Universal service, quality constraint and competition

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Summary

The paper analyses the consequences of introducing a regulation combining universal service and a standard of minimum quality on the strategies of the firms and on competition. We consider a model of vertical differentiation in which the number of consumers depending on universal service is endogenous. We examine two methods of financing : by sharing out the consumers depending on universal service between the firms or by a universal service fund financed by taxation. Whatever the financing method is, the introduction of universal service obligations with a standard of quality results in an increase of quality and an intensification of competition. However the two financing methods have different impacts on prices and incentives to reduce the cost of universal service. In the case of sharing out, the prices of the firms decrease and the low-quality firm distorts her strategy in order to reduce the number of consumers depending on universal service while in taxation, prices increase and both firms are blind to the effects their strategies have on the cost of universal service.

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Introduction

The liberalization of networks was accompanied in Europe by the definition of universal service obligations (USOs). Traditionally provided by a public operator in monopoly, the universal service is integrated today in a competing environment. Universal service can be defined in the following way : provision of a defined set of services of specified quality to all end-users at an affordable price. This is the definition we will adopt thereafter.

Thus, and although this aspect is often neglected, the standard of quality is an integral part of the definition of universal service obligations. In the sector of telecommunications for example, the 2002 directive on universal service (Directive 2002/22/EC) provides that all users have the right to enjoy a certain number of basic services such as being connected to the telephone network, having access to directories services or emergency numbers. In the same way, the directive on common rules for the development of the internal market of Community postal services and the improvement of quality of service defined a level of minimal quality for the universal service (Directive 97/67/EC). The universal service provider must guarantee every working day and not less than five days a week as a miminum :

- one clearance,
- one delivery to the home or premises of every natural or legal person.

Universal service obligations as well as the introduction of standards of quality have strong justifications.

The justification for universal service obligations is double. In one hand, it prevents competition from leading to the exclusion of part of the users. Indeed, by putting an end to the cross subsidies between the profitable and nonprofitable segments of the market, competition brings about cream skimming[1].

However to receive mail, to have electricity or to hold a bank account are considered today like essential to the exercise of fundamental rights. USOs thus aim at preventing any risk of exclusion. In addition, universal service is justified from the point of view of economic efficiency. Indeed, industries who

[1]Before the opening to competition, the regulated operator has the obligation to serve certain customers or certain nonprofitable geographical areas. It can finance these obligations by means of cross-subsidies between different segments of activity. Hence, the price offered by this operator to the low-cost consumers is higher than their cost of service. When a competitor enters on such a market, it can offer low-cost consumers a price lower than that of the incumbent. This operation, profitable for the competitor, induces the monopoly to lose the low-cost consumers. Thus the cream-skimming phenomenon comes from the fact, that given the tariff applied by the old monopoly, it is easy for new competitors to position in price in order to attract low-cost consumers.

are subject to USOs are often characterized by the presence of networks externalities (telecommunications, postal sector, transport, banking industry...). In the presence of such externalities, the network must be made available to the largest number of users. Thus these externalities justify the introduction of USOs in the banking sector (Rochet, 2000) or the Internet (Cremer, 2000) for example.

As for defining a minimal quality, it is justified by the fact that choices of quality by competing firms do not necessarily lead to a social optimum (Spence, 1976 ; Gabszewicz and Thisse, 1980 ; Gal-Or, 1983). The introduction of a standard of quality is then likely to increase the social welfare.

The existing literature has described the effects of introducing USOs or standards of quality on the strategic behaviour of the firms. Yet, to our knowledge, there is no work dealing with both aspects at the same time. This issue nevertheless seems to be of interest considering that in a number of economic sectors subject to USOs quality constraints are indeed imposed as part of the USOs. For instance, the postal directive imposes a maximal delivery time, a minimal number of services per week. The electricity directive deals with the number of power cuts, the time limits for restoring power ...

The definition of a standard of quality modifies the strategic behaviour of the firms. Ronnen (1991) and Crampes and Hollander (1995) show that introducing a standard of quality increases the levels of quality chosen by the firms. The firms are then less differentiated and compete more intensely, which induces a decrease of the prices.

Also, the introduction of universal service obligations is not competitively neutral. Choné, Flochel and Perrot (2002) consider the implications of USOs on the strategies of the firms and study mainly the welfare effects of alternative allocation and funding mechanisms (reserved services or pay or play). Anton, Vander Weide and Vettas (2002) analyse the effects on competition of strategic links due to a USO constraint of non-discrimination. They find that, when there is an uniform pricing constraint, the firm serving high-cost areas weakens competition on the duopoly low-costs areas in order to increase prices and subsidies. Valletti, Hoernig and Barros (2002) study coverage constraint in addition to the price constraints. As in Anton and alii, they show that the non discrimination constraint softens competition between firms and thus leads to a rise in market prices. The weakening of competition is all the more substantial since the coverage constraint is extensive.

Hence, if the introduction of a quality standard tends to induce an increase of competition, the universal service obligations tend to induce a decrease. Therefore, the induced effect of both constraints at the same time is a priori

indeterminate.

Yet, the USO and the standard of quality seem not to have been analysed jointly in the existing literature.

To analyse the consequences of an USO with quality standard, we consider a vertically differentiated model in which the number of consumers depending on USO is endogenous. We study in this case two financing methods : either by sharing out the consumers depending on universal service between the firms, or by setting up a universal service fund financed by a tax on the firms.

This article is structured as follows. In section 1 and 2 we introduce the model and the main hypothesis. In section 3, we study how the firms strategically react to the introduction of USO with a standard of quality in two cases : when the financing is provided by sharing out or by taxation. In section 4, we further complete the analysis by comparing the results in terms of price, quality and number of customers benefiting from the USO. We conclude with policy implications.

1 Presentation of the model

To deal simultaneously with problems of minimal quality and of USO, we resort to a standard model of competition with vertical differentiation[2].

1.1 The consumers

θ is supposed to be the consumers' availability to pay for quality. Each consumer has the choice between consuming one unit of service or nothing. The consumers are distributed uniformly according to the parameter θ out of $[0, 1]$.

The indirect utility of consumer θ is given by $V(p, s) = \theta s - p$ when the agent consume one unit of a good which quality is s and which price is p. His utility is null otherwise.

1.2 The firms

Two firms are in competition. They offer the good with a quality of service s_i ($s_i \in [0, \bar{s}]$) at a price of p_i. The good could be produced at a maximum quality of $\bar{s}$. Each firm offers only one couple quality-price. The firms can not

[2]This model was firstly developed by Mussa and Rosen (1978), Gabszewiscz and Thisse (1979) and Shaked and Sutton (1982).

differentiate their offers according to consumers, no discriminatory pricing is here considered.

Both firms use the same technology and have the same production cost.

Besides, we suppose that the marginal cost of quality is constant. The cost is then linear and increasing with the level of quality.

Two main approaches for quality production cost were to be found in classical models of vertical differentiation. These costs can either be linear or quadratic[3]. This choice has consequences. Indeed, if the cost is linear, pricing at the marginal cost leads to a situation where every consumer who has a preference for quality (an availability to pay) higher than marginal cost would consume whereas the others, those whose preference is not higher than marginal cost, would not consume. If the cost is quadratic, pricing at marginal cost leads to a situation where every consumer has a favorite quality. Moreover the quality choices made by the firms depend on the shape of the costs. If the cost is quadratic, the firms choose a level of quality below the maximal quality whereas if the cost is linear, the high-quality firm offers the exact maximal quality.

In this model, the cost is supposed to be linear in order to stress the effects of the USO as to firms location and market coverage. The conjonction of the hypothesis on consumers' availability and this form of cost brings about non coverage of the market at the duopoly equilibrium (without any constraint). Indeed, as soon as some consumers have an availability to pay lower than marginal cost, those consumers would not be spontaneously served by the market. To take a lower bound equal to zero is nothing but a normalization aimed at simplifying calculations.

Thus, one unit of service which quality is s_i costs (with $c < 1$) :

$$C_i(s_i) = cs_i$$

Firms play a two-stage game in which they first choose the level of quality they propose (s_i), and then both firms compete in price (p_i), subject to constraints possibly imposed on them.

The consumers choose between the offers (s_i, p_i) of the firms, or choose not to consume.

1.3 The universal service obligation

Given the shape of the indirect utility of the consumers and of the costs of the firms, if there is competition and no USO is imposed, not all consu-

[3]See Shaked and Sutton (1982) for developments.

mers will be served (cf. benchmark below). The market will indeed not spontaneously serve those consumers whose valuation of quality is too low (or whose income is too low).

We consider here that a regulator imposes universal service obligations, i.e. forces the firms to serve the entire market with an "affordable" price and a minimal level of quality.

The issue of the accessibility of the service arises then. Given the objective of non-exclusion and considering the distribution of consumers in $[0, 1]$, the only "affordable" price for the universal service that allows to cover all the market is 0 : it is the only price allowing to serve the consumers located in 0. The price of the contract of universal service is thus set to 0.

We also consider that the consumers are allowed to subscribe to the contract of universal service only if they are unable to pay for the offers of the competing firms. Consumers thus have to fulfill certain criteria to be eligible to benefit from the universal service. The regulator does not allow all the consumers that would wish to benefit from the universal service to subscribe to the contract of universal service. The objective is to avoid that consumers that could pay for a market offer benefit from the basic service set up by the regulator. The contract of universal service is only intended for those consumers that would be excluded without this contract. Actually, contracts of universal service are often made unattractive for the consumers in the profitable segment through constraints imposed e.g. on the quantity available for consumption[4]. Thus, if the regulator faces problems related to the observability of the characteristics of the consumers, these problems can be solved by defining incentive contracts.

We will make the assumption that the consumers can not make a trade-off between market offers and the contract of universal service. This assumption can seem quite strong but it is often confirmed by observation. In the banking sector, for instance, consumers can apply for basic banking service only after a bank actually refused to open them an account. Likewise, in the health sector (universal health cover) or in telecommunications or electricity sectors, the contract of universal service is only offered under conditions of resources. We consider implicitly that the regulator can set the condition allowing for the contract of universal service exactly at the level of the marginal consumer of low-quality firm, i.e. at the level of the first consumer not served by the firms.

We impose no obligation of non-discrimination (no uniform price) between the consumers of the universal service and other consumers. In the

[4]The case of telecommunications is representative : social aids are most often linked to a limitation, in time or in space, and a control of the communications.

sectors where differentiation is possible, there is no justification for non-discrimination. For instance, in the postal sector, the banking sector, insurances or telecommunications, the firms can offer different services at different prices to the consumers of the universal service and to other consumers.

Here the universal service obligation takes the form of a contract of universal service offered to the consumers left out of the competitive market. Such a USO represents a cost, which is proportional both to the standard of quality of the universal service and to the number of consumers concerned by the USO (which is endogenous to the model). This cost has to be financed. We consider here only internal financing mechanisms, i.e. the funds needed to finance the universal service are levied only on the sector under the USO.

We do not consider a financing mechanism by transfer of public funds (subsidies from the government budget). Yet, such a funding mechanism can be perfectly justified in these cases as the universal service is intended for consumers with low income[5].

1.3.1 Sharing out financing

In this first case, all the firms are subject to constraints and have to offer a contract of universal service, at a price and a level of quality fixed by the regulator. The regulator imposes an obligation to serve. This financing mechanism can be observed in several sectors, notably in the banking sector.

The act against exclusions of 1998 introduced a basic banking service. It states that every French resident is entitled to a bank account. If a bank refuses to open an account, a person can refer to the local branch of the Banque de France so that it designates a bank that will then have the obligation to open a current account. This universal service obligation is completed by a minimal standard of quality : banks have to offer a basic bank account (including notably a cash withdrawal card and a limited number of bank cheques.)[6] There is also a service obligation in the insurance sector, for automobile insurance or the insurance of health professionals.

With such a financing mechanism, as all firms have to offer the same contract of universal service, the consumers are distributed among the firms. We assume that this distribution is independent from the market shares of the firms : the consumers are equally distributed among the (two) firms, and

[5]It can be argued that it is more for the government than for the consumers of a given sector to aid the poorest. It would then be more transparent to make the government (i.e. all the taxpayers) pay for these subsidies to the poor.

[6]The French government has announced in January 2006 its intention to slightly simplify the process for the consumer, as well as to add a debit card to the definition of the basic bank account service.

each firm has to serve half of the consumers that would otherwise be left out. This strong hypothesis can nevertheless be justified : if the consumers of the universal service were distributed following the market shares, there would be an incentive for the firms to distort their market shares in order to minimize their contribution. The high-quality firm could raise her price, and thus reduce her market share but increase her profit margin per consumer.

1.3.2 Taxation financing

In the second case, we assume that the social contract is financed through a universal service fund based on a tax levied on the firms. This financing mechanism through a universal service fund is widely used ; it can be met for instance in the electricity sector or the telecommunications sector.

Establishing a tax "ad valorem" in a model of vertical differentiation can lead to an increase in welfare[7]. Indeed, in a case of imperfect vertical differentiation, the competing firms will choose non-optimal prices and levels of quality (in comparison with a first rank situation where prices and levels of quality are obtained by maximising a utilitarian welfare function.), but these imperfections can be reduced by taxation. Compared to another financing mechanism, it is conceivable in our model that a financing mechanism using taxation can allow to approach an optimal situation.

The tax set up (a) applies to the quantities sold[8]. As the firm in charge of the universal service is compensated for serving the consumers left out, only her contribution to the financing fund appears in her profit function.

Neither the payment from the regulator nor the cost for providing the universal service are visible in the profit function of the firm (or firms) in charge of the USO. Thus it is reasonable to assume at this stage that the incentives of this mechanism are less important than in the sharing out financing mechanism, because the firms will not internalise the effects of their strategies on the number of consumers relying on the universal service.

The firms have the following unit cost function :

$$C_i(s_i) = cs_i + a$$

2 Benchmarks

Some benchmarks will be studied in this section in order to allow us to determine by comparison the strategic impacts of introducing competition

[7]See Cremer and Thisse (1991) for further developments.

[8]Interconnexion surcharges in the electricity sector provide an example.

on financing the USOs, and of imposing USOs on competition.

First, the regulator states the rules of the game. She decides whether an universal service will be introduced or not and what obligations she sets to the firms. She also states whether the market will be opened to the competition.

In our context, if need be, the regulator specifies the universal service obligations in terms of quality and price. She defines the minimal quality s_b and the affordable price. She also specifies the universal service financing mechanism.

2.1 Monopoly with USO and minimal quality

Consider first a monopolist constrained to serve all the consumers. She could offer two tariffs : one contract characterized by a level of quality s_m at a price of p_m and one universal service contract available for the consumers who could not afford the (s_m, p_m) contract. The regulator specifies the universal service contract, its price is null and its quality is fixed at a s_b level. As a matter of fact, the monopolist sets up cross-subsidizes between the two groups of consumers.

- **Equilibrium price**

The quality s_m offered by the monopolist must be above the minimal quality chosen by the regulator which means $s_m > s_b$. The consumers θ like $\theta s_m - p_m \geq 0$ buy the contract (s_m, p_m). Those like $\theta s_m - p_m < 0$ get the universal service contract $(0, s_b)$.

The monopoly profit is :

$$\Pi_m(p_m, s_m) = (p_m - cs_m)(1 - \frac{p_m}{s_m}) - cs_b\frac{p_m}{s_m}$$

The monopolist maximize her profit which yields the price :

$$p_m = \frac{1}{2}((1+c)s_m - cs_b)$$

- **Quality choice**

We can then derive the program of the monopolist :

$$\begin{cases} Max_{s_m}\ \Pi_m(s_m) & = & \frac{1}{4s_m}((1-c)^2 s_m^2 - c^2 s_b^2) - \frac{1}{2s_m}cs_b((1+c)s_m - cs_b) \\ & \text{s/c} & s_m \geq s_b \end{cases}$$

We obtain the hereafter results depending on the minimum quality :

- if $s_b < \frac{(1-\sqrt{c})^2}{c}\bar{s}$, then the monopolist chooses the maximum level of quality $\bar{s}$ and makes a positive profit.
- if $s_b > \frac{(1-\sqrt{c})^2}{c}\bar{s}$, then whatever level of quality the monopolist chooses, she makes a negative profit and do not enter the market.

Proof : the proof can be found in appendix A ▲

Hence, if the regulator chooses a minimum quality higher than $\frac{(1-\sqrt{c})^2}{c}\bar{s}$, then the monopolist could not find a contract (p, s) that allows her to make a profit and to fulfil the universal service obligations. No firm enter the market and nobody is served.

The monopolist chooses her level of quality by arbitrating between two effects. When she raises her quality, she is able to ask consumers a higher price. However, when she raises the quality, she also increases the number of consumers who benefit from the USO contract and thus increases the cost of the universal service. In this case, as the first effect is stronger, the monopolist sets her quality to the maximum level.

Therefore, in the monopoly case, the number of consumers who benefit from universal service is equal to $\theta^m = \frac{p_m}{s_m} = \frac{1}{2} + \frac{1}{2}c(1 - \frac{s_b}{\bar{s}})$.

We thus find a seemingly counter-intuitive result, that is the number of consumers depending on the universal service contract decreases with s_b. This result can in fact be explained. If the minimal level of quality chosen by the regulator is high, the consumers under the contract of universal service are costly for the monopolist (all the more with the level of quality) and she can gain no profit from them as the price of the social contract is 0. So the monopolist will try to minimize the number of consumers under the contract of universal service. To do so, she has to lower her price so that more consumers can pay her contract (s_m, p_m) and she can have positive profit on this segment.

2.2 Duopoly without OSU

Let us now consider an unregulated duopoly.

The firms compete in two stages. In the first stage, they simultaneously choose their quality levels denoted s_1 and s_2 where $s_1 > s_2$.[9] In the second

[9]The role of each firm as high- or low-quality firm is determined prior to stage 1 and is considered as given

stage, they concurrently determine prices - given the qualities already chosen- and produce the output which satisfies consumers' demand.

The demands faced by the high- (firm 1) and low-quality (firm 2) firms depend on their prices respectively p_1 and p_2 and can be written :

$$D_1(p_1,p_2) = \begin{cases} 0 & \text{if } p_1 \geq \widehat{p_1}(p_2) \text{ or } p_1 \geq s_1 \\ q_1^d(p_1,p_2) = 1 - \frac{p_1 - p_2}{s_1 - s_2} & \text{if } \widetilde{p_1}(p_2) \leq p_1 \leq \widehat{p_1}(p_2) \\ 1 - \frac{p_1}{s_1} & \text{if } p_1 \leq \widetilde{p_1}(p_2) \end{cases}$$

with $\widetilde{p_1}(p_2) = p_2 \frac{s_1}{s_2}$ and $\widehat{p_1}(p_2) = p_2 + s_1 - s_2$.

$$D_2(p_1,p_2) = \begin{cases} 0 & \text{if } p_2 \geq \widetilde{p_2}(p_1) \text{ or } p_2 \geq s_2 \\ q_2^d(p_1,p_2) = \frac{p_1 - p_2}{s_1 - s_2} - \frac{p_2}{s_2} & \text{if } \widehat{p_2}(p_1) \leq p_2 \leq \widetilde{p_2}(p_1) \\ 1 - \frac{p_2}{s_2} & \text{if } p_2 \leq \widehat{p_2}(p_1) \end{cases}$$

with $\widetilde{p_2}(p_1) = p_1 \frac{s_2}{s_1}$ and $\widehat{p_2}(p_1) = p_1 + s_2 - s_1$.

These demand functions are continuous in prices.

The consumers who have the higher preference for the quality are then served by the high-quality firm (1), the middle consumers by the low-quality firm (2) and the consumers with a low quality preference are not served.

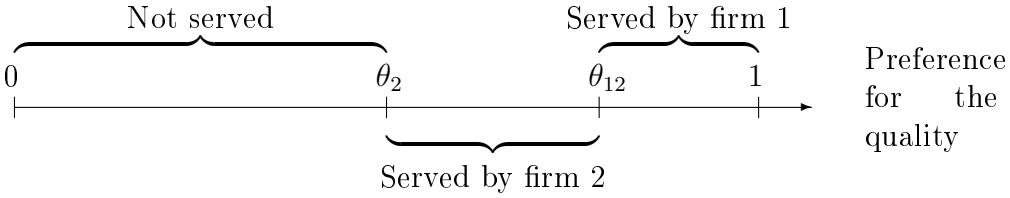

FIG. 1 – Market structure

We can then derive the profit functions from the demand functions :

$$\Pi_1(p_1,p_2) = \begin{cases} 0 & \text{if } p_1 \geq \widehat{p_1}(p_2) \text{ or } p_1 \geq s_1 \\ \Pi_1^d(p_1,p_2) = (p_1 - cs_1)(1 - \frac{p_1 - p_2}{s_1 - s_2}) & \text{if } \widetilde{p_1}(p_2) \leq p_1 \leq \widehat{p_1}(p_2) \\ \Pi_1^m(p_1,p_2) = (p_1 - cs_1)(1 - \frac{p_1}{s_1}) & \text{if } p_1 \leq \widetilde{p_1}(p_2) \end{cases}$$

$$\Pi_2(p_1,p_2)=\begin{cases}0 & \text{if } p_2\geq\widetilde{p}_2(p_1) \text{ or } p_2\geq s_2\\ \Pi_2^d(p_1,p_2)=(p_2-cs_2)(\frac{p_1-p_2}{s_1-s_2}-\frac{p_2}{s_2}) & \text{if } \widehat{p}_2(p_1)\leq p_2\leq\widetilde{p}_2(p_1)\\ \Pi_2^m(p_1,p_2)=(p_2-cs_2)(1-\frac{p_2}{s_2}) & \text{if } p_2\leq\widehat{p}_2(p_1)\end{cases}$$

The disparity of preference is in our model sufficiently large to guarantee the existence of a duopoly equilibrium. Anderson, De Palma and Thisse (1997) proved generically the following result : if $\overline{\theta}>2\underline{\theta}$, then the equilibrium of the game is a duopoly equilibrium. As we have here $\underline{\theta}=0$ and $\overline{\theta}=1$, the condition is necessarily checked.

• **Equilibrium price**

We can then restrict ourself to the duopoly equilibrium and rewrite the firms' profits :

$$\begin{cases}\Pi_1(p_1,p_2,s_1,s_2) &= (p_1-cs_1)(1-\frac{p_1-p_2}{s_1-s_2})\\ \Pi_2(p_1,p_2,s_1,s_2) &= (p_2-cs_2)(\frac{p_1-p_2}{s_1-s_2}-\frac{p_2}{s_2})\end{cases}$$

We can derive the reaction functions from the first-order conditions of the maximization of profits with respect to the price :

$$\begin{cases}p_1(p_2) &= \frac{p_2+cs_1+s_1-s_2}{2}\\ p_2(p_1) &= \frac{\frac{s_2}{s_1}p_1+cs_2}{2}\end{cases}$$

which yield the following equilibrium prices :

$$\begin{cases}p_1^d &= \frac{s_1}{4s_1-s_2}(cs_2+2(cs_1+s_1-s_2))\\ p_2^d &= \frac{1}{4s_1-s_2}(2s_1cs_2+s_2(cs_1+s_1-s_2))\end{cases}$$

• **Quality choice**

We can rewrite the profit functions :

$$\begin{cases}\Pi_1(s_1,s_2) &= \frac{(1-c)^2s_1^2(s_1-s_2)}{(4s_1-s_2)^2}\\ \Pi_2(s_1,s_2) &= \frac{(1-c)^2s_1(s_1-s_2)s_2}{(4s_1-s_2)^2}\end{cases}$$

These are classical results for vertical differentiation. The profit of the high-quality firm increases with her quality level s_1. This firm therefore chooses the maximum quality $\bar{s}$.

As for the low-quality firm, she chooses not to differentiate totally and offers the level of quality that maximizes her profit $s_2 = \frac{4}{7}s_1$.

There is the customary trade-off. Two effects are at stake : to soften the competition, the low-quality firm must differentiate from the high-quality firm and then must reduce the level of quality she offers. On the other hand, she has an incentive to increase her quality level in order to be able to increase her price.

• **Competition and exclusion**

We can rewrite the equilibrium price by taking the levels of quality chosen by the firms into account :

$$p_1^d = \frac{1+3c}{4}\bar{s}$$
$$p_2^d = \frac{1+7c}{14}\bar{s}$$

The market shares of the firms are then :
For firm 1, the high-quality firm :

$$1 - \frac{p_1^d - p_2^d}{s_1^d - s_2^d} = \frac{7-7c}{12}$$

And for firm 2, the low-quality firm :

$$\frac{p_1^d - p_2^d}{s_1^d - s_2^d} - \frac{p_2^d}{s_2^d} = \frac{7-7c}{24}$$

Finally, the equilibrium profits are :

$$\Pi_1^d = \frac{7}{48}(1-c)^2\bar{s}$$
$$\Pi_2^d = \frac{1}{48}(1-c)^2\bar{s}$$

If $\tilde{\theta}$ is the threshold between consumers who can buy the good provided by firm 2 and those who can not, then we have here :
$\tilde{\theta} = \frac{p_2^d}{s_2^d} = \frac{1+7c}{8}$

All the consumers below this threshold do not make any purchase. Hence, in the absence of any universal service obligations, the duopoly equilibrium leads to a situation in which a part of consumers equal to $\frac{1+7c}{8}$ is excluded from the market. This part increases with the quality cost.

Even if the quality cost is equal to zero, all the consumers will not be served. This result comes from the assumption about the distribution of the consumers' preferences ($\theta \in [0,1]$). It guarantees the non-coverage of the market and thus the need of setting up USO.

3 Financing mechanisms of the USO in competition

We consider here a situation where competition is allowed and universal service obligation imposed. Two financing methods are studied : by sharing out or by taxation.

The game between the regulator and the firms follows this timing :

1. The regulator chooses the financing method ; if the taxation is chosen, the regulator fixes the level of the tax a the firms will pay. He also determines the minimum standard of quality s_b. He thus sets the game rules for the firms to follow.
2. the firms simultaneously choose their quality levels.
3. The firms concurrently determine prices and produce the output which satisfies consumers' demands.

3.1 Financing by sharing out

This method of financing is actually a mechanism of sharing the USO costs between the firms. The regulator shares equally between the two firms the costs of service of the consumers that would have been excluded by a competition without constraint. Each firm must then furnish to half those consumers the universal service contract that is a service for a price of zero and of a quality of s_b. The firms integrate these costs when they make their strategy choices.

We proceed from the end of the game-tree back towards the beginning.

Profits can be written this way :

$$\Pi_1(p_1,p_2)=\begin{cases} 0 & \text{if } p_1 \geq \widehat{p_1}(p_2) \text{ or } p_1 \geq s_1 \\ \Pi_1^d(p_1,p_2) & \text{if } \widetilde{p_1}(p_2) \leq p_1 \leq \widehat{p_1}(p_2) \\ = \underbrace{(p_1-cs_1)(1-\dfrac{p_1-p_2}{s_1-s_2})}_{\text{duopoly profit}} - \underbrace{\dfrac{1}{2}cs_b\dfrac{p_2}{s_2}}_{\text{service cost of half}} & \\ \qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad \text{of excluded consumers} & \\ \Pi_1^m(p_1,p_2) & \text{if } p_1 \leq \widetilde{p_1}(p_2) \\ = \underbrace{(p_1-cs_1)(1-\dfrac{p_1}{s_1})}_{\text{monopoly profit}} - \underbrace{cs_b\dfrac{p_1}{s_1}}_{\text{service cost of all}} & \\ \qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad \text{excluded consumers} & \end{cases}$$

With : $\widetilde{p_1}(p_2)=p_2\frac{s_1}{s_2}$ and $\widehat{p_1}(p_2)=p_2+s_1-s_2$.

$$\Pi_2(p_1,p_2)=\begin{cases} 0 & \text{if } p_2 \geq \widetilde{p_2}(p_1) \text{ or } p_2 \geq s_2 \\ \Pi_2^d(p_1,p_2) & \text{if } \widehat{p_2}(p_1) \leq p_2 \leq \widetilde{p_2}(p_1) \\ = \underbrace{(p_2-cs_2)(\dfrac{p_1-p_2}{s_1-s_2}-\frac{p_2}{s_2})}_{\text{duopoly profit}} - \underbrace{\dfrac{1}{2}cs_b\dfrac{p_2}{s_2}}_{\text{service cost of half}} & \\ \qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad \text{excluded consumers} & \\ \Pi_2^m(p_1,p_2) & \text{if } p_2 \leq \widehat{p_2}(p_1) \\ = \underbrace{(p_2-cs_2)(1-\dfrac{p_2}{s_2})}_{\text{monopoly profit}} - \underbrace{cs_b\dfrac{p_2}{s_2}}_{\text{service cost of all}} & \\ \qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad \text{excluded consumers} & \end{cases}$$

With : $\widetilde{p_2}(p_1)=p_1\frac{s_2}{s_1}$ and $\widehat{p_2}(p_1)=p_1+s_2-s_1$.

In the presence of two potential producers, there exist three possible equilibrium configurations : there is one active firms which sets the monopoly price ; the market is supplied by a single firm setting a limit price ; both

firms are active. The duopoly equilibrium is the one of interest because we consider the imposition of USO when competition prevails on the market.

Duopoly case

Duopoly profits can be written :

$$\begin{cases} \Pi_1^r(p_1,p_2) &= (p_1 - cs_1)(1 - \frac{p_1-p_2}{s_1-s_2}) - \frac{1}{2}cs_b\frac{p_2}{s_2} \\ \Pi_2^r(p_1,p_2) &= (p_2 - cs_2)(\frac{p_1-p_2}{s_1-s_2} - \frac{p_2}{s_2}) - \frac{1}{2}cs_b\frac{p_2}{s_2} \end{cases}$$

The universal service has the effect of rising the unit cost of firms. We can then define universal service unit cost that is worth $\frac{cs_b}{2}$.

However this sharing out method of financing induces an asymmetry between the firms. If the US cost is a variable cost for firm 2 (the low-quality cost), as this cost depends on her choices, the US cost is more a fixed cost for the firm 1 as she can not control the universal service cost imposed on her, this cost does not depend directly on her choices. Whatever strategy she might choose, it has not any direct impact on the cost. She only has an indirect impact due the fact that the strategy choices of firm 2 depends on her own ones.

• Equilibrium prices

We can derive the best response functions from the maximization of profits with respect to prices. These functions depend on firms' qualities.

$$\begin{cases} p_1^r &= \frac{4s_1(s_1-s_2)+c(s_b(-s_1+s_2)+2s_1(2s_1+s_2)}{8s_1-2s_2} \\ p_2^r &= \frac{cs_bs_1-cs_bs_2-s_1s_2-3cs_1s_2+s_2^2}{s_2-4s_1} \end{cases}$$

We show that this couple of prices is an internal duopoly solution of the game in the case of sharing-out financing (proof in appendix B).

• Quality choice

We get the found reactions functions into profits, and then derive the following results about qualities :

⁎ ***Firm 1***

Proposition 1 *: Firm 1 always chooses the highest level of quality* $\bar{s}$.

Proof : We show that the second order profit derivative with respect to quality is always negative. The first order derivative is then strictly decreasing on $[s_2, +\infty[$. Moreover, as it is strictly positive in s_2 and has an asymptotic limit in $+\infty$, the first order derivative is then strictly positive on $[s_2, +\infty[$. So for $s_1 > s_2$, we have $\frac{\partial \Pi_1}{\partial s_1} > 0$. Firm 1 choose the highest level of quality $s_1^r = \bar{s}$.▲

It seems as if the setting up of US does not matter for the firm 1 strategy choices. It comes from the fact that her quality and price choices do not affect directly the universal service cost. The universal service cost affects the firms 1 as if it were a fixed cost. She has thus no incentives to soften competition as the only effect of a decrease of her quality would be an intensification of competition.

⁎ ***Firm 2***

The choice of quality of firm 2 depend on s_b and c. She can be either constrained by s_b and then offers s_b or not constrained and then offers s_2^r, where s_2^r is the interior maximum of the firm 2' profit function.

Proposition 2 *:*

The best response function of firm 2 that allows her to make a positive profit can be divided in three cases :

1. *If* $c < \widetilde{c}$ *and* $s_b \in [0, \widetilde{s}]$, *firm 2 chooses* s_2^r.
2. *If* $c < \widetilde{c}$ *and* $s_b \in [\widetilde{s}, \ddot{s}]$, *firm 2 offers* s_b.
3. *If* $c > \widetilde{c}$ *and* $s_b \in [0, \widehat{\widetilde{s}}]$, *firm 2 offers* s_2^r.

The choice of the low-quality firm could thus be constrained by the regulator's choice of the minimum quality standard.

The proof is detailed in appendix C. The expressions of the bounds $\widetilde{c}$, $\widetilde{s}$, $\ddot{s}$, $\widehat{\widetilde{s}}$ and of s_2^r can be found in this appendix.

The picture 2 shows the quality choice of firm 2 when she enters the market and makes a positive profit. Consequently this figure equally shows the constraint that hangs over the regulator's choice of quality standard if she want to secure the competition on the market. Indeed, the exterior borderline of the diagram demarcates the area of positive profit for firm 2.

The more the cost increase, the more the standard of quality the regulator could impose while securing competition decrease. This an intuitive result

FIG. 2 – Best response of firm 2

inasmuch as the universal cost depends on the marginal production cost of quality and on the minimum standard of quality. In case of increase of any of those variables, the cost beard by the firms increases too and that tightens the positivity constraint of profit.

Corollary 1 *: The quality choice of the low-quality firm is decreasing in the minimum quality standard until it is constrained by* s_b.

Proof : We show that s_2^r is a decreasing function with respect to s_b.▲

Indeed, as the cost of universal service is linear with respect to the standard of quality,it increases with the standard of quality. Firm 2 has thus incentives to minimize the number of consumers depending on USO in order to minimize the cost of serving them. To do that, she must lower her price to attract more consumers. she hence has to lower her quality too to prevent her profit from collapsing.

Therefore, in the case of sharing out financing, the low-quality firm internalize the impact of the increase of the universal service cost.

• **Game equilibrium**

To demonstrate that the interior equilibrium of the duopoly game are dependent on firm 2 profitability, we need the following lemma :

Lemma 1 *: Firm 1 profit is always higher than firm 2 profit whatever quality levels the firms choose.*

Proof : If $s_b < \frac{2(1-c)}{c}\bar{s}$, then we show that $\Pi_1(p_1) > \Pi_2(p_2)$. Now, for firm 2 to have a positive profit, we need : $s_b < \frac{2(1-c)}{c}\bar{s}$.▲

Hence, by using proposition 2 and lemma 1, we get :

Proposition 3 *: The game equilibriums depend on cost and quality standard levels :*

1. *If* $c < \widetilde{c}$ *and* $s_b \in [\widetilde{s}, \ddot{s}]$, *firms 1 and 2 offer respectively* $(\bar{s}, p_1^r)$ *and* (s_b, p_2^r).
2. *If* $c<\widetilde{c}$ *and* $s_b \in [0, \widetilde{s}]$, *or* $c>\widetilde{c}$ *and* $s_b \in [0, \widehat{\widehat{s}}]$, *firms 1 and 2 offers respectively* $(\bar{s}, p_1^r)$ *and* (s_2^r, p_2^r).

We can notice that firm 1 always chooses the maximum level f quality $(s_1 = \overline{s})$.

3.2 Taxation financing

In this section, we study the taxation financing of universal service. We consider a tax proportional to the output. The level of the tax a is chosen ex ante by the regulator such as the universal service fund exactly matches the universal service cost. he thus has no effect on the profit functions of the firms. The identity of the universal service incumbent is thus neutral. We could even consider that the universal service is provided by a third party such as the government. This assumption of precise compensation is based on a will that the universal service must neither be a burden neither a rent for the incumbent firm.

Profit functions can be written :

$$\Pi_1(p_1,p_2) = \begin{cases} 0 & \text{if } p_1 \geq \widehat{p_1}(p_2) \text{ or } p_1 \geq s_1 \\ \Pi_1^d(p_1,p_2) = (p_1 - cs_1 - a)(1 - \frac{p_1 - p_2}{s_1 - s_2}) & \text{if } \widetilde{p_1}(p_2) \leq p_1 \leq \widehat{p_1}(p_2) \\ \Pi_1^m(p_1,p_2) = (p_1 - cs_1 - a)(1 - \frac{p_1}{s_1}) & \text{if } p_1 \leq \widetilde{p_1}(p_2) \end{cases}$$

$$\Pi_2(p_1,p_2) = \begin{cases} 0 & \text{if } p_2 \geq \widetilde{p_2}(p_1) \text{ or } p_2 \geq s_2 \\ \Pi_2^d(p_1,p_2) = (p_2 - cs_2 - a)(\frac{p_1 - p_2}{s_1 - s_2} - \frac{p_2}{s_2}) & \text{if } \widehat{p_2}(p_1) \leq p_2 \leq \widetilde{p_2}(p_1) \\ \Pi_2^m(p_1,p_2) = (p_2 - cs_2 - a)(1 - \frac{p_2}{s_2}) & \text{if } p_2 \leq \widehat{p_2}(p_1) \end{cases}$$

- **Relative efficiency of firms and market structure**

We introduce the variable $\Delta = \frac{1 - \frac{a + cs_1}{s_1}}{1 - \frac{a + cs_2}{s_2}}$.

Δ represents the relative efficiency of firm 1 in relation to firm 2.

The lower the unit cost of quality is for firm 1 (the higher the unit cost of quality is for firm 2), the greater Δ becomes. The greater Δ becomes, the more efficient the firm 1 is in comparison with firm 2.

The possible equilibriums of the first stage game are among the following cases :

The equilibrium of the quality game can be found in one of the following five cases :

- Case 1 If $\Delta < \frac{s_2}{2s_1}$, there is a monopoly of firm 2. The unit cost of the quality offered by firm 1 is too high with respect to that of firm 2. Firm 1 does not enter the market. (Monopoly case)

- Case 2 If $\frac{s_2}{2s_1} < \Delta < \frac{1}{2\frac{s_1}{s_2}-1}$, both firms enters the market but firm 1 profit is equal to zero (she fixes a price equal to the marginal cost). Firm 2 profit is strictly positive but she sets a limit price. (Degenerated duopoly case)

- Case 3 If $\frac{1}{2\frac{s_1}{s_2}-1} < \Delta < 2 - \frac{s_2}{s_1}$, both firms enters the market, they fix their prices according to their duopoly best response. (Duopoly case)

- Case 4 If $2 - \frac{s_2}{s_1} < \Delta < 2$, both firms enters the market but firm 2 profit is equal to zero (she fixes a price equal to the marginal cost). Firm 1 profit is strictly positive but she sets a limit price. (Degenerated duopoly case)

- Case 5 If $2 < \Delta$, there is a monopoly of firm 1. The unit cost of the quality offered by firm 2 is too high with respect to that of firm 1. Firm 2 does not enter the market. (Monopoly case)

Proof : The proof can be found in appendix D alongside the best response prices.▲

Proposition 4 *: Only the equilibrium configurations 3, 4 and 5 are possible.*

Proof : We can found in appendix E not only the proof but also a precise study of the five cases.▲

Without taxation, the firms have identical unit cost and Δ is equal to 1. The taxation creates an asymmetry between the two cost functions because the tax is proportional to quantity and not to quality. It debases the efficiency of firm 2 in comparison with firm 1. Then, with taxation, the assumption $s_1 > s_2$ induces $\Delta > 1$. If the efficiency disparity between the firms, both could offer their duopoly price (case 3). When the efficiency of firm 2 becomes debased, she can maintain herself on the market but makes a null profit (case 4). Ultimately she must leave the market (case 5).

The picture 3 presents us with the three possible cases according to the firms quality choices.

Corollary 2 *: The fixing by the regulator of a level of tax too high leads to a monopoly market structure. To guarantee a competitive equilibrium with positive profits for both firms, it is necessary and sufficient that the regulator fixes a tax level such as* $a < \frac{1-c}{2}s_2$.

FIG. 3 – Taxation equilibrium

Proof : The first point of the corollary comes from :
if the regulator fixes a taxe level $a > \bar{a}$ (with $\bar{a} = \frac{s_1 s_2 + c s_2 - 2 c s_1}{2 s_1 - s_2}$), then $\Delta > 2$, and that corresponds to the case of firm 1 being a monopolist.
As for the second point : the condition $\frac{1}{2\frac{s_1}{s_2}-1} < \Delta < 2 - \frac{s_2}{s_1}$ is true when $s_1 > \frac{2a}{1-c}$ and $s_2 > \frac{2a}{1-c}$. As we have $s_1 > s_2$, the condition is true when $s_2 > \frac{2a}{1-c}$.
A more detailed demonstration can be found in appendix E.▲

The USO could thus impede firms from entering the market. If the regulator want to secure competition on the market, she has to fix a tax level inferior to $\bar{a}$.

Duopoly case

We will only focus on the duopoly case[10]. We then assume that the tax level fixed by the regulator is such as $a < \frac{1-c}{2} s_2$.

• Equilibrium price

Profit functions can be written :

$$\begin{aligned} \Pi_1^t &= (p_1 - c s_1 - a)(1 - \tfrac{p_1 - p_2}{s_1 - s_2}) \\ \Pi_2^t &= (p_2 - c s_2 - a)(\tfrac{p_1 - p_2}{s_1 - s_2} - \tfrac{p_2}{s_2}). \end{aligned}$$

The universal service obligation induces in this case an increase of the unit cost for both firms. The universal service unit cost is equal to a.
Using the best price responses of each firm to the prices set by its rival, we find that when both firms are active, prices are :

$$\begin{aligned} p_1^t &= \tfrac{s_1(3a + 2(1+c)s_1 + (c-2)s_2)}{4 s_1 - s_2} \\ p_2^t &= \tfrac{s_2(s_1 + 3 c s_1 - s_2) + a(2 s_1 + s_2)}{4 s_1 - s_2} \end{aligned}$$

The prices p_1^t and p_2^t are above the equilibrium prices obtained in the case of the unconstrained duopoly. This is due to the increase of the unit cost caused by the introduction of USO.

• Quality choice

The corresponding profits are :

[10]The other ones are developed in appendix E

$$\begin{aligned}\Pi_1^t &= \frac{(a-2(1-c)s_1)^2(s_1-s_2)}{s_2(s_2-4s_1)} \\ \Pi_2^t &= \frac{s_1(s_1-s_2)(2a-(1-c)s_2)^2}{s_2(s_2-4s_1)^2}\end{aligned}$$

Proposition 5 *: As in the case without any regulation, the high-quality firm chooses the maximum quality level, $s_1^t = \bar{s}$.*

Proof : We supposed here $a < \frac{1-c}{2}s_2$. Now, in this case, we have $\frac{\partial^2\Pi_1}{\partial s_1^2} < 0$. $\frac{\partial\Pi_1}{\partial s_1}$ is strictly decreasing on $[s_2, +\infty[$, strictly positive in s_2 and has an asymptotic limit in $+\infty$. The first order derivative is the strictly positive on $[s_2, +\infty[$. To conclude, for $s_1 > s_2 > \frac{2a}{1-c}$, we have $\frac{\partial\Pi_1}{\partial s_1} > 0$. Firm 1 chooses then the following quality level : $s_1^r = \bar{s}$.▲

The tax increases the cost of firm 1. She has incentives to raise her quality in order to be able to put up her price and thus to cover her cost. As she can not raise her quality above $\bar{s}$, she offers this maximum level of quality.

Proposition 6 *: The quality choice of firm 2 depends on the tax level. There exists a level of tax such as :*

– if $a > \tilde{a}$, then the firm 2 best response to s_1 is s_2^t ;

– if $a < \tilde{a}$, then the firm 2 best response to s_1 is s_b,

with s_2^t, internal solution from the maximization problem of the firm 2 profit.

Proof : The first order condition of the profit maximization for firm 2 give us three possibilities. Two of them are lower than $\frac{2a}{1-c}$ (with $\frac{2a}{1-c}$ such as $s_2 > \frac{2a}{1-c}$ is the condition to be in the duopoly case). the third solution is s_2^t. We show that the value of the second order derivative in this point is negative and that s_2^t is a maximum. Then we check that $s_2^t < s_1$ and $s_2^t > s_b$ ($s_2^t - s_b$ is a decreasing function with respect to a that takes the value zero in $\tilde{a}$). We can found details in appendix E.▲

Corollary 3 *The low-quality firm is constrained by the quality standard set by the regulator only when this standard is higher than the level of quality offered by the firm in the unregulated competition case.*

Proof : We show that

– $\widetilde{a} > 0$ if and only if $s_b > \frac{4}{7}\bar{s}$.
– If $s_b < \frac{4}{7}\bar{s}$, then, $\forall\, a$, the best response of firm 2 is s_2^t.▲

Hence, if the regulator defines a quality standard lower than the level that prevails in the duopoly case without USO and quality standard, then the firms are not constrained in their quality choice.

• Effects of the tax on the firms' strategies

When the universal service cost is financed by taxation, both firms react by increasing the quality level they offered in order to cover the additional cost induced by the tax.

The firms do not internalize the indirect consequences of their quality choices on universal service cost. They do not take the effect of their quality choices on the number of excluded consumers into account. The universal service fund plays here the role of a black box. In this case of financing by taxation, the firms experiment no incentives to lower the universal service cost. Both firms are blind contrary to what happens to firm 2 in the sharing out financing. Now, when s_b increases, the low-quality firm does not react by decreasing her quality.

Moreover,s_2^t is an increasing function with respect to a. Thus, when the tax increases, the firms' costs raise. The firm 2 has to increase her price and thus her quality to be in position to cover her cost. She miscalculates the impact of her choices on the universal service cost.

Therefore, when the tax level raises, the differentiation between the firms reduces and competition intensifies.

• The tax choice

We can write the balance of the universal service fund : $SF(a, s_2) = a(1 - \theta_2) - cs_b\theta_2$

The regulator's aim is to break even. She thus must levy just enough to cover the USO costs as these costs must be neither a burden nor a rent to the universal service incumbent.

It is possible to find tax levels that enables the regulator to balance the universal service fund[11]. However there is no general results and in some cases, no solution exist. In those cases the government has to intervene directly to guarantee the continuity of the service.

[11]Developments are available from the authors on request.

4 Comparisons between the two financing mechanisms

For the following discussion, we consider the tax level (a) as given.

- **Quality levels**

Proposition 7 *: Whichever financing mecanism is chosen and whichever standard of quality is imposed by the regulator, the introduction of universal service obligations leads to a general increase of the quality offered by the firms.*

Proof :

We show that, whatever the financing method is, the quality choice of firm 1 remains the same. As for firm 2, the quality she chooses is always higher than the one she picks in the case of unregulated competition (which is equal to $\frac{4}{7}\overline{s}$). We show the second point for each of financing method :

- in the sharing out financing case
  - if firm 2 chooses s_2^r : we have $s_2^r > \frac{4}{7}\overline{s}$ (by using the condition $s_b < \frac{2(1-c)}{c}\overline{s}$)
  - if firm 2 chooses s_b (that is the case when (proposition 4) $s_b > \widetilde{s}$ and $c > \widetilde{c}$). We then have $\widetilde{s} > \frac{4}{7}\overline{s}$, so $s_b > \frac{4}{7}\overline{s}$.
- in the taxation financing case,
  - firm 2 chooses s_b only if $s_b > \frac{4}{7}\overline{s}$.
  - if firm 2 chooses s_2^t : we have $s_2^t > \frac{4}{7}\overline{s}$ (by using the assumption $a < \frac{1-c}{2}\overline{s}$).▲

Hence, the setting up of universal service obligations with quality standard does not induce a decrease of the qualities offered by the firms, the low-quality firm does not choose to stick to the minimum quality standard. On the contrary, the introduction of a quality standard leads to an increase of the quality choice.

Proposition 8 *: The financing mecanism that has the highest marginal cost of universal service allows to attain a higher quality level.*

Proof :

- when $a > \frac{cs_b}{2}$, then $s_2^t > s_2^r$.
- when $a < \frac{cs_b}{2}$, then $s_2^t < s_2^r$.▲

As we have seen, the implementation of universal service has an effect on the unit cost of the firms with respect to the unregulated duopoly case equal to a in the case of taxation and to $\frac{cs_b}{2}$ in the case of sharing out.

The consumers demand encountered by a firm depends on the quality-price ratio offered by this firm. When the cost of this firm raises, if she want to keep her profit-margin, she has to increase her price. But when she increases her price, if she want to retain her consumers, she has to better her quality that in turn raises her cost. Both firms have then incitatives to raise their quality in order to dispose of more room to manoeuvre when they will increase their prices. That is a "cost effect".

When this cost effect is higher in the case of taxation (a) than in the case of sharing out ($\frac{cs_b}{2}$), then the level of quality offered in taxation is higher than the level of quality offered in sharing out.

When the tax level is equal to $\frac{cs_b}{2}$, both financing mechanisms leads to the same level of quality offered by the two firms.

- **Consequences on prices**

We henceforth study the effect of USO on the prices offered by the firms.

Proposition 9 *: To impose universal service obligations has contradictory consequences on prices depending on the financing mechanism :*

- *In the sharing out case, the universal service obligation leads to a decrease of the prices for both firms compared to the unregulated competition :* $p_2^r < p_2^d$ *and* $p_1^r < p_1^d$.
- *In the taxation case, the universal service obligation leads to an increase of the prices for both firms compared to the unregulated competition :* $p_2^t > p_2^d$ *and* $p_1^t > p_1^d$.

The increase of prices in the taxation case comes from a rise of costs that is not counterbalanced by taking into account the universal service. The firms do not internalize the universal service cost nor the impact their price increases have on this cost.

The decrease of prices in the sharing out case comes from the internalization of the universal service effect. The firms experiment incentives to reduce the numbers of consumers depending on universal service. Firm 2 decreases her price in order to attract more consumers to her contract. These consumers then cease depending on universal service which leads to a decrease of universal service cost. Moreover, the decrease of firm 2 price intensifies competition between the firms : the decrease of firm 2 price attracts also firm 1 consumers. Firm 1 has to react and to lower her price too.

• Consequences on the number of consumers depending on universal service

In our model, the number of consumers depending on universal service is endogenous. Because the financing mechanism acts upon the firms' strategies, it impacts directly the number of consumers depending on universal service.

The consumers depending on universal service are those who can not afford any contract offered by the firms. In term of taste for quality, the consumer indifferent between not consuming and buying the contract offered by firm 2 is the threshold.

Proposition 10 *: In the sharing out case, the number of consumers depending on universal service is lower than the number of consumers excluded in the unregulated competition case.*

Proof : Firm 2 always offers a higher quality in the sharing out case than in the unregulated competition and a lower price. We then have $\theta_2^r < \theta_2^d$.▲

In the case of sharing out financing, the low-quality firm integrates the impact of her choices on the universal service cost. She then try to lower the number of consumers depending on universal service whatever the standard of quality is.

Proposition 11 *: In the taxation case,*

- *if firm 2 is unconstrained by the quality standard and offers a quality s_2^t, then the number of consumers depending on universal service is higher than the number of consumers excluded in the unregulated competition case.*
- *if firm 2 is constrained by the quality standard and offers a quality s_b, then the number of consumers depending on universal service is lower than the number of consumers excluded in the unregulated competition case.*

Proof : We demonstrate the proposition in two cases :

- firm 2 chooses s_2^t when $a > \widetilde{a}$ (proposition 6). Moreover, at the competitive equilibrium, a can not be higher than $\frac{\bar{s}(1-c)}{2}$. Under these conditions, we then show that $\theta^t > \theta^d$.
- firm 2 chooses s_b only when $s_b > \frac{4}{7}\bar{s}$ and $a < \widetilde{a}$. By using these conditions, we show that $\theta^t < \theta^d$.▲

When the standard of quality is not constraining, firm 2 can sufficiently differentiate herself from firm 1 and can then raise her price. The increase of price is most sizeable than the increase of quality : the number of consumers depending on universal service raises.

When the standard of quality is constraining, firm 2 can not sufficiently differentiate herself from firm 1. Even if she can increase her price, she can not do it sufficiently. The increase of price is lower than the increase of quality : the number of consumers depending on universal service decreases.

Proposition 12 *: Whatever the chosen financing mechanism of the universal service is, the universal service result in an intensification of competition on the market.*

From proposition 7, the USO lead to an rise of the qualities offered by the firms, whatever the financing mechanism is. As firm 1 offers the maximum quality, the USO reduce the differentiation between the firms. Now, the degree of differentiation is, in vertically differentiated models, a measure of the competitive intensity.

To conclude, the institution of universal service constraint with quality standard, when it does not lead to the ousting of one of the firms, is pro-competitive.

5 Conclusion

Here we propose an integrated approach of universal service obligations taking into account simultaneously an obligation to cover the market and a standard of quality.

Whether it is financed by repartition or through taxation, introducing a USO leads to an increase in the overall level of quality. Nevertheless, the strategic effects in terms of pricing for both operators differ according to the financing mechanism chosen.

Thus, if repartition is chosen as financing mechanism, we obtain a price decrease for both operators compared to the situation of an unregulated market, even though they increase the levels of quality of their contracts.

The sharing out financing mechanism has an incentive effect on the low-quality firm : she internalizes the universal service cost and designs her strategy so as to cut down the number of consumers depending on universal service. Indeed, she offers a contract more attractive to consumers than the

one offered in the case of unregulated competition. But this contract, attractive for consumers who have a weak valuation for quality is also attractive for some customers of the high-quality firm. The high-quality firm has then to offer a more appealing contact to her customers to retain their consumption : to impose universal service strengthens competition.

The pro-competitive effects of this financing method induce an increase of the consumers' welfare with respect to the unregulated competition case. Moreover the welfare of all the consumers raises : firms offer to all consumers better contracts with a higher quality and a lower price and those who were not served in the unregulated competition case now have the universal service contract. The cost of universal service is here wholly borne by the firms.

However, in this case of universal service financed by sharing out, the conditions under which the duopoly equilibrium holds are rather restrictive. As soon as the quality cost c increases or the quality standard s_b is too high, the low-quality firm is driven out of the market, only the high-quality firm remains before she goes out too.

When taxation is chosen as financing mechanism, we obtain a quality and a price increase for both operators compared to the situation of an unregulated market. Firms do not internalize the universal service cost.

The effect on consumers' welfare is indeterminate. The joint raise of quality and price has a different impact according to the consumers :

- The consumers with a high valuation for quality who choose the high-quality firm contract now pay more for the same quality, their welfare decreases.
- The consumers with a very low valuation who were not served in the unregulated competition case are now offered the universal service contract : their welfare increases.
- The welfare of the intermediate consumers can grow up or decrease according to the tax level and their valuation.

Moreover, in this case of universal service financed by taxation, the conditions under which it is possible ti find a tax level to balance the universal service fund are equally restrictive.

This model allows us to bring to the fore the differentiated effects of the chosen financing method on the number of consumers depending on the universal service. In the sharing out case, it is lower than the number of excluded consumers in the unregulated competition case. On the contrary, in the taxation case, it is lower then the number of the excluded consumers only if the standard of quality is constraining for the low-quality firm. The

introduction of universal service with a quality standard could thus create incentives to serve more consumers.

In the sharing out case, the low-quality firm integrates directly in her choice of strategy the impact of this strategy on the consumers ad then on the cost of the universal service. She henceforth searches to minimize the number of consumers she will have to serve free.

In the taxation case, the only effect of the universal service the firms feel is an increase of their costs. This increase brings about a raise of prices. In order to retain their market shares despite the prices raise, they try to increase their quality but to restrict competition. However, as long as the standard of quality is not constraining, the low-quality firm is in position to preserve enough differentiation with the high-quality firm and the numbers of excluded consumers raises. As soon as the standard of quality becomes constraining, the low-quality firm can no longer preserve differentiation with the high-quality firm and the numbers of excluded consumers decreases.

We have studied here two methods of internal financing : one direct mechanism of repartition and one financing mechanism using a universal service fund. These two methods have different strategic impacts on the firms, specifically on their costs as well as on their incentives to serve more consumers. This study could be extended to an intermediary case between these two mechanism, namely the "pay or play" mechanism. In that situation, both firms would have a choice between on the one hand offering the universal service and directly assuming its cost and on the other hand paying a tax and not offering the service.

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