UNIVERSITÉ DE TOULOUSE 1 – SCIENCES SOCIALES
MIDI-PYRÉNÉES SCIENCES ÉCONOMIQUES

THÈSE

Pour le Doctorat es Sciences Économiques

GESTION ET RÉGLEMENTATION DES INFRASTRUCTURES

Présentée et soutenue publiquement le lundi 9 décembre 2002 par

CYRIL HARITON

sous la direction de

JACQUES CRÉMER

MEMBRES DU JURY

Bernard CAILLAUD, Professeur à l'École Nationale des Ponts et Chaussées (rapporteur)

Jacques CRÉMER, Directeur de recherche CNRS à l'Université Toulouse 1

Gérard GAUDET, Professeur à l'Université de Montréal (rapporteur)

Bruno JULLIEN, Directeur de Recherche CNRS à l'Université Toulouse 1

Patrick REY, Professeur à l'Université Toulouse 1

L’Université n’entend ni approuver ni désapprouver
les opinions particulières du candidat.

Table des matières

Table des figures

Liste des tableaux

Chapitre 2

Réglementation, facilité essentielle et extraction de rente

(Regulation, essential facility and rent extraction)

2.1 Introduction

Should a social planner regulate a downstream industry which purchases an input from an unregulated upstream essential facility? Would this essential facility seller benefit from the regulation of the final market? This chapter shows that when the essential facility seller uses non-linear tariffs and has bargaining power, first, it obtains a higher profit when regulation occurs and, second, it is better for the society not to regulate the downstream industry. Thus, this works suggests that regulators should take a more in-depth look at the upstream structure faced by the potentially regulated industry and *a priori* deny regulation of such industries.

Regulatory motivations. Usual candidates for regulation are "natural monopolies", i.e. firms characterized by subadditive cost functions.[1] This basically means that a single firm can supply the market at lower cost than two or more firms having the same cost function. In these cases, there is *a priori* neither social nor private interest to duplicate the production process and costs. The concept of

[1] Please refer to Tirole (1988, pp. 19-20), Sidak and Spulber (1997, pp. 20-25) or Laffont and Tirole (2000, Introduction).

natural monopoly was first proposed by Walras (1897), who suggested to price the product of these socially efficient monopolies by balancing their budget, and was followed by the optimal pricing rule under budget constraint developed by Boîteux (1956).[2] Thus, the property of "natural monopoly" is highly constrained by the technology available at the time, justifying the study of cost structure to assess subadditivity and the scrutiny of potential changes in this assessment (and the subsequent potential change in regulatory regime) when new technologies show up.[3]

Other elements may also justify some kind of regulation. Typically, production technologies that exhibit economies of scale are less costly to install, on a per user basis, in dense area (towns, e.g.) than in areas where the population is wide-spread (country-side, e.g.). This is the case for all networks industries, such as telecommunications (with the exception of satellite telecommunications), gas, postal services or railways, where operators used to be public or private regulated firms. Most of them have experienced technologies exhibiting subadditivity but, even if currently they do not *per se* require regulatory scrutiny, considerations such as redistribution and regional planning may impose some kind of universal service obligations on firms. These obligations typically consist in "a set of basic services that must be made available at an affordable price to all users by public or private operators irrespective of the user's geographical location," including high-cost areas.[4] This concern was previously solved internally by the former regulated monopolies through cross-subsidizations between high margin services (usually urban ones for the business community) and subsidized ones (often rural), ending with, e.g., an identical price for all geographical areas. After deregulation, universal service obligations funding and allocation had to be defined again with, e.g., taxes to raise specific budgets for these obligations and auctions to select firms in charge of their production.[5]

[2] Boîteux (1956) first studied the optimal pricing rule of a monopoly under budget constraint. Ramsey (1927) exhibited the same mathematical formula while studying a problem of indirect optimal taxation. This explains why this way of price fixing is often called *à la Ramsey-Boîteux*.

[3] This statement does not mean that the deregulation process, which is taking place in most of the network industries, has only been originated by technological changes. Indeed, as argued by Laffont and Tirole (2000, pp. 7-13) and Combes, Jullien and Salanié (1997, pp. 21-24), other factors have played a major role in this process such as the "growing awareness of the inefficiency of the incumbent monopolist" or the complexity of the regulation of industries with complex, numerous and increasingly new products/services.

[4] This is the generic definition given by the European Commission, in its website on the information society [http://europa.eu.int/information_society/glossary/index_en.htm#u]. Similar definitions can be found in several countries. In the United States, e.g., universal service for telecommunications is defined in section 254 of the "Telecommunication Act" of 1996 [http://www.fcc.gov/Reports/tcom1996.txt] as services "ensuring quality telecommunications services at affordable rates to consumers, including low-income consumers, in all regions of the nation, including rural, insular, and high cost areas" (as quoted by Laffont and Tirole 2000, p. 254).

[5] Please refer to Caillaud and Tirole (2000) for a formal study of the funding of an essential facility.

These are the main lines of the rationale yielding to the regulation of an industry. Nevertheless, as this chapter will argue, regulated industries characterized by an essential input sold through non-linear tariffs by an upstream monopolist require specific attention. And there are many important such industries.

Patents. The pharmaceutical industry is one of them. One of the main feature of this industry is that it is very R&D intensive. Laboratories protecthe t their investments by patenting their innovations in order to maintain a temporary legal monopoly on the use (and the related sale) of new medications in the development of drugs.[6]

Thus, investments in R&D are critical and substantial. According to OECD (2001, section A.6.3 on health-related R&D), R&D expenditure in pharmaceuticals represented a high ratio of GDP in developed countries, e.g. close to 0.47% in Sweden, 0.29% in the United Kingdom, 0.25% in Belgium and 0.24% in Denmark. Moreover, the share of pharmaceutical R&D in business sector R&D is also high in the United Kingdom and Denmark where they account for approximately 20% of total business R&D expenditure and, while the ratio of pharmaceutical R&D to GDP is low in Italy and Spain, this sector accounts for a significant share of total business R&D in both countries.

Once patented, the production of these medications typically takes one of two forms: (1) the laboratories produce the drugs themselves for all the geographical markets they serve; or (2) the laboratories delegate the production for some local markets to other firms which buy a license. Among these two possibilities, the latter is one of the most common choice. According to Shy (1996, chapter 9, p. 239), 80% of the inventions granted patents over all industries are licensed to other firms. Moreover, licensing contracts are typically non-linear and the sale of drugs to consumers is often regulated by the country in which they are sold.

These two elements are noticeable with respect to the formal analysis done in this chapter : the local firms are regulated and must purchase, through non-linear tariffs, an input, the license, from a firm that has monopoly power on this input.[7]

[6] Please refer to Viscusi et al. (2000, chapter 24, pp. 799-835) for a detailed description of the intensity of R&D in this industry and a presentation of the main insights related to the economic background on patents, i.e. the trade-off between monopolization and innovation, as well as insights on the central role of patents in the pharmaceutical industry.

[7] Of course, this example is only illustrative of the regulatory concerns studied in this chapter. Clearly, other significant elements of the pharmaceutical industry, such as specific regulatory elements related to the very nature of drugs

Infrastructure. Transportation related infrastructures, such as tunnels, airports or car parks, are another example. As they often require high level of financing, governments usually authorize long-term concessions to either fully or semi-private firms which most of the time have some degree of flexibility to fix (non-linear) prices. In a dynamic setting where the government may change over the duration of the concession, political priorities may also evolve, inducing different objective functions for the social planner at different points in time. Consider the following example. A first government that does not take fully into account consumer surplus, or alternatively that overweight firms profits, grants a contract to a firm in order to rule an underground car park. Qualitatively speaking, the concession contract will yield generous (short term, at least) profits for the firm. Imagine now that a change in the government occurs that sets a more “social welfare oriented” target. The new social planner would then want to renegotiate the concession contract in order to perform better with respect to its objective. In that case, it faces the concession owner that exhibits high market power due to, first, the terms and duration of its concession and, second, the dissuasive cost of any substitute. Once again, the same structure is present where a regulator may intervene in a final market but must deal with an upstream essential facility with high market power.

The framework. This chapter studies a model with a foreign monopoly uses non-linear tariffs (two-part tariffs) to sell an essential input to a local firm regulated by a domestic agency. The domestic regulator maximizes national social welfare and faces some constraints on its ability to raise funds. The goal of this chapter is to understand what are the benefits and costs of regulation and to exhibit the fundamentals and the limitations of the trade-off between efficiency and rent extraction.

Through all this chapter, except in section 2.9, the regulator faces an exogenous shadow cost of public funds caused by distorting taxation and regulates the downstream firm that needs the essential facility. This shadow cost of public funds is justified by two main assumptions. First, the regulator cannot benefit from first best lump-sum taxes to raise money but is restricted to the use of distorting tools. Second, the level of funds needed by the industry studied must be low with respect to the

and their high political and social interests, competition by generic drugs or R&D cycles, would have to be taken into consideration to reflect the economic background of this industry.

overall level of public funds raised by the government, leaving the distortion unrelated to the industry financial needs.

Then, in order to study how the results are affected by a change in the regulatory framework, section 2.9 studies a situation where the regulator faces a unique budget constraint for all regulated activities. These activities include the downstream firm that needs the essential facility and other unrelated firms with regulated final markets. The regulator has no access to any external source of public funds. In particular, money transfers between the government and the regulated firms other than revenues from the final markets are prohibited. Thus, the regulator can raise funds, if necessary, only through profits of the firms it regulates, ending up with an endogenous cost of public funds.[8]

Methodology. In a first part, the regulator is given two alternatives: to regulate the downstream firm or, as an outside option, to abandon the production of the final good. In a second part, the regulator has the opportunity either to regulate the industry or to shut it down, as before, or to let the industry unregulated, upstream and downstream firms being left free to contract together. Then, a few extensions are explored. What happens if the upstream firm is a domestic unregulated firm? If all parties have some degree of bargaining power? If there is asymmetric information between the downstream firm and both the upstream firm and the regulator? If the regulatory framework differs?

Main results. When the upstream firm has all the bargaining power, it is shown, first, that the upstream firm benefits from the downstream benevolent regulation because it can always extract more rent when there is regulation. More importantly, domestic consumers are hurt by the activity of the regulator even if they face lower prices with regulation. Consequently, it is better to leave the downstream firm unregulated. These two results are robust to various extensions (national but unregulated upstream firm, bargaining power, asymmetric information and a different regulatory framework) which mainly alter the level of rent extracted but not the two core results.[9]

The intuition behind the main results is simple. Take the case where the upstream firm has all the bargaining power. Basically, the industry structure[10] can take two simple shapes: either the

[8] These two regulatory models are often named, respectively, *à la Laffont-Tirole* and *à la Ramsey-Boîteux*.

[9] As far as bargaining power is concerned, the two results remain valid on a relevant set of parameter (measuring bargaining power) values.

[10] The industry structure is described in more details, for the two frameworks, by figures 2.1 (p. 58) and 2.5 (p. 86).

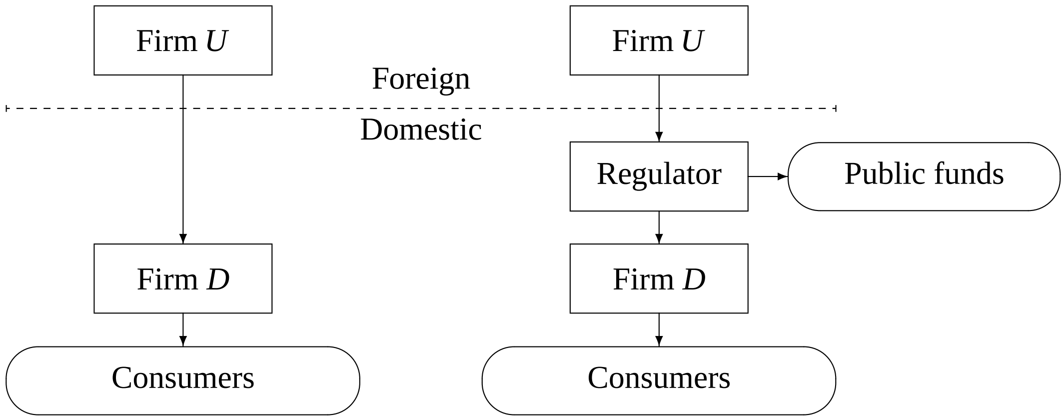

Figure 2.1: The industry vertical structure with exogenous cost of public funds: without (left) or with (right) regulation

downstream firm is not regulated and firms contract directly, or the regulator chooses the final output and the upstream firm contracts with the regulator. Without regulation, the upstream firm extracts, with a simple two-part tariff, a profit equal to the maximum profit of the structure made of both the upstream and the downstream firms. Under regulation, the same mechanism applies and it can extract all the utility of its contractual partner, i.e. not only the profit of the vertically integrated industry but all the increase in social welfare due to the consumption of the product. Therefore, the upstream firm will end with a higher profit under regulation and the regulator will, if possible, not regulate the downstream firm.

This chapter is organized as follows. Section 2.2 describes the formal model. Section 2.3 deals with some benchmark cases. Section 2.4 analyzes the equilibrium when the regulator is given two choices: either to regulate the downstream firm or to shut it down. Section 2.5 supplements the set of choices of the regulator by allowing him not to regulate the downstream firm. The following sections test the robustness of the result by relaxing, in section 2.6, the assumption that the essential facility is a foreign undertaking and by introducing, in section 2.7, shared bargaining power or, in section 2.8, some kind of asymmetric information between the downstream firm and both the upstream firm and the regulator. Then, section 2.9 turns to the study of regulation *à la Ramsey-Boîteux*. Finally, section 2.10 summarizes the results, discusses further extensions and concludes. All proofs are detailed in the appendix (section 2.C, page 102).

2.2 Regulation with exogenous cost of public funds

Economy. An upstream monopoly, firm U, sells an essential input to a regulated downstream monopoly, firm D. These two firms are located in two different countries. In order to produce q_1 units of good 1, firm D must purchase q_1 units of good 0 from firm U. The national economy consists of firm D, the consumers of good 1 and the domestic regulator (hereafter, the regulator) who maximizes national social welfare. Firm U is a foreign undertaking, is not regulated and its profit is not included in national social welfare. Moreover, firm U is assumed to have all the bargaining power in any negotiation.

Upstream sector. Firm U sells q_0 units of good 0 at a cost[11] $C^U(q_0) = F^U + c^U q_0$, with a two-part tariff $T^U(q_0) = H_0 + p_0 q_0$. This simple cost specification allows us to exhibit in a simple way the optimal two-part tariff and does not change the nature of the argument developed here. Firm U's profit function is then

$$\pi^U(q_0) = H_0 + p_0 q_0 - F^U - c^U q_0. \tag{2.1}$$

Downstream sector. The cost of firm D, exclusive of the two-part tariff T^U, is $C^D(q_1)$ with a constant fixed cost F^D which is assumed not to be sunk. The implicit assumption, made while assuming the existence of a fixed cost F^D is the *a priori* necessity for this industry to be regulated. Of course, more fundamentally, C^D needs to be subadditive. It would then be sufficient to assume that on top of the fixed cost, C^D is characterized by a constant marginal cost in order to get this property. Nevertheless, the cost function is not restricted more than by the existence of a fixed cost.[12] This eases the description of the trade-off and does not modify the intuition behind the results. When firm D is regulated, there is no loss of generality in assuming that the cost C^D and the tariff T^U are paid by the regulator which also receives all the revenues from the sale of good 1. Then, firm D receives a net transfer t and its profit function is

$$\pi^D = t. \tag{2.2}$$

[11] In general, superscripts are used to distinguish between firms (U and D) or situations (vi for "vertically integrated", R for "regulated") and subscripts denote markets (0 and 1) or derivatives (q).

[12] It is also necessary to assume that the cost function is such that maximization programs have an overall solution.

Finally, let denote V the vertically integrated firm, that is the hypothetical firm created by the merger of firms U and D, with $C^D(q_1) + C^U(q_1)$ as its cost function.

Consumers. The consumers gross surplus is $S_1(q_1)$ with $S_{1q}(q_1) = p_1(q_1)$ the inverse demand function and $S_{1qq} < 0$. As usual, consumers do not take into account the existence of the distortion due to the shadow cost of public funds λ in their decision to consume good 1.

Regulator. The regulator is characterized by an exogenous cost of public funds λ: for each euro spent by the regulator, the cost to the society is $(1+\lambda)$ euros. This assumes that the regulator does not have access to ideal lump-sum taxes but must use, in order to raise funds to finance the regulated downstream monopoly, distorting taxes such as taxes on labor, capital and excise taxes.[13] Moreover, if one assumes that the final product production cost and demand are not correlated to other goods potentially regulated by the government, then regulation of one product, in terms of prices or quantity, does not affect other regulated markets unless there are some restrictions on the allocation of funds between these industries. This is not the case because, in this chapter except in section 2.9, the cost of public funds is assumed to be exogenous and constant. Therefore, the regulator maximizes national social welfare

$$\begin{aligned} \mathrm{SW} &= [S_1(q_1) - p_1(q_1)q_1] + [t] - (1+\lambda)\left[t + C^D(q_1) + T^U(q_1) - p_1(q_1)q_1\right], \\ &= S_1(q_1) + \lambda p_1(q_1)q_1 - \lambda t - (1+\lambda)\left[C^D(q_1) + T^U(q_1)\right]. \end{aligned} \tag{2.3}$$

All information is common knowledge. Before detailing the timing of the game, two benchmark cases are studied for comparison convenience.

[13]More insights on the background of a regulatory framework *à la Laffont-Tirole* can be found in the introductive chapter of Laffont and Tirole (1993).

2.3 Benchmark cases

2.3.1 Regulation of both firms

Regulating both firms is equivalent to regulating firm V. In this case, social welfare becomes, omitting the arguments and assuming the same regulatory mechanism as the one described in section 2.2,

$$\mathrm{SW} = S_1 + \lambda p_1 q_1 - \lambda t - (1+\lambda)\left[C^D + C^U\right],$$

where t stands for the net transfer from the regulator to firm V. Maximizing social welfare under the participation constraint that firm V's profit should be positive, i.e. $t \geq 0$, yields this constraint to be binding and production[14] to be q_1^{viR} such that

$$q_1^{viR} = \arg\max_{q_1}\left[S_1(q_1) + \lambda p_1(q_1)q_1 - (1+\lambda)\left[C^D(q_1) + C^U(q_1)\right]\right]$$

which is equivalent to

$$p_1\left(q_1^{viR}\right) - C_q^D\left(q_1^{viR}\right) - C_q^U\left(q_1^{viR}\right) + \frac{\lambda}{1+\lambda} p_{1q}\left(q_1^{viR}\right)q_1^{viR} = 0. \tag{2.4}$$

It is assumed that the second order condition is satisfied and that there is a unique solution. Thus, regulating both firms yields an outcome q_1^{viR} which is socially efficient and which generates the highest total social welfare level possible in this setting, noted SW^{viR}.

2.3.2 No regulation at all

Without regulation, firm U, which has all the bargaining power, can extract the same profit that firm V could get from the final market, i.e. quantity[15] q_1^{vi} that maximizes firm V's profits

$$q_1^{vi} = \arg\max_{q_1}\left[p_1(q_1)q_1 - \left[C^D(q_1) + C^U(q_1)\right]\right],$$

[14] Superscript *viR* stands for "vertically integrated and regulated".
[15] Superscript *vi* stands for "vertically integrated".

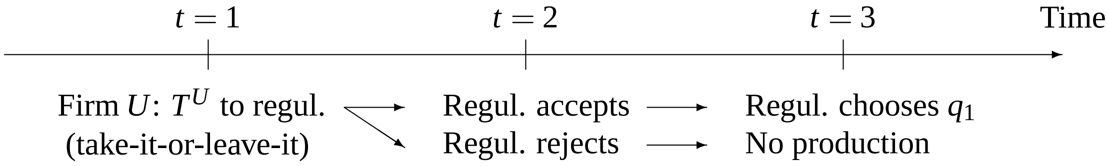

Figure 2.2: Timing of the game: regulation vs no production

which is equivalent to

$$p_1\left(q_1^{vi}\right) - C_q^D\left(q_1^{vi}\right) - C_q^U\left(q_1^{vi}\right) + p_{1q}\left(q_1^{vi}\right) q_1^{vi} = 0.$$

It is also assumed that the second order condition is satisfied and that there is a unique solution. The associated profit is noted π^{vi}.[16]

Lemma 2.1. *Without regulation, the optimal two-part tariff for firm U is $T^U\left(q_1\right) = \pi^{vi} + F^U + c^U q_1$. The quantity produced is q_1^{vi}. Firm U's profit is π^{vi} and social welfare is $S_1\left(q_1^{vi}\right) - p_1\left(q_1^{vi}\right) q_1^{vi}$. Firm D gets zero profit.*

This is the *no-regulation tariff* tariff which the upstream firm U proposes if there is no regulation of the downstream firm D.

2.4 Socially harmful regulation

Let us now examine the game in which the regulator regulates firm D. In order to model the bargaining power of U, the following game is studied: first, firm U makes a take-it-or-leave-it offer[17] to the regulator, which consists in a two-part tariff $T^U\left(q_1\right) = H_0 + p_0 q_1$; second, the regulator decides whether to accept the tariff and computes the optimal contract for firm D.

[16] All proofs are collected in the appendix.

[17] For an extension with a more balanced bargaining power, please refer to section 2.7.

2.4.1 Strategy of the regulator

In the second stage, if the regulator has accepted the tariff T^U, it faces the following problem

$$\max_{q_1,\pi^D}\left[S_1+\lambda p_1 q_1-\lambda\pi^D-(1+\lambda)\left(C^D+H_0+p_0q_1\right)\right]$$

subject to the participation constraint of firm D: $\pi^D \geqslant 0$.

Standard results are obtained

$$\begin{cases} p_1\left(q_1^*\right)-C_q^D\left(q_1^*\right)-p_0+\frac{\lambda}{1+\lambda}p_{1q}\left(q_1^*\right)q_1^*=0, \\ (1+2\lambda)\,p_{1q}(q_1^*)+\lambda p_{1qq}(q_1^*)q_1^*-(1+\lambda)C_{qq}^D\left(q_1^*\right)\leq 0, \\ \pi^D=0. \end{cases} \tag{2.5}$$

It is assumed that the second order condition is satisfied and that the first order condition has a unique solution $q_1^*\left(p_0\right)$ for any proposed p_0. Notice from the above system that, first, q_1^* depends on p_0 but is independent of H_0 (this is true unless the constraint specified next section is not binding) and that, second, the variation of q_1^* with respect to p_0 is set by

$$\frac{dq_1^*}{dp_0}=\frac{1+\lambda}{(1+2\lambda)\,p_{1q}\left(q_1^*\right)+\lambda p_{1qq}\left(q_1^*\right)q_1^*-(1+\lambda)C_{qq}^D\left(q_1^*\right)}<0. \tag{2.6}$$

If there is no production, the social welfare is $S_1(0)$. Thus, the regulator accepts T^U as long as social welfare with production is greater than $S_1(0)$.

2.4.2 Strategy of the upstream firm

Suppose firm U proposes the *no-regulation* tariff $T^U\left(q_1\right)=\pi^{vi}+F^U+c^U q_1$.

Lemma 2.2. *The regulator chooses a positive production if the upstream firm U proposes the* no-regulation *tariff.*

In that case, the regulation of firm D is not costly for firm U, but neither is it beneficial. Firm U can extract from the regulator what it could obtain directly from firm D in the absence of regulation. This tariff ends up with a high price but consumers preserve part of their surplus.

But is it the best strategy for firm U? With linear prices in the downstream sector, the downstream firm is usually not able to extract all the consumers' surplus. Therefore, when contracting with firm D, the upstream firm cannot gain more than the maximum profit of the vertically integrated firm (what firm U gets with its *no-regulation* tariff) and consumers keep this net surplus.[18] But, here, the upstream firm contracts with the regulator. For this latter, consumer surplus is part of its social welfare objective function and it has a strictly positive value. To abandon the production is therefore more costly for the regulator than for firm D. Moreover, the regulator has access to an extra source of financing, its public funds. To sum up, the regulator has a higher value for production and more money to pay for the essential facility.[19] Therefore, if firm U acts optimally, it should ask the regulator to pay at least for part of this consumer net surplus.

Proposition 2.1. *Firm U always obtains a greater profit when the downstream firm D is regulated. Moreover, the optimal two-part tariff for firm U is* $T^U(q_1) = \frac{1}{1+\lambda}\left[\mathrm{SW}^{viR} - S_1(0)\right] + F^U + c^U q_1$, *which yields a profit of* $\pi^U = \frac{1}{1+\lambda}\left[\mathrm{SW}^{viR} - S_1(0)\right]$ *and a final production* q_1^{viR}. *The level of social welfare is* $S_1(0)$. *Firm D gets zero profit.*

Lemma 2.3. *The profit of the upstream firm is decreasing in* λ.

The profit of firm U can be rewritten

$$\pi^U = \left[p_1^{viR} q_1^{viR} - C^U\left(q_1^{viR}\right) - C^D\left(q_1^{viR}\right)\right] + \frac{1}{1+\lambda}\left[S_1^{viR} - S_1(0) - p_1^{viR} q_1^{viR}\right].$$

This expression clearly demonstrates that the regulation of firm D allows firm U to indirectly collect part of the consumer net surplus (second term) on top of the vertically integrated monopoly profit when producing good 1 in quantity q_1^{viR} (first term). Because consumers do not pay directly firm U, the real cost for the regulator of an additional ε asked by firm U is $(1+\lambda)\varepsilon$, which explains the multiplicative factor in front of the net consumer surplus in the tariff.

[18] Other tools than non-linear prices may also be used in the downstream sector to extract consumer surplus. For instance, in another regulatory context, Segal (1998) uses the soft budget constraint to show that a monopoly can extract part of the social surplus in the form of a state subsidy.

[19] In other words, the upstream firm U can consider the regulator as a firm whose objective function is the sum of social welfare, consumer surplus and the cost of public funds. By using its non-linear tariff, firm U is able to extract all the surplus from this new downstream firm.

The intuition of this result is simple. Firm U has to set (H_0, p_0) such that it respects the acceptance constraint of the regulator that it gets at least as much as without producing good 1

$$S_1(q_1^*) + \lambda p_1(q_1^*) q_1^* - (1+\lambda)\left(C^D(q_1^*) + H_0 + p_0 q_1^*\right) \geq S_1(0)$$

and maximizes its profit. Assume that p_0 is fixed to c^U. Then, only H_0 remains to be set. What happens for the regulator if H_0 is increased? Each euro more in the fixed part, departing from an arbitrary low value, decreases social welfare in the following way

$$\frac{d\,\mathrm{SW}\left(q_1^*\left(H_0, c^U\right), H_0, c^U\right)}{dH_0} = \frac{\partial\,\mathrm{SW}(q_1^*, H_0, p_0)}{\partial q_1}\frac{dq_1^*}{dH_0} - (1+\lambda) = -(1+\lambda) < 0.$$

The first partial derivative is null because q_1^* is the best choice of the regulator given H_0 and p_0. Thus, by asking for one euro more, firm U increases its profit by one euro and decreases social welfare by one euro and λ, the cost of public funds associated to the extraction of this extra euro. This remains true until social welfare reaches the level $S_1(0)$. Let now move to the incentive of firm U to depart from unit price at marginal cost. The consequences in terms of social welfare of increasing p_0 are given by

$$\frac{d\,\mathrm{SW}(q_1^*(H_0, p_0), H_0, p_0)}{dp_0} = \frac{\partial\,\mathrm{SW}(q_1^*, H_0, p_0)}{\partial q_1}\frac{dq_1^*}{dp_0} - (1+\lambda) q_1^* = -(1+\lambda) q_1^* < 0.$$

But what is the consequence for firm U in terms of profit? If one does not take into account the constraint on social welfare level, increasing H_0 and p_0 yields

$$d\pi^U = \left[1 + \left(p_0 - c^U\right)\frac{dq_1^*}{dH_0}\right] dH_0 + \left[q_1 + \left(p_0 - c^U\right)\frac{dq_1^*}{dp_0}\right] dp_0,$$

with $\frac{dq_1^*}{dH_0} = 0$ until the constraint on social welfare is binding, and $\frac{dq_1^*}{dp_0} < 0$. On the one hand, increasing p_0 from c^U induces a gain of q_1 and narrows the margin on the constraint (that is reduces social welfare) by $(1+\lambda) q_1^*$. On the other hand, increasing H_0, still from the situation where $p_0 = c^U$, induces a gain in profit of 1 and narrows the margin on the constraint of $(1+\lambda)$. At $p_0 = c^U$, the gains in terms of direct profit of increasing either p_0 or H_0 equal the loss in terms of constraint margin. But as far as one departs from $p_0 = c^U$, this is not true any more as there is a lower gain in increasing p_0 ($\frac{dq_1^*}{dp_0} < 0$) than the reduction in terms of the constraint, compared to an increase in H_0. Increasing p_0 raises less "realized" profit than it limits "potential" ones by restraining the margin between the "realized" level of social welfare and the threshold level of $S_1(0)$. Thus the upstream firm has an interest in keeping $p_0 = c^U$ in order to keep the "cake" as big as possible and to extract all the social surplus through the fixed part of its tariff.

Finally, there are five interesting features of these results. First, when firm U maximizes its profits, its objective function becomes qualitatively identical to the one of the regulator when this latter regulates a vertically integrated monopoly. This translates the interest of firm U to generate the highest reachable total welfare level in order to extract it for its own benefit.

Second, as exhibited above, there is a separation in the role of p_0 and H_0. The first instrument p_0 is used to generate the highest social welfare, that is, induces socially efficient production, whereas H_0 is chosen to extract all social welfare just short of causing rejection of the tariff. This is a standard feature of vertical relationships with non-linear tariffs.

Third, consumers pay less for the good in the presence of regulation, as $p_1^{viR} < p_1^{vi}$. In a sense, they do not feel directly the effect of the rent extraction but rather *indirectly* through transfers generating the cost of public funds, i.e. through imperfect taxation.

Fourth, as the rent extracted by the upstream firm is decreasing in λ, the essential facility seller is better off dealing with countries characterized by low shadow cost of public funds, keeping cost and demand functions similar. In particular, this shadow cost is estimated[20] at around 30% in Western European countries, whereas it is often suggested to be up to 100% or more in some developing ones. In these countries, the upstream firm's profit is therefore *a priori* limited by the high cost to the regulator of raising money.

Finally, the equilibrium level of social welfare is equal to $S_1(0)$ and all the benefits derived from the production of good 1 are taken by firm U. Thus, with regulation, national social welfare is as low as if there were no production, despite the fact that the level of production is second-best[21] optimal. The natural question raised by this result is whether regulation is worthwhile.

[20] See Laffont and Tirole (1993, p. 38) and Ballard, Shoven and Whalley (1985) for discussions of the computation of the values of the parameter λ.

[21] The presence of λ does not allow to reach the first-best in this kind of model.

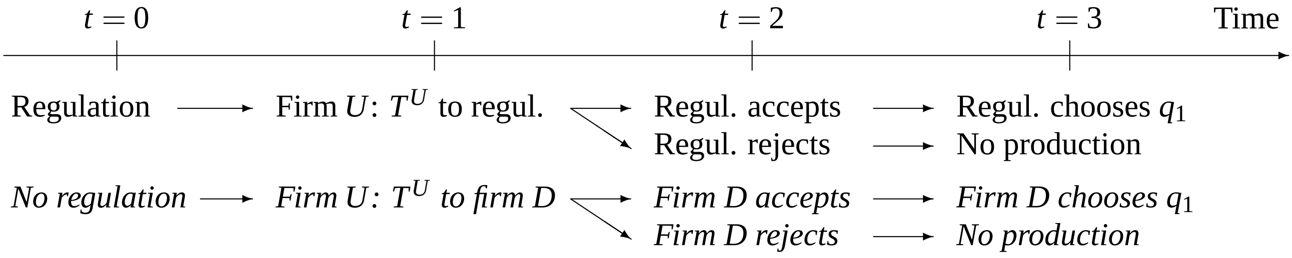

Figure 2.3: Timing of the game: regulation vs vertical contract

2.5 Endogenous decision to regulate

To handle this question, it is assumed that, in a first period, the regulator decides whether or not to regulate firm D. In a second period, firm U proposes a two-part tariff to the regulator if there is regulation, to firm D otherwise. In a third period, the tariff is accepted or rejected by the regulator if there is regulation, by firm D otherwise.

If, in the first period, the regulator decides to regulate firm D, social welfare is equal to $S_1(0)$, as shown in section 2.4. On the other hand, in the absence of regulation, social welfare is equal to $S_1\left(q_1^{vi}\right) - p_1\left(q_1^{vi}\right) q_1^{vi}$, as shown in section 2.3. Social welfare is higher without regulation, and this proves the following proposition.

Proposition 2.2. *The regulator never chooses to regulate firm D.*

Comparisons are summarized in table 2.1. Finally, the regulator does not regulate firm D, firm U extracts only π^{vi}, the final production is q_1^{vi} and firm D gets zero profit. Thus, the consumers are better off when there is no regulation even if they consume less ($q_1^{vi} < q_1^{viR}$).[22]

One can wonder what happens when the choice to regulate or not the downstream firm is given to the regulator after the two-part tariff is proposed by the upstream firm. If this was the case, given the two-part tariff T^U, the regulator computes first the optimal contract for the downstream firm when it decides to regulate it and, second, the social welfare level if it does not regulate this latter. But the optimal two-part tariff for firm U still remains the one described in lemma 2.1. Indeed, when facing this two-part tariff, the regulator compares its two potential possibilities: either it does not regulate,

[22]More precisely, consumers are worth off without regulation if they do not take into account the distortion induced by taxation, which is constantly assumed throughout this framework *à la Laffont-Tirole*. Nevertheless, when all effects are discounted, then they are better off because the absence of regulation avoids costly taxation distortions.

Perfect information	Regulation		No regulation
Production of good 1	q_1^{viR}	$>$	q_1^{vi}
Social welfare	$S_1(0)$	$<$	$S_1\left(q_1^{vi}\right) - p_1\left(q_1^{vi}\right) q_1^{vi}$
Firm U's profit	$\frac{1}{1+\lambda}\left[\mathrm{SW}^{viR} - S_1(0)\right]$	$>$	π^{vi}

Table 2.1: Results on the opportunity of regulating the downstream firm

but firm D cannot accept T^U because there is no way to respect its participation constraint, so there is no production; either it accepts the tariff which induces production at a level q_1^{viR}. It is clear that the choice of the regulator is not to use its power of refusing to regulate firm D but to accept the contract, which is the best firm U could have. Thus, in order to be worth it, the no-regulation outside option should be given before firm U proposes its tariff.

Nevertheless, this equilibrium is not Pareto optimal. Faced with the optimal two-part tariff described by lemma 2.1, the regulator would prefer to regulate firm D, while keeping unchanged the tariff. The price would then be set to p_1^{viR} which will increase social welfare while leaving unchanged firm U's profit, which is equal to π^{vi} irrespective of the production level.[23] Therefore, there is place in our model to introduce other bargaining procedures in order to reach a better final equilibrium for both agents. This is done in section 2.7.

Finally, one can still question the ability of the regulator to commit not to regulate at the equilibrium. Let begin with the case where the decision is made not to regulate. On the one hand, the equilibrium of this sub-game predicts $S_1\left(q_1^{vi}\right) - p_1^{vi}\left(q_1^{vi}\right) q_1^{vi}$ as final social welfare. On the other hand, were firm U to deviate from its predicted strategy and ask for more than what the downstream firm can pay, there will be no contract and no production, inducing $S_1(0)$ as social welfare. Does the regulator then have an interest to change its mind about regulation? The answer is no because this later can anticipate that regulation yields an equilibrium such that social welfare is equal to $S_1(0)$. Thus, unless the regulator can oblige firm U to commit to its tariff without regulation, which is rather unlikely,[24] it has no interest to depart from its choice of refusing to regulate firm D.

Consider now the case where the regulator commits to regulate. If firm U reacts optimally, social welfare ends at $S_1(0)$. At this point, this latter has no incentive to deviate from its strategy. As

[23]The assumption on firm U's cost function eases the justification of this argument.

[24]If this were the case, then one should probably have to consider the case where most of the bargaining power is in the hand of the regulator.

far as the regulator is concerned, it is indifferent between this situation and moving to a refusal of regulation, as this would also yield no production and $S_1(0)$ as social welfare. Thus the commitment to regulate may be weak, i.e. the regulator may deviate, to the contrary of the commitment no to regulate.

Now that the basic model has given its main insights, the following sections study to some extensions.

2.6 Unregulated national upstream firm

The goal of this section is to relax the assumption that firm U is a foreign undertaking. Therefore, this section departs from the reference model described in section 2.2 and considers the upstream firm as a domestic firm that cannot, for reasons not modeled here, be regulated. The profit of firm U is therefore added in the social welfare with a coefficient α in $[0,1]$. The other aspects of the framework remain the same, especially the timing of the game.

When the regulator wants to regulate the downstream sector, its program becomes (third period)

$$\max_{q_1,\pi^D}\left[S_1+\lambda p_1q_1-\lambda\pi^D-(1+\lambda)\left(C^D+H_0+p_0q_1\right)+\alpha\pi^U\right],$$

with $\pi^U = H_0 + p_0 q_1 - C^U(q_1)$ and under the participation constraint $\pi^D \geq 0$. As usual, it is costly to leave rents to the firm D, thus $\pi^D = 0$. The first order condition is

$$p_1(q_1)-C_q^D(q_1)-\frac{\alpha}{1+\lambda}C_q^U(q_1)-\left(1-\frac{\alpha}{1+\lambda}\right)p_0+\frac{\lambda}{1+\lambda}p_{1q}(q_1)\,q_1=0. \tag{2.7}$$

It is assumed that the second order condition is satisfied and that this equation has a unique solution $q_1^*(p_0)$ for any proposed p_0. The regulator accepts the two-part tariff if the social welfare is higher than its outside option of zero production

$$S_1+\lambda p_1^*q_1^*-(1+\lambda)\left[C^{D*}+\frac{\alpha}{1+\lambda}C^{U*}+\left(1-\frac{\alpha}{1+\lambda}\right)p_0q_1^*\right]-(1+\lambda-\alpha)H_0\geq S_1(0). \tag{2.8}$$

Domestic firm U	Regulation		No regulation
Production of good 1	q_1^{viR}	$>$	q_1^{vi}
Social welfare	$S_1(0)$	$<$	$S_1\left(q_1^{vi}\right) - p_1\left(q_1^{vi}\right) q_1^{vi}$
Firm U's profit	$\frac{1}{1+\lambda-\alpha}\left[\mathrm{SW}^{viR} - S_1(0)\right]$	$>$	π^{vi}

Table 2.2: Results on the opportunity of regulating the downstream firm, with a domestic upstream firm

The upstream firm U maximizes its profit (first period) under the constraints that, first, its two-part tariff is accepted by the regulator and, second, its two-part tariff induces certain level of production of good 1 given by equation (2.7). As usual, the quantity of good 1 is independent of the fixed part H_0 and the acceptance condition (2.8) is constraining the increase in H_0. Therefore, this condition is binding and H_0 can be substituted in the objective function of firm U, which yields, omitting the arguments, the following program

$$\max_{p_0} \frac{1}{1+\lambda-\alpha}\left[S_1^* - S_1(0) + \lambda p_1^* q_1^* - (1+\lambda)\left(C^{D*} + C^{U*}\right)\right].$$

Firm U's objective function qualitatively mimics the one of the regulator in the benchmark described in section 2.3.1. The function in the brackets is maximized for $q_1 = q_1^{viR}$, which can be generated by the choice of $p_0 = c^U$. This solves the problem of firm U. Results are summarized in table 2.2.

When the regulator can decide (at $t = 0$) whether it wishes to regulate or not firm D, the same kind of analysis as in section 2.5 can be followed. If taken before the proposal of the two-part tariff by firm U, the decision to regulate or not the downstream firm D allows the regulator to limit the rent extraction by firm U through the deny of regulation.[25] In this latter case, the equilibrium of the game is the same as the one described in proposition 2.2 and firm U only extracts the standard maximum vertically integrated profit.

Proposition 2.3. *When firm U's profit is added in the social welfare with a coefficient α, firm U can always obtain a greater profit when the downstream firm D is regulated. It obtains also a greater profit than what it obtains with regulation of firm D when firm U's profit is not added in the social welfare.*

[25]The decision to regulate or not the downstream firm D does not change the outcome described in proposition 2.3 if taken after the proposal of the two-part tariff by firm U, for the same reasons as explained in section 2.5.

Moreover, the optimal two-part tariff for firm U when there is regulation is $T^U(q_1) = \frac{1}{1+\lambda-\alpha}[\mathrm{SW}^{viR} - S_1(0)] + F^U + c^U q_1$, *which yields a profit of* $\pi^U = \frac{1}{1+\lambda-\alpha}\left[\mathrm{SW}^{viR} - S_1(0)\right]$ *and a final production* q_1^{viR}. *The level of social welfare is* $S_1(0)$ *and corresponds to the zero production one. Firm D gets zero profit.*
The regulator chooses not to regulate firm D.

Thus, both results on upstream rent extraction and regulatory decision are robust to firm U being a national undertaking. Moreover, one can verify, first, that the equilibrium described in the proposition 2.3 fits with the one exhibited in proposition 2.1 when $\alpha = 0$ and, second, that the upstream firm's profits are increasing in α. The five features discussed exhibited in section 2.5 remain valid.

The intuition behind this result is simple. Consider the new social welfare function and imagine that firm U asks for the two-part tariff described in proposition 2.1. Obviously, the regulator accepts T^U: this yields a social welfare equal to $S_1(0)$, as before, plus the part of firm U's profit, therefore the acceptance constraint (2.8) of the regulator is not binding any more. As the fixed part of the two-part tariff is designed to make this constraint binding, the optimal two-part tariff must be characterized by a higher fixed part, i.e. firm U gains more from the regulation than when its profit is not added in the social welfare function.

2.7 Shared bargaining power

The main two conclusions, more profits for firm U under regulation of the final market and preference of the regulator not to regulate, are robust to firm U being a national firm but still require firm U keeping all the bargaining power over firm D and the regulator. One can wonder if this latter assumption is necessary to obtain all or some of these results. Thus, this section introduces a more balanced bargaining power between firm U and its contractual counterpart through a simple model of bargaining power, the weighted Nash bargaining solution (see, e.g., Myerson 1991, chapter 8.6), following the seminal analysis of Nash (1950).

2.7.1 Bargaining procedure

Everything but step $t=1$ of the timing described by figure 2.3, page 67, is preserved: at $t=1$, bargaining occurs with respect to the two-part tariff (H_0, p_0). Then, at $t=3$, for the tariff set by this bargaining procedure, either firm D or the regulator reacts optimally by setting the appropriate production levels required to maximize their own objective function (respectively firm D's profit and social welfare)

$$\begin{cases} q_1^*(H_0,p_0) = \arg\max_q \left[\pi^D(H_0,p_0,q) = [p_1(q)-p_0]\,q - \left[C^D(q)+H_0\right]\right], \\ \tilde{q}_1(H_0,p_0) = \arg\max_q \left[\mathrm{SW}(H_0,p_0,q) = S_1(q) + \lambda p_1(q)\,q - (1+\lambda)\left[C^D(q)+H_0+p_0 q\right]\right]. \end{cases}$$

If one does not add any participation constraint regarding the definition of these solutions, i.e. if constraints $\pi^D \geq 0$ and $\mathrm{SW} \geq 0$ are not considered at this stage, then q_1^* and $\tilde{q}_1$ turn out to be independent from H_0, so that, in the rest of this section, participation constraints will be added explicitly and q_1^* and $\tilde{q}_1$ defined as functions of q_0 only.

The same outside options as in previous sections are kept for both firms and the regulator: firms either contract (firm U with firm D or firm U with the regulator) and produce according to the contract, or do not contract and get zero profit; the regulator either contracts (with firm U) and gets the benefits of production and consumption, or does not contract and faces social welfare of $S_1(0)$. The relationship between the regulator and firm D is kept at the complete advantage of the former.

To be individually rational, the contract must satisfy the usual participation constraints of participants in the bargaining process. When firm D is not regulated, the participation constraints to consider are

$$\begin{cases} \pi^U(H_0,p_0,q_1^*(p_0)) = H_0 + p_0 q_1^* - F^U - c^U q_1^* \geq 0, \\ \pi^D(H_0,p_0,q_1^*(p_0)) = [p_1(q_1^*)-p_0]\,q_1^* - \left[C^D(q_1^*)+H_0\right] \geq 0. \end{cases} \tag{2.9}$$

When firm D is regulated, the relevant participation constraints are

$$\begin{cases} \pi^U(H_0,p_0,\tilde{q}_1(p_0)) = H_0 + p_0\tilde{q}_1 - F^U - c^U\tilde{q}_1 \geq 0, \\ \mathrm{SW}(H_0,p_0,\tilde{q}_1(p_0)) = S_1(\tilde{q}_1) + \lambda p_1(\tilde{q}_1)\,\tilde{q}_1 - (1+\lambda)\left[C^D(\tilde{q}_1)+H_0+p_0\tilde{q}_1\right] \geq S_1(0). \end{cases} \tag{2.10}$$

Let $\gamma \in [0,1]$ denote the bargaining power of firm U with respect to firm D and $\beta \in [0,1]$ its relative bargaining power with respect to the regulator. The weighted Nash-bargaining solution is the contract which maximizes the weighted Nash-product of utilities over all contracts (H_0, p_0) satisfying the relevant participation constraints and reaction function. When firm D is not regulated, the objective function to maximize is

$$\Pi^* (H_0, p_0, q_1^*) = \left[\pi^U - 0\right]^\gamma \left[\pi^D - 0\right]^{1-\gamma} \tag{2.11}$$

under the constraints on the existence of q_1^* and participation constraints (2.9). When firm D is regulated, the objective function becomes

$$\tilde{\Pi} (H_0, p_0, \tilde{q}_1) = \left[\pi^U - 0\right]^\beta [\mathrm{SW} - S_1 (0)]^{1-\beta} \tag{2.12}$$

under the constraints on the existence of $\tilde{q}_1$ and the participation constraints (2.10).

2.7.2 Two examples

If $\beta = \gamma = 1$ then the situation is equivalent to the one studied until now where the upstream firm has all bargaining power and can extract more from the regulator than from firm D. The optimal tariffs are described in lemma 2.1 when firm D is not regulated and in proposition 2.1 when it is. *Ex ante*, the regulator prefers not to regulate firm D in order to limit the rent extraction, despite the high final price for good 1.

If, on the contrary, $\beta = \gamma = 0$ then all the bargaining power is in the hand of either the regulator or firm D. In these circumstances, at $t = 1$, both the regulator and firm D would propose a two-part tariff equal to $\left(F^U, c^U\right)$. Firm U ends at zero profit whatever the production level[26] and firm D chooses the vertically integrated monopoly production q_1^{vi} while the regulator chooses the second best[27] level q_1^{viR}. At $t = 0$, the regulator compares social welfare levels reached whether or not firm

[26]This analysis is simplified by the assumption that firm U has a constant marginal cost.

[27]Second best and not first best because the cost of public funds corresponds to a first level of (assumed) imperfection.

D is regulated. On the one hand, regulation yields

$$\mathrm{SW}^{viR} = \left\{S_1 + \lambda p_1 q_1 - (1+\lambda)\left[C^D + C^U\right]\right\}\Big|_{q_1 = q_1^{viR}},$$

where all benefits from production and consumption are kept by the regulator. On the other hand, the absence of regulation induces benefits from consumption of q_1^{vi} and the maximum benefit of the vertically integrated firm π^{vi}, which yields

$$\mathrm{SW} = \{S_1 - p_1 q_1\}\big|_{q_1 = q_1^{vi}} + (1+\lambda)\pi^{vi} = \left\{S_1 + \lambda p_1 q_1 - (1+\lambda)\left[C^D + C^U\right]\right\}\Big|_{q_1 = q_1^{vi}}$$

This is, by the very definition of q_1^{viR}, lower than social welfare associated with regulation. Thus, firm U gets zero profit in both situations, i.e. the first result of previous sections remains (weakly) valid but, *ex ante*, the regulator prefers to regulate, i.e. the second result is not robust. In order to specify the required conditions for validity of both results, let turn to the general case for β and γ.

2.7.3 General case

If firm D is not regulated, the first order equations[28] are

$$\frac{\partial \Pi^*}{\partial H_0} = (1-\gamma)X^{\gamma-1}\left[\frac{\gamma}{1-\gamma} - X\right] = 0,$$
$$\frac{\partial \Pi^*}{\partial p_0} = q_1^* \frac{\partial \Pi^*}{\partial H_0} + \gamma\left(p_0 - c^U\right)\frac{dq_1^*}{dp_0}X^{\gamma-1} = 0,$$

where X and Y are defined as the following ratio

$$X = \frac{\pi^U - 0}{\pi^D - 0}, \qquad Y = \frac{\pi^U - 0}{\mathrm{SW} - S_1(0)}.$$

Thus, the equilibrium is characterized by $p_0 = c^U$ and $X = \frac{\gamma}{1-\gamma}$ which induces the following solution

$$q_1 = q_1^{vi}, \qquad \pi^U = \gamma\pi^{vi}, \qquad \pi^D = (1-\gamma)\pi^{vi}. \tag{2.13}$$

[28] Please refer to section 2.C.5, p. 105, for the complete description of the computations.

Firm U's profit related to this equilibrium can be rewritten

$$\pi^U = \gamma \left\{ p_1 q_1 - \left[C^D + C^U \right] \right\} \Big|_{q_1 = q_1^{vi}}.$$

Moreover, the level of social welfare is equal to

$$\begin{aligned} \mathrm{SW} - S_1(0) = {} & \left\{ S_1 - p_1 q_1 \right\} \Big|_{q_1 = q_1^{vi}} - S_1(0) + (1+\lambda)(1-\gamma)\pi^{vi} \\ & = (1-\gamma) \left\{ S_1 + \lambda p_1 q_1 - S_1(0) - (1+\lambda)\left[C^D + C^U \right] \right\} \Big|_{q_1 = q_1^{vi}} \\ & \quad + \gamma \left\{ S_1 - p_1 q_1 - S_1(0) \right\} \Big|_{q_1 = q_1^{vi}}. \end{aligned}$$

This expression is due an implicit assumption on firm D being public. Indeed, when firm D is regulated, its profit or losses are added in the social welfare function with a multiplicative factor $(1+\lambda)$, i.e. with their associated benefit or cost, respectively, related to public funds. But when firm D is not any more regulated, there is *a priori* no reason why its profit should contribute to public funds, unless firm D is a public undertaking. This case, where firm D's profit when it is not regulated is added without the extra cost of public funds, is presented in the proof of lemma 2.4 (section 2.C.5, page 105).

If firm D is regulated, the first order equations are

$$\begin{aligned} \frac{\partial \tilde{\Pi}}{\partial H_0} &= (1+\lambda)(1-\beta) Y^{\beta-1} \left[\frac{\beta}{(1+\lambda)(1-\beta)} - Y \right], \\ \frac{\partial \tilde{\Pi}}{\partial p_0} &= \tilde{q}_1 \frac{\partial \tilde{\Pi}}{\partial H_0} + \beta \left(p_0 - c^U \right) \frac{d\tilde{q}_1}{dp_0} Y^{\beta-1} \end{aligned}$$

and the equilibrium is also characterized by $p_0 = c^U$ and, moreover, $Y = \frac{\beta}{(1+\lambda)(1-\beta)}$ which induces the following solution

$$q_1 = q_1^{viR}, \qquad \pi^U = \frac{\beta}{1+\lambda} \left[\mathrm{SW}^{viR} - S_1(0) \right], \qquad \mathrm{SW} - S_1(0) = (1-\beta) \left[\mathrm{SW}^{viR} - S_1(0) \right]. \tag{2.14}$$

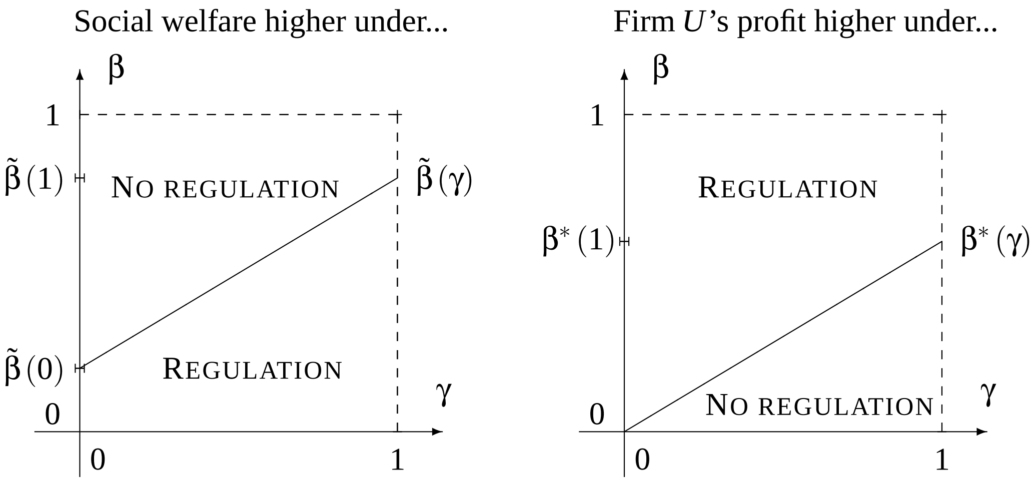

Figure 2.4: Thresholds for social welfare and firm U's profit relative to bargaining powers of firm U with respect to the regulator and firm D

Reminding the definition of SW^{viR}, social welfare can be rewritten

$$\mathrm{SW} - S_1(0) = (1-\beta)\left\{S_1 + \lambda p_1 q_1 - S_1(0) - (1+\lambda)\left[C^D + C^U\right]\right\}\Big|_{q_1 = q_1^{viR}}$$

and firm U's profit is then equal to

$$\begin{aligned}\pi^U &= \frac{\beta}{1+\lambda}\left\{S_1 + \lambda p_1 q_1 - S_1(0) - (1+\lambda)\left[C^D + C^U\right]\right\}\Big|_{q_1 = q_1^{viR}} \\ &= \beta\left\{p_1 q_1 - \left[C^D + C^U\right]\right\}\Big|_{q_1 = q_1^{viR}} + \frac{\beta}{1+\lambda}\left\{S_1 - p_1 q_1 - S_1(0)\right\}\Big|_{q_1 = q_1^{viR}}.\end{aligned}$$

Ex ante (at $t = 0$), the regulator makes its mind about the option to regulate firm D by comparing social welfare under the two possibilities. The corner examples given in the two previous paragraphs make clearly the point that there should exist a $\tilde{\beta}(\gamma)$ such that social welfare is equal in both situations. Alternatively, one can compare firm U's profit in both cases. This is the point of the following lemma.

Lemma 2.4. *For all γ in $[0,1]$, there exists $\beta^*(\gamma)$ such that firm U's profit at equilibrium under regulation of firm D is equal to firm U's profit at equilibrium without regulation, and $\tilde{\beta}(\gamma)$ such that social welfare at equilibrium under regulation is equal to social welfare at equilibrium without regulation. Moreover, these two thresholds are such that, for any γ in $[0,1]$, $\tilde{\beta}(\gamma) > \beta^*(\gamma)$ and*

$\tilde{\beta}' = \beta'^{*} < 1$. *The same conclusions, except the equality of derivatives, are derived when firm D's unregulated profit do not benefit public funds.*[29]

As shown by figure 2.4, parameters β and γ define three different regions. First, for a given γ and $\beta < \beta^{*}(\gamma)$, firm U would prefer firm D not to be regulated while the regulator decides the opposite. Indeed, as the regulator's bargaining power is high, i.e. β is low, it has a real interest to regulate because it keeps most of the social value created by its regulation. On the other side, because its bargaining power is too low when it faces the regulator, firm U extracts more rent from its direct bargaining process with firm D.

Second, for $\tilde{\beta}(\gamma) < \beta$, firm U would get higher profits if regulation of firm D occurs while the regulator favors the absence of regulation. In this case, the bargaining power between firm U and the regulator turns in favor of firm U which prefers to make the regulator generate the highest social value from production and consumption of good 1, and then extract most of it. This is the case of the reference model studied in previous sections.

Third, for $\beta^{*}(\gamma) < \beta < \tilde{\beta}(\gamma)$, both the regulator and firm U prefer regulation. On the one hand, the regulator is strong enough with respect to firm U so that it prefers to induce the consumption of q_1^{viR} instead of q_1^{vi}, i.e. the share of the higher "cake" $\mathrm{SW}^{viR} - S_1(0)$ it preserves when there is regulation is still higher than the one it gets without regulation. On the other hand, firm U is better with a portion of this larger "cake" than with what it gets from its bargaining with firm D (for which the "cake" to share is only π^{vi}).

Proposition 2.4. *When bargaining power is shared, firm U obtains a greater profit when the downstream firm D is regulated if firm U's bargaining power with respect to the regulator is larger than the threshold $\beta^{*}(\gamma)$. Moreover, the regulator chooses not to regulate firm D when this same bargaining power is larger than the threshold $\tilde{\beta}(\gamma)$. Whenever β lies between $\beta^{*}(\gamma)$ and $\tilde{\beta}(\gamma)$, both the regulator and firm U benefit from firm D's regulation.*

The introduction of bargaining power sheds some light on the benefits the regulator can find in regulating.

[29] This case refers to the comment on the value of social welfare when firm D is unregulated, i.e. on the way the regulator values the profit of the downstream firm with respect to the cost of public funds when this same downstream firm is not regulated.

On the one hand, bargaining between firm U and the regulator ends with efficient production and allocation[30] of good 1. Moreover, when the regulator's bargaining power with respect to firm U increases, i.e. β decreases, the regulator keeps a higher stake of the social value created by production and consumption of good 1, increasing the value associated with regulation. As regulation is Pareto optimal in this context, there exists a $\tilde{\beta}$ for every possible γ such that, for $\beta < \tilde{\beta}$, the regulator will prefer regulation.

On the other hand, in the absence of regulation, production occurs as the result of the bargaining process between upstream and downstream firms. This production induces efficient production but inefficient allocation of good 1. Nevertheless, both consumers and firm D benefit from production of good 1: consumers get a strictly positive surplus and firm U keeps a positive profit from its sale. This means that social welfare is higher than consumers surplus (strictly if $\gamma > 0$) and is worth being considered by the regulator. Thus, for a constant β, when the bargaining power of U with respect to D decreases, firm D keeps a higher part of the gain from production of good 1 and the regulator might want to abandon regulation because what firm U keeps is higher than what the regulator can hope to get in its bargaining process.

Let now move to the analysis of the influence of the asymmetric information in driving the main results.

2.8 Asymmetric information

One could suspect that asymmetries of information would modify the result. In order to have some insights with respect to this issue, the model has to be slightly modified. There are many ways through which some degree of asymmetry can be introduced: is the cost of public funds known by the foreign firm U? is firm D's cost a private information? is the asymmetry identical for the foreign firm U and the national regulator? The goal of this section is not to provide an exhaustive treatment of asymmetric information in this context but rather to get some idea on how the main results would be modified. For the purpose of this exercise, private information is added on the side

[30] Allocation is efficient in the sense that the quantity produced is q_1^{viR}.

of the downstream firm and both firm U and the regulator face the same lack of knowledge: they share the same beliefs on firm D's cost function.

2.8.1 Model with asymmetric information

Downstream sector. The cost of firm D, exclusive of the two-part tariff T^U, becomes $C^D(\beta, q_1, e)$ with a constant fixed cost F^D. The parameter β represents the type of firm D, an efficiency parameter chosen by nature, with $C^D_\beta > 0$, while e represents the manager's effort, with $C^D_e < 0$. This effort decreases the cost of production but implies a disutility of effort $\psi(e)$, with $\psi_e > 0$ and $\psi_{ee} > 0$ for $e > 0$ and $\psi(0) = 0$. For the sake of simplicity, the cost function is specified by $C^D(\beta, q_1, e) = F^D + (\beta - e)\, q_1$.[31] Keeping the same accountancy assumptions than in section 2.2, the utility or profit function of firm D is

$$\pi^D = t - \psi(e),$$

where t stands for the net transfer from the regulator to firm D.

Asymmetry of information. Neither the regulator nor firm U observe the effort e or the type β of firm D. The cost structure of firm D, its fixed cost and the beliefs on the distribution of the type β are common knowledge. The regulator and firm U observe the total cost and the quantity q_1. Moreover, they know that β can take two values: $\underline{\beta}$ (efficient firm) with probability ν and $\overline{\beta}$ (less efficient firm) with probability $1-\nu$, with $\Delta\beta = \overline{\beta} - \underline{\beta} > 0$.

The revelation principle is used for all contractual relationships such as between the regulator and firm D or, when there is no regulation, between firm U and firm D.

Thus, when it regulates firm D, the regulator proposes a menu of contracts, for each possible type of β, which associate a net transfer t, a final quantity q_1 and a cost C^D of producing q_1: $(t(\underline{\beta}), q_1(\underline{\beta}), C^D(\underline{\beta}))$, $(t(\overline{\beta}), q_1(\overline{\beta}), C^D(\overline{\beta}))$. This menu must be characterized under incentive compatibility constraints and it has to verify the individual participation constraints. Under these conditions, the type is revealed, the total cost and the fixed cost are observed, so the regulator can deduce

[31] The modified model is close to the generic model used in Laffont and Tirole (1993). This cost simplification plays its main role in the writing of the maximization programs and of the rent function.

the mean cost and the effort $e(\beta)$ exerted by the firm. Thus, by an abuse of notation, the menu of contracts is equivalently written $(\underline{t},\underline{q}_1,\underline{C}^D)$, $(\bar{t},\bar{q}_1,\overline{C}^D)$ or $(\underline{t},\underline{q}_1,\underline{e})$, $(\bar{t},\bar{q}_1,\bar{e})$.

When the regulator decides not to regulate the downstream firm, it allows firm U to contract directly with firm D and these contracts are assumed to be designed by the upstream firm under the same kind of assumptions and mechanism than the regulator.

2.8.2 Analysis of contracts

When there is full information, it has been shown in section 2.4 that firm U obtains more when firm D is regulated than when it is not by comparing two-part tariffs chosen in each case. The same trick cannot be used with asymmetric information because it is assumed that contracts that firm U propose to the regulator (single two-part tariff) or to firm D (menu of tariffs) are not of the same nature. This is due to the (assumed) absence of asymmetry of information between firm U and the regulator. But the essence of the argument is kept. Indeed, the relevant benchmark for firm U is what occurs if there is no regulation as opposed to when the regulator regulates firm D.

The line of attack used to address this asymmetric information is the following. First, as in section 2.3, the optimal contract when the regulator regulates the vertically integrated firm is exhibited and labeled "*viR*". Then, the optimal two-part tariff proposed by firm U to firm D, when this latter is not regulated, is computed and labeled "*vi*".[32]

The comparative statics of the asymmetric information case are summed up in table 2.3, using the notations described above and $\phi(e)$ as the rent extracted by an efficient firm exerting effort e. All computations are detailed in annex (section 2.A, page 93). They yield the following results.

Proposition 2.5. *Under asymmetric information, firm U can always obtain a greater profit when the downstream firm D is regulated, and the regulator never chooses to regulate firm D.*

Lemma 2.5. *If C^D_{eq} is negative, the informational rent of the efficient firm D is higher under regulation. Moreover, if beliefs of the regulator with respect to the efficiency parameter first order*

[32] It is clear that, at this stage, there is a (voluntary) mix between the optimal contract and its implementation: only the optimal two-part tariff is studied when there is no regulation even if this particular tariff may not be the optimal one over all possible contracts. A better way to proceed would be to compute the optimal contracts in both situations. Therefore, this section is not entirely satisfactory but, despite this limitation, the lessons it brings are worth being discussed. In particular, it is sufficient to show the influence of asymmetric information in this framework.

Asymmetric information	Regulation		No regulation
Production of good 1	$\begin{cases} \overline{\beta} : \overline{q}_1^{viR} \\ \underline{\beta} : \underline{q}_1^{viR} \end{cases}$	$>$	$\begin{cases} \overline{\beta} : \overline{q}_1^{vi} \\ \underline{\beta} : \underline{q}_1^{vi} \end{cases}$
Firm *D*'s effort level	$\begin{cases} \overline{\beta} : \overline{e}^{viR} \\ \underline{\beta} : \underline{e}^{viR} \end{cases}$	$>$	$\begin{cases} \overline{\beta} : \overline{e}^{vi} \\ \underline{\beta} : \underline{e}^{vi} \end{cases}$
Expected social welfare	$S_1(0)$	$<$	$\mathrm{E}\left[S_1\left(q_1^{vi}\right) - p_1\left(q_1^{vi}\right)q_1^{vi}\right]$ $+\nu\phi\left(\overline{e}^{vi}\right)$
Firm *D*'s informational rent	$\begin{cases} \overline{\beta} : 0 \\ \underline{\beta} : \phi\left(\overline{e}^{viR}\right) \end{cases}$	$=$ $>$	$\begin{cases} \overline{\beta} : 0 \\ \underline{\beta} : \phi\left(\overline{e}^{vi}\right) \end{cases}$
Firm *U*'s profit	$\frac{\mathrm{E}\left[\mathrm{SW}^{viR} - S_1(0)\right]}{1+\lambda}$	$>$	$\mathrm{E}\left[\pi^{vi}\right] - \nu\phi\left(\overline{e}^{vi}\right)$

Table 2.3: Results on the opportunity of regulating the downstream firm, with asymmetric information on its cost function

stochastically dominates those of the upstream firm, the difference in this informational rent decreases.

Thus, the introduction of asymmetric information does not modify the main results on rent extraction and regulatory decision. The only differences are that: (1) the upstream firm can extract less profits from regulation of the downstream sector than it could in the perfect information case; and (2) the efficient downstream firm *D* gets a higher informational rent when it is regulated. Indeed, the asymmetry of information limits the ability of the regulator to increase social welfare and, consequently, it limits the amount that the upstream firm can ask the regulator for its product. However, this does not change the way the rent is extracted and the fact that the final equilibrium is again not Pareto optimal.

Moreover, it turns out that the trade-off between rents and efficiency depends on the regulator's decision with respect to firm *D*: both types of firms *D* have to produce more and provide more efforts when regulation occurs.[33] This can be deduced from the first order conditions of firm *U* and the regulator, once the relevant constraints have been taken into account, which are summarized in

[33] This results requires C_{qe} to be negative, which is assumed in this section. Please refer to section 2.C.8, p. 112 for computations and the treatment of the alternative case.

the following equations

$$\begin{cases} p_1(q_1) + p_{1q}(q_1)\,q_1 + \left[-\frac{1}{1+\lambda}p_{1q}(q_1)\,q_1\right] = C_q^D(\beta, q_1, e) + C_q^U(q_1), \\ -C_e^D(\beta, q_1, e) = \psi_e(e) + \gamma\phi_e(e) - \left[\frac{1}{1+\lambda}\gamma\phi_e(e)\right], \end{cases}$$

where, first, the contracts proposed by firm U correspond to the limit case where $\lambda \to +\infty$ and, second, the contracts for the efficient type correspond to $\gamma = 0$. These equations show how, for given quantity and effort, either marginal profit is higher for the regulator than for firm U or marginal cost is lower. On the one hand, by marginally increasing the quantity produced, marginal costs (of production of intermediate and final goods) do not vary with λ while marginal benefits (given by the price of the final good and the negative effects related to price reduction) are higher for the regulator. This is related to the term in brackets which limits this negative effect for the regulator. Indeed, consumption allows this later to save public funds and the increase of output is less painful. On the other hand, by marginally increasing the required effort level of the inefficient type ($\gamma > 0$), marginal benefit (of this effort on cost) is identical for firm U and the regulator whereas marginal costs (of producing this effort and related to the informational rent of the efficient type) are lower for the regulator. Transferring one euro from firm U to the efficient firm D costs one euro to the former but the same operation from the regulator to firm U only costs λ euro, the cost of public funds associated to this transfer, because both consumers and firm U take part in social welfare. To sum up, first, chosen quantity is higher with regulation, for a given effort level and, second, chosen effort for the inefficient type is also higher with regulation, for a given quantity produced.

Eventually, the analysis of these informational rents may be of some importance here. When the regulator does not regulate firm D, the efficient type $\underline{\beta}$ saves a rent $\phi(\bar{e}^{vi})$. On the contrary, when it does regulate firm D, the same efficient type $\underline{\beta}$ gets $\phi(\bar{e}^{viR}) > \phi(\bar{e}^{vi})$. Assume a more general framework where there is a separation between the government and the regulator. On the basis of this chapter, the social planner should not regulate the final market. If there are different objective functions between the regulator and the government, let say the regulator gets a private benefit related to regulation or the government is sensitive to lobbying, then table 2.3 shows that both the efficient firm D and firm U could have an incentive to lobby for regulation to occur, whereas the regulator would argue the opposite decision.[34] This divergence of interests plays no role in the current framework because firm *D* has no power except to refuse the proposed contract, which is never in its interest. It is also of less importance whenever the regulator beliefs about the efficient type is higher than the one of the upstream firm. Nevertheless, lemma 2.5 exhibits a potential rationale for conflicts if one were to model lobbying in the regulatory process.

2.9 Regulation under budget constraint

One can still wonder whether the constant cost of public funds does not drive by itself the surprising result that the regulator does not want to regulate a monopoly, should this monopoly need an essential facility sold through non-linear tariffs. Indeed, thanks to this cost of public funds, the regulator has a higher buying power for this essential facility than the downstream firm itself. On the one hand, as shown by lemma 2.3, firm *U*'s profits are decreasing in λ. On the other hand, the more money the regulator extracts from its public funds, the more distorting the taxation should be, generating a higher λ. Now, this may be the case that, even if the industry by itself is of a small size, i.e. the *no-regulation* tariff is small relative to the overall amount of public funds, consumer surplus may be large enough so that, when raised by the regulator to pay the tariff under firm *D*'s regulation, this could influence (and increase) the value of λ. Thus, one would suspect that, if the logic behind the rent extraction does not change with the value of λ (the production of the final good has a higher value for the regulator than for the downstream firm, thanks to the consumer welfare), the level of the rent could be far less than what is scheduled by proposition 2.1.

Moreover, it has also been shown that regulation induces lower price for the final good and high rent extraction at the same time. This seems rather contradictory as the higher the transfer to the upstream firm, the larger the distortion related to taxation which translates in high prices of final goods to consumer. Thus, one may wonder what are the consequences on consumed goods of the size of the rent extracted by the upstream firm when regulation takes place.

[34] It is not clear that the efficient firm *D* will *always* have an interest to lobby as, "broadly writing", its private information could be signaled from this behavior, the inefficient firm *D* being indifferent between regulation or not. Nevertheless, this could play a role in the strategy of the efficient upstream firm.

This section is dedicated to the study of the same kind of regulatory problem as in previous sections but with a budget constraint and its endogenous associated cost, i.e. in the context of a regulation *à la Ramsey-Boîteux* where monetary transfers are prohibited between consumers and regulated firms. This restricts the financing of these industries to collecting and possibly sharing the gains from the sell of their final products. This assumption of budget constraint over the regulated industries does not allow to restore economic efficiency but, first, it allows another interpretation of the cost of public funds and, second, it exhibits the trade-off between the level of final products price and the need for downstream firms' fixed cost financing.[35]

2.9.1 Model

Economy. Introducing a regulatory framework *à la Ramsey-Boîteux* requires some modifications in the model proposed in section 2.2. In particular, it is necessary to introduce, on top of firm D's activity, $n-1$ additional (downstream) regulated goods produced by a multi-product national firm called N. Along with good $i=1$ produced by firm D, all these final goods indexed by $i=2,...,n$ are regulated[36] and regulating both firms under the same budget constraint allows a better flexibility. Therefore, altogether, firms D and N represent a conglomerate of all regulated activities in this economy,[37] i.e. they can be viewed as a single multi-product regulated firm with jointly liable activities. The question asked to the regulator is: should one separate from this conglomerate the activity of firm D which requires the essential input produced by firm U and priced through non-linear tariff? Firms D and U remain as in the reference model, i.e. all the bargaining power in the hand of the upstream firm and there is no asymmetry of information.

Downstream sector. Firm N has a cost function $C^N(q_2,\ldots,q_n)$, with marginal cost $C^N_{q_i}>0$ for each good i and with fixed (not sunk) costs $F^N_i \geq 0$ for the production of good i, as it is assumed

[35]Contrary to what is suggested in this presentation, the regulatory framework *à la Ramsey-Boîteux* is anterior to the one *à la Laffont-Tirole*. This latter has been proposed in reaction to the *ad hoc* constraints imposed by the former, such as the budget constraint and the lack of transfer between the regulator and the regulated firms. For a more detailed presentation of the regulatory framework *à la Ramsey-Boîteux*, please refer to Boîteux (1956), Laffont and Tirole (1993, pp. 30–34) and Brown and Sibley (1986).

[36]The other part of the national economy is assumed to have no link with the regulated one.

[37]These activities may be regulated for different reasons: natural monopolies, strategic industries, universal service obligations, etc.

for firm D. The cost function C^N is assumed to be separable, such that one can extract the cost of producing good i, C_i^N, for each $i = 2, ..., n$.[38] The profit of firm N's activity concerning good i is named $\pi_i^D(q_i)$ and is maximized by a production level called q_i^m. Profits are therefore

$$\begin{aligned}
\pi^U(q_0) &= T^U(q_0) - C^U(q_0), \\
\pi^D(q_1) &= p_1(q_1)q_1 - C^D(q_1) - T^U(q_1), \\
\pi^N(q_2, ..., q_n) &= \sum_{i=2}^n \left[p_i(q_i)q_i - C_i^D(q_i)\right].
\end{aligned}$$

Moreover, $\pi_1^{vi}(q_1) = p_1(q_1)q_1 - C_1^D(q_1) - C^U(q_1)$ is used to describe the profit of the (virtual) vertically integrated firm, made of firms U and D, producing good 1.

Consumers. Consumers are characterized by independent gross surpluses $S_i(q_i)$ for each good i,[39] with $S_{iq_i} = p_i(q_i)$, the inverse demand curve for good i, and $S_{iq_iq_i} < 0$.

Regulator. The regulator regulates firm D by choosing the final outputs in order to maximize social welfare $\mathrm{SW}(q_1, ..., q_n)$ while taking into account that prices ensure positive profits to the regulated sector, i.e. either firms D and N if D remains regulated, or firm N alone otherwise. As before, firm U's profit does not appear in the social welfare which is equal to the sum over all goods i of consumers' net surpluses and profits of firms D and N

$$\mathrm{SW}(q_1, q_2, ..., q_n) = \sum_{i=1}^n [S_i(q_i) - p_i(q_i)q_i] + \pi^D(q_1) + \pi^N(q_2, ..., q_n).$$

The problem studied remains the same: what is the influence of the regulatory activity on the strategy of the upstream firm? As in the Laffont-Tirole framework, two cases are studied: when the regulator decides to regulate firm D and when it decides not to regulate this latter, as subgames of

[38] The assumption of separability on the cost side eases the description of the argument but it is not essential. For instance, a common fixed cost between the production of good 1 and another good j could be introduced in the model. It does not change much the results in the sense that the optimal policy remains qualitatively the same but the allocation of this cost becomes part of the strategy. Indeed, when the regulator decides not to regulate firm D, the regulator separates firm D from the other activities of firm N and fully allocates the common fixed cost to firm D so that it decreases the rent of firm U and increases social welfare. Moreover, a common fixed cost between two activities i and j different than 1 does not change anything in the argument for rent extraction, but plays a role in the pricing of each of these activities.

[39] This assumption is also made to facilitate the writing of the maximization programs and allows to focus on the main effects of this model.

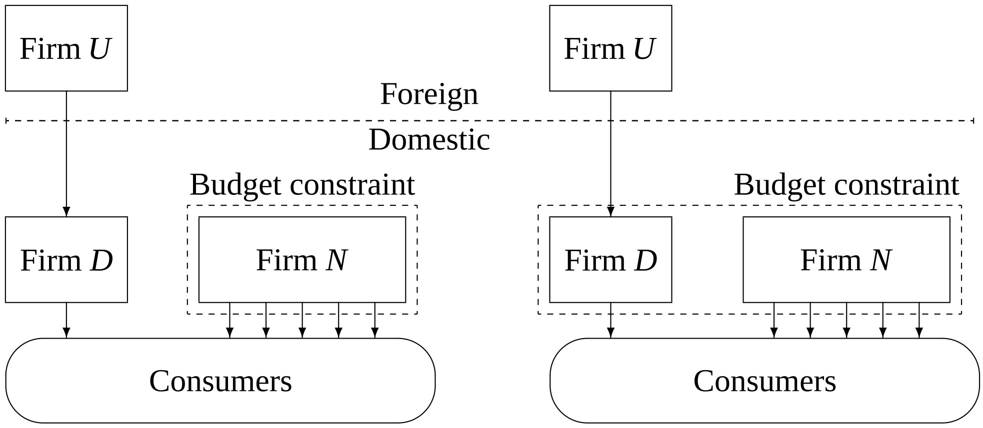

Figure 2.5: The industry vertical structure under budget constraint: without (left) or with (right) regulation

the game described by figure 2.3, page 67. This section goes through the analysis and discusses the results. All proofs are collected in the appendix (section 2.C, page 102).

2.9.2 No regulation of market 1

Firm U contracts directly with firm D when it is not regulated. This is a standard situation of vertical relationship with all bargaining power in the hand of the upstream firm. Moreover, there is no influence between different final markets. Thus, there is a complete separation between the policy of the regulator on markets $i = 2, \ldots, n$ and the strategy of the upstream firm.

As in section 2.3.2, the upstream firm extracts the maximum profit of the vertically integrated firm by proposing the tariff described in the following lemma.[40]

Lemma 2.6 (Lemma 2.1). *Without regulation, the optimal two-part tariff for firm U is* $T^U(q_1) = \pi_1^{vi}\left(q_1^{vi}\right) + F^U + c^U q_1$. *The quantity produced is* q_1^{vi}. *Firm U's profit is* $\pi_1^{vi}\left(q_1^{vi}\right)$ *and the social welfare level is* $S_1\left(q_1^{vi}\right) - p_1\left(q_1^{vi}\right) q_1^{vi}$. *Firm D gets zero profit.*

This is the *no-regulation* tariff in the Ramsey-Boîteux framework, i.e. the two-part tariff that firm U would ask the regulator if it considered this latter as a mail-box that transmits the proposal to firm D, but not as an active player. As in the Laffont-Tirole context, this tariff induces inefficient production of good 1.

[40] Please refer to the proof of lemma 2.1, p. 102.

As it does not intervene in market 1, the regulator maximizes social welfare by fixing the prices of goods $i = 2, \dots, n$, under the constraint that firm N gets at least zero profit

$$\begin{array}{ll} & \max_{q_2,\dots,q_n} \left[\sum_{i=2}^{n} S_i\left(q_i\right) - C^N\left(q_2,\dots,q_n\right)\right] \\ \text{s.t.} & \pi^N\left(q_2,\dots,q_n\right) \geq 0, \\ \text{i.e.} & p_i\left(\widehat{q}_i\right) - C^N_{q_i}\left(\widehat{q}_2,\dots,\widehat{q}_n\right) + \frac{\widehat{\lambda}}{1+\widehat{\lambda}} p_{iq}\left(\widehat{q}_i\right)\widehat{q}_i = 0 \quad \text{for } i = 2,..,n. \end{array} \tag{2.15}$$

where $\widehat{\lambda}$ is the Lagrange multiplier associated to the budget constraint.[41] It is assumed that second order conditions are satisfied and that there is a unique solution $\{\widehat{q}_i\left(p_0, H_0\right)\}_{i=2,\dots,n}$ for any proposed p_0 and H_0 of the accepted two-part tariff such that $\widehat{\lambda} > 0$.[42] Thus, regulation results in prices for good $i = 2, \dots, n$ *à la Ramsey-Boîteux* and firm D getting zero profit, i.e. social welfare ends up as consumers surpluses.

Thus, when there is no regulation of firm D, social welfare is equal to $\text{SW}\left(q_1^{vi}, \widehat{q}_2, \dots, \widehat{q}_n\right)$. Moreover, when there is no production of good 1, i.e. when $q_1 = 0$, the regulator still faces the same objective function which yields $\text{SW}\left(0, \widehat{q}_2, \dots, \widehat{q}_n\right)$.

2.9.3 Regulation of firm D

If the regulator decides to regulate firm D then, given T^U, it maximizes social welfare under the constraint that the entire regulated sector makes at least zero profit, i.e.

$$\begin{array}{ll} & \max_{q_1,q_2,\dots,q_n} \left[\sum_{i=1}^{n} S_i\left(q_i\right) - C^D\left(q_1\right) - C^N\left(q_2,\dots,q_n\right) - T^U\left(q_1\right)\right] \\ \text{s.t.} & \pi^D\left(q_1\right) + \pi^N\left(q_2,\dots,q_n\right) \geq 0, \\ \text{i.e.} & p_1\left(q_1^*\right) - C^D_{q_1}\left(q_1^*\right) - p_0 + \frac{\lambda^*}{1+\lambda^*} p_{1q}\left(q_1^*\right) q_1^* = 0 \\ & p_i\left(q_i^*\right) - C^N_{q_i}\left(q_2^*,\dots,q_n^*\right) + \frac{\lambda^*}{1+\lambda^*} p_{iq}\left(q_i^*\right) q_i^* = 0 \quad \text{for } i = 2,..,n. \end{array} \tag{2.16}$$

[41] In the absence of more detailed specification on the cost functions, i.e. related to the reasons for regulation of firm N's activities, all cases on $\widehat{\lambda}$ are possible: $\widehat{\lambda} = 0$ and $\widehat{\lambda} > 0$. Nevertheless, in the presence of fixed cost and with constant marginal cost, for example, the only possible solution becomes $\widehat{\lambda} > 0$, which seems more meaningful from the economic point of view because it induces zero profit for firm N.

[42] In particular, there may be some values for p_0 and H_0 such that this system has no solution, but these values will not be proposed by firm U.

It is assumed that second order conditions are satisfied and that there is a unique solution $\{q_i^*(p_0, H_0)\}_{i=2,\ldots,n}$ for any proposed p_0 and H_0 of the accepted two-part tariff such that $\lambda^* > 0$.[43] Firms D and N get zero overall profit and social welfare ends up as consumers surpluses.

The regulator refuses the proposed tariff T^U if one of the two following conditions is fulfilled: (1) paying T^U yields less social welfare than not providing good 1, i.e. the solution of (2.16) is such that $\mathrm{SW}(q_1^*, q_2^*, \ldots, q_n^*) < \mathrm{SW}(0, \widehat{q}_2, \ldots, \widehat{q}_n)$; (2) there is no way to raise enough funds from the economy to pay T_U, i.e. the proposed p_0 and H_0 are such that there is no possible solution $\{q_i^*(p_0, H_0)\}_{i=1,\ldots,n}$ to the program (2.16).

This second condition means that, for a given p_0, H_0 must not violate the budget constraint

$$\sum_{i=1}^n p_i(q_i)\, q_i - C^D(q_1) - C^N(q_2, \ldots, q_n) - F^U - p_0 q_1 \geq H_0 - F^U.$$

The left hand-side of the inequality corresponds to the profit of an integrated monopoly (firms U, D and N altogether) facing p_0 as marginal cost of producing good 0. This inequality clearly states that, for a given p_0, $H_0 - F^U$ cannot be higher than the maximum profit this integrated monopoly can obtain, i.e. for $q_1 = q_1^m$ (where monopoly output is defined for the given p_0) and $q_{i\neq 1} = q_i^m$. If this is not the case, then the regulatory body cannot extract from the n markets the required bill demanded by H_0.

It is not easy to predict which of these two constraints will be binding first when increasing H_0. Nevertheless, the following lemmas helps understanding how rent is extracted in this context.

Lemma 2.7. *The regulator always accepts the* no-regulation *tariff if the upstream firm U proposes it. Moreover, this tariff induces regulated outputs such that the resulting social welfare is strictly higher than social welfare in the absence of production of good* 1.

Lemma 2.8. *Assume that the upstream firm U proposes a tariff $T^U(q_1) = H_0 + p_0 q_1$, with the associated regulated output values $(\tilde{q}_1, \tilde{q}_2, \ldots, \tilde{q}_n)$ such that $\mathrm{SW}(\tilde{q}_1, \tilde{q}_2, \ldots, \tilde{q}_n) > \mathrm{SW}(0, \widehat{q}_2, \ldots, \widehat{q}_n)$. Except in the extreme case where $\tilde{q}_1 = q_1^m$ (where monopoly output is defined for the given p_0) and $\tilde{q}_{i\neq 1} = q_i^m$, it is always optimal for the upstream firm U to ask for a two-part tariff with a fixed part strictly higher than H_0.*

[43] The same remark applies for $\widehat{\lambda}$ and λ^*. See footnote 42.

Unless all prices have reached monopoly levels (with p_1^m being defined for the given p_0), the regulator is ready to distort them so that it can raise enough funds to pay for the fixed charge H_0. The increase in any price, and its consequences in terms of consumer surplus, is less socially costly than the absence of production of good 0. Thus, moving from the two-part tariff without regulation, firm U can raise H_0 unless either regulation imposes monopoly prices over all markets, or prices induced by regulation are such that the resulting level of social welfare is identical to its level when there is no production of good 1 and independent regulation of all other final products.

There are two possible situations at equilibrium, after acceptance of the tariff, depending on the structure of the economy. First, all prices are at monopoly levels (for a given p_0). Firm U cannot ask for a higher two-part tariff to the regulator who cannot raise more funds by distorting final markets, even if consumer surplus related to good 1 would justify such an increase. This case corresponds to a situation where good 1 is of a great importance for consumers.

Second, social welfare is equal to its level without production of good 1. The regulator will not accept a further increase because it would prefer not to produce any more good 1. This situation corresponds, for example, to an economy where good 1 is comparable in consumers' tastes to other goods. At equilibrium, social welfare ends up at the highest of these two levels.

Eventually, the mechanism of rent extraction turns out to be the same than in previous sections: the fixed-part is set so as to make the (most constraining) acceptance constraint binding, i.e. to extract all what is made available in the economy, and the unit price yields efficient production of good 1, i.e. $p_0 = c^U$ so as to maximize the overall social value for the production of good 1.

2.9.4 Choosing whether or not to regulate

When comes the time for the regulator to choose whether or not to regulate firm D (at $t = 0$), it has to compare potential equilibria in terms of social welfare. With regulation, it obtains either $\mathrm{SW}(0, \widehat{q}_2, ..., \widehat{q}_n)$ or $\mathrm{SW}\left(q_1^{vi}, q_2^m, ..., q_n^m\right)$; without regulation, $\mathrm{SW}\left(q_1^{vi}, \widehat{q}_2, ..., \widehat{q}_n\right)$. The consumer surplus associated with good 1 is always higher when there is consumption of this good, thus $S_1\left(q_1^{vi}\right) - p_1\left(q_1^{vi}\right) q_1 > S_1(0)$. Moreover, by definition of monopoly prices, $S_i(\widehat{q}_i) - p_i(\widehat{q}_i)\widehat{q}_i > S_i(q_i^m) - p_i(q_i^m) q_i$. Conclusion follows (for the case of firm U's profit valued by the regulator, please read the dedicated section 2.B, page 99).

Proposition 2.6. *When regulation is formalized à la Ramsey-Boîteux, the upstream firm U can always obtain a greater profit when the downstream firm D is regulated, and the regulator never chooses to regulate firm D. When firm U's profit is added in the social welfare with a coefficient α, it extracts at least as much as when it is not added at the expense of the regulator.*

Thus, both results are robust to a change in the regulatory framework. Moreover, as in the Laffont-Tirole framework, this equilibrium turns out not to be Pareto optimal: faced with the equilibrium tariff without regulation, the regulator would rather regulate good 1 output while keeping constant firm U's profits.

2.10 Conclusion

This chapter shows, first, that consumers do benefit when a regulator does not regulate an industry characterized by the need of input produced by an unregulated monopoly with all bargaining power and sold through non-linear tariff, even if regulation ends with lower price. Second, it shows that this unregulated upstream monopoly obtains a higher profit when the downstream firm is regulated.

From a regulatory policy point of view, the usual scrutiny of "which final good market" to regulate (subadditivity of cost, universal service obligations, e.g.) has to be reviewed in the sense of a deeper analysis of the upstream context of these industries. Upstream markets characterized by monopoly power on some inputs or essential facilities are clearly identified as markets for which the final good should not be regulated or, at least, should be regulated with caution. Moreover, the seller of the essential facility can benefit from the regulation of any firm requiring this input, by extracting part of the consumer surplus on the regulated markets.

The way the essential facility seller achieves this rent extraction stands in two main elements. First, because it takes into account consumers surplus in its objective function, the regulator attaches a higher value to the production of the final good than does the downstream firm producing this same good. Second, the regulator is endowed with a higher buying power than the downstream firm because it can make use of public funds coming either from imperfect taxation or from cross-subsidization among regulated industries. Thus, when considering the sale of its input, the upstream firm faces either the downstream firm or the regulator. And this latter has a higher value of the input and more money to pay for it. Therefore, it is not surprising that, on the one hand, the upstream firm prefers to contract with the regulator and that, on the other hand, the regulator wishes to limit this rent extraction by committing not to regulate the downstream firm before the upstream firm proposes its tariff.

These results are mainly driven by two assumptions. First, the upstream firm must use non-linear tariffs for the sale of the intermediate good. Second, it must also have some degree of bargaining power over the regulator and the downstream sector. Regarding non-linear tariffs, it turns out that they are widely used in many industries, especially regarding patents and licensing. Thus, this assumption is not *per se* restrictive. Regarding bargaining power, section 2.7 shows that, as far as the upstream firm's bargaining powers are over some thresholds, the same two results remain true when gains from the economic interaction between the upstream firm, the downstream firm and the regulator are shared.

Finally, the analysis is robust to changes in some other assumptions such as taking into account the upstream firm's profit in social welfare, asymmetric information with respect to the cost of the downstream firm, or the change in the regulatory framework. The main changes are related to the absolute levels of rent extracted by the upstream firm.

In political economy terms, one significant consequence of these results is that the upstream firm should be the most fervent supporter of regulation and, for instance, should lobby for it. This is rather surprising, at least at first sight. Another topic to be analyzed relies in the paradox of the equilibrium where the regulator, which is suppose to regulate, decides not to "work" because it is not socially optimal to regulate the market of the final good 1 at the equilibrium. Thus, one would want to extend the principal-agent framework used in this chapter in a government-regulator-agent model and study the interactions between all these players.

One can also point out the lack of outside options of both the regulator and the downstream firm. The upstream firm gets its power from its essential input which leaves the regulator wishing to regulate the final market either to accept the tariff or to deny production. But this latter could also try to invest in research and development in order to find a substitute to good 0. This would open the discussion related to private versus public research.

Moreover, in the presence of asymmetric information, the efficient downstream firm gets a higher informational rent with regulation. Its interest goes on the opposite side of the ones of the benevolent government, but in the same as the upstream firm. In this context, there is place in this model for lobbying by the downstream firm.

Finally, one can also wonder if this kind of argument still holds in a context where the upstream firm contracts with an unregulated downstream multi-products firm. In particular, when downstream markets are complementary, is it optimal for this latter to split in two different entities in order to avoid profit extraction by the upstream firm?

2.A Annex: Asymmetric information in the Laffont-Tirole framework

This annex contains all the elements necessary to assess the conclusions reached in section 2.8. First, some benchmarks are studied. Then the impact of the asymmetry of information is analyzed when the regulator either regulates firm D or shuts it down. Finally, the case where the regulator is given the opportunity not to regulate firm D is studied. For the sake of simplicity, firm D's cost function is assumed to be

$$C^D(\beta, q_1, e) = F^D + (\beta - e)\, q_1.$$

All proofs are collected in the appendix, page 102.

2.A.1 Benchmark cases

As in the full information case, the following benchmarks describe two well-know cases to which the reminding of the analysis can be compared. The first benchmark is the best situation for the regulator, in the presence of asymmetric information and costly public funds, from the total social welfare point of view. The regulator regulates both firms and takes into account firm U's whole profit in the social welfare. The second benchmark corresponds to what should be *a priori* the worst situation, where the regulator regulates none of the firms which directly contract one with another.

Regulation of both firms

As in section 2.3.1, let consider the case where the upstream firm is a national one, i.e. both firms are regulated as if they were vertically integrated and added in social welfare, with the asymmetry of information on the part of the cost due to C^D. If the regulator has an interest to propose an incentive contract to both types instead of proposing only a contract for the efficient firm, it maximizes expected social welfare (arguments omitted)

$$\max_{\underline{q}_1, \underline{e}, \underline{t}, \overline{q}_1, \overline{e}, \overline{t}} \mathrm{E}\left[S_1 + \lambda p_1 q_1 - \lambda\left[t - \psi\right] - (1+\lambda)\left[\psi + C^D + C^U\right]\right]$$

under the individual participation and incentive compatibility constraints for the vertically integrated firm. Following the standard analysis, as in Laffont and Tirole (1993, pp. 57-59), yields the usual system of first order conditions

$$\begin{cases} p_1\left(\underline{q}_1\right) - C_q^D\left(\underline{\beta}, \underline{q}_1, \underline{e}\right) - C_q^U\left(\underline{q}_1\right) + \frac{\lambda}{1+\lambda} p_{1q}\left(\underline{q}_1\right)\underline{q}_1 = 0, \\ \psi_e\left(\underline{e}\right) + C_e^D\left(\underline{\beta}, \underline{q}_1, \underline{e}\right) = 0, \\ p_1\left(\overline{q}_1\right) - C_q^D\left(\overline{\beta}, \overline{q}_1, \overline{e}\right) - C_q^U\left(\overline{q}_1\right) + \frac{\lambda}{1+\lambda} p_{1q}\left(\overline{q}_1\right)\overline{q}_1 = 0, \\ \psi_e\left(\overline{e}\right) + C_e^D\left(\overline{\beta}, \overline{q}_1, \overline{e}\right) + \frac{\lambda}{1+\lambda}\frac{\nu}{1-\nu}\phi_e\left(\overline{e}\right) = 0, \end{cases} \tag{2.17}$$

where $\phi\left(\overline{e}\right) = \psi\left(\overline{e}\right) - \psi\left(\overline{e} - \Delta\beta\right)$ is the informational rent that type $\underline{\beta}$ gets because it can pretend to be of type $\overline{\beta}$, with $\phi > 0$ and $\phi_e > 0$. It is assumed that the second order conditions are satisfied and that this system of equations has a unique solution $\{(\underline{e}^{viR}, \underline{q}_1^{viR}), (\overline{e}^{viR}, \overline{q}_1^{viR})\}$.

This is the best that the regulator is able to implement with asymmetric information. These social welfare levels associated to $\underline{\beta}$ and $\overline{\beta}$ are respectively noted $\underline{\mathrm{SW}}^{viR}$ and $\overline{\mathrm{SW}}^{viR}$ such that

$$\begin{cases} \underline{\mathrm{SW}}^{viR} = \underline{S}_1^{viR} + \lambda \underline{p}_1^{viR}\underline{q}_1^{viR} - \lambda\overline{\phi}^{viR} - (1+\lambda)\left[\underline{\psi}^{viR} + C^D\left(\underline{\beta}, \underline{q}_1^{viR}, \underline{e}^{viR}\right) + C^U\left(\underline{q}_1^{viR}\right)\right], \\ \overline{\mathrm{SW}}^{viR} = \overline{S}_1^{viR} + \lambda \overline{p}_1^{viR}\overline{q}_1^{viR} - (1+\lambda)\left[\overline{\psi}^{viR} + C^D\left(\overline{\beta}, \overline{q}_1^{viR}, \overline{e}^{viR}\right) + C^U\left(\overline{q}_1^{viR}\right)\right] \end{cases} \tag{2.18}$$

and the expectation over β is noted $\mathrm{E}\left[\mathrm{SW}^{viR}\right] = \nu\underline{\mathrm{SW}}^{viR} + (1-\nu)\overline{\mathrm{SW}}^{viR}$. The vertically integrated firm of inefficient type gets zero profit, while the efficient type gets an informational rent $\phi\left(\overline{e}^{viR}\right)$.

Let's note $\underline{\pi}^{viR}$ and $\overline{\pi}^{viR}$ the following levels

$$\begin{cases} \underline{\pi}^{viR} = p_1\left(\underline{q}_1^{viR}\right)\underline{q}_1^{viR} - \left[\psi\left(\underline{e}^{viR}\right) + C^D\left(\underline{\beta}, \underline{q}_1^{viR}, \underline{e}^{viR}\right) + C^U\left(\underline{q}_1^{viR}\right)\right], \\ \overline{\pi}^{viR} = p_1\left(\overline{q}_1^{viR}\right)\overline{q}_1^{viR} - \left[\psi\left(\overline{e}^{viR}\right) + C^D\left(\overline{\beta}, \overline{q}_1^{viR}, \overline{e}^{viR}\right) + C^U\left(\overline{q}_1^{viR}\right)\right] \end{cases} \tag{2.19}$$

and $\mathrm{E}\left[\pi^{viR}\right] = \nu\underline{\pi}^{viR} + (1-\nu)\overline{\pi}^{viR}$. They represent the profits of the vertically integrated firm of, respectively, efficient and inefficient type, when the production levels are, respectively, $(\underline{e}^{viR}, \underline{q}_1^{viR})$ and $(\overline{e}^{viR}, \overline{q}_1^{viR})$.

No regulation of the downstream firm

Consider now the case where there is no regulation of firm D, i.e. where firm U contracts directly with firm D. Assuming firm U has an interest to provide an incentive contract instead of proposing only a contract for the efficient firm D, it maximizes its expected profit under the individual participation and incentive compatibility constraints for firm D. Denoting

$$\mathrm{E}\left[\pi^{vi}\right] = \nu\pi^{vi}\left(\underline{\beta}\right) + (1-\nu)\,\pi^{vi}\left(\overline{\beta}\right),$$

the analysis is standard and is summarized in the following lemma.

Lemma 2.9. *If, under the same asymmetry of information as the regulator with respect to firm D, firm U proposes directly a menu of contracts to firm D, the optimal menu of contracts for firm U yields final outcomes* $\underline{q}_1^{vi}$ *and* $\underline{e}^{vi}$*, or* $\overline{q}_1^{vi}$ *and* $\overline{e}^{vi}$*. Firm U's expected profit is* $\mathrm{E}\left[\pi^{vi}\right] - \nu\phi\left(\overline{e}^{vi}\right)$ *and the expected social welfare level is* $\mathrm{E}\left[S_1\left(q_1^{vi}\right) - p_1\left(q_1^{vi}\right)q_1^{vi}\right] + \nu\phi\left(\overline{e}^{vi}\right)$*. Firm D's profit is* 0 *when it is of type* $\overline{\beta}$ *and* $\phi\left(\overline{e}^{vi}\right)$ *when it is of type* $\underline{\beta}$*.*

2.A.2 Socially harmful regulation

The timing of the game follows the same path as described in section 2.4: first, nature chooses the type β of firm D; second, the upstream firm U proposes the two-part tariff to the regulator; third, the regulator decides to accept or not the tariff and computes the optimal mechanism for firm D; and, finally, the downstream firm chooses a contract from the mechanism and produces the final good.

Strategy of the regulator

If it accepts the tariff T^U, assuming that the regulator prefers to make both firms produce than to propose a contract only to the efficient one, the regulator maximizes its expected profit, under the constraints of individual participation and incentive compatibility for each type of firm D

$$\max_{\underline{q}_1,\underline{e},\underline{t},\overline{q}_1,\overline{e},\overline{t}} \mathrm{E}\left[S_1 + \lambda p_1 q_1 - \lambda\pi^D - (1+\lambda)\left(\psi + C^D + H_0 + p_0 q_1\right)\right].$$

Standard analysis yields the system

$$\begin{cases} p_1\left(\underline{q}_1\right) - C_q^D\left(\underline{\beta}, \underline{q}_1, \underline{e}\right) - p_0 + \frac{\lambda}{1+\lambda} p_{1q}\left(\underline{q}_1\right) \underline{q}_1 = 0, \\ \psi_e\left(\underline{e}\right) + C_e^D\left(\underline{\beta}, \underline{q}_1, \underline{e}\right) = 0, \\ p_1\left(\overline{q}_1\right) - C_q^D\left(\overline{\beta}, \overline{q}_1, \overline{e}\right) - p_0 + \frac{\lambda}{1+\lambda} p_{1q}\left(\overline{q}_1\right) \overline{q}_1 = 0, \\ \psi_e\left(\overline{e}\right) + C_e^D\left(\overline{\beta}, \overline{q}_1, \overline{e}\right) + \frac{\lambda}{1+\lambda} \frac{\nu}{1-\nu} \phi_e\left(\overline{e}\right) = 0, \end{cases}$$

which is assumed to be uniquely solved for any proposed p_0 by $\left\{\left(\underline{q}_1^*\left(p_0\right), \underline{e}^*\left(p_0\right)\right), \left(\overline{q}_1^*\left(p_0\right), \overline{e}^*\left(p_0\right)\right)\right\}$. As in the full information case, this solution does not depend on H_0. Only the efficient type gets a strictly positive profit $\pi^D = \phi\left(\overline{e}^*\right)$, inducing socially efficient production and effort levels for the good type on the contrary of those of the bad type.

If there is no production, social welfare is equal to $S_1(0)$. Thus, the regulator accepts T^U as long as social welfare when there is production is greater than or equal to $S_1(0)$.

Strategy of the upstream firm

The same type of results are obtained as in the full information case. When maximizing its profits, firm U takes into account the constraints that, first, the final quantity and effort are determined by p_0 and, second, the acceptance of the tariff depends on the quantity and effort set by the contract of the regulator and on H_0. Therefore, for a given p_0, the acceptance of the tariff limits the raise of H_0 and the constraint is binding. Firm U has, up to a constant, the same objective as the regulator. Its optimal strategy with two-part tariff is to generate the highest possible social welfare by the choice of the quantity and effort through p_0, and to ask for it through H_0. The main difference with the full information case is that firm U has only one instrument, namely p_0, to generate the solution $\left\{\left(\underline{q}_1^*, \underline{e}^*\right), \left(\overline{q}_1^*, \overline{e}^*\right)\right\}$. But this is possible here because firm U's marginal cost is constant.[44] The equilibrium is summarized in the following lemma.

Lemma 2.10. *Under asymmetric information, firm U can always obtain a greater profit when the downstream firm D is regulated.*

[44] In case of non-constant marginal cost, proposing a single two-part tariff does not induce the optimal contract. In order to deal with such a case, one should consider the computation of the optimal contract and its further implementation.

Moreover, the optimal[45] *two-part tariff for firm U when there is regulation is*

$$T^U(q_1) = \frac{1}{1+\lambda}\mathrm{E}\left[\mathrm{SW}^{viR} - S_1(0)\right] + F^U + c^U q_1,$$

which yields a profit of $\pi^U = \frac{1}{1+\lambda}\mathrm{E}\left[\mathrm{SW}^{viR} - S_1(0)\right]$ *and final outcomes* $\underline{q}_1^{viR}$ *and* $\underline{e}^{viR}$*, or* $\overline{q}_1^{viR}$ *and* $\overline{e}^{viR}$*. The expected social welfare is* $S_1(0)$ *and corresponds to the zero production situation. Firm D gets zero profit when it is of type* $\overline{\beta}$ *and* $\phi\left(\overline{e}^{viR}\right)$ *when it is of type* $\underline{\beta}$*.*

The regulation of firm D under asymmetric information still allows firm U to collect part of the consumer net surplus on top of the expected regulated vertically integrated profit. Indeed, the profit of firm U can be rewritten[46] as

$$\pi^U = \mathrm{E}\left[\pi^{viR}\right] + \frac{1}{1+\lambda}\mathrm{E}\left[S_1^{viR} - S_1(0) - p_1^{viR}q_1^{viR}\right] - \frac{\lambda\nu}{1+\lambda}\phi\left(\overline{e}^{viR}\right).$$

The asymmetry of information limits the rent extraction by a factor $\frac{\lambda\nu}{1+\lambda}\phi\left(\overline{e}^{viR}\right)$, which represents the cost of public funds associated with the efficient firm's rent (the $1+\lambda$ in the denominator is due to the fact that H_0 is taken from public funds) but does not modify the fact that firm U manages to extract rents such that expected social welfare is equal to $S_1(0)$.

2.A.3 Endogenous decision to regulate

As in section 2.5, the setting is extended so as to introduce a new outside option for the regulator: to choose whether or not to regulate the downstream firm D before firm U proposes its tariff.

The time at which this outside opportunity should be given to the regulator is not as clear as it is in the full information case. Indeed, if the decision of the regulator is made after the upstream firm as proposed its two-part tariff T^U, the comparison is not easily tractable in our setting as two different tools are used: two-part tariff and contract. Therefore, the equilibrium of the game with this timing can differ from the systematic regulation case. But both asymmetric information as well as tools play a role in this change.

[45]Following the discussion in section 2.8.2 p. 80, this is the "best" two-part tariff from the point of view of firm U. Of course, this is not *a priori* the optimal (unrestricted) contract.

[46]The definition of $\overline{\mathrm{SW}}^{viR}$ and $\underline{\mathrm{SW}}^{viR}$ are given p. 94.

The timing of the game is the following: first, nature chooses the type of firm D; second, the regulator decides whether or not to regulate firm D; third, firm U proposes a tariff to the regulator if there is regulation, or a menu of tariffs to firm D otherwise; fourth, the tariff is accepted or rejected by the regulator, if regulation, or by firm D otherwise; fifth, final levels of good 1 and effort are set by the downstream firm.

If, in step 2, the regulator decides to regulate firm D, then the analysis is the same as in section 2.A.2. Lemma 2.10 exhibits the equilibrium of the subgame with an expected social welfare level of $S_1(0)$.

If, on the contrary, the regulator decides not to regulate firm D, then, in step 3, firm U proposes a menu of tariffs to firm D which, in step 4, accepts or rejects one of these tariffs. The subgame is analogous to the *no-regulation* benchmark studied in section 2.A.1. The optimal contract is described by lemma 2.9 and expected social welfare is $\mathrm{E}\left[S_1\left(q_1^{vi}\right) - p_1\left(q_1^{vi}\right) q_1^{vi}\right] + \nu\phi\left(\bar{e}^{vi}\right)$.

In step 2, the regulator compares the possible payoffs of the game in terms of expected social welfare. The equilibrium of the game is the absence of regulation of firm D.

Lemma 2.11. *When the regulator decides whether to regulate or not firm D before the two-part tariff T^U is proposed and when the regulator and firm U face the same asymmetry of information with respect to firm D, the regulator never regulates firm D and firm U extracts a profit of* $\mathrm{E}\left[\pi^{vi}\right] - \nu\phi\left(\bar{e}^{vi}\right)$. *The final outcomes are $\underline{q}_1^{vi}$ and $\underline{e}^{vi}$, or $\bar{q}_1^{vi}$ and $\bar{e}^{vi}$. Firm D's profit is* 0 *when it is of type $\bar{\beta}$ and* $\phi\left(\bar{e}^{vi}\right)$ *when it is of type $\underline{\beta}$.*

All these elements are used in section 2.8, page 78, for the discussion on the effects of the regulation.

2.B Annex: Unregulated national upstream firm in the Ramsey-Boîteux framework

In section 2.6, page 69, it has been shown that firm U's ability to obtain a rent from regulation is increased whenever its surplus is added in the social welfare objective function, i.e. if firm U is national. This was achieved through the increase in the fixed-part H_0 had no influence on the equilibrium level of the equilibrium . The main difference in a regulatory framework *à la Ramsey-Boîteux* is that one cannot increase the fixed part without changing output levels because of the budget constraint that links fixed and marginal costs, i.e. H_0 and q_i for $i = 1, \ldots, n$. This section aims at extending the framework *à la Ramsey-Boîteux* by relaxing the assumption that firm U is a foreign undertaking.

If firm U is national, its profits are added with a multiplicative coefficient $\alpha \in [0,1]$ in social welfare, named SW^{α}. When firm D is regulated, the program to be solved by the regulator is ($t = 3$ of the game described page 67)

$$\begin{aligned} &\max_{q_1,q_2,\ldots,q_n} \left[\begin{array}{c} \left[\sum_{i=1}^{n} S_i(q_i) - \sum_{i=1}^{n} p_i(q_i)\, q_i\right] + \alpha \left[T^U(q_1) - C^U(q_1)\right] \\ + \left[\sum_{i=1}^{n} p_i(q_i)\, q_i - C^D(q_1) - C^N(q_2,\ldots,q_n) - T^U(q_1)\right] \end{array} \right] \\ &\text{s.t.} \quad \pi^D(q_1) + \pi^N(q_2,\ldots,q_n) \geq 0. \end{aligned} \tag{2.20}$$

For given production levels, this new social welfare function is always greater than the one used until now that did not take into account firm U's profit, with

$$\begin{cases} \forall (q_1 \neq 0, q_2, \ldots, q_n), & \mathrm{SW}^{\alpha}(q_1, q_2, \ldots, q_n) > \mathrm{SW}(q_1, q_2, \ldots, q_n), \\ \forall (q_1 = 0, q_2, \ldots, q_n), & \mathrm{SW}^{\alpha}(0, q_2, \ldots, q_n) = \mathrm{SW}(0, q_2, \ldots, q_n). \end{cases}$$

Optimally solving this program yields once again prices *à la Ramsey-Boîteux*

$$\begin{cases} p_1(q_1^{**}) - C^D_{q_1}(q_1^{**}) - c^U - \left(1 - \frac{\alpha}{1+\lambda^{**}}\right) p_0 + \frac{\lambda^{**}}{1+\lambda^{**}} p_{1q}(q_1^{**})\, q_1^{**} = 0, \\ p_i(q_i^{**}) - C^N_{q_i}(q_2^{**}, \ldots, q_n^{**}) + \frac{\lambda^{**}}{1+\lambda^{**}} p_{iq}(q_i^{**})\, q_i^{**} = 0 \qquad \text{for } i = 2, .., n. \end{cases} \tag{2.21}$$

Thus, taking into account firm U's profit as welfare improving has two main effects. First, the perceived marginal cost of good 0 is decreasing with α and the influence of the price of good 0 on the outcome is restrained. Second, by modifying the level of production of good 1, it influences the level of all other goods because the Lagrangian multiplier of the budget constraint over all regulated goods changes.

Anticipating the behavior of the regulator, firm U (at $t = 1$) maximizes its profit over the two-part tariff under the constraint that the regulator is willing to accept this tariff. Thus, two constraints have to be verified. First, H_0 and p_0 must allow the regulator to raise enough money from the markets to pay for the tariff

$$\sum_{i=1}^{n} p_i(q_i^m)\, q_i^m - C^D(q_1^m) - C^N(q_2^m, \dots, q_n^m) - p_0^{**} q_1^m \geq H_0^{**}$$

where q_1^m is defined for the given p_0^{**}. Moreover, output levels induced by this tariff have to be such that the absence of production of good 1 is welfare enhancing

$$\mathrm{SW}^{\alpha}(q_1^{**}, \dots, q_n^{**}) \geq \mathrm{SW}^{\alpha}(0, \widehat{q}_2, \dots, \widehat{q}_n).$$

Let (H_0^*, p_0^*) be the tariff proposed by firm U if it was not national but foreign, as in section 2.9. With such a tariff, it has been shown that two possible equilibria could arise, depending on the structure of the economy: (1) all goods $i \neq 1$ are priced at monopoly price and good 1 is priced at the monopoly price of the vertically integrated firms (U and D altogether); (2) output levels $(q_1^*, \dots, q_n^*)$ induce the same level of social welfare as the one without production of good 1. Thus

$$\begin{aligned}
&(1) \quad p_1(q_1^{vi})\, q_1^{vi} + \textstyle\sum_{i=2}^{n} p_i(q_i^m)\, q_i^m - C^D(q_1^{vi}) - C^N(q_2, \dots, q_n) - F^U - p_0^* q_1^{vi} = H_0^* - F^U, \\
&(2) \quad \mathrm{SW}(q_1^*, \dots, q_n^*) = \mathrm{SW}(0, \widehat{q}_2, \dots, \widehat{q}_n).
\end{aligned} \tag{2.22}$$

When situation (1) occurs, firm U cannot obtain less than what it got when it was not added in social welfare ($\alpha = 0$) because, due to the assumption of constant marginal cost, the tariff $(H_0^*, p_0^* = c^U)$ would yield the same level of profit, whatever the quantity q_1^{**} really required by the regulator. Nevertheless, firm U has no chance to get more from the regulator because the upper limit that the economy as a whole can generate has been reached. In a sense, the "cake" cannot be increased any more and firm U's gain is equal whether or not it is added in social welfare, which ends at

$$\mathrm{SW}^{\alpha}\left(q_1^{vi}, q_2^{m} \ldots, q_n^{m}\right) > \mathrm{SW}\left(q_1^{vi}, q_2^{m} \ldots, q_n^{m}\right) > \mathrm{SW}\left(0, \widehat{q}_2, \ldots, \widehat{q}_n\right). \tag{2.23}$$

When situation (2) occurs, $\left(H_0^*, p_0^*\right)$ being accepted implies that $q_1^* > 0$ and, in turn, that $\mathrm{SW}^{\alpha}(q_1^*, \ldots, q_n^*) > \mathrm{SW}(q_1^*, \ldots, q_n^*)$. Moreover, quantities are assumed not to be monopoly ones. Thus, the tariff has all the necessary features for lemma 2.8, *mutatis mutandis*, to apply.[47] This yields the following lemma.

Lemma 2.12. *When firm U's profit is added in the social welfare with a coefficient α, firm U can always obtain a profit at least equal to the one it gets without being taken into account in social welfare, when the downstream firm D is regulated. Its profit will be strictly higher if, when it is not taken into account in social welfare, monopoly prices over all markets are not imposed by the regulator.*

Eventually, when comes the time for the regulator to choose whether or not to regulate firm D ($t = 0$ of the timing), it has to compare social welfare levels induced by both sub-games. If firm D is not regulated, social welfare ends at $S_1^{vi} - p_1^{vi} q_1^{vi} + \sum_{i=2}^{n} [\widehat{S}_i - \widehat{p}_i \widehat{q}_i] + \alpha \pi_1^{vi}$; otherwise, either $S_1^{vi} - p_1^{vi} q_1^{vi} + \sum_{i=2}^{n} [S_i^m - p_i^m q_i^m] + \alpha \left[\left(H_0^{**} - F^U\right) - \left(p_0^{**} - c^U\right) q_1^{vi}\right]$, or $S_1(0) + \sum_{i=2}^{n} [\widehat{S}_i - \widehat{p}_i \widehat{q}_i]$. The last level is always lower than the first one. Moreover, lemma 2.12 shows that firm U gets a higher profit when there is regulation. This helps comparing the first two levels. As in section 2.9, this comparison shows that the regulator chooses not to regulate firm D.

[47] The main difference is the social welfare function, but the proof is the same. Please refer to the proof of the lemma, p. 116.

2.C Appendix

Sections 2.C.1 to 2.C.8 are dedicated to proofs of results related to the regulatory framework *à la Laffont-Tirole*, and sections 2.C.9 to 2.C.12 to the one *à la Ramsey-Boîteux*.

2.C.1 Proof of lemma 2.1

This proof follows the same line as standard textbooks such as Tirole (1988, p. 176). At the second step, when the tariff is set, firm D decides whether or not to accept the tariff T^U. It accepts T^U if it can at least break even while maximizing its profit with the extra cost of T^U, that is if there exists $\tilde{q}_1$ such that

$$\tilde{q}_1 = \arg\max_q \left[p_1(q)\,q - C^D(q) - H_0 - p_0 q\right]$$

and

$$p_1(\tilde{q}_1)\,\tilde{q}_1 - C^D(\tilde{q}_1) - H_0 - p_0\tilde{q}_1 \geq 0.$$

If such a $\tilde{q}_1$ exists, then it is characterized by the first order condition which yields a solution noted $q_1^*(p_0)$. As usual, unless the constraint is binding, q_1 depends on p_0 only. The second order condition is assumed to be satisfied.

At the first step, firm U maximizes its profit subject to the constraint that firm D is maximizing its own profit under its participation constraint

$$\max_{p_0,H_0} \left[H_0 + p_0 q_1 - C^U(q_1)\right] \quad \text{s.t.} \quad \begin{cases} q_1 = q_1^*(p_0), \\ p_1(q_1^*)\,q_1^* - C^D(q_1^*) - H_0 - p_0 q_1^* \geq 0. \end{cases}$$

Because leaving profits to firm D is costly to firm U, the participation constraint of firm D is binding at the optimum, $\pi^D = 0$. This yields, omitting the arguments,

$$\max_{p_0} \left[p_1(q_1^*)\,q_1^* - C^D(q_1^*) - C^U(q_1^*)\right].$$

This program is the same as that of the vertically integrated firm V and attains its maximum for the value $q_1 = q_1^{vi}$. Therefore, the optimal tariff for firm U is to set $p_0 = c^U$. This yields $q_1^*\left(c^U\right) = q_1^{vi}$

which is the argument that maximizes the objective function of firm U. Finally, the fixed part is given by the participation constraint. Firm U gets $\pi^U = \pi^{vi}$, while social welfare is $S_1\left(q_1^{vi}\right) - p_1\left(q_1^{vi}\right)q_1^{vi}$.

2.C.2 Proof of lemma 2.2

Basically, the regulator can secure $S_1(0)$ by refusing to regulate firm D. As the tariff proposed induces a higher level of social welfare, the regulator accepts it. More formally, when the regulator faces $T^U(q_1) = \pi^{vi} + F^U + c^U q_1$, the regulator maximizes social welfare under the constraint $\pi^D \geq 0$. This constraint is binding and social welfare becomes

$$S_1 + \lambda p_1 q_1 - (1+\lambda)\left(C^D + T^U\right) = S_1 - p_1 q_1 + (1+\lambda)\left(p_1 q_1 - C^D - C^U - \pi^{vi}\right).$$

With $q_1 = q_1^{vi}$, social welfare is $S_1\left(q_1^{vi}\right) - p_1\left(q_1^{vi}\right)q_1^{vi} > S_1(0)$ and the regulator accepts the tariff.

2.C.3 Proof of proposition 2.1

From lemma 2.2, $S_1\left(q_1^{vi}\right) - p_1\left(q_1^{vi}\right)q_1^{vi} > S_1(0)$. Therefore, there exits some $\varepsilon > 0$ such that the left hand side minus ε remains greater than $S_1(0)$. This means that, when it faces the *no-regulation* tariff with $\varepsilon/(1+\lambda)$ more in the fixed part, the regulator gets more than the acceptance threshold $S_1(0)$ when it makes firm D produce q_1^{vi}. Thus, the regulator still accepts this two-part tariff thanks to which firm U obtains $\pi^{vi} + \varepsilon/(1+\lambda) > \pi^{vi}$. Thus, firm U has an incentive to depart from its *no-regulation* tariff by increasing the fixed part. Let now compute the optimal two-part tariff.

Given T^U, the regulator solves the following program

$$\max_{q_1,\pi^D}\left[S_1 + \lambda p_1 q_1 - \lambda\pi^D - (1+\lambda)\left(C^D + T^U\right)\right]$$

under the participation constraint of firm D: $\pi^D \geq 0$. Because leaving rents to firm D is costly, $\pi^D = 0$. This yields the standard first order equation inducing an outcome noted $q_1^*(p_0)$. The acceptance condition is

$$S_1(q_1^*) + \lambda p_1(q_1^*)q_1^* - (1+\lambda)\left[C^D(q_1^*) + H_0 + p_0 q_1^*\right] \geqslant S_1(0).$$

Firm U maximizes its profit with respect to p_0 and H_0, subject to the acceptance condition and the reaction of the regulator. For a given p_0, the acceptance condition defines an upper limit to the value of H_0. As firm U's profit is strictly increasing in H_0, the constraint is binding at the equilibrium and the objective function of firm U becomes

$$\max_{p_0} \frac{1}{1+\lambda}\left[S_1^* - S_1(0) + \lambda p_1^* q_1^* - (1+\lambda)\left(C^{D*} + C^{U*}\right)\right].$$

Except for the constant $S_1(0)$, this objective function is $(1+\lambda)^{-1}$ times the objective function of a regulator who would be surpervising the vertically integrated firm. Therefore, the optimal price is $p_0 = c^U$. The value of H_0 is given by the individual participation constraint which can be written in the two following ways

$$\begin{aligned} H_0 &= \frac{1}{1+\lambda}\left[\mathrm{SW}^{viR} - S_1(0)\right] + F^U \\ &= \left[p_1^{viR} q_1^{viR} - C^U\left(q_1^{viR}\right) - C^D\left(q_1^{viR}\right)\right] + \frac{1}{1+\lambda}\left[S_1^{viR} - S_1(0) - p_1^{viR} q_1^{viR}\right] + F^U. \end{aligned}$$

From the acceptance condition, the social welfare level is $S_1(0)$ and the final outcome is q_1^{viR}.

2.C.4 Proof of lemma 2.3

Recalling section 2.3.1, SW^{viR} stands for the highest social welfare in a situation where both firms are vertically integrated. By proposition 2.1, the rent of the upstream firm is

$$\pi^U = \frac{1}{1+\lambda}\left[\mathrm{SW}^{viR} - S_1(0)\right].$$

By the envelope theorem,

$$\frac{d\pi^U}{d\lambda} = \frac{\partial \pi^U}{\partial \lambda} = -\frac{1}{(1+\lambda)^2}\left[\mathrm{SW}^{viR} - S_1(0)\right] < 0.$$

Thus, the rent of firm U is decreasing in λ.

2.C.5 Proof of lemma 2.4

Firm D's profits benefit public funds. At $t=1$, when firm D is not regulated, the objective function (2.11) to maximize has the following first order conditions[48]

$$\begin{aligned}
\frac{\partial \Pi^*}{\partial H_0} &= \gamma \frac{d\pi^U}{dH_0} X^{\gamma-1} + (1-\gamma)\frac{d\pi^D}{dH_0} X^{\gamma} \\
&= (1-\gamma) X^{\gamma-1}\left[\frac{\gamma}{1-\gamma} - X\right], \\
\frac{\partial \Pi^*}{\partial p_0} &= \gamma \frac{d\pi^U}{dp_0} X^{\gamma-1} + (1-\gamma)\frac{d\pi^D}{dp_0} X^{\gamma} \\
&= \gamma\left[\frac{\partial \pi^U}{\partial p_0} + \frac{\partial \pi^U}{\partial q_1^*}\frac{dq_1^*}{dp_0}\right] X^{\gamma-1} + (1-\gamma)\left[\frac{\partial \pi^D}{\partial p_0} + \frac{\partial \pi^D}{\partial q_1^*}\frac{dq_1^*}{dp_0}\right] X^{\gamma} \\
&= q_1^* \frac{\partial \Pi^*}{\partial H_0} + \gamma\left(p_0 - c^U\right)\frac{dq_1^*}{dp_0} X^{\gamma-1},
\end{aligned}$$

where q_1^* is chosen, by definition, to maximize π^U for a given p_0. Second order conditions are

$$\begin{aligned}
\frac{\partial^2 \Pi^*}{\partial H_0^2} &= -\gamma(1-\gamma)\frac{dX}{dH_0}(1+X) X^{\gamma-2} < 0, \\
\frac{dX}{dH_0} &= \frac{\pi^D + \pi^U}{[\pi^D]^2} > 0, \\
\frac{\partial^2 \Pi^*}{\partial p_0^2} &= \gamma\left(p_0 - c^U\right)\frac{d}{dp_0}\left[\frac{dq_1^*}{dp_0} X^{\gamma-1}\right] + \gamma \frac{dq_1^*}{dp_0} X^{\gamma-1} = \gamma \frac{dq_1^*}{dp_0} X^{\gamma-1} < 0.
\end{aligned}$$

Thus, solution (2.13) exhibited page 74 is a maximum.

If firm D is regulated, first order equations are

$$\begin{aligned}
\frac{\partial \tilde{\Pi}}{\partial H_0} &= \beta \frac{d\pi^U}{dH_0} Y^{\beta-1} + (1-\beta)\frac{d\,\mathrm{SW}}{dH_0} Y^{\beta} \\
&= (1+\lambda)(1-\beta) Y^{\beta-1}\left[\frac{\beta}{(1+\lambda)(1-\beta)} - Y\right], \\
\frac{\partial \tilde{\Pi}}{\partial p_0} &= \beta \frac{d\pi^U}{dp_0} Y^{\beta-1} + (1-\beta)\frac{d\,\mathrm{SW}}{dp_0} Y^{\beta} \\
&= \beta\left[\frac{\partial \pi^U}{\partial p_0} + \frac{\partial \pi^U}{\partial \tilde{q}_1}\frac{d\tilde{q}_1}{dp_0}\right] Y^{\beta-1} + (1-\beta)\left[\frac{\partial\,\mathrm{SW}}{\partial p_0} + \frac{\partial\,\mathrm{SW}}{\partial \tilde{q}_1}\frac{d\tilde{q}_1}{dp_0}\right] Y^{\beta} \\
&= \tilde{q}_1 \frac{\partial \tilde{\Pi}}{\partial H_0} + \beta\left(p_0 - c^U\right)\frac{d\tilde{q}_1}{dp_0} Y^{\beta-1},
\end{aligned}$$

[48] X and Y are defined in section 2.7.3, p. 74, the following way: $X = \frac{\pi^U - 0}{\pi^D - 0}$ and $Y = \frac{\pi^U - 0}{\mathrm{SW} - S_1(0)}$.

with the following second order conditions

$$\frac{\partial^2\tilde{\Pi}}{\partial H_0^2} = -\beta(1-\beta)\frac{dY}{dH_0}[1+(1+\lambda)Y]Y^{\beta-2} < 0,$$
$$\frac{dY}{dH_0} = \frac{\mathrm{SW}+(1+\lambda)\pi^U}{[\mathrm{SW}]^2} > 0,$$
$$\frac{\partial^2\tilde{\Pi}}{\partial p_0^2} = \beta\left(p_0-c^U\right)\frac{d}{dp_0}\left[\frac{d\tilde{q}_1}{dp_0}Y^{\beta-1}\right]+\beta\frac{d\tilde{q}_1}{dp_0}Y^{\beta-1} = \beta\frac{d\tilde{q}_1}{dp_0}Y^{\beta-1} < 0.$$

Again, the solution (2.14) proposed page 75 is a maximum.

Denote

$$A = \left\{S_1+\lambda p_1q_1-S_1(0)-(1+\lambda)\left[C^D+C^U\right]\right\}\Big|_{q_1=q_1^{vi}},$$
$$B = \left\{S_1-p_1q_1-S_1(0)\right\}\big|_{q_1=q_1^{vi}},$$
$$C = \left\{S_1+\lambda p_1q_1-S_1(0)-(1+\lambda)\left[C^D+C^U\right]\right\}\Big|_{q_1=q_1^{viR}}.$$

Definitions of q_1^{viR} and q_1^{vi} yield $B<A<C$.

If $\tilde{\beta}$ exits, using (2.13) and (2.14), it must verify

$$(1-\gamma)A+\gamma B = (1-\beta)C$$

which is equivalent to

$$\tilde{\beta}(\gamma) = \frac{C-A}{C}+\frac{A-B}{C}\gamma.$$

Moreover, if β^* exists, it has to verify

$$\gamma\frac{A-B}{(1+\lambda)} = \frac{\beta}{(1+\lambda)}C$$

which is equivalent to

$$\beta^*(\gamma) = \frac{A-B}{C}\gamma.$$

Definitions of A, B and C show, first, that $\tilde{\beta}(\gamma)$ and $\beta^*(\gamma)$ exist for every possible $\gamma \in [0,1]$ and, second, that they are strictly increasing with $0 < \tilde{\beta}(0) < 1$ and $0 < \tilde{\beta}(1) < 1$, $\beta^*(0) = 0$, $0 < \beta^*(1) < 1$, $\tilde{\beta}(\gamma) > \beta^*(\gamma)$ and $\tilde{\beta}' = \beta'^* < 1$.

Firm *D*'s unregulated profits do not benefit public funds. When firm D's unregulated profit is not added in the social welfare with the multiplicative factor $(1+\lambda)$, everything but the expression of social welfare when firm D is unregulated stays equal. Thus, firm U's profit does not change either and $\beta^*(\gamma)$ is still defined the same way and equal to $= \frac{A-B}{C}\gamma$.

Then, one has to compare social welfare with regulation

$$\mathrm{SW} - S_1(0) = (1-\beta)\left\{S_1 + \lambda p_1 q_1 - S_1(0) - (1+\lambda)\left[C^D + C^U\right]\right\}\big|_{q_1 = q_1^{viR}}$$

to social welfare without regulation, where firm U's profit is simply added in social as consumer surplus, i.e.

$$\begin{aligned}\mathrm{SW} - S_1(0) &= \{S_1 - p_1 q_1\}\big|_{q_1=q_1^{vi}} - S_1(0) + (1-\gamma)\pi^{vi} \\ &= (1-\gamma)\left\{S_1 + \lambda p_1 q_1 - S_1(0) - (1+\lambda)\left[C^D + C^U\right]\right\}\big|_{q_1=q_1^{vi}} \\ &\quad + \gamma\{S_1 - p_1 q_1 - S_1(0)\}\big|_{q_1=q_1^{vi}} - \lambda(1-\gamma)\left\{p_1 q_1 - \left[C^D + C^U\right]\right\}\big|_{q_1=q_1^{vi}}.\end{aligned}$$

Define $\tilde{\tilde{\beta}}$ as firm U's bargaining power required by the regulator to be indifferent between regulating or not firm D, then it has to verify

$$(1-\gamma)A + \gamma B - \frac{\lambda(1-\gamma)}{(1+\lambda)}(A-B) = (1-\beta)C$$

which is equivalent to

$$\tilde{\tilde{\beta}}(\gamma) = \frac{(1+\lambda)C - A - \lambda B}{(1+\lambda)C} + \frac{A-B}{(1+\lambda)C}\gamma.$$

Thus, it is easily checked that for any γ in $[0,1]$, $\tilde{\tilde{\beta}}(\gamma) \geq \tilde{\beta}(\gamma) > \beta^*(\gamma)$, $\tilde{\tilde{\beta}}(1) = \tilde{\beta}(1)$ and $\tilde{\tilde{\beta}}' < \tilde{\beta}' = \beta'^* < 1$.

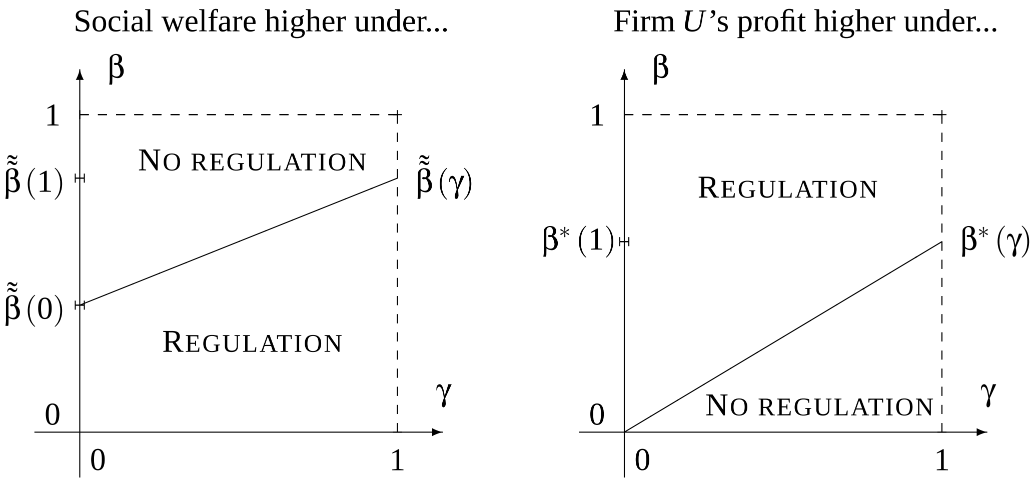

Figure 2.6: Thresholds for social welfare and firm U's profit, when firm U's unregulated profit do not benefit public funds

The two cases $\beta = 1$ and $\lambda = 0$ allows to verify that there is no contradiction in the computations. Both cases end with the same expressions for $\tilde{\beta}$ and $\tilde{\tilde{\beta}}$. On the one hand, when $\beta = 1$, firm U has all the bargaining power with respect to firm D. Thus, this latter ends with no profits, which eliminates the concern of how to account for them in social welfare. On the other hand, when $\lambda = 0$, public funds have no extra cost and the difference between the two cases considered for the allocation of firm D's unregulated profit disappears.

Eventually, the absence of regulation is less attractive for the regulator because firm D's actual profits have less value when they cannot benefit public funds. Thus, the regulator will content with a lower bargaining power with respect to firm U, i.e. a higher β, to favor firm D's regulation.

2.C.6 Proof of lemma 2.9

Firm U contracts directly with firm D and faces the same kind of asymmetry of information as the regulator. This means that firm U can base its contract on the observation of the cost C^D and the final output q_1, as the regulator does. Firm U uses the revelation principle so that it can propose contracts to firm D based on its true type: $(\underline{T}^U, \underline{q}_1, \underline{e})$, $(\overline{T}^U, \overline{q}_1, \overline{e})$. Define the function $e(\beta, \tilde{\beta}) = e(\tilde{\beta}) + \beta - \tilde{\beta}$. This is the effort that can be deduced from the contract taken when a type $\tilde{\beta}$ is announced and the real type is β.

The objective function of firm U is

$$\max_{\underline{T}^U,\underline{q}_1,\underline{e},\overline{T}^U,\overline{q}_1,\overline{e}} \left[\nu\left[\underline{T}^U - C^U(\underline{q}_1)\right] + (1-\nu)\left[\overline{T}^U - C^U(\overline{q}_1)\right]\right]$$

subject to the standard individual participation and incentive compatibility constraints

$$p_1(\overline{q}_1)\overline{q}_1 - \psi(\overline{e}) - C^D\left(\overline{\beta},\overline{q}_1,\overline{e}\right) - \overline{T}^U \geq p_1(\underline{q}_1)\underline{q}_1 - \psi\left(e\left(\overline{\beta},\underline{\beta}\right)\right) - C^D\left(\underline{\beta},\underline{q}_1,\underline{e}\right) - \underline{T}^U, \quad (\overline{IC})$$

$$p_1\left(\underline{q}_1\right)\underline{q}_1 - \psi(\underline{e}) - C^D\left(\underline{\beta},\underline{q}_1,\underline{e}\right) - \underline{T}^U \geq p_1(\overline{q}_1)\overline{q}_1 - \psi\left(e\left(\underline{\beta},\overline{\beta}\right)\right) - C^D\left(\overline{\beta},\overline{q}_1,\overline{e}\right) - \overline{T}^U, \quad (\underline{\mathrm{IC}})$$

$$p_1(\overline{q}_1)\overline{q}_1 - \psi(\overline{e}) - C^D\left(\overline{\beta},\overline{q}_1,\overline{e}\right) - \overline{T}^U \geq 0, \quad (\overline{IR})$$

$$p_1\left(\underline{q}_1\right)\underline{q}_1 - \psi(\underline{e}) - C^D\left(\underline{\beta},\underline{q}_1,\underline{e}\right) - \underline{T}^U \geq 0. \quad (\underline{\mathrm{IR}})$$

The standard analysis applies and constraint $\underline{\mathrm{IR}}$ is always satisfied as soon as $\overline{IR}$ and $\underline{\mathrm{IC}}$ are verified. Constraint $\overline{IC}$ is ignored in a first step and checked at the equilibrium and constraints $\overline{IR}$ and $\underline{\mathrm{IC}}$ are binding at the equilibrium. Rewriting the transfers, the objective function becomes, omitting the arguments,

$$\max_{\underline{q}_1,\underline{e},\overline{q}_1,\overline{e}} \begin{bmatrix} \nu\left[p_1\left(\underline{q}_1\right)\underline{q}_1 - C^D\left(\underline{\beta},\underline{q}_1,\underline{e}\right) - C^U\left(\underline{q}_1\right) - \psi(\underline{e}) - \phi(\overline{e})\right] \\ +(1-\nu)\left[p_1(\overline{q}_1)\overline{q}_1 - C^D\left(\overline{\beta},\overline{q}_1,\overline{e}\right) - C^U(\overline{q}_1) - \psi(\overline{e})\right] \end{bmatrix},$$

where $\phi(\overline{e}) = \psi(\overline{e}) - \psi(\overline{e} - \Delta\beta)$ represents the rent that gets the efficient type because it can always mimic the inefficient type by announcing $\overline{\beta}$ and exerting an effort $e\left(\underline{\beta},\overline{\beta}\right) = \overline{e} - \Delta\beta$. Thanks to the assumption on ψ, the function ϕ is such that $\phi_e > 0$ and $\phi_{ee} > 0$. Following the standard analysis – as in Laffont and Tirole (1993, pp. 57-59) – yields the usual system of first order conditions

$$\begin{cases} p_1\left(\underline{q}_1\right) - C_q^D\left(\underline{\beta},\underline{q}_1,\underline{e}\right) - C_q^U\left(\underline{q}_1\right) + p_{1q}\left(\underline{q}_1\right)\underline{q}_1 = 0, \\ \psi_e(\underline{e}) + C_e^D\left(\underline{\beta},\underline{q}_1,\underline{e}\right) = 0, \\ p_1(\overline{q}_1) - C_q^D\left(\overline{\beta},\overline{q}_1,\overline{e}\right) - C_q^U(\overline{q}_1) + p_{1q}(\overline{q}_1)\overline{q}_1 = 0, \\ \psi_e(\overline{e}) + C_e^D\left(\overline{\beta},\overline{q}_1,\overline{e}\right) + \frac{\nu}{1-\nu}\phi_e(\overline{e}) = 0. \end{cases} \quad (2.24)$$

This yields the following solutions $\left\{\left(\underline{q}_1^{vi},\underline{e}^{vi}\right),\left(\overline{q}_1^{vi},\overline{e}^{vi}\right)\right\}$ with tariffs

$$\begin{cases} \overline{T}^U = p_1\left(\overline{q}_1^{vi}\right)\overline{q}_1^{vi} - \psi\left(\overline{e}^{vi}\right) - C^D\left(\overline{\beta},\overline{q}_1^{vi},\overline{e}^{vi}\right), \\ \underline{T}^U = p_1\left(\underline{q}_1^{vi}\right)\underline{q}_1^{vi} - \psi\left(\underline{e}^{vi}\right) - C^D\left(\underline{\beta},\underline{q}_1^{vi},\underline{e}^{vi}\right) + \phi\left(\overline{e}^{vi}\right). \end{cases}$$

The constraint $\overline{IC}$ has to be checked. When rewriting this constraint using the final tariffs, one gets

$$\phi\left(e\left(\overline{\beta},\overline{\beta}\right)\right) - \phi\left(e\left(\overline{\beta},\underline{\beta}\right)\right) \leq 0.$$

Because the solution $\left\{\left(\underline{q}_1^{vi},\underline{e}^{vi}\right),\left(\overline{q}_1^{vi},\overline{e}^{vi}\right)\right\}$ maximizes the constrained social welfare, it should verify the revealed preferences

$$\begin{cases} \underline{p}_1\underline{q}_1 - \underline{C}^D - \underline{C}^U - \underline{\psi} \geq \underline{p}_1\underline{q}_1 - \underline{C}^D - \underline{C}^U - \psi\left(e\left(\underline{\beta},\overline{\beta}\right)\right), \\ \overline{p}_1\overline{q}_1 - \overline{C}^D - \overline{C}^U - \overline{\psi} - \frac{\nu}{1-\nu}\overline{\phi} \geq \overline{p}_1\overline{q}_1 - \overline{C}^D - \overline{C}^U - \psi\left(e\left(\overline{\beta},\underline{\beta}\right)\right) - \frac{\nu}{1-\nu}\phi\left(e\left(\overline{\beta},\underline{\beta}\right)\right). \end{cases}$$

Adding these two inequalities yields

$$\left(1+\frac{\nu}{1-\nu}\right)\left[\phi\left(e\left(\overline{\beta},\underline{\beta}\right)\right) - \phi\left(e\left(\overline{\beta},\overline{\beta}\right)\right)\right] \geq 0$$

which checks the constraint.

Finally, the expected social welfare is $\mathrm{E}\left[S_1\left(q_1^{vi}\right) - p_1\left(q_1^{vi}\right)q_1^{vi}\right] + \nu\phi\left(\overline{e}^{vi}\right)$, firm D gets 0 if it is of type $\overline{\beta}$ and $\phi\left(\overline{e}^{vi}\right)$ if it is of type $\underline{\beta}$. Firm U gets an expected profit of $\mathrm{E}\left[\pi^{vi}\right] - \nu\phi\left(\overline{e}^{vi}\right)$.

2.C.7 Proof of lemma 2.10

The proof follows the same path as the one of proposition 2.1. Given the two-part tariff T^U, the regulator ends up by proposing a contract $\{(\underline{q}_1^*(p_0),\underline{e}^*(p_0)),(\overline{q}_1^*(p_0),\overline{e}^*(p_0))\}$ to the downstream firm, as far as its acceptance condition, which sets that the final level of expected social welfare with these allocations is at least equal to $S_1(0)$, is satisfied.

The optimal strategy of firm U is given by the maximization of its profit with respect to p_0 and H_0, subject to the acceptance condition and the reaction of the regulator, i.e.

$$\max_{p_0,H_0}\left[H_0+\nu\left[p_0\underline{q}_1^*-C^U\left(\underline{q}_1^*\right)\right]+(1-\nu)\left[p_0\overline{q}_1^*-C^U\left(\overline{q}_1^*\right)\right]\right]$$

subject to

$$\begin{aligned}&\nu\left[S_1\left(\underline{q}_1^*\right)+\lambda p_1\left(\underline{q}_1^*\right)\underline{q}_1^*-\lambda\phi\left(\overline{e}^*\right)-(1+\lambda)\left[\psi\left(\underline{e}^*\right)+C^D\left(\underline{\beta},\underline{q}_1^*,\underline{e}^*\right)+H_0+p_0\underline{q}_1^*\right]\right]\\&+(1-\nu)\left[S_1\left(\overline{q}_1^*\right)+\lambda p_1\left(\overline{q}_1^*\right)\overline{q}_1^*-(1+\lambda)\left[\psi\left(\overline{e}^*\right)+C^D\left(\overline{\beta},\overline{q}_1^*,\overline{e}^*\right)+H_0+p_0\overline{q}_1^*\right]\right]\geqslant S_1(0).\end{aligned}$$

For a given p_0, this constraint defines an upper limit to the value of H_0. Therefore, the constraint is binding at the equilibrium and the objective function of firm U becomes, omitting the arguments

$$\begin{aligned}\max_{p_0}\tfrac{1}{1+\lambda}&\left\{\nu\left[S_1\left(\underline{q}_1^*\right)+\lambda p_1\left(\underline{q}_1^*\right)\underline{q}_1^*-\lambda\phi\left(\overline{e}^*\right)-(1+\lambda)\left[\psi\left(\underline{e}^*\right)+C^D\left(\underline{\beta},\underline{q}_1^*,\underline{e}^*\right)+C^U\left(\underline{q}_1^*\right)\right]\right]\right.\\&\left.+(1-\nu)\left[S_1\left(\overline{q}_1^*\right)+\lambda p_1\left(\overline{q}_1^*\right)\overline{q}_1^*-(1+\lambda)\left[\psi\left(\overline{e}^*\right)+C^D\left(\overline{\beta},\overline{q}_1^*,\overline{e}^*\right)+C^U\left(\overline{q}_1^*\right)\right]\right]-S_1(0)\right\}.\end{aligned}$$

This objective function is qualitatively the same as the one of a regulator which regulates the vertically integrated monopoly under asymmetric information, for which the optimum is described by $\left(\underline{q}_1^{viR},\underline{e}^{viR}\right)$ and $\left(\overline{q}_1^{viR},\overline{e}^{viR}\right)$. As the marginal cost of firm U is constant, setting $p_0=c^U$ induces both $\underline{q}_1^*=\underline{q}_1^{viR}$, $\underline{e}^*=\underline{e}^{viR}$ and $\overline{q}_1^*=\overline{q}_1^{viR}$, $\overline{e}^*=\overline{e}^{viR}$ (same first order conditions, refer to section 2.A.1). The informational rent is 0 for type $\overline{\beta}$ and $\phi\left(\overline{e}^{viR}\right)$ for type $\underline{\beta}$ and the expected social welfare is $S_1(0)$. Finally, the value of H_0 is given by the individual participation constraint which, as in proposition 2.1, can be written in two different ways

$$\begin{aligned}H_0&=\tfrac{1}{1+\lambda}\,\mathrm{E}\left[\mathrm{SW}^{viR}-S_1(0)\right]+F^U\\&=\mathrm{E}\left[\pi^{viR}\right]+\tfrac{1}{1+\lambda}\,\mathrm{E}\left[S_1^{viR}-S_1(0)-p_1^{viR}q_1^{viR}\right]-\tfrac{\lambda\nu}{1+\lambda}\phi\left(\overline{e}^{viR}\right)+F^U.\end{aligned}$$

The incentive constraint of the type $\overline{\beta}$ is checked with the same methodology as used in the previous proof (see also Laffont and Tirole 1993, p. 59).

It remains to be showed that firm U's current profit is higher than the one it gets without regulation, i.e.

$$\mathrm{E}\left[\pi^{viR}\right]+\frac{1}{1+\lambda}\mathrm{E}\left[S_1^{viR}-S_1(0)-p_1^{viR}q_1^{viR}\right]-\frac{\lambda\nu}{1+\lambda}\phi\left(\overline{e}^{viR}\right)>\mathrm{E}\left[\pi^{vi}\right]-\nu\phi\left(\overline{e}^{vi}\right).$$

Define

$$\begin{cases}\overline{f}(q,e)=\frac{1-\nu}{1+\lambda}\left[S_1(q)-S_1(0)-p_1(q)q\right]-\frac{\lambda\nu}{1+\lambda}\phi(e)\\ \qquad\qquad+(1-\nu)\left[p_1(q)q-\psi(e)-C^D(q)-C^U\left(\overline{\beta},q,e\right)\right],\\ \underline{f}(q,e)=\frac{\nu}{1+\lambda}\left[S_1(q)-S_1(0)-p_1(q)q\right]\\ \qquad\qquad+\nu\left[p_1(q)q-\psi(e)-C^D(q)-C^U\left(\underline{\beta},q,e\right)\right].\end{cases}$$

The function $(1+\lambda)\overline{f}$ is part of the program of a regulator that faces the vertically integrated firm, and it is maximized for $q=\overline{q}_1^{viR}$ and $e=\overline{e}^{viR}$. Therefore, $\overline{f}\left(\overline{q}_1^{viR},\overline{e}^{viR}\right)>\overline{f}\left(\overline{q}_1^{vi},\overline{e}^{vi}\right)$. As $0\leq\frac{\lambda}{1+\lambda}<1$, one gets

$$\begin{aligned}\overline{f}\left(\overline{q}_1^{vi},\overline{e}^{vi}\right)&=(1-\nu)\pi^{vi}\left(\overline{\beta}\right)-\tfrac{\lambda\nu}{1+\lambda}\phi\left(\overline{e}^{vi}\right)+\tfrac{1-\nu}{1+\lambda}\left[S_1\left(\overline{q}_1^{vi}\right)-S_1(0)-p_1\left(\overline{q}_1^{vi}\right)\overline{q}_1^{vi}\right]\\&>(1-\nu)\pi^{vi}\left(\overline{\beta}\right)-\nu\phi\left(\overline{e}^{vi}\right),\end{aligned}$$

which is part of the profit that firm U gets without regulation. The same thing occurs with $\underline{f}$: $\underline{f}\left(\underline{q}_1^{viR},\underline{e}^{viR}\right)>\nu\pi^{vi}\left(\underline{\beta}\right)$ and finally, the profit with regulation, $\underline{f}\left(\underline{q}_1^{viR},\underline{e}^{viR}\right)+\overline{f}\left(\overline{q}_1^{viR},\overline{e}^{viR}\right)$, is strictly greater than the one without regulation, $\nu\pi^{vi}\left(\underline{\beta}\right)+(1-\nu)\pi^{vi}\left(\overline{\beta}\right)-\nu\phi\left(\overline{e}^{vi}\right)$.

2.C.8 Proof of lemma 2.5

Both q_1 and e are computed simultaneously through first order equations: system (2.24), page 109, in the absence of regulation yields $\left(q_1^{vi},e^{vi}\right)$ and system (2.17), page 94, when the vertically integrated firm is regulated gives $\left(q_1^{viR},e^{viR}\right)$.

For the computations of $(\overline{q}_1,\overline{e})$, the only difference in these two systems of equations relies, for the system inducing e^{viR}, in the factor $\alpha=\frac{\lambda}{1+\lambda}$ in front of the $p_{1q}q_1$ in the equation for the quantity and in the same fraction in front of $\frac{\nu}{1-\nu}\phi$ in the equation for the effort, i.e.

$$\text{for } (\overline{q}_1^{vi}, \overline{e}^{vi})\text{: } \begin{cases} p_1(\overline{q}_1) - C_q^D\left(\overline{\beta}, \overline{q}_1, \overline{e}\right) - C_q^U(\overline{q}_1) + p_{1q}(\overline{q}_1)\overline{q}_1 = 0, \\ \psi_e(\overline{e}) + C_e^D\left(\overline{\beta}, \overline{q}_1, \overline{e}\right) + \frac{\nu}{1-\nu}\phi_e(\overline{e}) = 0, \end{cases}$$

$$\text{for } (\overline{q}_1^{viR}, \overline{e}^{viR})\text{: } \begin{cases} p_1(\overline{q}_1) - C_q^D\left(\overline{\beta}, \overline{q}_1, \overline{e}\right) - C_q^U(\overline{q}_1) + \left[\frac{\lambda}{1+\lambda}\right] p_{1q}(\overline{q}_1)\overline{q}_1 = 0, \\ \psi_e(\overline{e}) + C_e^D\left(\overline{\beta}, \overline{q}_1, \overline{e}\right) + \left[\frac{\lambda}{1+\lambda}\right]\frac{\nu}{1-\nu}\phi_e(\overline{e}) = 0. \end{cases}$$

This coefficient α is equal to 1 in the case of e^{vi} or, equivalently, vertical contracting mimics the limit case where $\lambda \to +\infty$. Thus, one can differentiate the "common" system of equations with respect to this multiplicative parameter α or λ. Moreover, one can also wonder what is the influence of the probability of the efficient type ν in driving the final outcomes. Let us note SOC_{q_1} the second order equation with respect to q_1 and SOC_e the second order equation with respect to e. Then, omitting the arguments, the differentiation yields

$$\begin{bmatrix} dq_1 \\ de \end{bmatrix} = \frac{\begin{bmatrix} \text{SOC}_e & C_{qe}^D \\ C_{eq}^D & \text{SOC}_{q_1} \end{bmatrix}}{\text{SOC}_{q_1}.\text{SOC}_e - \left(C_{qe}^D\right)^2} \begin{bmatrix} \left(\frac{1}{1+\lambda}\right)^2 \begin{bmatrix} -p_{1q}q \\ \frac{\nu}{1-\nu}\phi_e \end{bmatrix} d\lambda \\ +\frac{\lambda}{1+\lambda}\left(\frac{1}{1-\nu}\right)^2 \phi_e \begin{bmatrix} 0 \\ 1 \end{bmatrix} d\nu. \end{bmatrix}$$

where the numerator is positive to ensure global concavity of the maximization program.

For the computations of $(\underline{q}_1, \underline{e})$, ν does not play a role and one finds

$$\text{for } (\underline{q}_1^{vi}, \underline{e}^{vi})\text{: } \begin{cases} p_1\underline{q}_1) - C_q^D(\underline{\beta}, \underline{q}_1, \underline{e}) - C_q^U(\underline{q}_1) + p_{1q}(\underline{q}_1)\underline{q}_1 = 0, \\ \psi_e(\underline{e}) + C_e^D(\underline{\beta}, \underline{q}_1, \underline{e}) = 0, \end{cases}$$

$$\text{for } (\underline{q}_1^{viR}, \underline{e}^{viR})\text{: } \begin{cases} p_1(\underline{q}_1) - C_q^D(\underline{\beta}, \underline{q}_1, \underline{e}) - C_q^U(\underline{q}_1) + \left[\frac{\lambda}{1+\lambda}\right] p_{1q}(\underline{q}_1)\underline{q}_1 = 0, \\ \psi_e(\underline{e}) + C_e^D(\underline{\beta}, \underline{q}_1, \underline{e}) = 0, \end{cases}$$

which gives

$$\begin{bmatrix} dq_1 \\ de \end{bmatrix} = \frac{1}{\text{SOC}_{q_1}.\text{SOC}_e - \left(C_{qe}^D\right)^2}\left(\frac{1}{1+\lambda}\right)^2 \begin{bmatrix} \text{SOC}_e & C_{qe}^D \\ C_{eq}^D & \text{SOC}_{q_1} \end{bmatrix} \begin{bmatrix} -p_{1q}q \\ 0 \end{bmatrix} d\lambda.$$

C^D_{qe}, C^D_{eq}	$\overline{q}_1^{viR} \lesseqgtr \overline{q}_1^{vi}$	$\overline{e}^{viR} \lesseqgtr \overline{e}^{vi}$	$\underline{q}_1^{viR} \lesseqgtr \underline{q}_1^{vi}$	$\underline{e}^{viR} \lesseqgtr \underline{e}^{vi}$
$\oplus$	?	?	$>$	$<$
$\ominus$	$>$	$>$	$>$	$>$

Table 2.4: Influence of cost cross-derivatives on equilibrium outcomes

As $\frac{\lambda}{1+\lambda} < 1$, one needs to increase α, or alternatively to increase λ, to move from solutions to problem (2.17) to solutions to problem (2.24). Thus, the ranking of the efforts partly depends on the sign of the cross derivative C_{eq}. In the framework studied here, where it is equal to -1, $\overline{e}$ is increasing in α. This implies that $\overline{e}^{viR}$ is higher than $\overline{e}^{vi}$ and the result on the rent follows by reminding that ϕ is increasing in effort. Thus, as far as cross-derivatives are both negative, the efficient firm D's informational rents is higher when it is regulated. Other comparisons follow directly.

A point of interest is the influence of the probability of efficient firm D on the regulator's and firm U's contracts. This parameter does not influence both contracts for the efficient type (as there is no distortion) but distorts the ones of the inefficient downstream firm the following way

$$\begin{bmatrix} dq_1 \\ de \end{bmatrix} = \frac{1}{\mathrm{SOC}_{q_1} . \mathrm{SOC}_e - \left(C^D_{qe}\right)^2} \frac{\lambda}{1+\lambda} \left(\frac{1}{1-\nu}\right)^2 \phi_e \begin{bmatrix} C^D_{qe} \\ \mathrm{SOC}_{q1} \end{bmatrix} d\nu.$$

Thus, as ν increases, effort will decrease while quantity will also decrease if C^D_{qe} is negative and increase otherwise. The more likely firm D is efficient, the more distortive will be the effort level required by the inefficient type because this will limit the rent to the efficient one. Thus, if beliefs of the regulator about the efficient type is higher than the ones of the upstream firm (i.e. if the beliefs on efficiency of the regulator first order stochastically dominates those of firm U), the difference in informational rents of the efficient downstream firm is reduced.

2.C.9 Proof of lemma 2.6

Please refer to proof of lemma 2.1, page 102.

2.C.10 Proof of lemma 2.7

When firm U proposes its *no-regulation* tariff $T^U(q_1) = \pi_1^{vi}(q_1^{vi}) + F^U + c^U q_1$ to the regulator and when this latter accepts this tariff, its objective function becomes $\max_{q_1,q_2,...,q_n}[\mathrm{SW}(q_1,q_2,...,q_n)]$ under the constraint that $\pi^D(q_1) + \pi^N(q_2,...,q_n) \geq 0$. Call $(\tilde{q}_1,\tilde{q}_2,...,\tilde{q}_n)$ the solution associated with this program. These output quantities correspond to the overall solution of the optimization problem if the regulator indeed accepts T_U. If the regulator rejects this same $T_U(q_1)$, its objective function turns to $\max_{q_2,...,q_n}[\mathrm{SW}(0,q_2,...,q_n)]$ under the constraint that $\pi^N(q_2,...,q_n) \geq 0$. Call $(0,\widehat{q}_2,...,\widehat{q}_n)$ the output levels that solve this program.

Whenever the regulator accepts the tariff, it can still decide to produce final output in quantities $(q_1^{vi},\widehat{q}_2,...,\widehat{q}_n)$ even if these quantities are not *a priori* optimal. This would yield $\mathrm{SW}(q_1^{vi},\widehat{q}_2,...,\widehat{q}_n)$ $= S_1^{vi} - p_1^{vi}q_1^{vi} - S_1(0) + \mathrm{SW}(0,\widehat{q}_2,...,\widehat{q}_n)$ as social welfare. The first term in the right hand side of the equality is strictly positive, which implies that $\mathrm{SW}(q_1^{vi},\widehat{q}_2,...,\widehat{q}_n) > \mathrm{SW}(0,\widehat{q}_2,...,\widehat{q}_n)$ and the regulator accepts the *no-regulation* tariff. Moreover, social welfare with optimal output levels in reaction to this specific tariff is such that $\mathrm{SW}(\tilde{q}_1,\tilde{q}_2,...,\tilde{q}_n) \geq \mathrm{SW}(q_1^{vi},\widehat{q}_2,...,\widehat{q}_n) > \mathrm{SW}(0,\widehat{q}_2,...,\widehat{q}_n)$.

2.C.11 Proof of lemma 2.8

Assume that good 2 is one of the goods not sold at monopoly price. Let define $f(q_2,h) = \mathrm{SW}(\tilde{q}_1, q_2,\tilde{q}_3,...,\tilde{q}_n) - h$. This function corresponds to the level of social welfare if, first, the upstream firm proposes a tariff equal to $T^U(q_1) + h$ and, second, the regulator chooses output levels $\tilde{q}_i$ for all goods except good 2. Thus, only good 2 is distorted in response to the increase of the fixed part.

The proof stands in the continuity of f at $(\tilde{q}_2,0)$. By assumption, $T^U(q_1)$ is accepted and such that $f(\tilde{q}_2,0) > \mathrm{SW}(0,\widehat{q}_2,...,\widehat{q}_n)$. Moreover, as all quantities $\tilde{q}_{i\neq 2}$ are kept constant, the only relation between q_2 and h lies in the budget constraint at equilibrium

$$\tilde{p}_1\tilde{q}_1 - \tilde{C}^D - \tilde{T}^U - h + p_2(q_2)q_2 - C_2^N(q_2) + \sum_{i=3}^n \left[\tilde{p}_i\tilde{q}_i - \tilde{C}_i^N\right] = 0.$$

The implicit functions theorem applies if $p_{2q}q_2 + p_2 - C_{2q_2}^N(q_2) \neq 0$, i.e. if $q_2 \neq q_2^m$. As the only possible case is $\tilde{q}_2 > q_2^m$, then $\frac{dq_2}{dh}(\tilde{q}_2) < 0$ and the total differential of f with respect to h does exist at $q_2 = \tilde{q}_2$ and is negative.

Thus, it is possible to find small enough an $h > 0$ such that $f(\tilde{q}_2, 0) > f(q_2, h) > \mathrm{SW}(0, \widehat{q}_2, ..., \widehat{q}_n)$ and $(\tilde{q}_1, q_2, \tilde{q}_3, ..., \tilde{q}_n)$ is a solution to the program of the regulator when it faces $T^U(q_1) + h$. This solution yields a higher social welfare level than the one obtained when the tariff is refused. Eventually, the regulator accepts this increased tariff, which gives firm U a profit higher by h than the one it gets with $T^U(q_1)$.

The proof is identical if one of the good not sold at monopoly price was good $i = 3, ..., n$. Let turn now to the case of good 1. The existence condition becomes $p_{1q}(q_1) q_1 + p_1(q_1) - C^D_{q_1}(q_1)$ $- p_0 \neq 0$, i.e. $q_1 \neq q_1^m$ for the given p_0. If $p_0 = c^U$, the condition becomes $q_1 \neq q_1^{vi}$ and the rest of the proof is similar.

2.C.12 Proof of lemma 2.12

What rests to be proved from the text is the equivalent of lemma 2.8 in the context of firm U being added in social welfare. Assume that prices computed by the regulator in reaction to the tariff $\left(H_0^*, p_0^*\right)$ proposed by firm U if it was a foreign undertaking correspond to the second possibility described in system (2.22). As is always the case at equilibrium, the budget constraint must be binding. When it takes firm U into account in social welfare, the regulator faces exactly the same budget constraint, which embodies only regulated firms D and N's profits. System (2.21), page 99, describes how outputs are set. Thus, following the line of lemma 2.8, two cases are to be considered. First, one good not priced at monopoly level is different from good 1, say good 2. Let define $g(q_2, h)$ $= \mathrm{SW}^{\alpha}\left(q_1^*, q_2, q_3^*, ..., q_n^*\right) - h$. This function corresponds to the level of social welfare if only good 2 is distorted in response to the increase of the fixed part. Keeping $q^*_{i\neq 2}$ constant and changing h implies a change on q_2, through the budget constraint, and λ, through the first order condition relative to q_2. Thus, when h increases, unless $p_{2q} q_2 + p_2 - C^N_{2q_2}(q_2) = 0$, i.e. if $q_2 = q_2^m$, the differential of g with respect to h does exist at $q_2 = q_2^*$ and is negative.

The proof is identical if good 1 is not priced at its monopoly level.

Thus, unless all prices are prices at their monopoly level, an increase in h is feasible. It decreases social welfare but if h is small, the acceptance condition is not broken and firm U's profit increases.

Bibliographie

Anderson, S., de Palma, A. and Kreider, B.: 2001, Tax incidence in differentiated product oligopoly, *Journal of Public Economics* **81**(2), 173–192.

Anderson, S., de Palma, A. and Kreider, B.: 2001, Efficiency of indirect taxes under imperfect competition, *Journal of Public Economics* **81**(2), 231–251.

Arnott, R., de Palma, A. and Lindsey, R.: 1999, Information and time-of-usage decision in the bottleneck model with stochastic capacity and demand, *European Economic Review* **43**(3), 525–548.

Armstrong, M.: 1998, Network interconnection in telecommunications, *The Economic Journal* **108**, 545–564.

Armstrong, M.: 2001, The theory of access pricing and interconnection, in the *Handbook of Telecommunications Economics* (North-Holland), edited by Martin Cave, Sumit Majumdar and Ingo Vogelsang.

Armstrong, M., Doyle, C. and Vickers, J.: 1996, The access pricing problem: A synthesis, *Journal of Industrial Economics* **44**(2), 131–150.

Baake, P. and Wichmann, T.: 1999, On the economics of internet peering, *Netnomics* **1**, 89–105.

Bagnoli, M. and Bergström, T.: 1989, Log-concave probability and its applications, CREST working paper n. 89-23, University of Michigan, Usa [www.econ.ucsb.edu/ tedb/OldPap/logconc.ps].

Bailey, J.: 1995, Economics and internet interconnection agreements, MIT workshop on Internet Economics [www.press.umich.edu/jep/works/BailEconAg.html].

Bajari, P. and Hortacsu, A.: 2002, Cyberspace auctions and pricing issues: A review of empirical findings, Stanford University working paper n. 02-005 [www-econ.stanford.edu/faculty/workp/swp02005.pdf].

Ballard, C., Shoven, J. and Whalley, J.: 1985, General equilibrium computations of the marginal welfare costs of taxes in the united states, *American Economic Review* **75**, 128–138.

Barzel, Y.: 1976, An alternative approach to the analysis of taxation, *Journal of Political Economy* **84**, 1177–1197.

Bassanini, A. and Pouyet, J.: 2000, Access pricing for interconnected vertically separated industries, CORE discussion paper n. 2002-17 and ENPC/CERAS working paper n. 02-08 [www.enpc.fr/ceras/labo/Bassanini-Pouyet.pdf].

Bessen, J. and Maskin, E.: 1997, Intellectual property on the Internet: What's wrong with conventional wisdom?, mimeo, Harvard University [www.researchoninnovation.org/iippap2.pdf].

Boîteux, M.: 1956, Sur la gestion des monopoles publics astreints à l'équilibre budgétaire, *Econometrica* **24**, 22–40. Translated as: On the management of public monopolies subject to budget constraints, *Journal of Economic Theory*, 1971, **3**, 219–240.

Boldron, F.: 2001, *Pouvoir de marché, taxation et réglementation*, Ph.D. dissertation, University of Toulouse, France.

Boldron, F.: 2002, Le choix entre taxe unitaire et ad valorem, mimeo, University of Toulouse, France. forthcoming in *Revue Française d'Economie*.

Boldron, F. and Hariton, C.: 2001, Access charge and imperfect competition, GREMAQ working paper n. 21.06.571, University of Toulouse, France. Forthcoming in *Louvain Economic Review*.

Boldron, F. and Hariton, C.: 2001, Relation verticale et régulation : le problème des biens intermédiaires, *Revue Économique* **52**(3), 655–664.

Boldron, F. and Hariton, C.: 2002, Rent extraction by an unregulated essential facility, *Journal of Regulatory Economics* **22**(1), 85–95.

Bowley, A.: 1924, *The mathematical groundwork of economics*, Oxford University Press, Oxford.

Boyer, M. and Moreaux, M.: 1983, Consistent versus non-consistent conjectures in duopoly theory: Some examples, *The Journal of Industrial Economics* **32**, 97–110.

Branco, F.: 1995, Multi-object auctions: On the use of combinational bids, Centre for Economic Policy Research discussion paper n. 1216.

Branco, F.: 1996, Multiple unit auctions of an indivisible good, *Economic Theory* **8**, 77–101.

Brousseau, E. and Curien, N.: 2001, Economie d'Internet, économie du numérique, *Revue Economique* **52**, 7–38.

Brown, S. and Sibley, D.: 1986, *The theory of public utility pricing*, 2d edn, Cambridge University Press, Cambridge.

Caillaud, B.: 2000, Allocation des sillons ferroviaires : Problématique économique, mimeo, ENPC/CERAS, France [www.enpc.fr/ceras/caillaud/pdf/Microsoft Word - Alloc-sillons-note3.pdf].

Caillaud, B. and Jullien, B.: 2001, Competing matchmakers on the internet, mimeo, ENPC/CERAS, France [www.enpc.fr/ceras/caillaud/pdf/cjeer00.pdf].

Caillaud, B. and Tirole, J.: 2000, Essential facility financing and market structure, mimeo, ENPC/CERAS, France [www.enpc.fr/ceras/caillaud/pdf/essfac.pdf].

Carter, M. and Wright, J.: 1999, Interconnection in network industries, *Review of Industrial Organization* **14**, 1–25.

Cave, M. and Mason, R.: 2001, The economics and regulation of the Internet, *Oxford Review of Economic Policy* **17**(2), 188–210.

Clark, D.: 1995, A model for cost allocation and pricing in the internet, MIT Workshop on Internet Economics [www.press.umich.edu/jep/works/ClarkModel.html].

CNN: 09/20/2001, Surgeons perform trans-Atlantic operation, CNN [www.cnn.com/2001/-TECH/industry/09/28/telecom.surgery.idg/].

Coates, K.: 1998, Competing for the internet, *European Commission*, DG IV–C–1 [europa.eu.int/comm/competition/speeches/text/sp1998_006_en.html].

Combes, P.-P., Jullien, B. and Salanié, B.: 1997, La réglementation des monopoles naturels, *in* A. Perrot (ed.), *Réglementation et Concurrence*, Economica, Paris, chapter 1, 9–29.

Cournot, A.: 1838, *Principes mathématiques de la théorie des richesses*, Hachette, Paris. Translated as:*Researches Into the Mathematical Principles of the Theory of Wealth* by N. Bacon, 1897, MacMillan Company, New York.

Crémer, J.: 1994, The value of large extensive form games, *Games Economic Behavior* **7**(3), 309–317.

Crémer, J.: 2000, Network externalities and universal service obligation in the internet, *European Economic Review* **44**(4-6), 1021–1031.

Crémer, J. and Hariton, C.: 1999, The pricing of critical application in the internet, *Journal of the Japanese and International Economies* **13**, 281–310.

Crémer, J., Rey, P. and Tirole, J.: 1999, Connectivity to the commercial internet, mimeo, University of Toulouse, France [www.idei.asso.fr/Commun/Articles/JCremer/connectivity.pdf]

Dana, J. and Spier, K.: 1994, Designing a private industry - Government auctions with endogenous market structure, *Journal of Public Economics* **53**(1), 127–147.

DangNguyen, G. and Pénard, T.: 1999, Interconnection between Isps, capacity constraints and vertical differentiation, mimeo, Université de Rennes 1, France [perso.univ-rennes1.fr:/Thierry.Penard/biblio/pendang1.pdf].

Delipalla, S. and Keen, M.: 1992, The comparison between ad valorem and specific taxation under imperfect competition, *Journal of Public Economics* **49**, 351–367.

Delipalla, S. and O'Donnell, O.: 1998, The comparison between ad valorem and specific taxation under imperfect competition: Evidence from the European cigarette industry, University of Kent discussion paper n. 98/02 [www.ukc.ac.uk/economics/papers/papers-pdf/1998/9802.pdf].

Denicolo, V. and Matteuzzi, M.: 2000, Specific and ad valorem taxation in asymetric Cournot oligopolies, *International Tax and Public Finance* **3**, 335–342.

Dessein, W.: 1998, Network competition when customers are heterogeneous, mimeo, University of Toulouse, France and Université Libre de Bruxelles, Belgium.

Dogan, P.: 2000, Vertical integration in the internet industry, mimeo, University of Toulouse, France.

Dovens, M.: 2001, Relationships between networks: A global perspective [www.oecd.org/pdf/-M00003000/M00003123.pdf].

Estache, A. and Valetti, T.: 1999, The theory of access pricing: An oveview for infrastructure regulators, Centre for Economic Policy Research working paper n. 2133.

European Commission: 01/10/1998, Status of voice communication on internet under community law and, in particular, under directive 90/338/EEC, *Official Journal* **C6**, 4 [europa.eu.int/comm/competition/liberalization/legislation/].

Financial Times: 06/13/2002, Europe: Commission will not allow renegotiation of 3G licences, *Financial Times*.

Foros, O. and Hansen, B.: 1999, Competition and compatibility among internet servide providers, *Information Economics and Policy* **13**(4), 411-425.

Frisch, R.: 1933, Monopoly, polypoly: The concept of force in the economy, *Nationalokonomisk Tidsskrift* **71**, 241–259. Reprinted in 1951 in *International Economic Papers*, **1**, 23–36.

Gupta, A., Stahl, D. and Whinston, A.: 1997, A stochastic equilibrium model of internet pricing, *Journal of Economic Dynamics and Control* **21**, 697–722.

Hahn, F.: 1982, Stability, *in* K. Arrows and M. Intriligators (eds), *Handbook of Mathematical Economics*, Vol. 2, North-Holland, Amsterdam.

Hamilton, S.: 1999, Tax incidence under oligopoly: A comparison of policy approaches, *Journal of Public Economics* **71**, 233–245.

Holt, C.: 1980, Competitive bidding for contracts under alternative auction procedure, *Journal of Political Economy* **88**(3), 433–435.

Huston, G.: 1999, Interconnection, peering and settlements [www.potaroo.net/papers/inet99/peering.htm].

Jean-Marie, A., Querou , N. and Tidball, M.: 2000, Conjectural variation equilibrium, reaction functions and indifference curves: A survey, mimeo, Université de Montpellier, France.

Johnson, T.: 1978, Additional evidence on the effects of alternative taxes on cigarette prices, *Journal of Political Economy* **86**, 325–328.

Keen, M.: 1998, Specific vs ad valorem taxation, *Fiscal Studies* **19**, 1–37.

Keen, M.: 1998, The balance between specific and ad valorem taxation, *Fiscal studies* **19**(1), 1–37.

Klemperer, P.: 1999, Auction theory: A guide to the literature, *Journal of Economic Surveys* **13**(3), 227–286.

Kowalczyk, C. and Skeath, S.: 1994, Pareto ranking optimal tariffs under foreign monopoly, *Economic Letters* **45**(3), 355–359.

Laffont, J.-J., Marcus, S., Rey, P. and Tirole, J.: 2001, Internet interconnection and the off-net-cost pricing principle, mimeo, IDEI and University of Toulouse, France [www.idei.asso.fr/Commun/Articles/Tirole/LMRTjuin21.pdf].

Laffont, J.-J., Rey, P. and Tirole, J.: 1998a, Network competition: I. Overview and non discriminatory pricing, *Rand Journal of Economics* **29**(1), 1–37.

Laffont, J.-J., Rey, P. and Tirole, J.: 1998b, Network competition: II. Price discrimination, *Rand Journal of Economics* **29**(1), 38–56.

Laffont, J.-J. and Tirole, J.: 1987, Comparative statics of the optimal dynamic incentive contract, *European Economic Review* **31**, 901–926.

Laffont, J.-J. and Tirole, J.: 1988, The dynamics of incentive contracts, *Econometrica* **56**, 1153–1175.

Laffont, J.-J. and Tirole, J.: 1990, Adverse selection and renegotiation in procurement, *Review of Economic Studies* **75**, 597–626.

Laffont, J.-J. and Tirole, J.: 1993, *A Theory of Incentives in Procurement and Regulation*, 2d edn, MIT Press, Cambridge.

Laffont, J.-J. and Tirole, J.: 1994, Access pricing and competition, *European Economic Review* **38**(9), 1673–1710.

Laffont, J.-J. and Tirole, J.: 1996, Creating competition through interconnection - theory and practice, *Journal of Regulatory Economics* **10**, 227–256.

Laffont, J.-J. and Tirole, J.: 2000, *Competition in Telecommunications*, MIT Press, Cambridge.

Lee, S. and Hamilton, J.: 1998, Using market structure to regulate a vertically integrated monopolist, *Journal of Regulatory Economics* **15**(3), 223–248.

Le Monde: 09/20/2001, Un chirurgien français opère une patiente distante de 7.500 km, *Le Monde* [www.lemonde.fr/article/0,5987,3244–222630-,00.html].

Maloff, J.: 1995, *1994-1995 Internet Access Provides Marketplace Analysis*, Greyden Press.

Mason, R.: 1999, Compatibility between differentiated networks, University of Southampton discussion paper in Economics and Econometrics n. 9909 [www.soton.ac.uk/ ram2/papers/interc8.pdf].

Mason, R.: 2000, Simple competitive internet pricing, *European Economic Review* **44**(4-6), 1045-1056.

McGarty, T.: 2002, Peering, transit, interconnection: Internet access in central Europe, mimeo, presented at MIT Internet & Telephony Consortium meeting (Cambridge, January 17, 2002) [mertongroup.com/Peering Central Europe.pdf].

Mc-Kie Mason, J.: 1997, A smart market resource reservation in a multiple quality of service information network, mimeo, University of Michigan, Usa [www-personal.umich.edu/ jmm/papers/reserve3.pdf].

McKie-Mason, J. and Varian, H.: 1995, Pricing the internet, *in* B. Kahin and J. Keller (eds), *Public Access to the Internet*, MIT Press, Cambridge, 269–314 [www-personal.umich.edu/ jmm/papers/Pricing_the_Internet.pdf].

McKie-Mason, J. and Varian, H.: 1996, Some economics of the internet, *in* B. Sichel and D. Alexander (eds), *Networks, Infrastructure, and the New Task for Regulation*, The University of Michigan Press, Ann Arbor, 107–136 [www-personal.umich.edu/ jmm/papers/Economics_of_Internet.pdf].

McKie-Mason, J. and Varian, H.: 1997, Economics FAQs about the internet, *in* L. McKnight and J. Bailey (eds), *Internet Economics*, MIT Press, Cambridge, 27–62 [www-personal.umich.edu/ jmm/papers/FAQs/econ-faqs-mit96-net.pdf].

Mitra, M.: 1999a, Achieving the first best in sequencing problems, Indian Statistical Institute (Delhi Center) manuscript n. 99-02.

Mitra, M.: 1999b, Mechanism design in queuing problems, Indian Statistical Institute (Delhi Center) manuscript n. 99-01.

Mitra, M. and Sen, A.: 1998, Dominant strategy implementation of first-best public decisions, Indian Statistical Institute (Delhi Center) manuscript n. 98-02.

Myerson, R.: 1981, Optimal auction design, *Mathematics of Operations Research* **6**(1), 58–73.

Myerson, R.: 1991, *Game Theory*, Harvard University Press, Cambridge.

Myles, G.: 1995, *Public Economics*, Cambridge University Press, Cambridge.

Myles, G.: 1996, Imperfect competition and the optimal combination of ad valorem and specific taxation, *International Tax and Public Finance* **3**, 29–44.

Nash, J.: 1950, The bargaining problem, *Econometrica* **36**, 155–162.

Odlyzko, A.: 1997, A modest proposal for preventing Internet congestion, mimeo, University of Minnesota, Usa [www.dtc.umn.edu/ odlyzko/doc/modest.proposal.pdf].

Odlyzko, A.: 1998, The economics of the Internet: Utility, utilization, pricing, and quality of service, mimeo, University of Minnesota, Usa
[www.dtc.umn.edu/ odlyzko/doc/internet.economics.pdf].

Odlyzko, A.: 1999, Paris Metro pricing for the Internet, *Proc.* ACM *Conference on Electronic Commerce 1999*, 144–147 [www.dtc.umn.edu/ odlyzko/doc/paris.metro.pricing.pdf].

Odlyzko, A.: 2000, The history of communications and its implications for the Internet, mimeo, University of Minnesota, Usa [www.dtc.umn.edu/ odlyzko/doc/history.communications0.pdf].

OECD: 1997, Internet domain names: Allocation policies, *Technical Report OCDE/GD(97)207*, OECD [www.oecd.org/dsti/sti/it/cm/prod/e_97-207.pdf].

OECD: 1998a, Internet infrastructure indicators, *Technical Report DSTI/ICPP/TISP(98)7/FINAL*, OECD [www.oecd.org/dsti/sti/it/cm/prod/tisp98-7e.pdf].

OECD: 1998b, Internet traffic exchange: Developments and policy, *Technical Report DSTI/ICPP/TISP(98)1/FINAL*, OECD [www.oecd.org/dsti/sti/it/cm/prod/traffic.pdf].

OECD: 2001, OECD *Science, Technology and Industry Scoreboard 2001: Towards a knowledge-based economy*, OECD, Paris [www1.oecd.org/publications/e-book/92-2001-04-1-2987/index.htm].

Ramsey, F.: 1927, A contribution to the theory of taxation, *Economic Journal* **37**, 47–61.

Reinhorn, L.: 1999, Optimal taxation with cournot oligopoly, mimeo, University of Durham, England.

Riley, J. and Samuelson, W.: 1981, Optimal auctions, *American Economic Review* **71**(3), 381–392.

Salanié, B.: 1998, *Microéconomie : Les Défaillances Du Marché*, Economica, Paris.

Seade, J.: 1980, The stability of Cournot revisited, *Journal of Economic Theory* **23**, 15–27.

Segal, I.: 1998, Monopoly and soft budget constraint, *Rand Journal of Economics* **29**(3), 596–609.

Shy, O.: 1996, *Industrial Organization: Theory and Applications*, 5th edn, MIT Press, Cambridge.

Sidak, G. and Spulber, D.: 1997, *Deregulatory Takings and the Regulatory Contract*, Cambridge University Press, Cambridge.

Skeath, S. and Trandel, G.: 1994, A pareto comparison of ad valorem and unit taxes in non competitive environments, *Journal of Public Economics* **53**, 53–71.

Suits, D. and Musgrave, R.: 1955, Ad valorem and unit taxes compared, *Quaterly Journal of Economics* **67**, 598–604.

The Guardian: Phone companies can renegotiate 3G terms, *The Guardian* [media.guardian.co.uk/newmedia/story/0,7496,735941,00.html].

Tirole, J.: 1988, *The Theory of Industrial Organization*, 1st edn, MIT Press, Cambridge.

Vickers, J.: 1995, Competition and regulation in vertically related markets, *Review of Economic Studies* **62**, 1–17.

Vickers, J.: 1989, The nature of costs and the number of firms at equilibrium, *International Journal of Industrial Organization* **7**, 503–509.

Viscusi, W. and Vernon, J. and Harrington, J.: 2000, *Economics of regulation and antitrust*, 3rd edn, MIT Press, Cambridge.

Vives, X.: 1999, *Oligopoly Pricing: Old Ideas and New Tools*, MIT Press, Cambridge.

Walras, L.: 1897, L'Etat et le chemins de fer, *Revue du Droit Publique et de la Science Politique*.

Werbach, K.: 1997, Digital tornado: The internet and telecommunications policy, Federal Commission, Office of Plans and Policy working paper series n. 29 [www.fcc.gov/Bureaus/OPP/working_papers/oppwp29.pdf].

Wicksell, M.: 1896, *Finanztheoretische Untersuchunfen, nebst Darstellung und Kritik des Steuerwesens Scwedens*, Gustav Ficher, Jena. Translated as: Taxation in the monopoly case *in* R. Musgrave and C. Shoup (eds), *Readings in the Economics of Taxation*, 1959, Allen and Unwin, London.

Wright, J.: 2000, Access pricing under competition: An application to cellular networks. Forthcoming in *Journal of Industrial Economics*.

Yeats, A.: 1990, Do African countries pay more for imports? Yes, *World Bank Economic Review* **4**(1), 1–20.

Zakon, R.: 2002, Hobbes' Internet Timeline v5.6 [http://www.zakon.org/robert/internet/timeline/].

Zheng, C.: 2002, Optimal auction with resale. Forthcoming in *Econometrica* [faculty-web.at.northwestern.edu/economics/zheng/research/zhengResale.pdf].