Access charge and imperfect competition

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1 Introduction

In the past few years, significant network economic sectors have been de-regulated, such as telecommunications, postal services, air or rail transportation. Most of the time, monopolistic situation was the main concern of these deregulations which induced deep changes in the monopolies' economic environment and activities. Broadly speaking, some activities previously dedicated to a monopoly are now open to competition, while some others remain exclusively to the monopoly. It is often the case that these latter constitute essential facilities for the production of the newly liberalized activities. In that sense, the still-monopolistic sector is the upstream one and the liberalized one the downstream sector.

An example can be found in the telecommunication industry. The local telecommunications are, in France and in other countries, under the responsibility of the former telecommunication monopoly, while inter-regional telecommunications are open to competitors. But inter-regional calls need to be originated and terminated by local telecommunication loops, which belong to the monopoly. This point is under debate in several competition

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authorities all around the world. The European Commission is in favor of the deregulation of the local telecommunication market. But, in France for example, an Administrative Court in Nancy denied authorization to a group of towns to give private firms access to their optic fiber network, and to sub-contract the management of this network to a private firm. Nevertheless, attempts have been made by the regulator to authorize either the unbundling of the “copper” local loop (in order for competitors to be connected as near to the customers as possible and, thus, to allow them to provide more added value services) or alternative local loop technologies (such as TV cable or wireless local loop that allows competitors to completely bypass the incumbent operator) and, the 1st of January 2002, one should be free to choose its operator in the European local telephony market. Even if the regulatory legal enforcement of these alternatives is often currently in place it is, first, not yet of a significant importance in most of the European countries and, second, all these solutions do not avoid the access charge problem (unbundling, e.g.).

Moreover, new competitive markets, which were not previously regulated, are raising where the monopoly faces competitors, but for which the monopoly (upstream) product constitutes also an essential facility. This is the case, for example, for mobile telephony and for Internet access. Both products need, in different ways, the local telecommunication loop: in order to deliver some calls for the mobile telephone company, or in order to be accessed by consumers for Internet access providers.

All these changes do not avoid the need for regulation. To follow our telecommunication example, there is currently a virulent debate in the US and in Europe in order to set what status Internet access providers should have: are they telecommunication companies—and thus should pay and receive access charges for incoming and outgoing calls, but also participate to the financing of universal service for telecommunication—or are they simple customers of telecommunication firms?

In fact, the scope of the regulation in the local and long-distance telecommunication sector moved from a control over the local and inter-regional prices, to a scrutiny of the local prices and of the interconnection prices among networks. As shown by the preceding example, universal service also plays an important place in the regulatory agenda, as well as the appropriate structure of the market (should the upstream monopoly firm be allowed to operate in the downstream sector?) and other aspects. In this paper, we focus on the interconnection aspect.

2 Mobile telephony is also regulated. But the regulation is not of the same scope and strength than for the usual telephony through copper lines.
3 Please refer to European Commission (01/10/1998) and Werbach (1997) for insights on this subject.
4 These changes also raise the point of the appropriate structure of the market. The question about the opportunity to let the monopoly operate or not in the downstream sector is one example of the problems that emerge.
5 For a good development related to universal service, see Laffont and Tirole (2000, section 6).
The interconnection price, or access charge, is the price paid by a downstream competitor to the upstream monopoly in order to access the upstream network. More precisely, an access charge is the price paid by any network which wants to access another network in order to provide the good or services sold to the end user. We focus our analysis on one-way networks and do not consider the possibility that the access charge can be asked by a downstream firm to the upstream monopoly, that is, following our analogy with the telecommunication sector, by a long distance operator to the local upstream monopolist network.

The question of the access charge has been recently the focus of numerous papers with, in particular, Laffont and Tirole (1994), Armstrong (1998) and Armstrong, Doyle and Vickers (1996). In Laffont and Tirole (1994), the upstream monopoly also competes in the downstream sector with a perfectly competitive fringe which produces an homogeneous good differentiated from the monopoly's one. The final good is made of one good from the upstream monopoly plus one good produced either by the monopoly in the downstream sector or by the fringe. They study the optimal pricing under the assumption that the fringe pays an access charge based on the quantity of goods it produces, or specific access charge.

The main goal of this paper is to introduce imperfect competition in the fringe and to see what are the incidences of this imperfect competition on the regulatory policy and in particular on final prices. In their paper, Laffont and Tirole show that the optimal access charge is higher than the monopoly's marginal cost to produce the upstream good. They interpret this mark-up as a tax that enables the social planner to raise funds in order to finance part of the monopoly's fixed cost. But, as stated by the public economics literature, if there is no need to differentiate between an ad valorem or a specific tax (or access charge) in a perfectly competitive market, the introduction of an imperfectly competitive fringe yields a necessary distinction of the two taxes because they become two regulatory tools with different effects. Thus, the introduction of imperfect competition has an incidence on the choice of access charge type.

The comparison between specific and ad valorem taxation is an old topic in public economics. Recently, there has been several works on different models of imperfect competition in different contexts. In particular, Delipalla and Keen (1992) show that, with a Cournot oligopoly (with and without free entry), predominantly ad valorem taxation leads to relatively low price and low profits for the firms. Skeath and Trandel (1994) prove that, for some markets, ad valorem taxation Pareto dominates a specific one (hi-
gher consumer surplus, larger fiscal revenue and profits). In the context of international trade, Kowalczyk and Skeath (1994) show that ad valorem tariffs are better than specific tariffs in the case of a country importing from a foreign monopoly.

Thus, we would like, first, to point out the similarities and common features between public economics and network access pricing literatures and, as an application, we want to study what kind of regulatory tool, specific or ad valorem, is needed in an access pricing framework with downstream imperfect competition.

This paper is organized the following way. Section 2 sets the framework of the economy under scrutiny and the conditions under which it is studied. Section 3 describes the behavior of the oligopoly when facing taxes, or access charges, set by the regulator. In particular, the marginal effects of each tax on some of the fundamentals of the economy are derived. Next, section 4 gives the programs to be solved by the regulator. Section 5 first derives the superiority of ad valorem access charge over a specific one when these charges are restricted to be positive. Section 6 exhibits the optimal final prices associated with a positive ad valorem access charge. Finally, section 7 sums up the results, discusses further extensions and concludes. All the proofs are detailed in the appendix.

2 Framework

The framework we consider is inspired by Laffont and Tirole (1994). An industry produces two goods for consumers. Good 0 is produced by the upstream sector and good 1 by the downstream sector, using good 0 as an input. The production of one unit of good 1 requires one unit of good 0. Moreover, good 0 is assumed to have no substitute for the production of good 1. In other words, good 0 is an essential facility for the production of good 1.

In all this paper, the word “tax” is a generic term for both access charge (a positive tax) and subsidy (a negative tax). Moreover, access charges usually refer to money raised by and for the upstream monopolist in exchange for its product. We extend this to the case where the access charges are collected by the regulator.

Consumers

Consumers have an aggregated surplus \( S_0(Q) \) and \( S_1(Q) \) when consuming the quantity \( Q \) of, respectively, good 0 and good 1. These functions are assumed to verify \( S_{0Q} > 0 \) and \( S_{0QQ} < 0 \). The inverse demand functions of good 0 and 1 are, respectively, \( p_0(Q) \) and \( p_1(Q) \), with \( p_{0Q}(Q), p_{1Q}(Q) < 0 \).
\( \eta_0 = -\frac{p_0}{q_0 p_0 q_0} \) and \( \eta_1 = -\frac{p_1}{Q_1 p_1 Q_1} \). All functions are assumed to be continuously differentiable.

**Upstream sector**

The upstream sector is assumed to be a monopoly, producing \( q_0 \) for the market of the good 0 alone and \( Q_1 \) for the downstream market, at a cost \( C_0(q_0 + Q_1) \), which is assumed to be continuously differentiable. There is a fixed cost \( C_0(0) > 0 \) and the marginal cost is noted \( C_{0q}(q) \). This monopoly is regulated in the sense that the price of the good 0 is set by the regulator and that the monopoly does not interfere with the production choice of good 1.

**Downstream sector**

The downstream sector is composed of \( n \) firms indexed by \( i \). Each firm produces the same homogeneous good in quantity \( q_{1;i} \) at a cost \( C_i(q_{1;i}) \) with a marginal cost \( C_{iq}(q_{1;i}) \) and gets a profit \( \pi_i \). Both cost functions are assumed to be continuously differentiable. In order to produce \( q_{1;i} \) units of the final good, a downstream firm needs \( q_{r1;i} \) units of the intermediate good produced by the upstream monopoly. The aggregated production is then equal to \( Q_1 \) and the aggregated profit of the oligopoly is denoted \( \Pi_1 \). As we focus on the symmetric case, all firms \( i \) are assumed to have the same cost function \( C_1(q_1) \) and are treated as a representative firm indexed by 1.

Moreover, to give the model the widest possible interpretation, the conjectural framework is used, following the formalization indicated in Delipalla and Keen (1992). The conjecture, common to all firms, of the variation of total output induced by a marginal change of firm \( i \)'s production is denoted by \( \alpha = \frac{dQ_1}{dq_{1;i}} \), with \( 0 < \alpha \leq n \). The case \( \alpha = 1 \) corresponds to the Cournot equilibrium, the Bertrand's one is approached as \( \alpha \) tends to 0, and the case \( \alpha = n \) represents tacit collusion among all firms of the oligopoly. As all firms share identical cost functions and conjecture, we will focus on symmetric equilibria.

**Regulator**

The regulator wants to maximize social welfare which is the sum of the surplus of the consumers and the profits of the monopoly and the oligopoly. But the regulator has to take into account the shadow cost of the public funds associated with the money it raises in order to finance, for example, the monopoly. To be more precise, when the regulator wants to transfer funds from consumers to the monopoly through the fiscal system,
this transfer induces a social cost $\lambda$, i.e. 1 euro given to the firm has a cost in term of social welfare of $(1 + \lambda)$ euros. The underlying assumption driving this shortcut is the inability of the regulator to use lump sum transfers to collect money, which is replaced by a distorting taxation system.\textsuperscript{10} This is a second best setting.\textsuperscript{11}

In our model, the regulator has to determine whether or not it has to intervene in the downstream market, i.e. it has to choose the optimal level of taxes (no intervention corresponds to taxes equal to zero). Without loss of generality, the regulator is assumed to reimburse the costs of the monopoly dedicated to the upstream sector and, on top of that, it gives to this latter a monetary transfer $T$. Moreover, the regulator is credited with the payments induced by the sell of the upstream good $q_0$ and with the revenues from the access charges.

In order to maximize social welfare, the regulator controls the price $p_0$ of the upstream good, the monetary transfer $T$, the specific access charge $t_s$ and the ad valorem one $t_v$. Of course, the analysis can be extended with other forms of access charge, like digressive sales taxes,\textsuperscript{12} but we prefer to focus on the most common commodity taxes.

The regulator is supposed to observe the cost of the upstream monopoly. The observability of the cost of the upstream monopoly is an important issue addressed in Laffont and Tirole (1994), where the distortion is created by the asymmetry of information. Our aim is to concentrate on the taxation distortion. Therefore, we do not take into account this informational distortion, i.e. we assume that there exists no asymmetric information between the regulator and the monopoly.

The constraints of the regulator are the following: the output and the oligopolist profits have to be positive (and the profit null in the free entry case), the output and the access charges have to be related by the behavior of the oligopoly and the consumers. For the moment, there is no restriction on the taxes except that the ad valorem should not be greater than one ($t_v \leq 1$).

**Economic structures of the industry**

As in the paper of Delipalla and Keen (1992), two scenarii are considered: in the first one, $n$ is fixed exogenously — case hereafter called Generalized Cournot; in the second one, $n$ is determined endogenously with the zero profit condition — case hereafter called free entry oligopoly. In the latter, $n$ is treated as a real number.

\textsuperscript{10} Laffont and Tirole (1993) provide a detailed analysis of this framework.

\textsuperscript{11} The introduction of imperfect downstream competition is another distortion on top of the cost of public funds. The absence of control over the competitive firms leads, in fact, to a third best world. When there is no shadow cost of public fund, i.e. $\lambda = 0$, we move back in a first best setting and the optimal policy of the regulator is to ensure a marginal cost pricing and to use lump sum transfers to restore positive profits (in fact zero profit) for the firms.

\textsuperscript{12} Recently, Hamilton (1999) studied oligopoly taxation in a more general way.
More notations

A few more notations are needed in order to simplify the computations. Five aggregates are defined

\[
\begin{align*}
K_1 &= -\frac{C_{1 qq}(q_1)}{\alpha(1-t_v)p_1Q(Q_1)}, \quad \text{with } \text{sgn}(K_1) = \text{sgn}(C_{1 qq}) \\
K_2 &= -\frac{p_1qq(Q_1)q_1}{p_1Q(Q_1)}, \quad \text{with } \text{sgn}(K_2) = \text{sgn}(p_1QQ) \\
K_3 &= \frac{C_{1 qq}(q_1)+2}{1-t_v}>0, \\
K_4 &= \frac{p_1(Q_1)(1+K_1)+K_3}{2+K_1}, \\
K_5 &= C_1(q_1) - q_1C_{1 q}(q_1).
\end{align*}
\]

The aggregate \( K_3 \) is the perceived marginal cost of the oligopoly when it faces the two taxes (see next section) and \( K_5 \) measures the influence of the cost structure of the downstream sector. Indeed, \( K_5 > 0 \) can occur only when this production is characterized either by strictly positive fixed costs with increasing \( (C_{1 qq} > 0) \) or constant \( (C_{1 qq} = 0) \) marginal cost, or by decreasing \( (C_{1 qq} < 0) \) marginal cost. Moreover, it is assumed that \( 2+K_1 > 0 \).

We now turn to the analysis of the behavior of the oligopoly and derive comparative statics which will be helpful for the comparison of the two instruments.

3 Symmetric oligopoly with homogeneous good

3.1 Symmetric Generalized Cournot

Behavior of the oligopoly

In the framework described in section 2, the profit of a representative firm 1 of the downstream oligopoly is given by

\[
\pi_1 = [(1-t_v)p_1(Q_1) - t_s]q_1 - C_1(q_1).
\]

The representative firm faces the taxes and chooses its output level of good \( q_1(t_s,t_v,n,\alpha) \). This choice is driven by the first and second order conditions over \( q_1 \)

\[
\begin{align*}
\frac{d\pi_1}{dq_1} &= (1-t_v)[\gamma p_1Q_Q + p_1 - K_3] = 0, \\
\frac{d^2\pi_1}{dq_1^2} &= \alpha(1-t_v)p_1Q[2+K_1 - \alpha K_2] < 0,
\end{align*}
\]}
where $\gamma = \frac{a}{n}$.

One implication of the first order condition is that $p_1 > K_3$, which means that, naturally, price is greater than the perceived marginal cost. This yields, first, the equality

$$t_v = 1 - \frac{C_1 q + t_s}{p_1 + \gamma p_1 q Q_1}$$

and, from equation (3), the condition that $2 + K_1 - \alpha K_2 > 0$. We impose a stronger condition by assuming the stability condition of Seade (1980b): $1 + \gamma(1 + K_1 - nK_2) > 0$.

**Marginal effect of taxes**

In a symmetric Generalized Cournot framework, taxes affect the oligopolistic behavior the following way\(^{13}\)

$$\frac{dp_1}{dt_s} = \frac{1}{(1 - t_v)(1 + \gamma(1 + K_1 - nK_2))} > 0,$$

$$\frac{dp_1}{dt_v} = K_3 \frac{dp_1}{dt_s} > 0,$$

$$\frac{d\Pi_1}{dt_s} = \left[(1 - t_v)(1 - \gamma) \frac{dp_1}{dt_s} - 1 \right] Q_1,$$

$$\frac{d\Pi_1}{dt_v} = \left[(1 - t_v)(1 - \gamma) \frac{dp_1}{dt_v} - p_1 \right] Q_1 < p_1 \frac{d\Pi_1}{dt_s}.$$

An increase in any of the two taxes increases the final price and decreases the aggregated and individual quantities. But the effect on the profits is ambiguous. Even when the economic background is such that an increase in any tax increases the total pie $p_1 Q_1 - nC_1$, one can have that the fiscal revenue and the profit increase, or that only one of them increases. This depends on the market structure, the level of taxation, and that is why the effect of taxes on profits is ambiguous. For instance, suppose that there is no over-shifting of specific taxation, i.e. $dp/dt_s < 1$. From equations (7) and (8), this is a sufficient condition to have decreasing profits with the two types of taxes.

Moreover, one can remark that taxes affect price and profit in the same way as in Delipalla and Keen (1992).\(^{14}\) As they noted, broadly speaking,

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\(^{13}\) The effects on good V’s price are obtained with the implicit function theorem applied to equation (2). The effects on the oligopolistic profits need the differentiation of equation (1), where the first order condition (2) is used in order to simplify the computations. Detailed computations are available from the authors upon request.

\(^{14}\) In their article, Delipalla and Keen (1992) discuss the case of tax over-shifting.
more ad valorem taxation leads to relatively low price and low profit. From an empirical point of view, there are not much works comparing specific and ad valorem taxation, but they all tend to confirm that specific taxes lead to higher price.\footnote{In his paper, Keen (1998) quotes three studies: Barzel (1976), Johnson (1978) and Delipalla and O’Donnell (2001).}

A note on the effect of the number of firms

When the number of firms increases, the competition between those firms is tougher and the price equilibrium tends to be lower.

Lemma 1 In the Generalized Cournot framework with constant or increasing marginal cost in the downstream sector, an increase in the (exogenous) number of firms increases the ad valorem tax that keeps the prices of goods 0 and 1 constant (in the context where the specific tax is equal to zero).

This means that, on the one hand, more firms generate more fiscal revenue for the regulator (as the price is constant) and increase social welfare. But, on the other hand, this latter is decreased because of the replication of the fixed costs. Thus, there is a strong incentive for the regulator to control the number of active firms on the market.

3.2 Symmetric free entry oligopoly

Behavior of the oligopoly

In this framework, the firms have no profit at the equilibrium

\[ 0 = [(1 - t_v) p_1 - t_s] Q_1 - n C_1. \] \hspace{1cm} (9)

In the free entry oligopoly, the cost structure is constrained by \( K_5 > 0 \). Indeed, the zero profit condition can be written:

\[ K_5 = -(1-t_v) \alpha p_1 Q(q_1)^2 > 0. \]

The downstream individual output \( q_1(t_s, t_v, \alpha) \) and the number of active firms \( n(t_s, t_v, \alpha) \) are the solutions\footnote{There is nothing guaranteeing the uniqueness of \( n \). If all entry costs are sunk cost, this would induce one solution. Please refer to Vickers (1969) for a detailed treatment of the subject.} of the first order condition (2), the second order inequality (3) and the zero profit condition (9).

Marginal effect of taxes
In a symmetric free entry oligopoly, the taxes affect the oligopolistic behavior the following way\(^{17}\)

\[
\frac{dp_1}{dt_s} = \frac{2 + K_1}{(1 - t_v)(2 + K_1 - \alpha K_2)} > 0, \tag{10}
\]

\[
\frac{dp_1}{dt_v} = K_1 \frac{dp_1}{dt_s} > 0, \tag{11}
\]

\[
\frac{dn}{dt_s} = -\frac{\alpha q_1 (2 + K_1 - nK_2)}{K_2 (2 + K_1 - \alpha K_2)}, \tag{12}
\]

\[
\frac{dn}{dt_v} = p_1 \frac{dn}{dt_s} + \frac{n(1 - \gamma)}{(1 - t_v)(2 + K_1 - \alpha K_2)}. \tag{13}
\]

Now that the oligopolistic response to the tax instruments is better known, we can focus on the problem of the regulator.

### 4 The programs of the regulator

As stated in section 2, the regulator maximizes, over the transfer, the two taxes and the price of the good 0, social welfare which is written as the sum of the consumers surplus, the firms’ profits and the cost of the funds raised by the regulator, or the benefit if the regulator gets more money than it gives, i.e.

\[
SW = [S_0(q_0) + S_1(Q_1) - p_0(q_0)q_0 - p_1(Q_1)Q_1] + [T] + \left[(1 - t_v)p_1(Q_1) - t_sQ_1 - nC_1(q_1)\right]
\]

\[
- (1 + \lambda) \left[T + C_0(q_0 + Q_1) - p_0(q_0)q_0 - [t_s + t_vp_1(Q_1)]Q_1\right].
\]

The constraints that the regulator faces are the following: the symmetry of the oligopoly, the oligopolistic behavior in reaction to the setting of the taxes, the participation condition of the oligopoly, the consumer behavior in reaction to the prices and the constraints on the taxes.

#### Symmetric Generalized Cournot (GC)

The program of the regulator is to maximize, over \(T, p_0, t_s\) and \(t_v\),

\[
SW_{GC} = S_0(q_0) + S_1(Q_1) + \lambda \left[p_0(q_0)q_0 + p_1(Q_1)Q_1\right] - \lambda T - \lambda \Pi_1(q_1) - (1 + \lambda) \left[C_0(q_0 + Q_1) + nC_1(q_1)\right]. \tag{15}
\]

\(^{17}\) Using the implicit function theorem with equations (2) and (9) and the simplifications that, from equation (2),

\[K_2 = \gamma p_1Q_1 + p_1,\]

and that, from equation (9),

\[p_1Q_1 = \frac{t_sQ_1 - nC_1}{(1 - t_v)},\]

one can find a system which, once inverted, gives the results exhibited. Detailed computations are available from the authors on request.
subject to the constraints

\begin{align*}
\text{Symmetric oligopoly} & : \quad Q_1 = nq_1, \\
\text{Oligopoly conduct} & : \quad (1 - t_v) [\gamma p_1 Q_1 + p_1] - t_s - C_{1q} = 0, \\
& \quad [2 + K_1 - \alpha K_2] > 0, \\
\text{Oligopoly participation} & : \quad [(1 - t_v) p_1 - t_s] Q_1 - nC_1 \geq 0, \\
\text{Monopoly participation} & : \quad T \geq 0, \\
\text{Ad valorem tax} & : \quad t_v \leq 1, \\
\text{Consumer} & : \quad S_{0Q} = p_0 \text{ and } S_{1Q} = p_1.
\end{align*}

\textbf{Symmetric free entry oligopoly (FE)}

The program of the regulator becomes the maximization, over $T$, $p_0$, $t_s$, and $t_v$, of

$$SW_{FE} = S_0 (q_0) + S_1 (Q_1) + \lambda p_0 (q_0) q_0 + \lambda p_1 (Q_1) Q_1 - \lambda T - (1 + \lambda) [C_0 (q_0 + Q_1) + nC_1 (q_1)]$$

subject to the constraints

\begin{align*}
\text{Symmetric oligopoly} & : \quad Q_1 = nq_1, \\
\text{Oligopoly conduct} & : \quad (1 - t_v) [\gamma p_1 Q_1 + p_1] - t_s - C_{1q} = 0, \\
& \quad [2 + K_1 - \alpha K_2] > 0, \\
\text{Free entry condition} & : \quad [(1 - t_v) p_1 - t_s] Q_1 - nC_1 = 0, \\
\text{Oligopoly participation} & : \quad n \geq 1, \\
\text{Monopoly participation} & : \quad T \geq 0, \\
\text{Ad valorem tax} & : \quad t_v \leq 1, \\
\text{Consumer} & : \quad S_{0Q} = p_0 \text{ and } S_{1Q} = p_1.
\end{align*}

\textbf{The optimization problem}

First, one can note that it clearly appears from equations (15) and (16) that the transfer $T$ from the regulator to the upstream monopoly is always socially costly and therefore is optimally set to 0 in both cases.

Second as noticed by Delipalla and Keen (1992, p. 361), "it may (in most case will) be the case that these optimization problems have no solution interior to the implicit requirement of the Generalized Cournot model that profits be non-negative or to the requirement of the model of free entry oligopoly that there be at least one active firm". Therefore, two strategies arise. The first one is to impose explicit constraints while leaving unrestrained the tax instruments. This is the one used by Myles (1996). The second one is to ignore some of the constraints, while using limited instruments. This is the one used by Delipalla and Keen (1992) and this paper.
5 Pure ad valorem access charge

In this section, we assume that taxes are restrained to be positive: $t_v \geq 0$ and $t_s \geq 0$. This restriction occurs when it is forbidden for governments to subsidize unregulated private firms, which is often the case. Therefore, the only monetary transfers that are allowed in the downstream sector are the ones from the firms to the government.

The goal of this section is to show, without making the computation of the optimal level of both access charges, that the regulator will only use the ad valorem tool. There are mainly two techniques in order to assess the superiority of one or another pair of taxes. The first one is to take two different pairs and to compute the difference in the associated social welfare levels. The second is to select a specific path of tax variation and to analyze what is the influence of a move along this path in terms of social welfare. This is the technique used here with changes in taxes that lead to the same prices for goods 0 and 1.

Symmetric Generalized Cournot

In order to have an easier comparison, the downstream firms' positive profit constraint is ignored. If the optimal price leads to negative profits, the problem of the choice of the regulatory tool should be revised.18

Proposition 1 In a symmetric Generalized Cournot framework, when the taxes are restrained to be positive and the constraint of positive oligopolistic profit is ignored, the optimal tax or access charge structure is a pure ad valorem one.

The keypoint of the proof is that a pure ad valorem tax that leads to an equilibrium price $\bar{p}$ yields a greater fiscal revenue than any combination of ad valorem and specific taxes that leads to the same price $\bar{p}$. Equation (14) shows that the regulator prefers to raise 1 euro in fiscal revenue, which gives $(1 + \lambda)$ euros, instead of 1 euro in profits, which only counts for 1 euro in the social welfare. As the regulator prefers to have more fiscal revenue than profits, this explains why the regulator will only use the ad valorem tool when taxes are restrained to be positive.

Moreover, the variation in social welfare along the path of taxes with constant prices for goods 0 and 1 is

$$dSW = -\gamma (Q_1)^2 p_1 Q dt_v.$$

Under perfect competition ($\gamma = \frac{a}{n} = 0$), $dSW = 0$ and there is no gain to shift from the specific tax to the ad valorem tax. This is the standard result

18 In that case, the regulator's program is modified in the sense that the oligopoly binds its constraint of positive profit. The question is to compare the social welfare levels associated with, first, a mix of specific and ad valorem taxes, and, second, the highest ad valorem tax, both leading to zero oligopolistic profits. This question is the object of current research.
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of equivalence between ad valorem and specific taxes. Moreover, as one gets away from perfect competition (\(\gamma\) increasing), the marginal social value of the shift increases.

This result can be interpreted another way. If the regulator is constrained, for any reason, to use only one type of tax then, for a given final price, consumers prefer that the regulator uses ad valorem taxation whereas firms prefer a specific one. This is because, for a given final price, ad valorem taxation leads to higher fiscal revenue (and then less profits!). Of course, if consumers are not aware of the social cost of public funds, they are indifferent because prices are the same. In that case, there is more room for capture of the regulator by the industry: “more room” because consumers are less able to discover the capture (same prices), but “capture” because firms are not indifferent in the kind of taxation used (they prefer specific).

Symmetric free entry oligopoly

With this type of imperfect competition, the profits of the downstream firms are always equal to zero but it is assumed that there is at least one active firm in the oligopoly.

Proposition 2 In a symmetric free entry oligopoly framework, when the taxes are constrained to be positive and the constraint that at least one firm is active is ignored, the optimal tax or access charge structure is a pure ad valorem one.

In the free entry framework, there is no profit for the downstream firms and the comparison of the two tools can not be based on profit levels. Nevertheless, in this framework, the two taxes do not affect the number of active firm at equilibrium the same way. Take the case of constant marginal cost\(^{19}\) and a positive fixed cost for the downstream sector. To prove the result, we use the fact that with a pure ad valorem tax that leads to an equilibrium price \(\bar{p}\), there is less active firms than with any combination of ad valorem and specific taxes that leads to the same equilibrium price \(\bar{p}\). As the marginal cost is constant, the number of firms does not affect the total variable cost. Then, the decision of the regulator will be based on the number of active firms. The regulator prefers to have less active firms because it means less fixed cost and a higher social welfare, so the ad valorem tax is a better regulatory instrument.

Reverse case: Pure specific subsidization

Assume now that the reverse case occurs, i.e. the regulator can only use a mix of ad valorem and specific access charges which are restricted to be negative. This restriction could be an interesting case to study if, for instance, the regulator could not use lump-sum transfers to finance Universal

\(^{19}\) Of course, the proof holds for more general cost functions.
Service obligations, but is still allowed to use access charge subsidization. Then, the better regulatory tool is the specific access charge.

**Proposition 3** In a symmetric Generalized Cournot (respectively, free entry oligopoly) framework, when the taxes are restrained to be negative and the constraint of positive oligopolistic profit (resp., that at least one firm is active) is ignored, the optimal tax or subsidy structure is a pure specific one.

Broadly speaking, the same reasoning applies as for propositions 1 and 2. For example, in the symmetric Generalized Cournot framework, the amount of money needed for a given price to finance the downstream market is greater with a combination of specific and ad valorem subsidies than with a pure specific subsidy. Therefore, achieving any given equilibrium price is obtained less costly by the regulator with a specific subsidy.

### 6 Optimal prices

The goal of this section is to show the incidence of imperfect competition on the final price. The optimal prices of goods 0 and 1 are derived in the two proposed frameworks: symmetric Generalized Cournot and symmetric free entry. In this section, the taxes are still restrained to be positive.

In the two frameworks, the optimal prices correspond to the constrained maximization of the social welfare with respect to the taxes. Moreover, propositions 1 and 2 set that the optimal solution is characterized by $t_s = 0$ in both frameworks. Therefore, the research of the optimal ad valorem access charge is simplified by the resolution of the equation for this particular value of the specific tax. This access charge fully determines the price of good 1, while the price of good 0 is directly controlled by the regulator. Therefore, the maximization can be done with respect to the access charge $t_V$ or the price $p_1$.

**Benchmark**

As we want to compare our final prices with the ones of Laffont and Tirole (1994) which are derived in the case of perfect (downstream) competition, the cost function of the downstream firms is assumed, as they do, to have a constant marginal cost. The imperfect competition aspect is generated by an additional fixed cost $F$. This cost function is assumed to be the same for all downstream firms

$$C_1(q_1) = c_1 q_1 + F_1.$$
In the case of perfect competition, the optimal prices for good 0 and 1 are
\[
\begin{align*}
\frac{p_0 - C_{0q}}{p_0} &= \frac{\lambda}{1 + \lambda \eta_0}, \\
\frac{p_1 - C_{0q} - c_1}{p_1} &= \frac{\lambda}{1 + \lambda \eta_1}.
\end{align*}
\]

The prices are à la Ramsey, where \(\eta_i\) is the price elasticity of good \(i\).

**Symmetric Generalized Cournot**

The derivatives of the social welfare, equation (15), with respect to \(p_0\) and \(p_1\) are
\[
\begin{align*}
\frac{\partial \text{SW}_{p_0}}{\partial p_0} &= p_0 + \lambda q_0 p_0 q + \lambda p_0 - (1 + \lambda) C_{0q} (q_0 + Q_1), \\
\frac{\partial \text{SW}_{p_1}}{\partial p_1} &= p_1 + \lambda Q_1 p_1 q + \lambda p_1 - (1 + \lambda) [C_{0q} (q_0 + Q_1) + n C_1 q (q_1)] - \lambda \Pi_{1p},
\end{align*}
\]

which give the two associated Lerner indexes.\(^2\) Then, in a symmetric Generalized Cournot framework, when the taxes are restrained to be positive and the constraint of positive oligopolistic profit ignored, the optimal prices are such that\(^3\)
\[
\begin{align*}
\frac{p_0 - C_{0q}}{p_0} &= \frac{\lambda}{1 + \lambda \eta_0}, \\
\frac{p_1 - C_{0q} - c_1}{p_1} &= \frac{\lambda}{1 + \lambda \eta_1} + \frac{\lambda}{1 + \lambda} \frac{p_1 Q}{p_1} \Pi_{1p},
\end{align*}
\]

where \(\Pi_{1p} = \frac{d\Pi_1}{dp_1}\).

In comparison to a price à la Ramsey, the optimal price of good 1 includes a corrective term linked to the profits made by the downstream firms. These profits are socially costly because they could have been used to finance the upstream monopoly in place of public funds. If the derivative of the oligopolistic profits at the optimum is positive, the corrective term is negative and the mark-up of the price to the marginal costs is decreased;\(^4\) profits are socially costly and are limited through a price decrease. If the

---

\(^2\) These computations are quoted from the paper of Laffont and Tirole (1994), section 2.
\(^3\) To ensure that \(t_u > 0\), we assume that a marginal increase of \(t_u\) when \(t_u = 0\) has a positive effect on social welfare.
\(^4\) One as to remember from section 4 that the monetary transfer \(T\) is equal to zero.
\(^5\) Without constant marginal costs, the different mark-ups are not really of the same size, because the productions of good 1 are different in the two cases and influence the level of marginal cost \(C_{0q}\). Despite that limit, the spirit of the reasoning remains true.
derivative is negative, the corrective term is positive and the mark-up increased: increasing the price reduces the profits and extracts enough fiscal revenue. So the price of good 1 is different with imperfect competition.

The good 0 is still priced à la Ramsey. But, in general, imperfect competition has also an impact on its level, which may differ from the one with perfect competition. Indeed, the production of good 1 has an incidence on the level of the total quantity of good 0 produced and, therefore, it modifies the marginal cost of production of the upstream monopoly. As the quantities of good 1 produced are not the same, prices of good 0 will differ too. Of course, if the marginal cost of the upstream firm is constant, the price of good 0 is unaffected by imperfect competition.

Symmetric free entry oligopoly

The derivatives of the social welfare, equation (16), with respect to $p_0$ and $p_1$ are

$$
\begin{align*}
\frac{\partial SW_{p_0}}{\partial p_0} &= p_0 + \lambda q_0 p_0 q + \lambda p_0 - (1 + \lambda)C_0 (q_0 + Q_1), \\
\frac{\partial SW_{p_1}}{\partial p_1} &= p_1 + \lambda Q_1 p_1 q + \lambda p_1 - (1 + \lambda)C_0 (q_0 + Q_1) + \frac{d}{dQ_1} (nC_1 (Q_1)),
\end{align*}
$$

with $\frac{d}{dQ_1} (nC_1) = C_1 + (C_1 - q_1 C_1) \frac{dn}{dQ_1}$.

Therefore, in a symmetric free entry oligopoly framework, when the taxes are constrained to be positive, the optimal prices are such that

$$
\begin{align*}
\frac{p_0 - C_0}{p_0} &= \frac{\lambda}{1 + \lambda} \frac{1}{\eta_0}, \\
\frac{p_1 - C_0 - C_1}{p_1} &= \frac{\lambda}{1 + \lambda} \frac{1}{\eta_1} + \frac{K_n}{p_1} n_Q,
\end{align*}
$$

where $n_Q = \frac{dn}{dQ_1}$. The difference with a price à la Ramsey is the corrective term linked to the fact that free entry induces an endogenous replication of the fixed costs. This corrective term takes into account the incidence of the choice of $p_1$ on the number of active firms at the equilibrium, which itself has an incidence on the social welfare level. The price of good 0 is still priced à la Ramsey but it will in general be different from the price of good 0 in case of perfect competition for the same reason as in the symmetric generalized Cournot framework.

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24 Again, to ensure that $\eta_0 > 0$, we also assume here that a marginal increase of $\eta_0$ when $\eta_0 = 0$ has a positive effect on social welfare.
7 Conclusion

This paper shows that, depending on the economic background, the optimal regulatory tool for access charge is the ad valorem one, and the optimal regulatory tool for subsidization is the specific one. Furthermore, the imperfect competition has an incidence on optimal price. Moreover, in a companion working paper Boldron and Hariton (2001), we show that, following Myles' (1996) results, the absence of restriction on taxes allows to recover a situation in which the downstream firms have no market power.

Nevertheless, the exhibited dominance of ad valorem taxation should be moderated if the regulator has to take into account the quality of the final good. Indeed, as Keen (1998) remarked, specific taxation leads to a relatively higher quality product.

There are many ways to extend this model, among which some are our current research agenda. First, from the technical point of view, the case where the optimal ad valorem access charge leads to negative profits for the firm should be analyzed with much scrutiny. In particular, we would like to derive conditions on the economic parameters of our model that ensure that the optimal access charge leads to positive profits.

Second, one should consider other usual taxation tools such as profit taxation. Indeed, in a recent paper, Reinhorn (1999) argues that the tax choice should be affected by other type of fiscal instruments and in particular profit taxation. More generally, this stresses the question of non linear access charge/taxation.

Third, we shall generalize the ad valorem dominance (or specific in the case of subsidies) to other forms of imperfect competition and in particular the study of price competition with imperfect substitute. This analysis should be based on the work of Anderson, de Palma and Kreider (2001a and 2001b), who study particular forms of price competition. Moreover, we think that, with this kind of competition, it will be easier to study the taxation of two-part tariffs which are common practice in the telephony sector.

Finally, we shall go deeper in the study of the tax choice incidence on the way to organize vertically related industries where natural monopolies supply an essential facility to potentially competitive sectors. In the context of liberalization of network industries, the basic questions one has to answer are, first, in which conditions the regulator should break the vertically integrated monopoly into one upstream regulated essential facility monopolistic producer and in a competitive downstream final good sector and, second, if the upstream monopoly should be authorized to compete in the downstream competitive market. These questions have been studied by, for example, Vickers (1995) and Lee and Hamilton (1998) but in a regulatory context where the contracts are based on a per unit access charge. Our intuition is that an ad valorem access charge could change the arbitrage exhibited in such works.
Appendix

Proof of lemma 1. For a given price $p_1$ and $t_s = 0$, the equation (4) defines the ad valorem tax as a function of the aggregated quantity $Q_1$ and the number $n$ of firms. Thus, the implicit derivation yields

$$
\frac{\partial t_v}{\partial n} = - \frac{\frac{\partial}{\partial t_v} \left[ \frac{(1 - t_v) \left( \frac{\alpha}{n} p_1 Q_1 + p_1 \right) - (t_s + C_{1q})}{(1 - t_v) \left( \frac{\alpha}{n} p_1 Q_1 + p_1 \right) - (t_s + C_{1q})} \right]}{n^2 \frac{\alpha p_1 Q_1}{\gamma p_1 Q_1 + p_1}}
$$

$$
= - \frac{\alpha p_1 Q_1}{(1 - t_v) n^2} \frac{K_1 + 1}{K_3}.
$$

The sign of the right-hand side expression is the sign of $(1 + K_1)$. Therefore, there is no general conclusion when marginal cost $C_{1q}$ is decreasing because the condition required is stronger than the assumption made that $2 + K_1 > 0$. Nevertheless, when marginal cost are constant or increasing, $K_1$ is positive or null and therefore the derivative is positive.

Proof of proposition 1. The technic used here is the one of Delipalla and Keen (1992, proposition 8). Let us take a pair of tax $(t_s > 0, t_v > 0)$ such that it yields a positive profit for the oligopoly and respects the first-order condition

$$
\begin{cases}
1 - t_v = \frac{(t_s + C_{1q}) n}{np_1 + \alpha p_1 Q_1}, \\
[(1 - t_v) p_1 - t_s] Q_1 - nC_1 \geq 0.
\end{cases}
$$

From this situation, consider the following shift from the specific tax to the ad valorem tax: $K_3 dt_v = -dt_s > 0$. Remembering that the marginal effect of taxes on $p_1$ as described by (6) and that $dp_1 = \left( \frac{dp_1}{dt_s} \right) dt_s + \left( \frac{dp_1}{dt_v} \right) dt_v$, we get $dp_1 = 0$. Therefore, with this particular shift, prices stay equal, as aggregated quantities. As $n$ is fixed exogenously, individual quantities also stay equal.

Moreover, the transfer $T$, given by the regulator over the cost of production, is always costly for the social welfare and set to zero. Thus, using equation (15), the computation of the variation of the social welfare, at $(t_s, t_v)$ and on this particular shift of taxes, can be written the following way

$$
dSW = \lambda Q_1 dt_s + \lambda p_1 Q_1 dt_v - d \left[ nC_1 \left( \frac{Q_1}{n} \right) \right]
$$

$$
= \lambda Q_1 [dt_s + p_1 dt_v]
$$

$$
[K_3 dt_v = -dt_s] = \lambda Q_1 [p_1 - K_3] dt_v
$$

$$
[equation (2)] = -\lambda \gamma (Q_1)^2 p_1 Q_1 dt_v,
$$

$$
dSW > 0.
$$
This conclusion is true for every pair of taxes such that it sustains an oligopolistic equilibrium. But it does not insure that the new pair of taxes yields a positive profit for the oligopoly. Therefore, if the constraint of positive oligopolistic profit is ignored, the shift of taxes can be done until the constraint on $t_s$ is reached, i.e. $t_s = 0$ and the optimal pair of taxes is just made of an ad valorem tax.

**Proof of proposition 2.** Let us take a pair of tax $(t_s > 0, t_v > 0)$ such that it yields no profit for the oligopoly and respects the first-order condition

\[
\begin{align*}
1 - t_v &= \frac{t_s Q_1 + n C_1}{p_1 Q_1; n}, \\
1 - t_v &= \frac{(t_s + C_{1q}) n}{np_1 + \alpha p_1 Q_1; n}.
\end{align*}
\]

From this situation, consider the following shift from the specific tax to the ad valorem tax: $K_4 d t_v = -d t_s > 0$. Remembering that the marginal effect of taxes on $p_1$ as described by (11) and that $d p_1 = \left( \frac{d p_1}{d t_s} \right) d t_s + \left( \frac{d p_1}{d t_v} \right) d t_v$, we get $d p_1 = 0$. Therefore, with this particular shift, prices stay equal, as aggregated quantities.

Moreover, the transfer $T$, given by the regulator over the cost of production, is always costly for the social welfare and set to zero. Thus, the computation of the variation of the social welfare on a move of taxes can be written the following way

\[
dSW = \lambda Q_1 d t_s + \lambda p_1 Q_1 d t_v - d \left[ n C_1 \left( \frac{Q_1}{n} \right) \right]
\]

[equation (9)] = \lambda Q_1 [d t_s + p_1 d t_v] - d [(1 - t_v) p_1 - t_s] Q_1

= (1 + \lambda) Q_1 [d t_s + p_1 d t_v],

\[K_4 d t_v = -d t_s\] = (1 + \lambda) Q_1 [p_1 - K_4] d t_v,

\[dSW > 0,
\]

because, as far as $2 + K_1 > 0$, $p_1 > K_4$. As the conclusion is true for every pair of taxes such that is sustains an oligopolistic equilibrium, the shift of taxes can be done until the constraint on $t_s$ is reached, i.e. $t_s = 0$ and the optimal pair of taxes is just composed of an ad valorem tax. The dual problem of the Generalized framework is that this new pair of taxes does not insure that $n \geq 1$.

**Proof of proposition 3.** Symmetric Generalized Cournot framework. The proof is as for the proposition 1. Let us take a pair of tax $(t_s < 0, t_v < 0)$ such that it yields a positive profit for the oligopoly and respects the first-order condition. From this situation, consider the following shift from the specific tax to the ad valorem tax: $K_3 d t_v = -d t_s > 0$, i.e. the specific tax becomes more negative, while the ad valorem increases, but remains
negative. This particular shift yields no change in prices, as in aggregated and individual quantities. The change in social welfare is given by $dSW = \lambda Q_1 [p_1 - K_4] dt_v > 0$. This conclusion is true for every pair of taxes such that is sustains an oligopolistic equilibrium. But it does not insure that the new pair of taxes yields a positive profit for the oligopoly. Therefore, if the constraint of positive oligopolistic profit is ignored, the shift of taxes can be done until the constraint on $t_v$ is reached, i.e. $t_v = 0$ and the optimal pair of taxes is just made of a specific tax.

Symmetric free entry oligopoly framework. The proof is as for the proposition 2. Let us take a pair of tax $(t_s < 0, t_v < 0)$ such that it yields no profit for the oligopoly and respects the first-order condition. From this situation, consider the following shift from the specific tax to the ad valorem tax: $Kadt_v = -dt_s > 0$, i.e. the specific tax becomes more negative, while the ad valorem increases, but remains negative. This particular shift yields no change in prices and aggregated quantities. The change in social welfare is given by $dSW = (1 + \lambda) Q_1[ p_1 - K_4 ] dt_v > 0$. This conclusion is true for every pair of taxes such that is sustains an oligopolistic equilibrium. But it does not insure that the new pair of taxes yields at least one active firm in the oligopoly. Therefore, if this constraint is ignored, the shift of taxes can be done until the constraint on $t_v$ is reached, i.e. $t_v = 0$ and the optimal pair of taxes is just made of a specific tax.

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