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Incomplete Regulation, Competition and Entry in Increasing Returns to Scale Industries

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Abstract

The paper analyzes the effects of liberalization in increasing returns to scale industries. It studies the optimal regulation of an incumbent competing with an unregulated strategic competitor, when public funds are costly. The model shows a trade off between productive and allocative efficiency. Moreover, the welfare gains of liberalization, as compared with regulated monopoly, are a non monotonic function of the cost of public funds. Finally, in the case of severe cash constraint of the government, incomplete regulation may also dominate full regulation of duopoly.
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1 Introduction

Over the last 25 years many regulated markets have been reformed, both in developed and developing countries. Technological changes and the growing dissatisfaction with the performance of regulated monopolies led to the introduction of pro-competitive reforms. We refer to this process of market opening as to *liberalization*[1] and, in this context, the present paper studies the optimal regulation of an incumbent exposed to unregulated competition. This is particularly relevant in the contexts of regional integration such as the European Union, where the EC legislation prescribes progressive opening to competition of formerly regulated monopolies. Similarly, other regions promote market integration in regulated markets (examples are the experiences of energy market integration in Latin America, East-Asia, West and South Africa). An important feature of these markets is that, due to residual increasing returns to scale and incumbency advantage, they tend to remain concentrated and the national leaders stay dominant. For this reason, regulation is needed even after liberalization. Often this regulation is *incomplete* (or *asymmetric*): the regulator directly influences the operations of the incumbent, while competitors are less regulated (or unregulated). This can arise for many reasons. In many cases the incumbent is subject to additional requirements to correct for the consequences of market power (this is common in both electricity and telecommunication markets) or because it is the universal service provider (universal service obligations are usually contracted with incumbent firms on a long term basis). In addition, incomplete regulation may emerge because regulators are not able to extend an effective regulatory control on large multinational firms (especially in developing countries). Finally, incomplete market regulation may depend on the fact that regulated firms are exposed to competition from unregulated producers adopting alternative technologies. For instance, trains and trucks compete in freight transportation and the truck industry is usually unregulated while railways are heavily regulated. Similarly, high speed railways compete on some routes with airlines (which are subject to lighter regulation). In telecommunications, the heavily regulated fixed lines operators are increasingly exposed to competition from mobiles and internet services.

Several empirical studies have tried to measure the impact of increasing competition in regulated markets. Most of them agree that an increase in competition induces an increase in efficiency (see for instance the cross-country analysis of Boylaud and Nicoletti, 2000 for telecommunications, Pollit, 1995 for electricity, and the studies of Wilson, 1997 and Pollit and Smith, 2001 for railways in the US and UK respectively). The impact of competition on prices is by far less clear. The results are mixed and debated. Hausman, Leonard, and Sidak (2002) analyzing the entry of the Bell Companies in the US long distance telecommunication market, find that increased competition has been associated with a decrease of the per minute price but an increase in the monthly fee (with the net effect of reducing the annual bill of the average consumer). In the case of electricity, the empirical evidence does not support the idea the liberalization is associated with decreasing prices. There are some positive results (Steiner, 2001) and many negative (Green and Newbery in Helm and Jenkinson, 1998, Domah and Pollit, 2001, Zhang, Parker, and Kirkpatrick, 2002, Hattori and Tsutsui, 2003). Summarizing, pro competitive reforms increase efficiency but do not necessary translate into lower prices. The broad welfare consequences of these reforms are easy to understand.

[1] In contrast, the reforms involving a change of ownership are referred to as *privatization*. The question of ownership, which has been widely studied in the literature, is not explicitly considered here. For surveys of the theoretical and empirical contributions on the topic, see for instance Shleifer (1998) and Meggison and Netter (2001).

In what follows we study the effects of liberalization in an incomplete regulation framework. The regulator controls the production of the regulated firm and sets a regulatory instrument (tax or transfer), but public funds are costly. In this context, the shadow cost of public funds plays an important role, because it is related to the weight put on the incumbent's profit in the social welfare function. Indeed, the chosen modeling strategy is a way to capture in a reduced form the idea that the operating profits of the regulated incumbent are socially valuable, because they help to reduce distortive taxation.[2] Consistent with the empirical evidence, we find that the introduction of competition does not always decrease prices. More precisely, we identify a trade off between productive and allocative efficiency. When asymmetric information is added to the picture, the presence of an unregulated competitor has an additional value because it helps to reduce the information rent captured by the regulated firm: we explore this possibility introducing yardstick competition. The theoretical benefits of yardstick competition have been analyzed in the literature starting with the work of Shleifer (1985). In recent years, regulators have started applying several form of benchmarking, inspired by this theoretical literature. For instance, yardstick competition have been applied to hospital regulation in many countries, following the example of the American Medicare system. Moreover, yardstick competition has been used for regulating buses in Norway and water utilities in the UK. Our model shows how the presence of unregulated competitors may help to regulate regulated producers. Although this has not received a lot of attention, some evidence of this possibility has been documented empirically in Bhaskar, Gupta, and Khan (2006), analyzing the yardstick effect of partial privatization of the Bangladesh jute sector.

Introducing yardstick competition in an incomplete regulation framework, we show a non-monotonic relationship between the welfare gains of liberalization and the cost of public funds. We also show that these welfare gains are robust and do not depend crucially on the chosen market structure. In particular, under asymmetric information, partial regulation may dominate full regulation of duopoly. This occurs in case of severe cash constraint of the government.

1.1 Relationship with the literature

The virtues of the two pure models of monopoly regulation and perfect competition are well understood. However, the conditions under which regulated supply is preferable to unregulated competition in concentrated markets are less clear (see Armstrong and Sappington, 2006). In particular, as Armstrong and Sappington (2005) observe, *unfettered competition can complicate regulatory policy by undermining preferred pricing structures* (i.e. taxation by regulation). The public finance aspect of deregulation is analyzed in Auriol and Picard (2007), who compare full regulation of monopoly to full privatization (which is equivalent to *laissez-faire* in their context). They show how the public budget conditions of countries can influence the optimal privatization policy. Our paper shows that the fiscal aspect of monopoly regulation matters not only when considering privatization, but also liberalization. Other works have introduced competition in regulated markets, often adapting the classical regulation model of Baron and Myerson (1982). One possible approach is to assume that the entire industry is regulated, like

[2]For simplicity, you can think of the revenue of a public or mixed incumbent. However model is also consistent with the imposition of taxes on the rents made by private firms. Indeed, incumbents are often vertically and/or horizontally integrated with firms operating in non-competitive segments and their operating profits may help to cross subsidize non-competitive activities (e.g. infrastructure investment and universal service obligations). A reduction of the incumbent's profit may thus undermine taxation by regulation. More in general, governments can can tax more easily domestic firms than foreign ones. Rents extraction does not apply to the same extent to domestic and foreign firms because the latter do not report most of their profits locally.

in the duopoly model of Auriol and Laffont (1993). Closer to the kind of situation we have in mind (regulated firm *vs* unregulated competitors), Laffont and Tirole (1993) look at the case of a multi-product regulated monopoly exposed to a competitive fringe. They show that, when competition is responsible for an increase in variety, the optimal pricing rule can be higher than the monopoly Ramsey benchmark.[3] De Fraja (1997) extends the analysis to the case in which the unregulated competitor has an (unknown) entry cost, with similar results on this point. Caillaud (1990) considers competition between a dominant regulated firm and an unregulated fringe under asymmetric information and cost correlation. He shows that competition has a positive effect on overall efficiency and helps to reduce the rent of the regulated firm. However, the welfare maximizing behavior of the regulator produces a non-standard optimization problem, which admits a complete characterization only in the limiting cases of perfect correlation and full independence of marginal costs.[4] In the present paper, we introduce yardstick competition, using a stochastic structure inspired by Auriol and Laffont (1993). This allows to study in a tractable way the impact of an unregulated competition on prices and welfare in the realistic case of partial cost correlation.

Most of existing literature considers a non-strategic competitive fringe. However, this assumption does not fit particularly well oligopolistic industries. One noticeable exception is the work of Biglaiser and Ma (1995), who build a model of horizontal and vertical differentiation, in which consumers have an exogenous preference for the variety produced by the monopolist. They find that competition helps to extract the rent of the regulated firm, but allocative inefficiency arises in equilibrium. In the present paper, we consider both the impact of competition on productive and allocative efficiency, when firms have asymmetric information about their production cost. We also introduce a shadow cost of public funds, which allows to study the effect of competition on taxpayers.

In a similar framework, Aubert and Pouyet (2004, 2006) consider the possibility of collusion in an incomplete regulation framework. They show that in some cases the regulator might not be willing to fight collusive agreements.[5] Collusion and the optimal enforcement of competition policy are out of the scope of the present paper. We concentrate instead on the broad welfare consequences of the trade off between the loss of control on part of the industry and the efficiency enhancing value of competition. We refer to their work for antitrust issues and related distortions, which would not change the main insights of our paper (see discussions in Sections 4 and 5).

Our results are also reminiscent of the literature on mixed markets (Beato and Mas-Colell, 1984, Vickers and Yarrow, 1988, Cremer, Marchand, and Thisse, 1989, 1991, De Fraja and Delbono, 1989). These papers look at markets with public and private participants. In particular, Cremer, Marchand and Thisse argue that a mixed market can be preferred to both full privatization and full nationalization. This depends on the assumption that public firms are pure welfare

[3] In an oligopolistic context, this effect does not crucially depend on the presence of partial substitution. It also arises in our model, though we do not make the assumption that competition is responsible for an increase in variety. Indeed, if it was the case, it should be explained why the monopoly did not produced more varieties in the first place. We show that in an oligopolistic context an increase in the Ramsey markup can come from a rather different source: the trade off between productive and allocative efficiency.

[4] Similarly, Boyer and Laffont (2003), analyzing the effect of competition on the power of incentives in a regulated industry, limit their analysis to the case of independence of marginal costs, even though in regulated industries the costs of the different operators are generally correlated.

[5] Instead, Tangeras (2002) introduces collusion under yardstick competition in a complete regulation framework à la Auriol and Laffont (1993). He shows that collusion arises only if firms can commit to side payments. In this case, the collusion proof contract introduces an additional distortion which partly reduces the benefits of yardstick competition.

maximizers, but have the disadvantage of paying an exogenous wage premium to workers. In our framework, this exogenous cost disadvantage is replaced by the endogenous rent seeking behavior of the regulated firm, which makes regulation socially onerous.

1.2 Plan of the paper

The paper proceeds as follows. In Section 2 the basic model is presented. Section 3 and 4 treat the cases of symmetric and asymmetric information respectively. Optimal price, quantities and market structure are described. For performing comparative statics, the solution is fully characterized for the case of linear demand and uniform distribution. Section 5 presents the welfare analysis, comparing regulated monopoly to liberalization. Section 6 considers the issue of excess entry. Section 7 compares incomplete regulation to full duopoly regulation. Section 8 concludes.

2 The model

There are two firms, identified by 1 and 2. Firm 1 denotes the incumbent. Its quantity is determined by a regulator[6], who also sets a regulatory instrument τ (tax or transfer). Firm 2, the entrant, is a fully unregulated private competitor. As such, it takes full accountability of its profits and losses. For simplicity, one can think of the case in which the national firm is public or mixed. Even in the case of privatized firms, asymmetric regulation is a relevant framework in many liberalized market, as explained in Section 1.
The regulator acts as a Stackelgerg leader through the quantity produced by Firm 1. Firm 2 is a Stackelberg follower. It maximizes profit choosing quantity q_2 after q_1 is determined.[7] The cost functions of the two firms take the form:

$$C_i(q_i) = \theta_i q_i + k$$

where the index $i \in \{1, 2\}$ indicates the two firms, θ_i is the constant marginal cost of firm i and k the fixed cost.[8] Marginal costs θ_i are common knowledge in the symmetric information case and private information of the firms in the asymmetric information one. We assume that the fixed cost k has to be spent before θ_1 and θ_2 are discovered. The profits of the two firms write:

$$\begin{aligned} \Pi_1 &= P(Q)q_1 - \theta_1 q_1 - k - \tau, \\ \Pi_2 &= P(Q)q_2 - \theta_2 q_2 - k, \end{aligned}$$

[6] One may argue that it is much more common to regulate prices than quantities. Indeed, quantity competition allows to concentrate on the direct impact of competition in concentrated market, without incurring in Bertrand-type paradoxes. However, a model of price competition with closely substitute goods would deliver the same qualitative predictions, especially concerning the welfare impact of liberalization.

[7] One important simplification of this model is that vertical issues (control of bottleneck facilities by the incumbent) are neglected. This can represent the case in which the entrant can bypass the infrastructure of the incumbent. Alternatively, one can think of industries in which there is vertical unbundling (or at least formal separation) and access is priced at marginal cost.

[8] We could assume that the fixed costs are different between firms. In this case, the cost of the competitor would explicitly represent the level of duplication of fixed costs and possibly include and entry cost. This would not alter the nature of the results.

τ represents the regulatory instrument. It is a tax on profit when positive and a transfer when negative. $r_2(q_1)$ is the reaction function of firm 2, i.e. $r_2(q_1) = \text{argmax}_{q_2} \Pi_2$. We assume that public funds have a positive opportunity cost, namely λ, deriving, for example, from the need to raise taxes through distortive taxation. On the contrary. The profit of Firm 2 cannot be taxed away.[9] The social welfare function takes the form:

$$W = S(Q) - P(Q)Q + (1+\lambda)\tau + \Pi_1 + \Pi_2 \tag{1}$$

where $S(Q)$ is gross consumer welfare and $Q = q_1 + q_2$ is the total quantity. The definition given in Equation (1) implies that the profits of both firms enter the social welfare function. This would be the case if we consider two national firms. Alternatively, we can think of a foreign firm which participation brings some welfare gains to the host country (for instance because it creates employment). This specification has the advantage of allowing easy comparisons of our results with the existing literature on liberalization. However it is not crucial for the nature of the results. An alternative version of the model without the profit of Firm 2 in the social welfare function gives the same qualitative results.

We start considering the case in which both firms have entered the market. The decision of entry is studied in more detail in Section 6.

3 Symmetric information

In the benchmark case of symmetric information, the regulator observes both the variable costs θ_1 and θ_2. The regulator maximizes social welfare (1) with respect to q_1 and τ, under the participation constraint of the regulated firm and the reaction function of the competitor.[10] The participation constraint takes the form:

$$\Pi_1 = P(Q)q_1 - \theta_1 q_1 - k - \tau \geq 0 \tag{2}$$

This constraint is binding at optimum and the social welfare can be written:

$$W^{SI} = S(Q) - \theta_1 q_1 - \theta_2 q_2 + \lambda(P(Q) - \theta_1)q_1 - (2+\lambda)k \tag{3}$$

Equation (3) makes it apparent how the existence of a cost of public funds puts a higher weight on the operating profit of Firm 1. The regulator maximizes (3) with respect to q_1 under the constraints:

$$\begin{aligned} q_2 &= r_2(q_1) && (4)\\ q_1 &\geq 0 && (5)\\ q_2 &\geq 0 && (6)\\ & && (7) \end{aligned}$$

[9] This is a simplification to describe the empirically relevant case where national firms are more easily taxed than foreign competitors.

[10] As in the mixed market framework, the regulator uses its control on the regulated firm to maximize welfare. However, contrarily to the mixed market case, we do not assume a hard budget constraint between the regulated firm and the government (i.e. average cost pricing). When λ is positive, the operating profit of the firm can help to reduce distortive taxation and increase economy welfare.

Constraint (4) states that the competitor follows a (Cournot) best response function. Constraints (5) and (6) are the non-negativity constraints on the produced quantities. For solving the regulator's problem, we make the following Assumption:

Assumption 1 *W^{SI} is a continuous twice differentiable function of q_1. The second order condition $\partial^2 W^{SI}/\partial q_1^2 \leq 0$ is satisfied and the regulator's problem is concave.*[11]

Let $P(q_1^{M,SI})$ the regulated monopoly price under asymmetric information (Ramsey benchmark) and $P(q_2^M)$ the private monopoly price charged by Firm 2 when Firm 1 does not produce. We denote ε the elasticity of demand ($\varepsilon \equiv -\frac{\partial Q}{\partial P}\frac{P}{Q}$). The solution of the regulator's program is characterized by the following Proposition.

Proposition 1 *Let q_1^S be such that $\frac{\partial W^{SI}(q_1, r_2(q_1))}{\partial q_1}\big|_{q_1=q_1^S} = 0$. Under Assumption 1, the price under symmetric information is given by:*

$$P(Q) = \begin{cases} P(q_1^{M,SI}), & \text{if } (\theta_1, \theta_2) \in M; \\ \theta_2, & \text{if } (\theta_1, \theta_2) \in M1; \\ \theta_1 + \frac{\lambda}{1+\lambda}\frac{1}{\varepsilon}\left[1 + r_2'(q_1)\right]\frac{q_1}{Q}P(Q) - \frac{1}{1+\lambda}\big(P(Q) - \theta_2\big)r_2'(q_1), & \text{if } (\theta_1, \theta_2) \in D; \\ P(q_2^M), & \text{if } (\theta_1, \theta_2) \in M2. \end{cases}$$

where:
$M = \{(\theta_1, \theta_2) \mid q_1^S > 0, P(q_1^{M,SI}) \leq \theta_2\}$
$M1 = \{(\theta_1, \theta_2) \mid q_1^S > 0, P(q_1^S) \leq \theta_2 < P(q_1^{M,SI})\}$
$D = \{(\theta_1, \theta_2) \mid q_1^S > 0, P(q_1^S) > \theta_2\}$
$M2 = \{(\theta_1, \theta_2) \mid q_1^S \leq 0\}$

Proof See Appendix 1. ■

Price and market structure depend on the level of θ_2, and more precisely on relative efficiency of the competitor with respect to the incumbent. They change in the different sub-regions (namely M, M1, D and M2). We now discuss the characteristics of the different regions.

Region M:

In the region denoted by M, the price is equal to the one which would be chosen the in case of regulated monopoly. Firm 2 does not produce and there is a monopoly with Firm 1 even if Firm 2 is allowed to produce. In this case, removing barriers to entry does not change the market outcome. The potential entrant turns out to be too inefficient to participate.

Region M1:

In region $M1$, the price is equal to θ_2. We are in a region in which Firm 2 would produce if the price was equal to $P(q_1^M)$ but does not do it under duopoly pricing. In this region, the pricing rule keeps out the competitor. This "limit pricing" behavior differs from other results in the literature, which emphasize the risk of predation by a regulated incumbent.[12] In our case,

[11] It can be easily verified this assumption always hold if the demand function is concave and the reaction function of firm 2 has the standard Cournot-Stackelberg properties.

[12] For instance, Faure-Grimaud (1997), considering a regulated firm, shows that, in a dynamic framework, the rent of the regulated firm decreases with the number of competitors. For this reason a regulated firm has an incentive to foreclose rivals. Similarly, Sappington and Sidak (1994), considering the particular case of state owned enterprizes, argue that the anticompetitive behavior can be reinforced with respect to the case of private profit maximizers.

the outcome depends on the behavior of the regulator, which acts as a pure welfare maximizer. Notice that this region exists only when $\lambda > 0$.[13] In this case, the regulated monopoly price would be higher than marginal cost pricing. The price reduction under duopoly aims then to discourage inefficient entry.

Region D:

In Region D both firms are active: the market is a true duopoly. In this case, the price is given by a modified Ramsey rule. It is easy to verify that the price is always higher than the marginal cost of Firm 1, because both the second and the third term in the price formula are positive. The second term corresponds to the usual Ramsey term, but it is here multiplied by the elasticity of the total quantity to the quantity produced by Firm 1 (i.e. $\left[1 + r_2'(q_1)\right]\frac{q_1}{Q} = \frac{\partial Q}{\partial q_1}\frac{q_1}{Q} < 1$). The Ramsey term is thus *reduced* with respect to the traditional regulated monopoly case. The third term is an additional term which is positive for all prices such that the second firm produces a positive quantity (i.e. $P(Q) \geq \theta_2$). This term *increases* the Lerner index with respect to the regulated monopoly case. When the quantity produced by Firm 1 is reduced to leave space to the more efficient competitor, the increase in the quantity produced by the latter is small. This terms captures the trade off between producing at lower cost (i.e. letting a greater market share to an oligopolistic firm) and reducing the price. This effect is described more formally in Proposition 2.

Region M2:

The last region to consider is the one denoted $M2$, where the optimal quantity produced by Firm is equal to zero. In this case, Firm 2 produces its monopoly quantity and it is the only firm on the market. The regulator prefers to shut down the regulated firm and let the private competitor take over.

3.1 Linear demand

We now take a linear specification of the demand function, which allows to explicitly compute the price and quantities and to compare them with the regulated monopoly ones.

Assumption 2 *The (inverse) demand function is $P(Q) = 1 - Q$.*

The linear demand function is associated with a consumer surplus of the form: $S(Q) = Q - Q^2/2$. In this case, the reaction function of Firm 2 is given by:

$$r_2(q_1) = \frac{1}{2}(1 - q_1 - \theta_2)$$

Under Assumption 2, the quantities and price can be expressed as a function of the marginal costs and λ (see Appendix 1 for details). This allows to explicitly compare the duopoly quantities and price with the ones obtained under regulated monopoly. Developing computations, we obtain the following result, which illustrates the trade off described in the discussion following Proposition 1.

Proposition 2 *Let $Q^{D,SI}$ be the duopoly quantity produced for $\theta_1, \theta_2 \in D$. Under Assumption 2 the following holds:*

[13] When $\lambda = 0$, $P_1^{M,SI}$ corresponds to the marginal cost θ_1. Then region M1 would be such that $P(q_1^D) \leq \theta_2 < \theta_1$. However, from the implicit definition of q_1^D, one can easily verify that, for $\lambda = 0$, $P(q_1^D) \leq \theta_1$ if and only if $\theta_2 > \theta_1$. Therefore, for $\lambda = 0$, there is no pair $\{\theta_1, \theta_2\}$ which satisfies the definition of region D.

- *If* $\lambda > 1$, $P(Q^{D,SI}) < P(q_1^M)$, $\forall \theta_1, \theta_2 \in D$;
- *If* $\lambda \leq 1$, $P(Q^{D,SI}) \leq P(q_1^M)$ *if and only if:*

$$\theta_2 \quad \geq \quad \theta_1 - \frac{2\lambda^2(1-\theta_1)}{(1+2\lambda)(1-\lambda)} \tag{8}$$

For the empirically more relevant case ($\lambda \leq 1$)[14], there is a trade off between productive and allocative efficiency. A price decrease does not depend on the fact that the relative efficiency of the entrant is large (i.e. $\theta_2 \ll \theta_1$), but it tends to occur when Firm 2 is not too efficient. In this case, the regulator expands the quantity produced by Firm 1 in order to reduce the scale of entry of the unregulated firm. This increases the total quantity and reduces the price. On the contrary, a decrease in the average cost of production is not systematically transmitted to the price. When Firm 2 is relatively efficient, the price tends to increase with respect to monopoly, because the reduction in the quantity produced by the regulated firm is not fully compensated by the production of Firm 2.

4 Asymmetric information

We now turn to the case of asymmetric information. We assume that production costs are private information of the firms, but their distribution is common knowledge. Under asymmetric information, the regulator has to leave a rent to the regulated firm to extract the information about the realization of the marginal cost. However, the regulator observes the market final price and/or quantity. This gives some information about the level of θ_2 (and thus, in the presence of correlation, about θ_1). The regulator can use this information to perform yardstick competition. As Crémer and Mc Lean (1988) show, under some conditions partial correlation can be sufficient to allow a principal to fully extract the surplus in an asymmetric information problem. However, it seems reasonable to assume that in practice yardstick competition reduces the agency cost of asymmetric information without making it vanish. To convey this idea, we take a specification which is inspired by Auriol and Laffont (1993). We assume that the marginal costs of the two firms have the shape $\theta_i = \beta + \varepsilon_i$, where β is the common part of marginal costs and ε_i is an idiosyncratic shock with zero mean. The correlation between the costs of the two firms is captured by the common parameter β, which represents the average cost in the industry, that is $E(\theta_i) = \beta$. Firms sustain some common production cost (e.g. same cost of inputs, similar technologies), but they are subject to idiosyncratic shocks which determine the relative efficiency of the different providers. This specification does not respect the assumption of the Crémer and Mc Lean (1988) theorem and the full extraction property does not hold. However, contrarily to more general specifications (see Caillaud, 1990 on this point), it allows to capture in a tractable way the impact of imperfect cost correlation. For the analytical solution of the model, we thus precise this stochastic structure as follows:

Assumption 3 *Let the marginal cost be of the form* $\theta_i = \beta + \varepsilon_i$. β *is a discrete random variable which takes values* $\underline{\beta}$ *or* $\overline{\beta}$ *with* $Prob(\beta = \underline{\beta}) = \nu$. ε *is a continuous variable with distribution on the support* $[\underline{\varepsilon}, \overline{\varepsilon}]$. *Moreover,* $\overline{\beta} + \underline{\varepsilon} = \underline{\beta} + \overline{\varepsilon} = z$.

[14] This threshold does not depend on imposing $P(Q) = 1 - Q$. The same threshold holds for all linear demand specifications of the kind $P(Q) = d - bQ$.

This specification is simply a way to assume that the marginal costs are both distributed either on the support $Z_1 = [\underline{\theta}, z]$ or on $Z_2 = [z, \overline{\theta}]$, with $\underline{\theta} < z < \overline{\theta}$. It is never the case that $\theta_i \in Z_1$ and $\theta_j \in Z_2$, $i \neq j$ (either the two costs are "low" or they are both "high"). For simplicity, we assume that the two possible intervals do not overlap.

The contract is now contingent on the realization of q_2. Since the competitor is a Stackelberg follower, its quantity is observed after Firm 1 produces q_1. We assume that the regulator is able to commit to punish the manager of Firm 1 after q_2 has been observed, in case the deduced θ_2 is inconsistent with the report on θ_1. This notion of punishment has not to be confused with the fact that the rationality constraint of the firm is always satisfied (Firm 1 never makes *accidental* losses). This does not exclude that managers can be persecuted and/or replaced for fraudulent behavior. We consider a direct revelation mechanism in which Firm 1 reports its cost and the regulator offers a menu of contracts $[q_1(\theta_1), \tau(\theta_1, q_2)]$ for each possible type θ_1 (the revelation principle ensures that there is no loss of generality in restricting the attention to direct revelation mechanisms). With the stochastic structure described in Assumption 3, $\partial F(\theta_2|\theta_1)/\partial\theta_1$ is zero almost everywhere (i.e. except if $\theta_1 = z$). A marginal variation of θ_1 does not change Firm's 1 conditional expectation on Firm's 2 characteristic (except in one case which occurs with probability zero). We denote $\Pi(\theta_1) = E_{\theta_2|\theta_1}\Pi_1(\theta_1, \theta_2)$ the expected profit of Firm 1. Yardstick competition ensures that the rent is paid only on the relevant interval of θ_1 and types $\theta_1 = 1$ and $\theta_1 = z$ get zero rent.[15] The information rent can be computed following the by now standard technique (see for instance Laffont and Martimort, 2002). When $\beta = \overline{\beta}$ (i.e. $\theta_1 \in Z_2$), we have:

$$\Pi^D(\theta_1) = \int_{\theta_1}^{\overline{\theta}} E_{\theta_2|\theta_1}[q_1]d\theta_1$$

When $\beta = \underline{\beta}$ (i.e. $\theta_1 \in Z_1$):

$$\Pi^D(\theta_1) = \int_{\theta_1}^{z} E_{\theta_2|\theta_1}[q_1]d\theta_1$$

We thus obtain:

$$E_{\theta_1}\Pi_1^D(\theta_1) = \int_{\underline{\theta}}^{\overline{\theta}} \int_{\underline{\theta}}^{\overline{\theta}} \frac{F(\theta_1) - I_{Z_2}(\theta_1)F(z)}{f(\theta_1)} \, q_1(\theta_1)\, f(\theta_1, \theta_2)d\theta_1 d\theta_2 \tag{9}$$

where I_{Z_2} is the indicator function of θ_1 falling in region Z_2, which means:

$$I_{Z_2} = \begin{cases} 1, & \text{if } \theta_1 \in Z_2; \\ 0, & \text{otherwise.} \end{cases}$$

From Equation (9), we see that the slope is reduced with respect to the monopoly case in which the rent is proportional to the full hazard rate:[16]

[15] This rent reducing effect on the rent is different with respect to the correlation effect studied in Caillaud (1990) and afterwards in the literature on strategic trade policy (see Brainard and Martimort, 1996, 1997 and Combes, Caillaud, and Jullien, 1997). In all these cases, the rent seeking behavior of the regulated firm is modified by competition through the term $\partial F(\theta_2|\theta_1)/\partial\theta_1$. In our case $\partial F(\theta_2|\theta_1)/\partial\theta_1 = 0$ almost everywhere, but the yardstick effect cuts down the rent of the regulated firm. Our specification avoids technical difficulties and allows to characterize the effect of partial correlation on the optimal contract, relying on the realistic hypothesis that yardstick competition is used to reduce the agency cost of asymmetric information.

[16] In the case of shut down of Firm 2, the regulator cannot deduce the exact value of θ_2. Nevertheless, this does not need to affect the capability of the regulator to reduce the rent of Firm 1. It is sufficient to assume that,

$$E_{\theta_1}\Pi_1^M(\theta_1) = \int_{\underline{\theta}}^{\overline{\theta}} \frac{F(\theta_1)}{f(\theta_1)}\, q_1(\theta_1)\, f(\theta_1) d\theta_1 \tag{10}$$

We make the following standard assumption:

Assumption 4 *The hazard rate $F(\theta_1)/f(\theta_1)$ is non-decreasing for all θ_1.*

The regulator chooses q_1 without observing θ_2, maximizing expected welfare. Replacing for the value of the rent (in order to satisfy the incentive constraint of truthful revelation), we have:

$$W^{AI} = E_{\theta_1,\theta_2}\ \ S(Q) + \lambda P(Q) q_1 - (1+\lambda)(\theta_1 q_1 + k) - \theta_2 q_2 - \lambda \frac{F(\theta_1) - I_{Z_2}(\theta_1)F(z)}{f(\theta_1)} q_1 - k \tag{11}$$

The solution of the problem gives a rule on the expected price, which is characterized in the following Proposition:

Proposition 3 *Let q_1^A be such that $\frac{\partial W^{AI}(q_1, r_2(q_1))}{\partial q_1}\big|_{q_1=q_1^A} = 0$. Under Assumption 1 and 4, in the case of asymmetric information the pricing rule is given by:*

$$E_{\theta_2|\theta_1} P(Q) = \begin{cases} \theta_1^v + \frac{\lambda}{1+\lambda} E_{\theta_2|\theta_1}\left[\frac{1}{\varepsilon}\left(1 + r_2'(q_1)\right)\frac{q_1}{Q} P(Q)\right] - \frac{1}{1+\lambda} E_{\theta_2|\theta_1}\left[(P(Q) - \theta_2) r_2'(q_1)\right], & \text{if } (\theta_1,\theta_2) \in M1 \cup D; \\ E_{\theta_2|\theta_1} P(q_2^M), & \text{if } (\theta_1,\theta_2) \in M2. \end{cases}$$

where:
$M1 \cup D = \{(\theta_1,\theta_2) \mid q_1^A > 0\ \}$
$M2 = \{(\theta_1,\theta_2) \mid q_1^A \leq 0\}$
and θ_1^v is the virtual cost including the distortion related to the information rent:
$\theta_1^v = \theta_1 + \frac{\lambda}{1+\lambda} \frac{F(\theta_1) - I_{Z_2}(\theta_1)F(z)}{f(\theta_1)}$.

Proof See Appendix 2. ■

As in the case of symmetric information, the quantities and price are different in different regions, depending on cost realizations.

Region M1 $\cup$ D:

In this region Firm 1 produces a positive quantity. Because the θ_2 is not observed, the quantity produced by firm 1 is set maximizing expected welfare, while the realized market structure depends on the realization of θ_2. There can be a monopoly with firm 1 if $q_2 = 0$ (region M1) or a duopoly (region D). In region D the pricing rule has the same form as in Proposition 1, except that it is a rule on the expected price. Moreover, the cost θ_1 is replaced by the virtual cost θ_1^v.

Region M2:

In region $M2$, the quantity produced by Firm 1 is equal to zero. In this case, Firm 2 produces its monopoly quantity and the price.

whenever the regulated firm is lying across intervals, Firm 2 produces a positive quantity, revealing the relevant subinterval of the variable costs. For instance, one can easily show that this always holds under Assumptions 2 and 5. At the optimal menu of contracts, $q_2(q_1|\theta_1 \in Z_1, \hat{\theta}_1 \in Z_2) > 0$, $\forall \theta_1, \theta_2 \in Z_1$.

4.1 Linear demand

As in Section 3.1, we now completely characterize the solution for the case of linear demand in Assumption 2. Moreover, we precise the stochastic structure of Assumption 3 as follows:

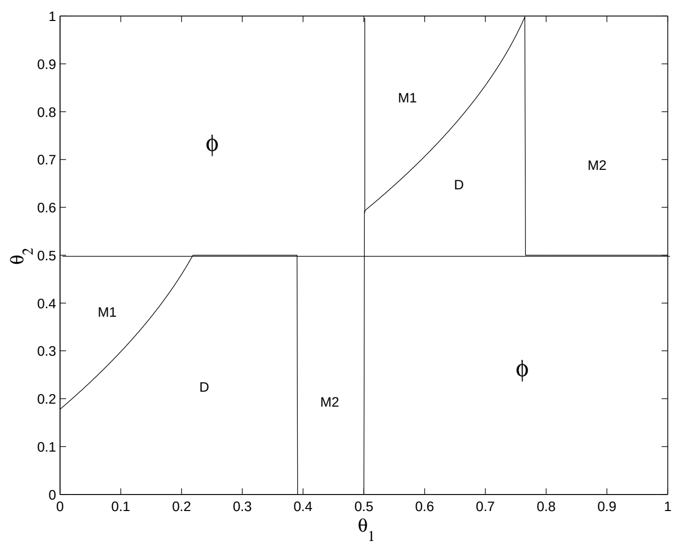
Assumption 5 *Let Assumption 3 hold and:*

$$\beta \in \{\tfrac{1}{4}, \tfrac{3}{4}\}\ ,\quad Prob\{\beta = \tfrac{1}{4}\} = \tfrac{1}{2}\ ,\quad \varepsilon \sim U[-\tfrac{1}{4}, \tfrac{1}{4}]$$

In this case, θ_i is uniformly distributed either on $Z_1 = [0, \frac{1}{2}]$ (with probability $\frac{1}{2}$) or on $Z_2 = [\frac{1}{2}, 1]$. Moreover, $z = \frac{1}{2}$. We thus have $E(\varepsilon_i) = 0$, $E(\theta_i) = E(\beta) = \frac{1}{2}$.

Under Assumption 2 and 5, the regions implicitly characterized in Proposition 3 can be explicitly expressed in terms of the efficiency parameters θ_1 and θ_2. They are illustrated in Figure 1.[17]

Figure 1: Market structure with asymmetric information.



Due to Assumption 5, the two marginal costs fall either in the North-East or in the South-West regions. Region M1 corresponds to the case in which the relative inefficiency of the entrant is very high ($\theta_1 \ll \theta_2$) and no entry occurs. In Region D, both firms produce. The pricing rule, described in Proposition 3, in the case of linear demand become equivalent to the one given in Proposition 1, replacing θ_2 with its expectation and θ_1 with the virtual cost θ_1^v. Then, the qualitative results of Proposition 1 are preserved. More precisely, it can be shown that the expected price decreases more when the expected relative efficiency of Firm 2 is not too large. However, because of yardstick competition, the price is closer to efficiency. The virtual cost of production is smaller than in the case of regulated monopoly, i.e. $\theta_1 + \frac{\lambda}{1+\lambda}\frac{F(\theta_1)}{f(\theta_1)} \leq \theta_1 + \frac{\lambda}{1+\lambda}\frac{F(\theta_1) - I_{Z_2}(\theta_1)F(z)}{f(\theta_1)}$. For this reason, the price decreases *more often* than in the case of complete

[17] The figure is plotted for $\lambda = 0.3$, but the same qualitative shape is obtained for all $\lambda > 0$.

information. Yardstick competition, increasing the productive efficiency of the regulated firm, allows to increase the produced quantity at a lower cost. Observing the market behavior of an unregulated firm provides precious information to the regulator, since this behavior is not distorted by regulation.[18]
One may also note that, because θ_2 is not observable, the shut down rule for Firm 1 depends now only on θ_1. There can hence be a monopoly with Firm 2 for each level of θ_2 (Region M2). This region of the parameters includes the one in which there would be shut down under monopoly (and no production in the absence of Firm 2). In this case, a competitor with market power is valuable with respect to the alternative of not providing the service at all.

5 Welfare analysis

In this section, we compare expected welfare under regulated monopoly and partially regulated duopoly. First of all, we note that, when $\lambda \rightarrow 0$, transfers are not costly and entry is accomodated only when it is beneficial (i.e. when the competitor is more efficient than the entrant). The expected welfare under duopoly (net of fixed costs) would then be larger than under monopoly. On the contrary, when $\lambda \rightarrow \infty$, only the profit of the regulated firm matters. Since the monopoly profit is always larger than the Stackelberg one, the welfare gains associated with competition go to $-\infty$ when $\lambda \rightarrow \infty$. For intermediate values of λ, the business stealing effect of competition decreases the size of the tax (increase the size of transfers). This has a negative impact on welfare. In the case of asymmetric information, the negative fiscal effect is mitigated by the fact that the presence of a competitor allows to reduce the information rent of the incumbent. In order to characterize more precisely what happens for intermediate values of λ, we use again the linear specification proposed in Assumption 2. This allows to compute explicitly the welfare gains in the cases of symmetric and asymmetric competition respectively.

5.1 Symmetric information:

We denote $q_i^{D,SI}$ the duopoly quantity produced under symmetric information by Firm i, $i \in \{1,2\}$ and $Q^{D,SI}$ the total quantity. Under Assumption 2, expected welfare under monopoly and duopoly is respectively:

$$
\begin{aligned}
W^{M,SI} &= E_{\theta_1,\theta_2}[q_1^{M,SI} - \frac{(q_1^{M,SI})^2}{2} - \theta_1 q_1 + \lambda(1 - q_1^{M,SI} - \theta_1)q_1^{M,SI} - (1+\lambda)k] \\
W^{D,SI} &= E_{\theta_1,\theta_2}[Q^{D,SI} - \frac{(Q^{D,SI})^2}{2} - \theta_1 q_1 - \theta_2 q_2 + \lambda(1 - Q^{D,SI} - \theta_1)q_1^{D,SI} - (2+\lambda)k]
\end{aligned}
$$

We deduce that under symmetric information, duopoly is preferred to monopoly whenever $W^{D,SI} - W^{M,SI} \geq 0$. This determines a threshold value of k, characterized by the following Proposition.

[18]Naturally, this also depends on the fact that we rule out the possibility of collusion between the incumbent and the entrant. Aubert and Pouyet (2006) show that in a incomplete regulation framework, collusion (with transfers) could be preferred to a collusion proof contract, because it allows the regulator and the incumbent to "team up" and tax or subsidize the entrant. The possibility of extracting a collusive transfer from the entrant could reduce the negative impact of business stealing. On the other hand, if firms collude, the effectiveness of yardstick competition might be reduced (see also Pouyet, 2002). Qualitatively, the main insights of our paper would carry on.

Proposition 4 *Let Assumptions 2 and 5 hold. In the case of symmetric information, we have two cases:*

1. *For $\lambda \leq 1.1$, there exists a threshold k^{SI} such that liberalization dominates partially regulated monopoly for $k \leq k^{SI}$. Moreover, k^{SI} increases in a small neighborhood of $\lambda = 0$. Afterwards, it is decreasing.*

2. *For $\lambda > 1.1$ regulated monopoly always dominates partially regulated monopoly.*

Proof See Appendix 3. ■

When λ increases, the profit of the regulated firm becomes valuable and the business stealing effect starts making entry less desirable.[19] When λ is high ($\lambda > 1.1$), a regulated monopoly is preferred to liberalization for all levels of the increasing returns to scale (this range of λ can describe severely constrained governments, such as the ones of many developing countries). For lower values, the desirability of incomplete regulation, as compared to monopoly, generally decreases with the value of λ (except in a small neighborhood of zero, $\lambda \leq 0.0001$). The results of this section are in line with the common view that competition can be welfare increasing if the economies of scale are not very large. However, we have shown that there is another important condition: the cost of public funds has to be not too large either. For the same level of economies of scales, countries with different cost of public funds would optimally choose different industrial policies. The threshold k^{SI} is plotted in Figure 2 (dotted line).

5.2 Asymmetric information:

We denote $q_i^{D,AI}$ the duopoly quantity produced under asymmetric information by Firm i, $i \in \{1,2\}$ and $Q^{D,AI}$ the total quantity. Under Assumptions 2 and 5, expected welfare under monopoly and duopoly is respectively:

$$\begin{aligned}
W^{M,AI} &= E_{\theta_1,\theta_2}[q_1^{M,AI} - \frac{(q_1^{M,AI})^2}{2} - \theta_1 q_1 + \lambda(1 - q_1^{M,AI} - \theta_1)q_1^{M,AI} - (1+\lambda)k - \lambda\frac{F(\theta_1)}{f(\theta_1)}] \\
W^{D,AI} &= E_{\theta_1,\theta_2}[Q^{D,AI} - \frac{(Q^{D,AI})^2}{2} - \theta_1 q_1^{D,AI} - \theta_2 q_2^{D,AI} + \lambda(1 - Q^{D,AI} - \theta_1)q_1^{D,AI} - (2+\lambda)k] \\
& -\frac{F(\theta_1) - I_{Z_2}(\theta_1)F(z)}{f(\theta_1)}
\end{aligned}$$

Under asymmetric information, duopoly is preferred to monopoly whenever $W^{D,AI} - W^{M,AI} \geq 0$. This determines a threshold value of k, characterized by the following Proposition.

Proposition 5 *Let Assumptions 2 and 5 hold. In the case of asymmetric information, we have two cases:*

[19] This welfare result does not crucially depend on the duopoly structure. Indeed, Aubert and Pouyet (2004) show that, when a regulated incumbent is exposed to a competitive fringe, welfare can be higher when the fringe collude (behaving as a duopolistic competitor) rather than behave competitively. A similar effect is playing here: introducing competition does not necessarily increase welfare when λ is high. However, with more competitors, the sampling effect (i.e. the probability of finding more efficient producers) would also be larger (Aubert and Pouyet, 2004 concentrate only on the case of identical costs).

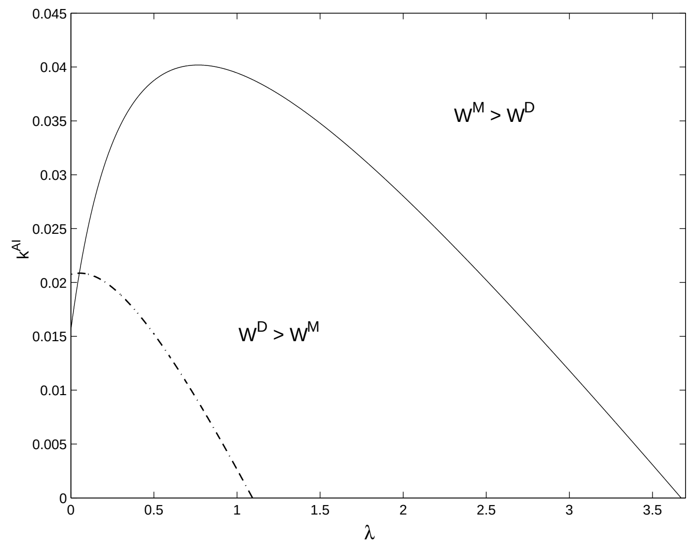
1. For $\lambda \leq 3.7$, there exists a threshold k^{AI} such that partially regulated duopoly dominates regulated monopoly for $k \leq k^{AI}$; The threshold k^{AI} has an inverse U-shape.

2. For $\lambda > 3.7$ regulated monopoly always dominates partially regulated duopoly.

Proof See Appendix 3. ■

In the case of asymmetric information, regulated monopoly always (i.e. independently on the level of economies of scale) dominates incomplete regulation only if λ is very large (values larger than 3 are usually considered not empirically relevant). For lower values, the threshold k^{AI} has an inverse U shape. In Figure 2, k^{AI} (solid line) is compared with k^{SI} (dotted line).

Figure 2: The thresholds k^{SI} and k^{AI}



For any value of λ significatively different from 0 (more precisely, $\lambda \geq 0.05$)[20], partial regulation is preferred to monopoly for higher values of k than in the case of symmetric information. In other words, for $\lambda \geq 0.05$ asymmetric information favors duopoly. Once again, different countries have different optimal industry structure, for the same level of increasing returns to scale. For instance, in our specification, if $k \simeq 0.03$, countries with low cost of public funds prefer keeping a statutory monopoly, for intermediate values the duopoly structure is preferred and finally for very large values of λ the monopoly structure is again optimal.
Naturally, the precise shape of the curves depends on the assumption made on the support of the distribution of marginal costs. We have assumed that marginal costs are distributed on symmetric subintervals of the interval [0,1]. This maximizes ex-ante technological uncertainty[21] and,

[20] When $\lambda = 0$, the rent left to the firm does not affect the expected welfare. In this case, the only difference between the problem under symmetric and asymmetric information is in the fact that under asymmetric information the regulator cannot observe θ_2 (and chooses on the base of an expectation). If θ_2 was either observable or unobservable in both cases (which means that the symmetric/asymmetric information would then only be about the cost of the regulated firm), the two curves would cross in $\lambda = 0$.

[21] The intercept of the demand function is also equal to 1. Then $\overline{\theta} = 1$ is the maximum value that makes production desirable in a complete information benchmark.

consequently, the potential gains from yardstick competition (as Equation (10) shows, the rent reduction depends the support of marginal costs). If the variance of marginal cost was smaller, the difference between the two thresholds k^{SI} and k^{AI} would be reduced, but their qualitative shape would not be affected.

6 Excess entry:

Until now, we have supposed that both firms have invested k and entered the market. Indeed, the regulatory contract satisfies the ex post participation constraint of Firm 1. Then, Firm 1 is always in the market. We now consider the entry decision of Firm 2. To participate, Firm 2 has to spend k before knowing the realization of the variable costs. We denote k_2^{SI} and k_2^{AI} the thresholds of k below which Firm 2 finds *privately* profitable to enter the market under symmetric and asymmetric information respectively. They are given by the value of the fixed cost below which the expected profit is non negative. We compare these thresholds with k^{SI} and k^{AI}. The results are summarized in the following Proposition.

Proposition 6 *Under Assumptions 2 and 5, the level of fixed costs under which Firm 2 finds privately profitable to enter the market is higher than the level below which entry is socially valuable. Excess entry occurs, both under symmetric and asymmetric information.*

Proof See Appendix 3. ■

The results are represented in Figure 3. The shaded regions correspond to values of the parameters for which excess entry occurs.

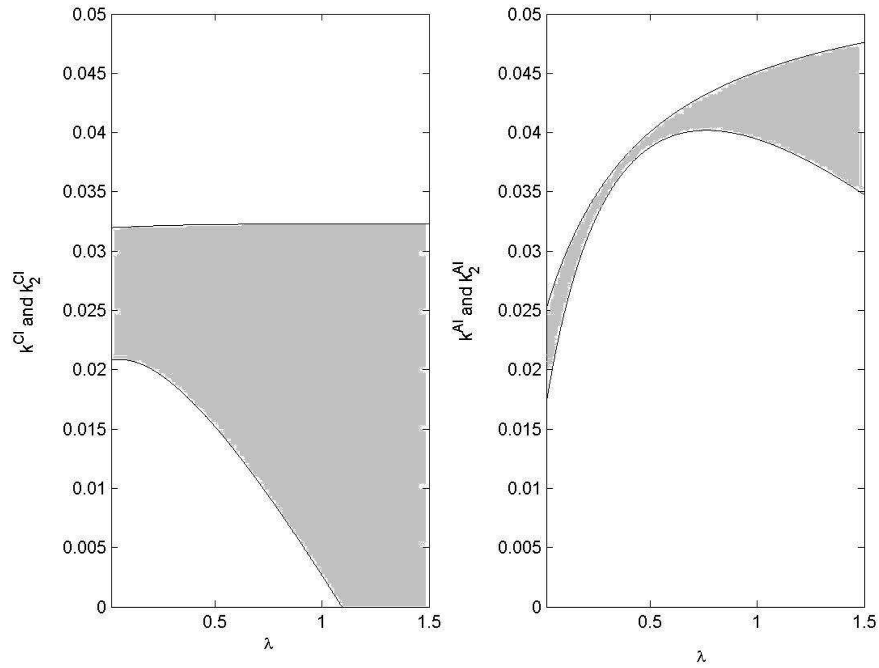
Excess entry depends on the fact that Firm 2 does not internalize the impact of entry on the operating profit of Firm 1 (and on taxpayers). Thus, there are cases in which the regulator is willing to control entry. It can be formally shown that the problem is less severe in the case of asymmetric information, as the graph qualitatively shows. In the case of asymmetric information, the perceived production cost is the virtual cost (which is lower in the case of duopoly, because of yardstick competition). Then, efficiency gains are larger and the divergence of private and social gains from entry is less pronounced.

7 Incomplete vs full regulation

Insofar, we have analyzed a partially regulated market, ruling out the possibility that all firms in the market are subject to the same regulatory scheme. One could think that, at least from a theoretical point of view, full regulation of the market, when feasible, would always be preferable to incomplete regulation, unless extending the scope of regulation is costly for some exogenous reason. It turns out that the welfare gains of liberalization under partial regulation are quite robust. In what follows, we compare welfare under incomplete regulation with welfare in the case of full regulation of duopoly. As a full regulation benchmark, we use the model of Auriol and Laffont (1993). In their model, the quantities of both firms are regulated and subject to a lump sum tax/tranfer. Then, the profit of Firm i can be written as:

$$\Pi_i = P(Q)q_i - \theta_i q_i - k - \tau_i, \quad i \in \{1, 2\}$$

Figure 3: Excess Entry



In our notation, the regulator's problem is to maximize welfare with respect to q_1, q_2, τ_1, τ_2:

$$W^R = E_{\theta_1,\theta_2}\ S(Q) - P(Q)Q + \Pi_1 + \Pi_2 + (1+\lambda)(\tau_1 + \tau_2) \tag{12}$$

Since variable costs are linear, at the optimum only the most efficient firm produces and the pricing rule is given by the traditional regulated monopoly Ramsey pricing. Due to yardstick competition, under asymmetric information the virtual cost is the same as in Proposition 3 (for further details, see Auriol and Laffont, 1993). Then the pricing rule satisfies:

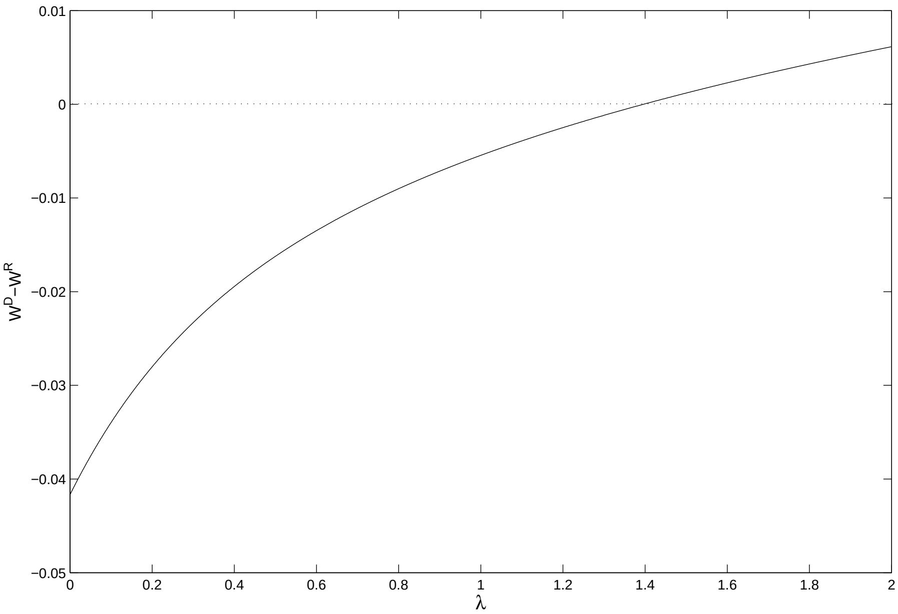
$$P(Q) = \min\{\theta_1^v, \theta_2^v\} + \frac{\lambda}{1+\lambda}\frac{P(Q)}{\varepsilon}$$

Under symmetric information, full regulation always dominates incomplete regulation. The intuition is very natural. The regulator commits to cover the fixed costs of both firms, but at the same time she can extract their full operating profit. As a result, she can at least replicate the results of an unregulated firm. Under asymmetric information, the situation is more complex. Regulated firms are able to get some information rent and the relevant production cost for the regulator is the virtual cost $\theta_i^v \geq \theta_i$. Because of this distortion, the regulator cannot extract the full operating profit. Under full regulation, she induces production at the distorted virtual cost, while covering both fixed costs. On the contrary, under incomplete regulation the unregulated competitor gets full accountability for its profits/losses. When λ is high, the agency cost of regulation may overweight its benefits. In this case, there exists a threshold value of λ above which incomplete regulation dominates full regulation of duopoly. The result is stated formally in the following proposition for the case of linear demand.

Proposition 7 *Let Assumption 2 and 5 hold. Then, in the case of asymmetric information, partial regulation dominates full duopoly regulation when λ and k are sufficiently large.*

Proof See Appendix 3. ■

Figure 4: Incomplete vs full regulation



In Figure 4 the solid line represents difference between welfare under incomplete and full regulation when $k = k_2^{AI}$, which is the maximum value of fixed costs that a private firm is willing to pay (i.e. the maximum value under which a second firm exists). When $k = k_2^{AI}$ the "savings" related to not committing to cover the fixed costs of Firm 2 are maximal. However, the same result could be obtained for any value of k introducing an ex-ante fixed fee for the unregulated competitor (licence fee). The model shows that incomplete regulation can be an interesting option for governments limited by severe cash constraint. In fact, this conciliates the benefits of keeping some regulated provision with the advantages of private participation.

8 Conclusion

The paper discusses the impact of opening a regulated monopoly to unregulated competition. It is a model of liberalization with incomplete regulation: the regulator contracts with the incumbent, but can only indirectly influence the behavior of the competitor. We have shown a trade off between encouraging the production of a relatively efficient competitor (increasing productive efficiency) and the market power of this competitor (which leads to allocative inefficiency). We show that entry can be associated to an increase in the price when the entrant is more efficient than the incumbent. An increase in efficiency is generally associated with an increase in the price and profits, which is consistent with the empirical evidence. The desirability of introducing this kind of competition is thus sensible to the weight the regulator puts on consumer surplus. The cost public funds, determining the weight put on the incumbent's operating profits, is shown to play an important role in the welfare analysis. In particular, the welfare gains of liberalization do not only depend on the degree of increasing returns to scale (measured by the fixed costs), but also on the magnitude of the cost of public funds. The relationship between the cost of public funds and the welfare gains associated to liberalization is non-monotone. For the same level of increasing returns to scales, different countries can have different optimal industry structures. The fiscal aspects of competition, related to taxation by regulation, should be taken into account by policy makers. When other forms of taxation (e.g. income taxation) are costly, business stealing can reduce the gains from deregulation. When asymmetric information is added to the picture, yardstick competition gives a new value to competition. The negative impact of business stealing is mitigated because the presence of a competitor allows to reduce the burden of the information rent. The importance of the asymmetry of information and the tightness of the cash constraint of the government are empirical issues. Assessing the relevance of the two can help governments to choose the optimal industry regulation. In the last section of the paper, we show that the welfare gains associated to liberalization under incomplete regulation are robust. For large values of the cost of public funds, incomplete regulation may even dominate full regulation of duopoly. Developing countries are typically characterized by tighten budget constraints. Partial liberalization could be a response to their peculiar problems, conciliating some form of publicly managed provision with the advantage of shifting part of the fixed investment and accountability for market results on the private sector. One possible drawback of partial deregulation is that excess entry occurs. Our analysis in this sense confirms the importance of entry regulation in increasing returns to scale industries.

References

Armstrong, M., and D. Sappington (2005): "Recent developments in the theory of regulation," in *Handbook of Industrial Organization*, ed. by M. Armstrong, and D. Sappington, vol. 3. North-Holland.

——— (2006): "Regulation, Competition and Liberalization," *Journal of Economic Literature*, 44(2), 325–366.

Aubert, C., and J. Pouyet (2004): "Competition policy, regulation and the institutional design of industry supervision," *Louvain Economic Papers*, pp. 153–168.

——— (2006): "Incomplete regulation, market competition and collusion," *Review of Economic Design*, 10(2), 113–142.

Auriol, E., and J. Laffont (1993): "Regulation by duopoly," *Journal of Economics and Management Strategy*, 1, 92–101.

Auriol, E., and P. Picard (2007): "Infrastructure and Public Utilities Privatization in Developing Countries," *The World Bank Economic Review*.

BARON, D., AND R. MYERSON (1982): "Regulating a monopolist with unknown costs," *Econometrica*, 50(4), 911–930.

BEATO, P., AND A. MAS-COLELL (1984): "The Marginal Cost Pricing as a Regulation Mechanism in Mixed Markets," *The Performance of Public Enterprises*, pp. 81–100.

BHASKAR, V., B. GUPTA, AND M. KHAN (2006): "Partial privatization and yardstick competition," *Economics of Transition*, 14, 459.

BIGLAISER, G., AND C. MA (1995): "Regulating a dominant firm, unknown demand and industry structure," *RAND Journal of Economics*, 26, 1–19.

BOYER, M., AND J. LAFFONT (2003): "Competition and the reform of incentive schemes in the regulated sector," *Journal of Public Economics*, 87(1353-1381).

BOYLAUD, O., AND G. NICOLETTI (2000): "Regulation, market structure and performance in telecommunications," *World Bank*.

BRAINARD, S., AND D. MARTIMORT (1996): "Strategic trade policy design with asymmetric information and public contracts," *Review of Economic Studies*, 63(1), 81–105.

BRAINARD, S., AND D. MARTIMORT (1997): "Strategic trade policy with incompletely informed policymakers," *Journal of International Economics*, 42(1), 33–65.

CAILLAUD, B. (1990): "Regulation, competition and asymmetric information," *Journal of Economic Theory*, 52, 87–100.

COMBES, P., B. CAILLAUD, AND B. JULLIEN (1997): "Common market with regulated firms," *Annales d'Economie et Statistique*, 47.

CREMER, H., M. MARCHAND, AND J. THISSE (1989): "The public firm as an instrument for regulating an oligopolistic market," *Oxford Economic Papers*, 41, 283–301.

——— (1991): "Mixed oligopoly with differentiated products," *International Journal of Industrial Organization*, 9, 43–53.

CRÉMER, J., AND R. MC LEAN (1988): "Full extraction of the surplus in bayesian and dominant strategy auctions," *Econometrica*, 56(6), 1247–1258.

DE FRAJA, G. (1997): "Pricing and entry in regulated industries : the role of regulatory design," *Journal of Public Economics*, 64, 259–278.

DE FRAJA, G., AND F. DELBONO (1989): "Alternative strategies of a public enterprise in oligopoly," *Oxford Economic Papers*.

DOMAH, P., AND M. POLLIT (2001): "The restructuring and privatization of the regional electricity companies in England and Wales: a social cost-benefit analysis," *Fiscal Studies*, 22(1), 107–146.

FAURE-GRIMAUD, A. (1997): "The regulation of predatory firms," *Journal of Economics and Management Strategy*, 6(2), 425–451.

Hattori, T., and M. Tsutsui (2003): “Economic impact of regulatory reforms in the elettricity supply industry: a panel data analysis for OECD countries,” *Energy Policy*.

Hausman, J., G. Leonard, and J. Sidak (2002): “Does Bell Company entry into long-distance telecommunications benefit consumers?,” *Antitrust Law Journal*, 70(2), 463–484.

Helm, D., and T. Jenkinson (1998): *Competition in regulated industries*. Oxford University Press.

Laffont, J., and D. Martimort (2002): *The Theory of Incentives: The Principal-Agent Model*. Princeton University Press.

Laffont, J., and J. Tirole (1993): *A theory of incentives in procurement and regulation*. MIT Press.

Meggison, W., and J. Netter (2001): “From state to market: a survey of empirical studies on privatization,” *Journal of Economic Literature*, 39(2), 321–389.

Pollit, M. (1995): *Ownership and performance in electrical utilities: the international evidence on privatization and efficiency*. Oxford University Press.

Pollit, M., and A. Smith (2001): “The restructuring and privatization of British rail: was it really that bad?,” *Cambridge Working Papers*.

Pouyet, J. (2002): “Collusion Under Asymmetric Information: The Role of the Correlation,” *Journal of Public Economic Theory*, 4(4), 543–572.

Sappington, D., and J. Sidak (1994): “Anticompetitive behavior by state owned enterprises,” in *Competing with the Government: Anticompetitive Behavior and Public Enterprises*. Hoover Institution.

Shleifer, A. (1985): “A theory of yardstick competition,” *RAND Journal of Economics*, 16(3), 319–327.

——— (1998): “State vs Private Ownership,” *Journal of Economic Perspectives*, 4, 133–150.

Steiner, F. (2001): “Regulation, industry structure and performance in the elctricity supply industry,” *OECD Economic Studies*, 32.

Tangeras, T. (2002): “Collusion proof yardstick competition,” *Journal of Public Economics*, 83(2), 231–254.

Vickers, J., and G. Yarrow (1988): *Privatization: An Economic Analysis*. Mit Press.

Wilson, W. (1997): “Cost savings and productivity in the railroad industry,” *Journal of Regulatory Economics*, 11, 21–40.

Zhang, C., D. Parker, and Y. Kirkpatrick (2002): “Electricity sector reforms in developing countries: an econometric assessment of the effects of privatization, regulation and competition,” *University of Manchester*.

Appendix 1

Proof of Proposition 1:

The problem is given in 3. When the non-negativity constraints (5) and (6) are not binding, the solution is given by the first order condition $\frac{\partial W^{SI}}{\partial q_1} = 0$. Rearranging this condition we obtain the pricing rule associated with region D (no shut down case). If the non-negative constraint (5) is binding, then $q_1 = 0$ and firm 2 acts as a monopoly. Then, by definition, firm 2 produces its monopoly quantity defined as q_2^M, which induces a price equal $P(q_2^M)$ (region M2). If the non-negative constraint (6) is binding, there is a monopoly with firm 1. There are two different cases. If $P(q_1^M) < \theta_2$, then $r_2(q_1^M) = 0$ and $\frac{\partial r_2(q_1)}{\partial q_1}\Big|_{q_1=q_1^M} = 0$. Then, the second best solution is equivalent to the case of regulated monopoly, namely q_1^M associated with price $P(q_1^M)$ (region M). If $P(q_1^M) \geq \theta_2$, $\partial r_2/\partial q_1 > 0$ and (6) can be binding if and only if $P(Q) = \theta_2$ (region M1).

Linear Demand:

Replacing $S(Q) = Q - \frac{Q^2}{2}$ and $q_2 = \text{Max}\left[0, \frac{1}{2}(1 - q_1 - \theta_2)\right]$ in the social welfare function and maximizing with respect to q_1, we obtain:

$$\begin{aligned} q_1^{D,SI} &= \frac{1 + 2\lambda - 4\theta_1(1+\lambda) + \theta_2(3+2\lambda)}{1+4\lambda} \\ q_2^{D,SI} &= \frac{\lambda - \theta_2(2+3\lambda) + 2\theta_1(1+\lambda)}{1+4\lambda} \\ P(Q^{D,SI}) &= \frac{\lambda - \theta_2(1-\lambda) + 2\theta_1(1+\lambda)}{1+4\lambda} \end{aligned}$$

Moreover, we have:

$$\begin{aligned} q_2^{M,SI} &= \frac{1-\theta_2}{2} \\ P(q_2^{M,SI}) &= \frac{1+\theta_2}{2} \end{aligned}$$

To make a comparison with the case of regulated monopoly we derive the optimal price and quantity under monopoly in the case of linear demand:

$$\begin{aligned} q_1^{M,SI} &= \frac{(1+\lambda)(1-\theta_1)}{1+2\lambda} \\ P(q_1^{M,SI}) &= \frac{\lambda + \theta_1(1+\lambda)}{1+2\lambda} \end{aligned}$$

From these expressions we obtain the results in Proposition 2.

Appendix 2

Proof of Proposition 3:

The regulator maximizes the expected welfare (11), taking into account (10) and (4) The solution is obtained by the first order condition with respect to q_1, when this gives a positive quantity (i.e. $q_1 \geq 0$ not binding). If $q_1 = 0$, the expected price is given by the expected monopoly price of the competitor. This characterization of the expected price is summarized in Proposition 3.

Linear Demand:

We now consider the case of linear demand and θ_i distributed as in Assumption 4. In this case:

$$q_2 = \max\left[0, \frac{1}{2}(1 - q_1 - \theta_2)\right]$$

Notice that $q_2 = 0$ whenever $\theta_2 \leq 1 - q_1$. The optimal q_1 is obtained considering separately the two cases θ_1 in $[0, \frac{1}{2}]$ or θ_1 in $[\frac{1}{2}, 1]$. For any of the two cases, we have to consider the possibility that $1 - q_1 \leq \frac{1}{2}$ and $1 - q_1 \geq \frac{1}{2}$. We have thus four possible cases:

Case 1: Consider first θ_1 in $[0, \frac{1}{2}]$ and $[1 - q_1 \leq \frac{1}{2}]$ (i.e. $q_1 \geq \frac{1}{2}$). The objective is:

$$\begin{aligned}\max_{q_1 \in [\frac{1}{2},1]} \quad & \int_{1-q_1}^{\frac{1}{2}} \left[q_1 - \frac{q_1^2}{2} + \lambda(1 - q_1)q_1 - (1 + \lambda)\theta_1 q_1 - \lambda\theta_1 q_1\right] 2\, d\theta_2 + \\ & \int_0^{1-q_1} \left[q_1 + q_2 - \frac{(q_1 + q_2)^2}{2} + \lambda(1 - q_1 - q_2)q_1 - (1 + \lambda)\theta_1 q_1 - \theta_2 q_2 - \lambda\theta_1 q_1\right] 2\, d\theta_2\end{aligned}$$

The first order condition with respect to q_1 gives:

$$q_1 = \frac{1 + 2\sqrt{1 + 3\lambda(1 + \lambda) - 3\theta_1(1 + 2\lambda)^2}}{3(1 + 2\lambda)}$$

Case 2: Consider now θ_1 in $[0, \frac{1}{2}]$ and q_1 is such that $[1 - q_1 > \frac{1}{2}]$. The objective is in this case:

$$\max_{q_1 \in [0,\frac{1}{2}]} \int_0^{\frac{1}{2}} \left[q_1 + q_2 - \frac{(q_1 + q_2)^2}{2} + \lambda(1 - q_1 - q_2)q_1 - (1 + \lambda)\theta_1 q_1 - \theta_2 q_2 - \lambda\theta_1 q_1\right] 2\, d\theta_2$$

The first order condition gives:

$$q_1 = \frac{7 + 10\lambda - 16\theta_1(1 + 2\lambda)}{4\,(1 + 4\lambda)}$$

Case 3: Take θ_1 in $[\frac{1}{2}, 1]$ and q_1 such that $[1 - q_1 \leq \frac{1}{2}]$. The objective becomes:

$$\max_{q_1 \in [\frac{1}{2},1]} \int_{\frac{1}{2}}^1 \left[q_1 - \frac{q_1^2}{2} + \lambda(1 - q_1)q_1 - (1 + \lambda)\theta_1 q_1 - \lambda\theta_1 q_1\right] 2\, d\theta_2$$

The first order condition gives:

$$q_1 = \frac{2 + 3\lambda - 2\theta_1(1 + 2\lambda)}{2\,(1 + 2\,\lambda)}$$

Case 4: Take θ_1 in $[\frac{1}{2}, 1]$ and q_1 such that $[1 - q_1 > \frac{1}{2}]$. The objective becomes:

$$\begin{aligned}\max_{q_1 \in [0,\frac{1}{2}]} \quad & \int_{1-q_1}^{1} \left[q_1 - \frac{q_1^2}{2} + \lambda(1 - q_1)q_1 - (1 + \lambda)\theta_1 q_1 - \lambda\theta_1 q_1\right] 2\, d\theta_2 + \\ & + \int_{\frac{1}{2}}^{1-q_1} \left[q_1 + q_2 - \frac{(q_1 + q_2)^2}{2} + \lambda(1 - q_1 - q_2)q_1 - (1 + \lambda)\theta_1 q_1 - \theta_2 q_2 - \lambda\theta_1 q_1\right] 2\, d\theta_2\end{aligned}$$

The first order condition gives:

$$q_1 = \frac{(-1-4\lambda+2\sqrt{10+38\lambda+37\lambda^2-12\theta_1(1+2\lambda)^2}}{6(1+2\lambda)}$$

Checking for the second order condition an controlling for the fact that any quantity has to belong to the interval $[0,1]$, we have a solution of the form:

$$q_1^{D,AI} = \begin{cases} \frac{1+2\sqrt{1+3\lambda(1+\lambda)-3\theta_1(1+2\lambda)^2}}{3(1+2\lambda)}, & 0 \leq \theta_1 \leq \frac{5+2\lambda}{16(1+2\lambda)}; \\ \frac{7+10\lambda-16\theta_1(1+2\lambda)}{4(1+4\lambda)}, & \frac{5+2\lambda}{16(1+2\lambda)} \leq \theta_1 \leq \frac{7+10\lambda}{16(1+2\lambda)}; \\ 0, & \frac{7+10\lambda}{16(1+2\lambda)} \leq \theta_1 \leq \frac{1}{2} \text{ or } \frac{13+22\lambda}{16(1+2\lambda)} \leq \theta_1 \leq 1; \\ \frac{-1-4\lambda+2\sqrt{10+38\lambda+37\lambda^2-12\theta_1(1+2\lambda)^2}}{6(1+2\lambda)}, & \frac{1}{2} < \theta_1 \leq \frac{13+22\lambda}{16(1+2\lambda)}. \end{cases}$$

$$q_2^{D,AI} = \begin{cases} \max\left[0, \frac{2+6\lambda-3\theta_2(1+2\lambda)-2\sqrt{1+3\lambda(1+\lambda)-3\theta_1(1+2\lambda)^2}}{6(1+2\lambda)}\right], & 0 \leq \theta_1 \leq \frac{5+2\lambda}{16(1+2\lambda)}; \\ \frac{-3+6\lambda+16\theta_1(1+2\lambda)-4\theta_2(1+4\lambda)}{8(1+4\lambda)}, & \frac{5+2\lambda}{16(1+2\lambda)} \leq \theta_1 \leq \frac{7+10\lambda}{16(1+2\lambda)}; \\ \frac{1-\theta_2}{2}, & \frac{7+10\lambda}{16(1+2\lambda)} \leq \theta_1 \leq \frac{1}{2} \text{ or } \frac{13+22\lambda}{16(1+2\lambda)} \leq \theta_1 \leq 1; \\ \max\left[0, \frac{(7+16\lambda-6\theta_2(1+2\lambda)-2\sqrt{10+38\lambda+37\lambda^2-12\theta_1(1+2\lambda)^2}}{12(1+2\lambda)}\right], & \frac{1}{2} < \theta_1 \leq \frac{13+22\lambda}{16(1+2\lambda)}. \end{cases}$$

Appendix 3

All the results of Propositions 4-7 require to compute expectations with respect to θ_1 and θ_2. Under both symmetric and asymmetric information, we assume that the two parameters are distributed as in Assumption 5. Then, all expectations are obtained integrating across the different intervals characterized in Proposition 1 and 3. Using the quantities computed in Appendix 1, we can derive the explicit expressions for the different regions.

Under symmetric information we have:

$$\begin{aligned} M &= \left\{(\theta_1,\theta_2) \in [0,\frac{1}{2}] \bigcup (\theta_1,\theta_2) \in [\frac{1}{2},1] \text{ s.t. } \theta_1 \leq \frac{\theta_2(1+2\lambda)-\lambda}{1+\lambda}\right\} \\ M1 &= \left\{(\theta_1,\theta_2) \in [0,\frac{1}{2}]\ (\theta_1,\theta_2) \in [\frac{1}{2},1] \text{ s.t. } \frac{\theta_2(1+2\lambda)-\lambda}{1+\lambda} \leq \theta_1 \leq \frac{\theta_2(2+3\lambda)-\lambda}{2(1+\lambda)}\right\} \\ D &= \left\{(\theta_1,\theta_2) \in [0,\frac{1}{2}]\ (\theta_1,\theta_2) \in [\frac{1}{2},1] \text{ s.t. } \frac{\theta_2(2+3\lambda)-\lambda}{2(1+\lambda)} \leq \theta_1 \leq \frac{\theta_2(3+2\lambda)+1+2\lambda}{4(1+\lambda)}\right\} \\ M2 &= \left\{(\theta_1,\theta_2) \in [0,\frac{1}{2}]\ (\theta_1,\theta_2) \in [\frac{1}{2},1] \text{ s.t. } \theta_1 \geq \frac{\theta_2(3+2\lambda)+1+2\lambda}{4(1+\lambda)}\right\} \end{aligned}$$

Under asymmetric information:

$$
\begin{aligned}
M1 &= \left\{(\theta_1,\theta_2)\in[0,\frac{1}{2}] \text{ s.t. } \theta_1 \leq \frac{4\theta_2(1+3\lambda)-4\lambda-3\theta_2^2(1+2\lambda)}{1+2\lambda}\right\}\\
&\quad \bigcup \left\{(\theta_1,\theta_2)\in[\frac{1}{2},1] \text{ s.t. } \theta_1 \leq \frac{4\theta_2(7+16\lambda)-12\theta_2^2(1+2\lambda)-3(1+6\lambda)}{16(1+2\lambda)}\right\}\\
D &= \left\{(\theta_1,\theta_2)\in[0,\frac{1}{2}] \text{ s.t. } \frac{4\theta_2(1+3\lambda)-4\lambda-3\theta_2^2(1+2\lambda)}{1+2\lambda} \leq \theta_1 \leq \frac{7+6\lambda}{16(1+2\lambda)}\right\}\\
&\quad \bigcup \left\{(\theta_1,\theta_2)\in[\frac{1}{2},1] \text{ s.t. } \frac{4\theta_2(7+16\lambda)-12\theta_2^2(1+2\lambda)-3(1+6\lambda)}{16(1+2\lambda)} \leq \theta_1 \leq \frac{13+22\lambda}{16(1+2\lambda)}\right\}\\
M2 &= \left\{(\theta_1,\theta_2)\in[0,\frac{1}{2}] \text{ s.t. } \theta_1 \geq \frac{7+6\lambda}{16(1+2\lambda)}\right\} \bigcup \left\{(\theta_1,\theta_2)\in[\frac{1}{2},1] \text{ s.t. } \theta_1 \geq \frac{13+22\lambda}{16(1+2\lambda)}\right\}
\end{aligned}
$$

The thresholds k^{SI}, k^{AI}, k_2^{SI}, k_2^{AI} and the threshold value of Proposition 7 are obtained as analytical functions of λ integrating above these intervals of realizations of θ_1 and θ_2. The study of the behavior of these functions gives all the results described in Proposition 4-7 (more details are available on request).