi}_M(t) - \dot{\pi}_1(t) \right] dt.$$

Budget balance requires:

$$x(\theta)a_M(\theta) + (1 - x(\theta)) \left[a_2(\theta) + a_1(\theta) \right] \geq I.$$

Finally, ex ante acceptability for the entrant requires:

$$\int_{\theta_*}^{\theta_H} (1 - x(\theta)) \left[\pi_2(\theta) - a_2(\theta) \right] dF(\theta) \geq 0.$$

It is clear that only $a_I(\theta) \equiv x(\theta)a_M(\theta) + (1 - x(\theta))a_1(\theta)$ matters. So,

$$\int_{\theta_*}^{\theta_H} \left\{ x(\theta)\pi_M(\theta) + (1 - x(\theta)) \left[\pi_1(\theta) + \pi_2(\theta) \right] - I - \int_{\theta_*}^{\theta} x(t) \left[\dot{\pi}_M(t) - \dot{\pi}_1(t) \right] dt \right\} dF(\theta) \geq 0,$$

and after integration by parts,

$$\int_{\theta_*}^{\theta_H} \left\{ x(\theta) \left[\pi_M(\theta) - \frac{1 - F(\theta)}{f(\theta)} \left[\dot{\pi}_M(\theta) - \dot{\pi}_1(\theta) \right] \right] + (1 - x(\theta)) \left[\pi_1(\theta) + \pi_2(\theta) \right] - I \right\} dF(\theta)$$

$$\equiv \int_{\theta_*}^{\theta_H} \left\{ x(\theta) B_M(\theta) + (1 - x(\theta)) B_D(\theta) \right\} dF(\theta) \geq 0. \quad (16)$$

The program that determines the optimal policy is then:

$$\max_{x(.)} \int_{\theta_*}^{\theta_H} \left\{ x(\theta) W_M(\theta) + (1 - x(\theta)) W_D(\theta) \right\} dF(\theta)$$

s.t.(16) and $x(.)$ non-decreasing.

Letting μ denote the Lagrange multiplier associated to the constraint, the Lagrangian can be written as:

$$\int_{\theta_*}^{\theta_H} \left\{ x(\theta) \left[W_M(\theta) + \mu B_M(\theta) \right] + (1 - x(\theta) \left[W_D(\theta) + \mu B_D(\theta) \right] \right\} dF(\theta).$$

The unconstrained optimization of this Lagrangian would deliver a bang-bang solution in terms of x, that is $x(\theta)$ would be either equal to 0 or 1. Optimizing with the monotonicity constraint, however, imposes $\dot{x} \geq 0$. If the solution is such that on an open set $\dot{x} > 0$, then this solution should locally be the same as the solution to the unconstrained program, which can never be strictly upward sloping.

Consequently, we obtain the following claim:

Claim 11 : *The optimal stochastic policy $x(.)$ is a step (increasing) function, with bunching on subintervals of $[\theta_*, \theta_H]$.*

That is, eliciting information from the incumbent is of little help in designing the optimal policy. The complete derivation of the solution follows standard optimal control methods (see e.g. Guesnerie-Laffont [1984]).

Let us finally turn to the specific program in the text with a constant x. The limit values for x determine the value of the corresponding θ_*, namely: $x = 0$ implies $\theta_* = \theta_D$ while $x = 1$ implies $\theta_* = \theta_M$. The constraint shows that x and θ_* are linked so that:

$$\frac{d\theta_*}{dx} \bigg|_{x=0} = -\frac{\pi_M(\theta_D) - I}{\dot{a}_D(\theta_D)} < 0,$$

$$\frac{d\theta_*}{dx} \bigg|_{x=1} = -\frac{I - a_D(\theta_M)}{\dot{\pi}_M(\theta_M)} < 0.$$

The total derivative of social objectives w.r.t. x taking the constraint into account, is given at $x = 0$ by:

$$-\int_{\theta_D}^{\theta_H} [W_D(\theta) - W_M(\theta)]\, dF(\theta) + W_D(\theta_D)f(\theta_D)\frac{\pi_M(\theta_D) - I}{\dot{a}_D(\theta_D)}.$$

The first term is negative; the second term is positive and proportional to $f(\theta_D)$. If we let the density $f(.)$ increase on a left neighborhood of θ_D, the positive effect of expanding the range of implemented projects dominates the cost of granting a monopoly franchise with some probability on all inframarginal projects. So, $x > 0$ at the optimum.

Similarly, the total derivative of social objectives w.r.t. x at $x = 1$ is given by:

$$-\int_{\theta_M}^{\theta_H} [W_D(\theta) - W_M(\theta)]\, dF(\theta) + W_M(\theta_M)f(\theta_M)\frac{I - a_D(\theta_M)}{\dot{\pi}_M(\theta_M)},$$

which can be made negative by letting the density $f(.)$ be small enough in a right neighborhood of θ_M. So, $x < 1$ at the optimum.

Item ii) of the proposition follows.

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B   Appendix 2: Proof of Proposition 7

Letting λ denote the shadow price of the network-wide budget constraint, the derivatives of the Lagrangian L with respect to $\hat{\theta}_M$ and $\hat{\theta}_D$ are:

$$\frac{\partial L}{\partial \hat{\theta}_M} = m_M f(\hat{\theta}_M) \left[-W_M(\hat{\theta}_M) + \lambda \left[\frac{1 - F(\hat{\theta}_M)}{f(\hat{\theta}_M)} \right] \dot{\pi}_M(\hat{\theta}_M) + \lambda \left[I - \pi_M(\hat{\theta}_M) \right] \right]$$

and

$$\frac{\partial L}{\partial \hat{\theta}_D} = m_D f(\hat{\theta}_D) \left[-W_D(\hat{\theta}_D) + \lambda \left[\frac{1 - F(\hat{\theta}_D)}{f(\hat{\theta}_D)} \right] \dot{a}_D(\hat{\theta}_D) + \lambda \left[I - a_D(\hat{\theta}_D) \right] \right].$$

Note that the sign of these derivatives does not depend directly on the proportion of segments that are assigned to either regime.

We now show that, under assumption A.6, open access segments are subsidized by the monopoly segments. Suppose to the contrary that

$$a_D(\hat{\theta}_D) - I \geq 0 \geq \pi_M(\hat{\theta}_M) - I$$

(from (11), these net contributions to the network's budget must have opposite signs). Then from A.5, $\hat{\theta}_D > \hat{\theta}_M$. The monotone hazard rate assumption implies that

$$\frac{1 - F(\hat{\theta}_D)}{f(\hat{\theta}_D)} < \frac{1 - F(\hat{\theta}_M)}{f(\hat{\theta}_M)}.$$

Assumption A.6, together with $\hat{\theta}_D > \hat{\theta}_M$, then implies that $\partial L/\partial \hat{\theta}_M = 0$ and $\partial L/\partial \hat{\theta}_D =$

0 are inconsistent.

Last, let us show that it may be optimal to treat otherwise identical segments differently. To this purpose, consider first the special case in which open access and monopoly franchise are equivalent in the single-segment context (that is, (6) is satisfied with equality). Then social welfare is insensitive to the number of segments operated under open access as long as $\hat{\theta}_M = \theta_M$ and $\hat{\theta}_D = \theta_D$ (recall that $a_D(\theta_D) - I = 0 = \pi_M(\theta_M) - I$). From the previous reasoning, welfare can be strictly improved by lowering $\hat{\theta}_D$ below θ_D and increasing $\hat{\theta}_M$ above θ_M. By continuity, the same holds when (6) is close to be satisfied with equality.