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THIRD PARTY ACCESS PRICING TO THE NETWORK, SECONDARY CAPACITY MARKET AND ECONOMIC OPTIMUM : THE CASE OF NATURAL GAS

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Abstract+

The gas deregulation process implies crucial choices concerning access to transportation networks. These choices deal with the nature, the structure and the level of access fees. This paper proposes an evaluation of different systems implemented both in Europe and North America, in relation to normative pricing references. The rules according to which shippers can buy or sell capacity represent another kind of choice that Regulators have to make. This paper proposes a simple model which demonstrates that secondary market prices should not be subject to a cap and emphasizes the need of a 'use-it-or-lose-it' rule on this market.

1. Introduction

The opening to competition of the gas industry has been an obligation in the Europe Union since the adoption in 1998 of the ‘Gas Directive’ under which ‘eligible’ customers would be able to choose their supplier : 20 % in 2000, 28 % in 2003 and 33 % in 2008. These are however minimum threshold of opening because each country may opt for a superior one. An extension of the Directive aims to widen this opening to 100 % of the customers in 2005 but it has not come into effect yet. This opening comes with an ‘unbundling’ of the different segments of activity in the gas chain : production, transmission, distribution and even supply. When for technical and economic reasons this opening clashes with the existence of natural monopoly, this is notably the case with the transmission because it is characterized by increasing returns, the search for collective efficiency leads to the establishment of a third party access (TPA) to the network. The network is then considered as an ‘essential’ facility and the ex-monopoly (incumbent), which generally remains the operator of this facility, has to give access to those who wish to use it with a regulated or negotiated toll determined according to transparent and non-discriminatory rules. The operator of the transport system can remain the main supplier but it is then important to distinguish well this activity from the

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operation of his network to prevent the operator from transportation to supply cross subsidizing which would distort the competition between suppliers.

Two sets of questions arise when we wish to set up such a TPA system :

· How to fix tolls? What does the theory say and what are the current practices in Europe and in the United States? How to solve the problem of the congestions on the network and how to make sure that the chosen system will not favor the predation and foreclosure practices?

· Does the implementation of a secondary market in transportation capacities improve collective welfare? What are rules to be respected if we want to avoid collusion strategies?

2. The Fixing of Access Tolls

Economic theory gives normative answers to this question but, in practice, the different systems adopted in Europe or in the United States do not always respect the rules of productive efficiency and allocative efficiency suggested by Armstrong and Doyle (1995). The principle of productive efficiency implies that every firm runs its activities minimizing its cost and requires that the activities are distributed between firms so as to minimize the sum of the costs of the industry. The principle of allocative efficiency implies that scarce resources are assigned between the economic agents (producers and consumers) so as to obtain the maximum welfare. The second rule is more general than the first one which can respect for example the first one without satisfying the second.

2.1. A first best pricing system : nodal pricing

A gas transportation system can be schematized in the shape of a graph summits constituted by ‘nodes’ that is places where linked pipelines join together and where flows of gas can be injected or taken off. The sides represent the pipelines of the network. A convex non-directed network with n summits is said to be ‘treelike’ if it contains n-1 sides. There is then one and only one path to go from some node i to another node j. In the case of a treelike network with a single source of gas injection, the marginal cost grows with the distance. Where the number of sides m is superior to n-1, the network is said to be ‘meshed’. There are

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then at least two nodes which can communicate by several different paths. To track down the direction of flows circulating on the network we decide on a positive direction on every side. An 'injection' I_i observed at the node i will be positively counted if it is a supply and negatively if it is a withdrawal (consumption). There thus exists at some point t a set of "supply" summits S_t where the injections are positive and a set of "consumer" summits C_t where the injections are negative. According to periods a summit where is localized a storage will be a supplier or a consumer.

Let be A^+ all the arcs 'entering' i and A^- all the 'outgoing' arcs i. A positive or negative injection in the node i is I_i : the system of flows will be said to be 'conservative' if the balance of flows entering and leaving is nil at any node i ('the law of nodes') i.e.

$$I_i + \sum_{ji \in A^+} Q_{ij} - \sum_{ij \in A^-} Q_{ij} = 0, \forall_i$$

where Q_{ij} represents the flow circulating in the pipeline ij. Let $f_k(Q_k)$ be all the cost functions of the transport of a flow Q on each of the side k (with $f_k(0) = 0$, $f_k' > 0$ and $f_k'' < 0$); the cost of the transport grows with the transported quantity and the function is concave. The total cost of the transportation of a flow Q is given by :

$$T = \sum_k f_k(Q_k)$$

Due to the concave conditions imposed on the functions f_k, there is a system of conservative flows and only one associated to an injection or a set of injections which minimizes the cost of transportation T. This system is said to be optimal.

Let ΔQ be a supplementary flow injected in i and transported on the whole network to come back in i. When ΔQ goes through the arc k it provokes a increase of the marginal cost of transportation at k if it goes in the same direction as the basic flow Q_k and a decrease in the cost if it goes in the opposite direction. The marginal variation of the transportation cost is given by

$$\Delta T = \sum \alpha_k f_k'(Q_k) \Delta Q$$

with $\alpha_k = +1$ if ΔQ goes to the same direction as Q_k and $\alpha_k = -1$ if ΔQ goes in the opposite direction. If the initial system of flows is optimal that is it minimizes the total cost of transportation, we must observe $\Delta T = 0$. Along any closed path the algebraic sum of the marginal costs of transport on each of the traversed side is zero (‘the law of nodes’ on a closed network). Thus it is possible to define a marginal cost to transport gas from a point i to a point j :

$$\delta_{ij} = \sum_{k} \alpha_k f_k'(Q_k) \qquad (1)$$

This marginal cost of transportation from i to j is independent of the path chosen to go from i to j. From a system of optimal flows, we can then define a matrix of short term marginal costs of transportation between the various nodes of the network.

Given a transport system with n nodes (i=1,2,.. n) on which is established a optimal system of conservative flows Q, there is a "nodal prices vector" with n elements such as the marginal cost of transport between two nodes i and j may be considered as the difference between nodal prices:

$$\delta_{ij} = d_j - d_i$$

The transportation cost of a flow Q circulating along a side of the system may, in the case of natural gas, be considered as the cost of compensation of the losses resulting from this transit i.e. a re-compression cost of the gas. According to the Renouard’s formula we know that the transport of a quantity of gas Q (expressed in m^3/second) on a distance L in a pipeline of diameter D entails a loss of load between the point of departure 0 and the point of destination A such that,

$$\Delta P^2 = P_0^2 - P_A^2 = kQ^2 D^{-5}\ L$$

where P represents the pressure of the gas (in 0 and A respectively). We can then demonstrate (Bergougnoux, 2001) that the cost of short-term transport on the side k (i.e. the cost of the necessary energy to compensate for the observed losses of load) is given by

$$f_k(Q_k) = aQ_k^3 D_k^{-5} L_k \qquad (2)$$

where **a** is a constant. Thus the marginal cost, that is the cost of transport between two nodes i and j for a some path W is given by :

$$\delta_{ij} = 3a \sum_{k \in w} \alpha_k Q_k^2 D_k^{-5} L_k \quad \text{(we use (1) and (2))}$$

α_k being equal to +1 or -1 according to whether ΔQ goes in the same direction as Q_k or in opposite direction (sum made for all the arcs constituting the path W). This marginal cost of transportation is independent of the path W chosen to go from i to j. We may notice that, unlike a network in tree form, the marginal cost of transportation in a meshed network is no longer proportional to the distance. When a network possesses several sources of gas injection, the marginal cost of transportation between a source and various nodes of the network does not vary in a monotonous way as we move away from this source (we generally observe 'bell-shaped curve' with distance).

On a treelike transport system, it is thus justified to opt for a TPA pricing system proportional to the distance. On a strongly meshed network it does not justify itself and it is the nodal pricing system which best expresses the reality of the physical flows of natural gas. As an illustration from Gaz de France network, an increment in consumption at node 7 (the South of France), itself close to an importing point, compensated with an supplementary injection at the node 1 (the North of France) will not induce an increase in transportation volumes between node 1 and 7. Rather there will be an increase in transportation volumes between node 1 and node 5 (in the center of France), and a reduction in the flow transported between node 7 and the same node 5 (Bergougnoux, 2001). This is because swaps have been made at the level of the physical flows.

2.2. A Second Best Pricing System: RAMSEY-BOITEUX Tariffs

Ramsey-Boiteux tariffs are the solution proposed by Armstrong, Doyle and Vickers (1996) when the incumbent, is both in charge of the transportation system and also competing as a supplier with new entrants which are in turn the incumbent's clients for transportation services. Let C(z, q) be the cost supported by the incumbent I when it offers q units of gas to consumers and z units of access to the entrant E, with $C_1 = \frac{\delta C}{\delta q}$ et $C_2 = \frac{\delta C}{\delta z}$.

Let p be the final selling price of the gas and a the access toll to the network, both being simultaneously fixed by the Regulator. Let X(p) be the demand function of the final consumer on the market and V(p) the surplus of the consumer with $V'(p) = -X(p)$. Let s be the quantity of gas sold by the entrant E, with the incumbent feeding the rest of the demand. Let Π_I be the profit of the incumbent, Π_E the profit of the entrant and m the available mark-up equal to p-a.

The measure of the total welfare is the sum of the surplus of the consumer and the profits of the industry (incumbent and new entrants)

$$W(p,m) \;=\; V(p)+\Pi_E(m)+\Pi_I(pm) \tag{3}$$

The first-order conditions maximizing the total welfare when we introduce a constraint on the profits of the incumbent are the following ones (the profit must be positive):

$$\frac{p-C_1}{p}=\frac{\theta}{\eta_x} \tag{4}$$

and

$$\frac{m-[C_1-C_2]}{m}=-\frac{\theta}{\eta_s} \tag{5}$$

with $\theta=\lambda/1+\lambda\leq 1$, ($\lambda$ being the Lagrange multiplier), $\eta_x=-(p/X)(dX/dp)>0$ and $\eta_s=-(m/s)(ds/dm)>0$.

Prices are Ramsey-Boiteux tariffs : the final price of the gas and the access toll on the transportation system deviate from the corresponding marginal cost in a way conversely proportional to the price elasticity-price of demand. It is thus the captive customers who pay the highest price. So when the operator of the transport system is subjected to increasing returns (natural monopoly), the relations (4) and (5) gives us :

$$(C_1-C_2)-(p-a)>0\text{, i.e. } p-(C_1-C_2)<a\,.$$

$$\text{and } p-C_1>0 \text{ i.e. } p-(C_1-C_2)>C_2\,.$$

$$\text{thus } a>p-(C_1-C_2)>C_2 \tag{6}$$

It is optimal where the access toll is superior to marginal cost C_2. If, on the contrary, the cost function of the firm in charge of the network is such that the constraint ‘profit not negative’ has not come to play, we have $\lambda=0$, thus $p=C_1$and $a=C_2$. Pricing based on the marginal cost is therefore feasible and corresponds to a first-order optimum.

If the final selling price p of the natural gas and the access toll to the network a are not simultaneously fixed by the Regulator but this is done in a sequential way with the Regulator fixing the access toll with an exogenously given price of the gas downstream, we find the optimal first-order pricing system proposed by Baumol and Sidak (1995) for the access toll to the network. In that case the Regulator determines the access toll which will maximize total welfare, the final price of natural gas being exogenously given. We have then according to (5), $p - a - (C_1 - C_2) = 0$

$$\text{i.e. } a = C_2 + (p - C_1) \qquad (7)$$

Equation (7) defines the access toll according to the rule ECP (Efficient Component Pricing Rule).

The optimal toll is equal to the incremental average cost due to the entry of a shipper on the network (C2) plus the opportunity cost undergone by the incumbent who, because of this competitor, loses a customer ($p - C_1$). This pricing system satisfies both indifference and efficiency principles defined by Baumol and Sidak. The indifference principle expresses the fact that the operator of the network is indifferent to the entry of a competitor on the downstream market: its profits are the same in both cases and the operator will not therefore try to block the entry. The efficiency principle expresses the fact that only potential competitors at least as efficient as the incumbent are going to want to use the network. This concept was criticized for several reasons: the ECPR allows the incumbent to preserve its monopoly rent which existed before the arrival of potential competitors. We can show that the exclusion of entrants less efficient than the incumbent is not still socially optimal. Finally, the operator of the network may use such a pricing to exclude a more efficient rival (Economides and White, 1995). Moreover, the inclusion of an opportunity cost is also questionable. Do we indeed have to consider that every customer serviced by a new entrant is inevitably a customer who would have been a customer of the incumbent?

Let us note with David and Mirabel (1998) that the Regulator often has to arbitrate between productive efficiency and allocative efficiency. Where total welfare is maximized via the simultaneous fixing of the price of the gas (p) and of the access toll (a) we notice that the access toll to the network is higher than the toll fixed according to the ECPR system (where the Regulator maximizes welfare via the fixing of the access toll for a gas price given on the final market). But the final price p is lower in the first case than in the second one. It can be collectively better to lower the price of gas in the market downstream and, at the same, increase the access toll for the transportation system. A Ramsey-Boiteux pricing system can thus improve the welfare of the consumers with regard to an ECPR tariff. This can be discovered by comparing the ‘profit’ obtained by consumers because of the decline in gas price on the final market and the ‘damage’ undergone by entrants because of the increase in the access toll to the network. The inverse relationship between the gas price on the final market and the access toll for the transportation system leads the Regulator to opt for a Ramsey-Boiteux tariff and to arbitrate between allocative efficiency and productive efficiency.

Table 1 : Comparison of access prices and gas prices

	Objectives	
	Maximization of the global welfare via the simultaneous fixing of p and a by the Regulator (case 1)	**Maximization of the total welfare via the fixing of a by the Regulator (case 2)**
Level of the access toll to the network a	RAMSEY pricing a_1	ECPR pricing a_2
	$a_1 > a_2$	
Level of the gas price on the final market p	RAMSEY pricing p_1	$p_2 = \overline{p}$ exogenous price
	$p_1 < p_2$	
Criteria of efficiency	Improve the productive and allocative efficiencies	Improve the productive efficiency

Source : David and Mirabel (1998)

2.3. Some experiences of TPA pricing systems in natural gas

Three questions must be simultaneously resolved when a TPA pricing system is set up, whether the incumbent operator of the transportation system remains present ore not in the market downstream : the nature of the toll (that is the role of the distance in the cost supported by the shippers), the level of the toll (that is the link which must exist between the access toll and the costs supported by the network), the structure of the toll (that is the portion between fixed costs and variable costs). Different solutions were adopted in the United States and in the European countries.

2.3.1. The nature of the tolls

There are three main practical methods for pricing natural gas transportation by pipeline:

- A ‘postage stamp’ pricing system which consists of fixing a constant toll independent of the distance, generally at the entry to the network. This system, close to the one which was set up and generalized in Europe for the electricity, is at present time used in Denmark, Spain, Finland and Sweden. This system does not reflect the incidence of fixed costs and penalizes consumers located close to entry points; it does not invite a multiplication of entry points and is efficient only for networks of modest length.

- A ‘distance related’ or ‘point to point’ pricing system as currently used in Germany, Belgium, France, and the Netherlands. The access toll is proportional to the distance which separates the point of delivery and the point of injection of the gas ; some countries introduced an upper limit (ceiling in 200 or 500 km) on the tariff distance to avoid penalizing consumers located far from injection points too much. This system which takes into account the physical reality of the network is justified if the network is treelike. On the other hand, it becomes questionable if the network is meshed because, as we saw above, the physical reality of gas flows does not necessarily coincide with geographic distance. This is the reason why a discount can be granted (50 % in France) when the new flow allows swap to be made across the transportation network. This system can certainly provide incentives to the operators for developing new entry points, which is a good thing, but it also risks penalizing the consumers located far from the injection points. Moreover, the competition risks disappearing beyond a certain distance if the access toll paid by the entrants is proportional to the distance while the incumbent has the possibility of realizing swaps.

- A ‘entry-exit’ or ‘input-output’ pricing system (location-related system) is at present used in the United Kingdom and in Italy. A toll is applied at the point of injection and another one at the off-take point, according to different criteria. The distance is then a parameter among the others and such a system is closer to a nodal pricing system because of a differentiation of access tolls according to the different nodes of a meshed network.

2.3.2. The level of the tariffs

There are two main approaches:

1) A pricing based on cost of service or rate of return (a ‘cost-plus’ system). The regulator makes an evaluation of the operating costs of the network over a reference period, and estimates the value of the stock of capital which represents this network. The level of the revenues is then determined in order to allow the network operator to cover its costs while benefiting from a ‘fair and reasonable’ rate of profitability on capital invested. The regulator has to estimate correctly costs and the value of the capital and this is difficult because of the asymmetry of information between operator and regulator. But the main criticism of this pricing system based on cost of the

service is the lack of incentive to minimize costs. The operator of the network is sure to receive its costs and it can be encouraged to invest too much in order to increase the asset value applied to the rate of return decided by the regulator (Averch-Johnson effect).

2) A 'price-cap' system where the regulator fixes price ceiling that the network operator must not exceed during the regulatory period (4 or 5 years). The evolution of this ceiling price is not connected in an explicit way to the evolution of the costs but depends on the rate of inflation and the estimates of the impact of productivity gains. Naturally the Regulator has to know information about costs to prevent the ceiling price from being fixed too high (there would then be an excess of profits for the operator) or too low (the long-term viability of transportation would be under threat). The operator of the network can adjust its tariffs for different segments of the market as long as it does not exceed, on average, the ceiling-price, and it is strongly incited to reduce costs because any difference between the price cap and costs is profit which the operator can appropriate. Brennan (1991) shows that this kind of tariff rule leads the firm to adopt a Ramsey-Boiteux pricing.

For one year t, the regulated price has to satisfy the following relation :

$$p_t \leq \overline{p}_t \text{ with } \overline{p}_t = \left[1+\left(RPI - X\right)\right]\overline{p}_{t-1}, \text{ or } \overline{p}_t = \left[1+\left(RPI - X\right)\right]^{t-1}\overline{p}_1 \qquad (8)$$

with RPI = Retail Price Index (in %) and X is the anticipated productivity gain (in %).

It is a system of this type which was adopted in United Kingdom from 1994. Moreover it can engender windfall profits for the operator if the Regulator overestimates the initial ceiling price or underestimates the potential of reduction of the costs (via the technical progress). Estimations of volume transported during the regulatory period is also a crucial point. It is one of the reasons why a 'hybrid price-cap' system has been adopted the United Kingdom in 1997, which introduces a double ceiling : a ceiling-price and a ceiling of revenues. For one year t, the price level of the firm has to be such as :

$$p_t \leq \overline{p}'_t \text{ with } \overline{p}'_t = \frac{1}{2}\frac{\overline{R}_t}{Q^*_t} + \frac{1}{2}\overline{p}_t$$

where Q^*_t represents the quantity estimated for year t, $\overline{R}_t$ the ceiling of revenues wished by the Regulator and $\overline{p}_t$, the price cap defined by (8). To determine the price cap the Regulator has to consider the volume of gas transported every year. The introduction of a ceiling on revenues in the formula of Transco does not give the network operator the incentive to develop its activity. As far as a part of its revenues is limited at the level calculated by the Regulator, the monopoly is less concerned to increase transported volumes. In the formula implemented by the United Kingdom Regulator, part of this incentive is reintroduced via the implementation of a mechanism of adjustment of the ceiling price according to the gap noticed between the actual and estimated transported gas.

Let us also note that the distinction cost-plus versus price-cap is not so clear as it appears. Everything depends in fact on the duration of the regulatory period. A cost-plus pricing system can provides incentive to the operator to cut its costs if the regulatory period is long (more than 4 or 5 years) because tariffs are going to remain constant during this period, implying for the operator supplementary profits. On the contrary, a price-cap system implemented over short periods (less than 3 years), will not give the operator incentives to increase productivity because the Regulator is going to take these gains into account at the next price review. This leads to intermediate, sliding scale forms of regulation, which combine a price-cap system with consideration of a criterion of rate of return on capital: the operator of the network is authorized to keep the profits which it made over the period according to the 'price-cap' procedure as long as the rate of return remains lower than a certain limit (Braeutingan and Panzar, 1993).

2.3.3. The tariffs structure

We generally consider that the burden sharing on a gas transportation system between fixed costs (capital depreciation) and variable costs (proportional to the volume transported in the pipeline) is about 80 to 90 % for the first ones and about 10 to 20 % for variable costs. That is why a binomial tariff is mostly operated with a fixed premium which depends on the capacity reserved in the pipe and a variable toll which is a function of the quantity transported.

The pricing system proposed by Gaz de France, which is a cost-plus based system, takes into account three parameters: the maximum daily capacity reserved on the network, the annual quantity of gas which is transported in the network and the distance which separates the entry point and the exit point. This distance is taken into account through a multiplier coefficient (which varies from 1 to 49 in the price formula). The burden-sharing between capacity and volume is made on this basis : 80 % for the capacity and 20 % for volume.

In the UK (for the Transco system), in contrast, 65 % is allocated to capacity and 35 % to the volume. Moreover, capacity element is itself shared between an entry term paid on a monthly basis (the basis is the maximum daily volume on month by month basis with a mechanism of bids for the injection capacities) and a annualized exit term (the basis is the maximum daily off-take volume). This exit term varies according to different zones. The commodity term is applicable to the volumes taken off the system and is independent from the distance. This entry-exit system does not take into account explicitly the distance even if the differentiation of the exit terms can indirectly reintroduce such a parameter. Tolls vary from one exit to another. There is besides a balancing market for gas supply and demand located at the NBP (National Balancing Point) which is a notional point where offers and bids which have only paid the entry term converge.

In the United States the system has seen considerable evolution. Since 1992, the Order 636 of the Federal Energy Regulatory Commission obliges gas pipeline operators to calculate their tariffs according to the SFV method (Straight Fixed Variable) which stipulates that 100 % of the fixed costs must be recovered through the capacity term. The customers which may be interrupted do not reserve daily capacity and therefore do not pay capacity term. All variable costs are recovered by means of a user toll applied to the actually volume of gas transported. This SFV method replaced the MFV method (Modified Fixed Variable) which was effective until 1992 and which involved recovering 87% of fixed costs from a capacity charge and 13% from a volume charge. This last method had already limited the distortions of the United Method applied between 1973 and 1989 and which involved the recovery of 25% of fixed costs through a reservation charge and 75% from the volume charge (variable costs were 100% recovered from the volume charge). To recover an important part of fixed costs through the volume component of charges penalizes industrial consumers who have a high average load factor and favors local distribution companies (and thus the domestic customers) which reserve substantial capacity but use it in a very variable load factor. The SFV method which consists of recovering 100% of the fixed costs through the reserved capacity charge led to an increase of transportation tolls for customers with low average load factor. Shippers who have a very seasonal demand are obliged to reserve capacity equivalent to their maximum output while they will use this capacity only for short periods. On the contrary, customers or shippers with high load factors (big manufacturers mostly) saw their transportation costs decreasing appreciably.

We have to take notice of the fact that customers can be obliged to balance their input-output volumes each day or each month and that penalties are foreseen in the case of non-compliance with contractual clauses. Nevertheless, operators can avoid these penalties in selling or buying capacity on secondary markets. As we shall show it in the second part of this paper, the participation of the capacity holders in such secondary market and the result of this participation depend on the rules which govern this market.

2.4. Congestions pricing and strategies

In case of congestion on the network, how should the available capacity be allocated? According to the rule ‘first come first served’? By aiming to satisfy all shippers but reducing their capacity pro-rata? By using auctions? Auctions seems to have the favor of the European regulators, even if currently only TRANSCO uses them for entry capacity to its transportation and storage network. If the operator of the network is present downstream in the gas chain, it is for the Regulator to organize such auctions.

There are theoretically four main systems of auction:

1) ‘English bids’: the auctioneer quotes a price and increases it gradually (ascending bids). The good is allocated to the highest bidder. Under this system, bids are made in public (they are known to all participants) and are dynamic (a potential buyer can bid several times during the auction and can therefore take into account the information acquired about the strategy of competitors).

2) ‘Dutch bids’: the auctioneer quotes a maximum price and decreases it gradually until a buyer bids and obtains the good. This system is also public and dynamic.

3) ‘Bids sealed at the first price’: sealed bids are made and the good allocated to the highest bidder and at the price bid. This system is both private (bids are not revealed to other participants) and static (participants can only bid once).

4) ‘Bids sealed at the second price’ (Vickrey’s bids): sealed bids are made and the good is allocated to the highest bidder at the price bid by the first loser. This system is also

private and static.

Each of system presents advantages and drawbacks but in each case it is necessary to consider four aspects : the asymmetry of information between the participants, the collusion strategies between participants, the more or less expensive strategies of collection of private information, the aversion to risk of the participants notably in relation to the ‘winner curse’. The latter comes about because although a participant may have won an auction, the good has been over-valued and resale on a secondary market is therefore difficult and involves the risk of loss.

An important point must be mentioned here: the revenues from the auctions should not constitute a revenue for the operator of the transportation system, otherwise this operator may have an incentive to artificially provoke such congestion. This revenue has to be allocated to the financing of capacity investments. It is probably within the management of congestion that predatory and foreclosure strategies can be used by the incumbent against potential entrants. The foreclosure strategy is a strategy aimed at reducing the access of buyers to a supplier or limiting the access of suppliers to a buyer (see Tirole, 1993). A behavior aiming to refuse access to the network by a potential downstream competitor can be likened to a foreclosure strategy. The predatory strategy has for its objective to damage an existing competitor by forcing it to leave the market. The Regulator must thus be very watchful and make sure that the operator of the transportation system does not manipulate information about the available capacities to eliminate potential entrants.

3. The Role of Secondary Markets

3.1. The capacity release market in North America

In the United States and in Canada, shippers can sell, in the short run, their excess capacity on a secondary market. This market gives them a certain degree of flexibility in the management of their transportation capacity. Shippers can resell their excess capacity with relatively short notice about the volumes to be placed in the capacity release market. Capacity offered on the secondary market have durations which extend from a day to the total duration of the initial contract. The upper limit for prices on the secondary market is the maximum regulated rate. Shippers can place an option on the repurchase of the capacity which they resell thereby avoiding the risk of lacking transportation capacity. In Canada, there is no limit on the price of the capacity release market.

The secondary market also presents advantages for buyers. They can intervene for a very short term. This market allows them to get transportation capacity in order to face increases of demand in interesting financial conditions. Shippers can acquire some transportation capacity when it is necessary, without being bound by contract for the flat periods. When the whole capacity of a gas network is reserved, a shipper can nevertheless obtain some on the secondary market.

This kind of market also presents drawbacks. Firstly, the complexity of the electronic board bulletin (EBB) system on which the capacities are posted can limit the access. In order to get capacity on a long distance, a shipper has to know several EBB. Secondly, the coordination of contracts to achieve a specific path for gas can turn out to be difficult, because the shipper has to buy capacity on several segments of networks. Finally, the last drawback of the secondary market is the lack of available capacity during peak-load period. In spite of these inconveniences, the secondary markets in United States and Canada keeps on growing.

Secondary market does not allow the capacity holders to recover the totality of the cost due to their unused reserved capacity. The price cap on the secondary market implies a revenue from this market necessary lower than the costs of the shippers. To appreciate the consequences of this cap and a capacity secondary market on the behavior of suppliers at a theoretical level, we propose a simple model in which two firms compete in the end-users' market and reserve their transportation capacity with the same gas network. The network operator does not sell gas, in other words we suppose that the unbundling of the incumbent is complete.

3.2. Model specifications

The gas network operator is an independent firm. Gas is sold to the end users by two firms. First, the Regulator defines the tariff conditions of third party access to the network. Each of the two shippers is characterized by its load factor measured between 0 and 1. The load factor is equal to the relationship between gas actually transported and capacity reserved. A high load factor characterizes a shipper who does not experience variations in demand of gas (e.g. a supplier whose clientele is industrial) while on the contrary a low load factor implies a high level of capacity reservation related to fluctuating demand (e.g. the one of a local distribution company). In our model the year is split into a peak period and an off-peak period. According to what generally can be observed in the natural gas industry, we suppose that each of the shippers reserves a certain capacity on the network for the whole year. Then, part of this reserved capacity can be sold or added to from the capacity available on a secondary market. A purchase or a sale in the secondary market can be made during the peak load period or during the normal load period. Thus the game which we describe here takes place in several phases :

- 1st phase : each firm reserves transportation capacity on the network ;
- 2nd phase : the shipper characterized by a low load factor places his superfluous capacity on the secondary market and the shipper characterized by a more stable demand may acquire this capacity.

Our objective is to show the impact of the secondary market on the choices of the shippers and to illuminate the behavior of this secondary market in capacity.

$CT(q_k, \alpha_k)$ represents the transportation cost of shipper k ($k = i, j$). This cost depends on the volume sold by k (q_k) and on a parameter α_k which we shall clarify below. We suppose here that the demand served by each shipper includes a peak load period and a period during which base-load demand is served. The annual quantity requested by each shipper i may thus be decomposed as :

$$q_k = t_k \alpha_k q_k + (1 - t_k)\beta_k q_k \tag{9}$$

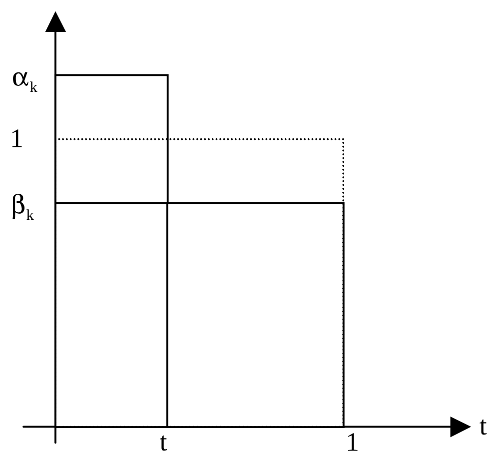
with $\alpha_k > 1$ et $\beta_k < 1$.

During the peak load period, which lasts a fraction of the year t_k ($0 < t_k < 1$), quantity sold ($\alpha_k q_k$) is higher than the average annual quantity (q_k) whereas the off-peak quantity ($\beta_k q_k$) is lower than the average quantity. We suppose that the duration of peak demand is equal for both shippers. The load factor of shipper i is lower than that of shipper j. The demand served by i varies more (because its customers are small natural gas users) than that served by shipper j (whose customers are manufacturers). In other words we suppose that $t_i = t_j = t$ and $\alpha_i > \alpha_j$ (which implies $\beta_i < \beta_j$). The relationship (9) becomes $(1-t)\beta_k + \alpha_k t = 1$, what implies :

$$\beta_k = \frac{1-\alpha_k t}{(1-t)} \tag{10}$$

The more the firm k is subjected to peak load phenomenon, the more α_k increases and the more β_k decreases. The load factor curve that we proposed is represented on figure 1.

Figure 1 Simplified Load Factor Curve



The load factor of a shipper k becomes then $f_k = \frac{1}{\alpha_k}$.

The transportation cost for a shipper is :

$$CT(q_k, \alpha_k) = (u_k p_r + p_u) q_k \tag{11}$$

The term p_r corresponds to the capacity price ($u_k q_k$) and p_u represents the commodity price - that is to say the price corresponding to the volume actually transported on the network (q_k).

3.3. Equilibria of the game

The game between shipper i and shipper j whose objectives are to minimize their transportation costs includes two stages :

- 1st stage : every shipper reserves capacity so that :
    - o the shipper j reserves capacity which is lower than the one needed for his peak demand ($u_j \leq \alpha_j$)

- the shipper i reserves the capacity needed to satisfy his peak demand plus the capacity needed by shipper j ($u_i = \alpha_i + \alpha_j - u_j$),

- 2nd stage : the shippers exchange off-peak and peak capacity in the secondary market. Two situations can therefore arise :
  - case A : the capacity reserved by shipper j does not allow him to cover his base-load, in which case he will buy off-peak capacity from the shipper i ;
  - case B : his capacity reserved covers his off-peak capacity needs and the exchange in the secondary market will only concern peak capacity

The computation of the Nash equilibria of this game leads us to consider the trade in the secondary market during peak and off-peak periods.

Off-peak period

During peak period shipper i wish to sell in the secondary market capacity which corresponds to the difference between the capacity which he reserved and the one which it needs ($u_i - \beta_i$). As we mentioned above, we have to deal with two cases :

- case A : $u_j < \beta_j$, in which case shipper j has to buy some capacity from i
- case B : $u_j > \beta_j$, in which case shipper j doesn't need capacity from i

We denote the price at which the capacity for the off-peak period is exchanged as p_s^{hp} .

Peak period and case A

We suppose that there is a capacity exchange during this period between i and j at a price denoted by p_s^p . The objective of the two shippers is to lower their transportation cost. For both of them in this case, their average transportation costs are

$$ATC_i^A = u_i p_r - \left(\beta_j - u_j\right)\left(1 - t\right) p_s^{hp} - \left(\alpha_j - u_j\right) t p_s^p + p_u \quad (12)$$

$$ATC_j^A = u_j p_r + \left(\beta_j - u_j\right)\left(1 - t\right) p_s^{hp} + \left(\alpha_j - u_j\right) t p_s^p + p_u \quad (13)$$

Shipper i has to pay his capacity reservation (u_i) and his transportation cost is lowered by his revenues in the secondary market during the off-peak period ($\left(\beta_j - u_j\right)\left(1-t\right)p_s^{hp}$) and during the peak period ($\left(\alpha_j - u_j\right)tp_s^p$). Shipper j has to pay his capacity reservation plus his purchases on the secondary market.

Secondary market trade will take place only if the transportation costs for both shippers are lower than the ones they have to pay without this market. So, two conditions should be simultaneously satisfied :

$$\begin{aligned} ATC_i^A &\leq \alpha_i p_r + p_u \\ ATC_j^A &\leq \alpha_j p_r + p_u \end{aligned} \tag{14}$$

Using relations (12), (13) and the fact that $u_i = \alpha_i + \alpha_j - u_j$, the prices in the secondary market that satisfy conditions (14) are described by

$$p_s^p = \frac{1}{t}\left[p_r - \frac{\left(\beta_j - u_j\right)}{\left(\alpha_j - u_j\right)}\left(1-t\right)p_s^{hp}\right] \tag{15}$$

This case (A) is characterized by capacity reservation of shipper j such that $u_j < \beta_j$. The relationship (15) describes all the values of p_s^{hp} and p_s^p such that the average transportation cost for i and j are respectively $\alpha_i p_r + p_u$ and $\alpha_j p_r + p_u$. The capacity price in the secondary market during the peak period in this case is a decreasing function of the off-peak price. It also depends on the capacity reserved by shipper j on the network (u_j).

<u>Peak period and case B</u>

In this case, the capacity reserved by shipper j is $\beta_j \leq u_j < \alpha_j$. There is no capacity trade during off-peak period so the transportation costs for i and j are

$$ATC_i^B = u_i p_r - \left(\alpha_j - u_j\right)tp_s^p + p_u \tag{16}$$

$$ATC_j^B = u_j p_r + \left(\alpha_j - u_j\right)tp_s^p + p_u \tag{17}$$

The transportation costs should satisfy the following conditions :

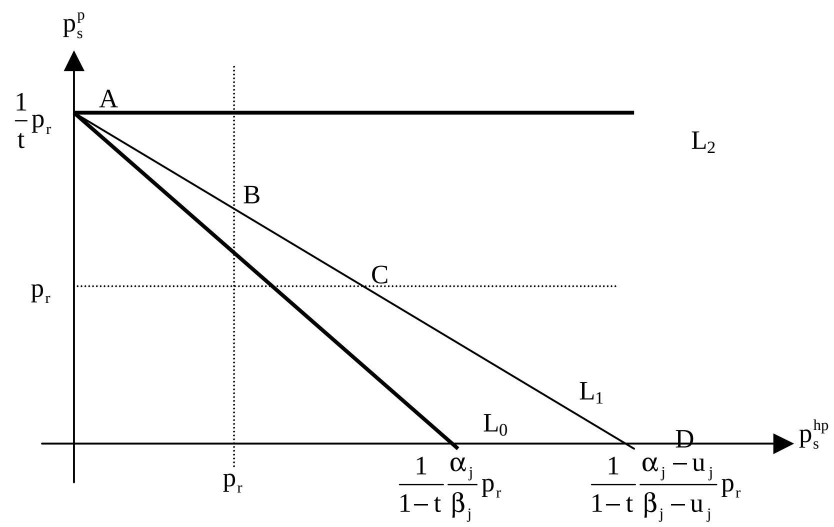
$$\begin{aligned} ATC_i^B &\leq \alpha_i p_r + p_u \\ ATC_j^B &\leq \alpha_j p_r + p_u \end{aligned} \quad (18)$$

The price in the secondary that involves a Nash equilibrium of that game is

$$p_s^p = \frac{p_r}{t} \quad (19)$$

Comparing equation (19) with relationship (15) shows us that when then the capacity reserved by shipper j tends to β_j, the peak period price of capacity tends to p_r/t and is less and less dependent on the price during during off-peak period. Figure 2 describes these results.

Figure 2 Relationship between the peak and off-peak periods prices in capacity release market



If shipper j relies completely on the secondary market to obtain his capacity (i.e. his reservation is $u_j = 0$) the prices which he is ready to pay during the peak and off-peak periods are represented by all the points located under the line L_0. For this reservation, the prices that shipper i will be disposed to propose are located above the line L_0. Thus, the Nash equilibria for this reservation are represented by L_0. The off-peak price such that peak price is zero (represented by the intersection between L_0 and the abscissa axis) is necessarily higher than p_r because $1/(1-t) > 1$ and $\alpha_j/\beta_j > 1$. The peak price such taht off-peak price is zero is also necessarily higher than p_r because $t < 1$.

For any level of capacity reserved made by j included in the interval $\left[0, \beta_j\right[$, the Nash equilibria of the game are represented by L_1. As u_j tends to β_j, the straight line L_1 move towards L_2 that describes the peak price when there is no capacity trade during the off-peak period, that is to say when $u_j \geq \beta_j$.

Figure 2 shows clearly that prices (p_s^p, p_s^{hp}) on the secondary market have to be higher than the capacity price (p_r). Indeed, for any capacity reservation made by shipper j with the network operator such that $\beta_j < u_j < \alpha_j$, the Nash equilibria are represented by L_1 and three cases have to be considered:

- if shipper i chooses a couple (p_s^p, p_s^{hp}) located between points A and B, then the price paid by j during the peak period (p_s^p) is higher than the capacity price and the one paid during the off-peak period (p_s^{hp}) is lower ;

- if shipper i chooses a couple (p_s^p, p_s^{hp}) located between B and C, the both prices are higher than p_r ;

- if shipper i chooses a couple (p_s^p, p_s^{hp}) located between C and D, then the peak price on the secondary market is above the capacity price and the off-peak price is higher.

If shipper j reserves a capacity embraced by the interval $\left[\beta_j, \alpha_j\right]$, the peak price is given by equation (19) and it is necessarily above p_r. Given the prices in the secondary market, shipper j can reserve any amount of capacity with the network operator between 0 and his peak period need, and then acquire the rest in the secondary market. Whatever is his level of capacity reservation, his average transportation cost will be equal to $\alpha_j p_r + p_u$. The secondary market does not reduce his transportation cost but offers him flexibility.

3.4. Comments

A first result deserves to be emphasized : the price in the secondary market should not be limited by the initial capacity price. Indeed, so that the shippers having excess capacity are given incentives to place this on the market, it seems necessary that, over a limited period, they can sell them at a price higher than the reservation price. This result tends to show that the introduction of a ceiling on the price of the transportation capacity on the secondary market such as it has been applied in the United States can limit the exchanges of capacities on this market.

The fact that the shipper i can acquire the whole capacity necessary for his sales and for those of his competitor in peak periods raises an essential question, that of the eviction of the shipper j. Indeed, the shipper i, by reserving the whole capacity can be in situation of monopoly and so increase his profits resulting from the sale of the gas molecule. This situation is possible if this increase of his downstream profits compensates the cost generated by the capacity reservation, costs that are no longer recoverable on the secondary market. To avoid this kind of behavior, transportation contracts between pipelines and suppliers include "use-it-or-lose-it" clauses. So, if a capacity is reserved without being used, it returns to the network operator who can replace it. This rule allows to avoid the behavior of exclusion linked to the capacity reservation, i.e. foreclosure and predatory strategies.

4. Conclusions

The confrontation between the theoretical rules and the lessons drawn from experiences turn out to be helpful to understand the stakes involved by the implementation of an efficient third party access to the gas networks. Concerning the access price, the definition of an efficient tariff according to economic theory should lead to the adoption, in the case of a meshed network, of nodal pricing because the transportation costs of such a network are widely disconnected from the distance gone through. When the cost structure (presence of fixed costs) does not allow the establishment of first rank price without lump sum, the second rank optimum can be reached by the implementation of Ramsey prices. If the network operator remains a downstream gas supplier, the second-best optimum implies simultaneous regulation of the gas price and the access price. If the gas price is not regulated, the access price defined by a Regulator concerned about social welfare follows the Efficient Component Pricing Rule (ECPR). This rule makes the incumbent indifferent to the entry of a competitor into the supply business. With the ECPR, only efficient entrants will sell gas to end-users.

According to various normative benchmarks proposed by economic theory, Regulators have to define the nature, the level and the structure of transportation tariffs. The nature of the tariff refers to the impact of distance on the rate. By opting for a postage stamp tariff, the

Regulator totally excludes the role of the distance, whereas with a ‘point-to-point’ tariff distance becomes the determining factor. Transportation prices differentiated according to the points of entry and exit include distance in a implicit way in the tariff are closer to nodal prices. The method chosen by the Regulator to control the level of transportation prices (price cap or cost plus regulation) will allow to obtain Ramsey prices. Finally, the choice of the tariff structure implies for the Regulator an arbitrage between efficiency which requires allocation of the whole of fixed costs on the capacity part of the tariff and equity which would provide incentives to low load factor users by allocating a part of the fixed costs to the commodity part.

While third party access (TPA) tariffs incorporate a capacity reservation part which depends on the maximum volume which the supplier has to supply, the introduction of a secondary market in transportation capacity allows the latter to reduce some of his costs (if he resells part of his unused capacity) or to adjust the level of his capacity reservation (if he obtains a part of his capacity in the secondary market). So that buyers and sellers can meet in peak and off-peak periods, regulators must not put a limit on the prices of the secondary market. To avoid any strategic behavior, it is necessary to apply a ‘use-it-or-lose-it’ rule to avoid the exclusion from the supply market of one supplier by another by means of excess capacity reservation. Indeed, if this rule is not applied, a supplier could reserve all the capacity on a network in order to eliminate his competitors. By not reselling excess capacity on the secondary market, this supplier becomes a monopolist. This kind of strategy is possible as long as the reservation cost of the capacity is offset by the monopoly rent from downstream supply market.

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