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Entry Without Competition*

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Abstract

This paper examines competition in a liberalized market, with reference to some key features of the natural gas industry.. Each firm has a low (zero) marginal cost core capacity, due to long term contracts with take or pay obligations, and additional capacity at higher marginal costs. The market is decentralized and the firms decide which customers to serve, competing then in prices. We show that under both sequential and simultaneous entry, there is a strong incentive to segment the market: when take-or-pay obligations are still to be covered, entering and competing for the same customers implies low margins. If instead a firm is left as a monopolist on a fraction of the market, exhausting its obligation, it has no further incentive to enter a second market, where the rival will be monopolist as well. Hence, we obtain entry without competition. Antitrust ceilings do not prevent such an outcome while a wholesale pool market induces generalized competition and low margins in the retail segment.

1 Introduction

In the second part of the Nineties the European Commission has promoted through several Directives the liberalization of the main public utility markets, namely the telecommunications, the electricity and the natural gas industries. This policy, that can be traced back to the pioneering experience of the early Nineties in the UK, was rooted in the goals of enhancing competition and efficiency and completing the unification of European markets.

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Some common principles can be found in the liberalization frameworks designed in the Directives: entry and competition should be promoted in those segments of the industry where the technology allows to implement a more fragmented structure; in order to overcome the bottlenecks of the natural monopoly segments (networks) owned by the incumbent, third party access (TPA) and access regulation are prescribed; finally, a more active role of the demand side is pursued by recognizing to an increasing portion of the customers the right to look for the most convenient supplier. These general principles are consistent with the idea of removing the foreclosure opportunities of the incumbent, creating a level playing field where the new comers can develop their business.

We argue that the main focus of the European Directive and of the national liberalization plans has been so far on creating an entry opportunity of new comers. Although this is undoubtly the first step, avoiding foreclosure is only a necessary condition for a competitive environment to emerge. Less attention, so far, has been devoted to the design of public policies that can promote competition in the market[1].

In this paper we want to analyze the potential problems that can arise when competition should develop once the new comers are established in the market, with a particular focus on the natural gas liberalization process.

The natural gas Directive 98/30 have specified the lines of reform that the Member Countries then followed in the national liberalization plans. Today, we can evaluate the first steps of the liberalization process in the member Countries as designed in the national liberalization plans and implemented in the current policies[2]. The general principle of TPA has been confirmed, although some exceptions are admitted, namely when giving access to the transmission or distribution infrastructures would create technical or financial problems to the incumbent due to capacity constraints of take-or-pay obligations. Customers' eligibility has been promoted at different speed in the member Countries, with France at the lowest extreme (28% in 2003) and UK on the other (100% in 1998); the year when full eligibility will be realized varies across countries, with Germany reaching 100% of demand in 2000, Italy, Finland and Spain in 2003, Netherlands in 2004, Belgium and Ireland in 2005, Sweden in 2006; France has not yet set a final date for the opening of the demand side.

The principle of unbundling of the network assets and activities has been realized under different terms. The proprietary separation of the pipelines from the other activities have been chosen only in the UK and in Finland, while the milder solution of legal separation has been adopted in Belgium, Denmark, Italy and Spain; the simple accounting separation has found widespread acceptance as well (Sweden, Netherlands, Germany and France). The low profile solution to the unbundling principle, toghether with the exceptions admitted to the TPA principle and the insufficient information on available capacity of the pipelines suggest that foreclosure of the essential infrastructures will be a relevant problem in the industry, that calls for an active role of the regulators.

[1] For an extensive discussion of the liberalization process in the energy markets along these lines see Polo and Scarpa (2003).

[2] See European Commission (2002).

Turning to the creation of a competitive environment, in very few cases the liberalization plans have tried to limit the incumbent market power, by completely reorganizing the proprietary structure (UK), by forcing divestiture of import contracts (UK and Spain) or by setting market share ceilings (Italy and Spain). No deeper discussion took place on the features of market organization (centralized pool market vs. decentralized trades, balancing issues) that would help promoting a competitive market. And no analysis have been tempted, to the best of our knowledge, to evaluate if, once solved the foreclosure issues, the structural features of the natural gas industry would allow to obtain the expected benefits from entry.

This paper wants to explore these issues, and analyze how competition in the natural gas industry might evolve once entry barriers are removed (TPA has been fully implemented). We build our model around three key features of the industry. First, long term import contracts, the bulk of gas supply in most European countries, impose take-or-pay (TOP) obligations to the buyer, that pays a high portion of the contracted gas no matter if it is sold or not. Consequently, each seller has negligible marginal costs on its core capacity, although it has additional capacity at higher marginal cost, coming from extentions of the long term contracts and/or from purchases on the spot market. Secondly, in a decentralized market setting each firm decides which customers to approach; this marketing decision requires to sink some resources (say, local commercial networks), and it is therefore medium term in nature. Thirdly, once chosen their potential customers firms compete in prices, with some horizontal differentiation in their service, leaving Bertrand competition as a limit case.

In this setting we study the market equilibria in the sequential and in the simultaneous entry cases: the former wants to capture the initial phase after the liberalization, when the incumbent has a first mover advantage in selecting and contracting with the customers; the latter instead might be appropriate to represent a more symmetric environment, as in a more mature phase of the market.

In both situations we find a strong and mutual incentive of the firms to segment the market and maintain high prices. In a decentralized market each firm decides which customers to serve. When two firms with TOP obligations target the same customers, the two firms have the same (zero) marginal costs, and equilibrium margins are low due to competition. When instead only one firm has TOP obligations, if the (high marginal cost) rival tries to compete it is unable in a price equilibrium to obtain positive profits. This feature of price competition with TOP obligations drives the commercial strategies of the firms: leaving a fraction of the customers to the rival allows it to exhaust its TOP obligations and makes it a high cost (potential) rival with no incentive to compete on the residual customers. In a word, leaving the rival to act as a monopolist on a fraction of the market allows a firm to be a monopolist on the residual demand.

It should be stressed that the high fixed TOP payments play no role in our result, that would still hold even with no fixed cost. The segmentation result, instead, is driven entirely by the existence of low cost capacity due to TOP obligations. Hence our segmentation result requires simply low marginal cost core capacity and decentralized markets, and is therefore not necessary specific to the natural gas industry.

Our benchmark model puts some doubts on the fact that, once successfully solved the entry barriers issues through TPA, entry will bring in competition in gas. We consider therefore if antitrust ceilings or forced divestitures of gas contracts, by limiting the incumbent market share, can help promoting competition. We find that the segmentation outcome is not prevented under this regime, and a redistribution of market shares is the only relevant effect.

A more competitive outcome might instead be obtained if the market is centralized, preventing selective entry in particular submarkets. In this case, in fact, the retailers when designing their marketing strategies, have the same flat marginal cost equal to the wholesale price for any amount of gas they want to supply, and therefore they will obtain positive margins in any market they enter. A wholesale market, therefore, ensure to enhance competition and to squeeze the margins over the wholesale price in the retail market.

The paper is organized as follows. In section 2 we decrive the main assumptions of the model; section 3 analyzes the sequential entry case; section 4 considers the endogenous choice of TOP obligations by the entrant. Antitrust ceilings and centralized vs. decentralized markets are discussed in section 5 and 6, while the simultaneous entry case is considered in section 7. Concluding remarks thefollow.

2 The model

Our model is based on three main assumptions:

1. The firms hav a low (zero) marginal cost core capacity, and unbounded additional capacity with higher marginal costs.
2. The market is decentralized and each firm has to commit on which submarkets it wants to serve, an irreversible decision in the short run.
3. Once chosen their marketing strategy, the firms compete in prices, with slight differentiation in the commercial service provided.

Although these features can be found in different industries, we'll further discuss and make explicit there assumptions with reference to the gas industry.

Costs

Two firms, the incumbent (I) and the entrant (E), are active in this market. The firms purchase the natural gas from the extractors and resell it to the final consumers, once delivered it through the pipeline network. Although third party access is far from established in the natural gas industry in most European countries[3], in this paper we want to study the effects of entry in the

[3] On the liberalization of energy markets in Europe, see Polo and Scarpa (2003) and European Commission (2002).

retail market, absent any entry barriers to the transport infrastructures. Consequently, we assume that no bottleneck or abusive conduct prevents the access of the entrant to the transportation network at non discriminatory terms. Hence, the network access costs are assumed to be the same for E and I and, w.l.o.g., equal to zero.

Each (retail) firm i has a portfolio of long term contracts with the extractors, where the unit cost of gas w_i and a TOP obligation $\overline{q}_i$ per unit of time are specified, such that the purchaser has to pay to the extractor an amount $w_i\overline{q}_i$ no matter if the gas is taken or not, while it can receive additional gas at the unit cost w_i. Hence, the firms have no capacity constraints but a discontinuous marginal cost curve, that jumps from 0 to w once the obligations are exhausted [4] For simplicity, we assume $w_E = w_I = w$.

The cost function of firm i is therefore:

$$C_i(q_i, \overline{q}_i, k_i) = \begin{cases} w\overline{q}_i & \text{for } 0 \leq q_i \leq \overline{q}_i \\ w\overline{q}_i + w(q_i - \overline{q}_i) & \text{for } q_i \geq \overline{q}_i \end{cases} \quad (1)$$

Demand

Individual consumers $d = 1, .., D$ have completely inelastic unit demand; total demand is therefore D. They view the gas supplied in the market as perfectly homogeneous, but attach to each firm other (commercial or locational) characteristics that make the services slightly differentiated. The customers are uniformely distributed with respect to their preferred variety of the service according to a parameter $v \in [0, 1]$. The utility of a consumer with preferred variety v purchasing one unit of gas at price p_i from firm i offering a service with characteristic $x_i \in [0, 1]$ is $u^* - p_i - \psi(v - x_i)^2$, where ψ is a parameter describing the importance of the commercial services (product differentiation) for the client. Since gas is a commodity, we assume that product differentiation is very limited in scope, i.e. ψ is very low, with $\psi = 0$ as the limit case of perfectly homogenous sales. The parameter u^*, instead, indicates the maximum reservation price and captures the overall importance of gas for the clients. We assume that, since gas is an essential input in many activities, the provision of gas creates a large surplus for the client, i.e. u^* is much larger than the unit cost of gas: more precisely, we assume that $u^* \gg w$.

Each firm $i = I, E$ is characterized by a specific variety x_i of the service, due to its location and/or commercial practices. We assume that $x_I = 1/4$ and $x_E = 3/4$, i.e. the two firms have some (exogenous) difference in the

[4] Usually long term contracts specify also a total annual capacity, which is 25-30% larger than the TOP obligations. If a firm wants to deliver more gas than the long term capacity, a firm can purchase on the spot market. Hence, even in a more complete setting we have no absolute capacity constraint and a marginal cost schedule that jumps up (once the obligations are exhausted and once the capacity is fullfilled). TOP obligations are sufficient to obtain a discontinuous marginal cost curve, and including also capacity constraints and the spot market doesn't add anything to the results. Hence, we use the simpler setting with TOP obligations and no capacity constraint in the long term contracts..

service provided[5]. The firms do not observe the individual customer's tastes (her preferred service variety v) but know only the (uniform) distribution of the customers according to their tastes. We can easily derive the expected demand of the two firms from a subset of $D^t \leq D$ consumers (market t). Let us define $\widehat{t}$ as the consumer indifferent between the offers of I and E, $\overline{t}_I$ as the consumer indifferent between the offer of the incumbent and buying nothing, and $\overline{t}_E$ as the consumer indifferent between buying from E or nothing. It is easy to check that:

$$\begin{aligned} \widehat{t} &= \frac{1}{2} + \frac{p_E - p_I}{\psi} \\ \overline{t}_I &= \left[\frac{u^* - p_I}{\psi}\right]^{\frac{1}{2}} + \frac{1}{4} \\ \overline{t}_E &= \left[\frac{u^* - p_E}{\psi}\right]^{\frac{1}{2}} + \frac{3}{4} \end{aligned}$$

Then, the demand for firm I in market t is

$$D_I^t = D^t \cdot \left[\max\left\{0, \min\left\{\widehat{t}, \overline{t}_I, 1\right\}\right\} - \max\left\{\frac{1}{2} - \overline{t}_I, 0\right\}\right] \tag{2}$$

and the demand for E corresponds to

$$D_E^t = D^t \cdot \left[\min\left\{1, \overline{t}_E\right\} - \min\left\{1, \max\left\{0, \widehat{t}, \frac{3}{2} - \overline{t}_E\right\}\right\}\right] \tag{3}$$

The two expressions give the demand for the active firm if one or both firms are active (and offer relevant prices to the customers): for instance, when both firms are active and the market is covered we obtain the usual demand system of the Hotelling model, $D_I^t = D^t \widehat{t}$ and $D_E^t = D^t(1 - \widehat{t})$; when only the incumbent entered in market t and the market is not completely covered, due to the very high price set, the demand is $D_I^t = D^t \overline{t}_I$, etc.

TOP obligations and capacities

The portfolios of long term contracts of the two firms reflect their different positions: before the liberalization, the incumbent was the only supplier of the market, while the entrant is trying to capture some market share. The obligations of the incumbent, given its previous position, are very large but smaller than market demand, i.e $\overline{q}_I < D$. We can justify this assumption with two different arguments. First, we can argue that the incumbent, before the liberalization, would have preferred not to commit to TOP obligations equal

[5]Since we already analyze an asymmetric model, with the incumbent endowed with larger obligations and with and advantage in approaching the customers, we do not endogenize the choice of variety, where the incumbent might obtain additional advantages.

to market demand, as they would become financially risky if a fall in demand occurs. Moreover, analyzing the entry and pricing equilibrium under this assumption we'll be able to understand what happens if the incumbent is endowed with obligations equal to market demand. Regarding the entrant's long term contracts, we assume that its obligations are equal to the residual demand, i.e

$$\overline{q}_I + \overline{q}_E = D \tag{4}$$

Once analyzed the benchmark model we'll consider the entrant choice of obligations $\overline{q}_E$. In summary, the long term contracts of the two firms enable them to supply the market at zero marginal cost, since total obligations are equal to total demand. Moreover, the market is very liquid, as each firm can obtain additional capacity (at the same unit cost w) from the extractors.

Competition and timing

The market is decentralized, so that firms compete for each customer separately. Firms have to decide which clients to deal with, and propose a price to their potential customers. A given customer may thus face no offer, one offer (by a firm that would then be a monopolist for that customer), or two offers from the two competing firms. Price competition arises if both firms approach the same group of customers, *and it arises for those customers only.* We assume that the decision to serve a submarket is irreversible in the short run, as it requires to sink some resources (e.g. local distribution networks). Moreover, the incumbent is able to move first in approaching the customers, due to his existing relationships with the clients, followed by the entrant. Simultaneous marketing choices will be considered later on.

Customers are visited by the firms in sequence, and, for each customer, once the marketing choices are taken, the active firms propose simultaneously to her a price. When we analyze price competition for the single customer, the crucial element is the amount of TOP residual obligations of the firms, that enable them to serve the customer at zero marginal cost. Then, from the point of view of equilibrium analysis, since the incumbent moves first, all the contracting episodes where the incumbent has residual TOP obligations greater (or equal) than the submarket demand are similar: if I decides to enter, E anticipates that by entering in its turn, total TOPobligations will exceed submarket demand. Hence, analyzing all these contracting episodes sequentially, with I and then E deciding to enter or not, is equivalent to grouping them together, assuming that there are only two relevant submarkets, the first one as large as the incumbent's obligations, $D^1 = \overline{q}_I$, and the second one covering the residual demand, $D^2 = D - D^1 = \overline{q}_E$.

As the latter formulation lends itself to a simpler presentation, we assume that the two firms decide sequentially whether or not to enter at first market 1 and then market 2. We thus define a variable $e_i^t = \{0, 1\}$, $i = I, E$, $t = 1, 2$, which refers to the decision to enter ($e = 1$) or not ($e = 0$). After the marketing decisions are taken in a market, the active firms set simultanously a price. From our discussion, the timing is as follows:

- at $t = 1$ the incumbent decides whether to enter ($e_I^1 = 1$) or not ($e_I^1 = 0$) in D^1; then, having observed whether or not I participates, the entrant chooses to enter ($e_E^1 = 1$) or not ($e_E^1 = 0$) in market D^1. Then the participating firm(s) (if any) set a price simultaneously.
- at $t = 2$ the incumbent decides whether to enter ($e_I^2 = 1$) or not ($e_I^2 = 0$) in D^2; then, having observed whether or not I participates, the entrant chooses to enter ($e_E^2 = 1$) or not ($e_E^2 = 0$) in market D^2. Then the participating firm(s) (if any) set a price simultaneously.

Although we have derived (1), (2), (3), (4) and the timing from some key features of the gas industry, it should be clear that none of them is entirely specific to this market.

3 The sequential entry game

Let us now proceed to analyze the subgame perfect equilibria in the sequential entry game, where competition in the second market takes place once the outcome in the first one is determined. Although the two markets are separate, a strategic link between them remains, because the residual TOP obligations in the second market depend on the outcome of the game in the first stage. As we solve the model backwards, we must first consider the price equilibria and entry decisions in the second market as a function of the number of firms applying for the second group of customers and their residual TOP obligations.

3.1 The second market price subgames

The entry and price subgames in the second stage depend on the entry and price decisions in the first market, which, in turn, determine the amount of residual obligations: we can therefore parametrize the second stage subgames to $(\overline{q}_I^2, \overline{q}_E^2)$, where $\overline{q}_i^2$ is the residual TOP capacity of firm i in the second market. The profit function of firm i in the second market is:

$$\Pi_i^2 = e_i^2 \left[p_i D_i^2(p_i, p_j) - C_i(q_i, \overline{q}_i^2, k_i) \right]$$

The following Proposition addresses the easier case when only one firm enters in the second market.

Proposition 1 *For any outcome of the first stage game, if in stage* 2 *only firm* i *enters, it sets price* $\widehat{p}_i^2 = u^* - \frac{9}{16}\psi$ *and serves the entire market* D^2*.*

Proof. If only firm i enters market 2, the demand is described above by (2) or (3). It is easy to verify that if, as assumed, $u^* \gg w \gg \psi$, the profits are maximized by setting the highest price such that all the customers purchase, i.e. $\widehat{p}_i^2 = u^* - \frac{9}{16}\psi$. ■

We now move to price equilibria when both firms enter in the second market. Notice that the profit functions are continuous and concave, but kinked at $\overline{q}_i^2$, due to the jump in the marginal costs from 0 to w once the TOP obligations are exhausted. Hence, the necessary and sufficient conditions for a maximum are:

$$\begin{aligned} \left.\frac{\partial \Pi_i^2(\widehat{p}_I^2, \widehat{p}_E^2)}{\partial p_i}\right|_{p^-} &\geq 0 \\ \left.\frac{\partial \Pi_i^2(\widehat{p}_I^2, \widehat{p}_E^2)}{\partial p_i}\right|_{p^+} &\leq 0 \end{aligned} \tag{5}$$

Since $\overline{q}_I + \overline{q}_E = D$, the residual TOP obligations cannot be lower than D^2, and thus we have to consider two possible cases.

- If $D_i^2(\widehat{p}_I^2, \widehat{p}_E^2) > (<) \overline{q}_i^2$, i.e. if the quantity sold in equilibrium by firm i is larger (smaller) than its residual obligations, the profit function is smooth at the equilibrium prices and the two inequalities collapse to the single condition that the firm's first derivative is zero, with a marginal cost equal to w (0).
- If $D_i^2(\widehat{p}_I^2, \widehat{p}_E^2) = \overline{q}_i^2$, i.e. if at the equilibrium prices firm i uses exactly its obligations, both inequalities must be satisfied: notice that since the first one is computed with a marginal cost equal to w while the second one with a marginal cost equal to 0, they will identify a region of prices consistent with a maximum.

Figure 1 about here

The following Proposition first identifies a set of equilibrium prices; given the multiplicity of Nash equilibria, we single out Pareto superior price pairs as "the" equilibrium prices.

Proposition 2 *Assume that both firms enter the second market. If* $\overline{q}_I^2 \geq 0, \overline{q}_E^2 \geq 0, \overline{q}_I^2 + \overline{q}_E^2 = D^2$, *the (Pareto efficient) equilibrium prices are*

$$\begin{aligned} \widehat{p}_i^2 &= w + \psi \frac{\overline{q}_i^2}{D^2} \\ \widehat{p}_j^2 &= w + \psi \frac{3D^2 - 4\overline{q}_j^2}{2D^2} \end{aligned} \tag{6}$$

where $\overline{q}_i^2 \in [0, D^2/2]$ *and* $\overline{q}_j^2 \in [D^2/2, D^2]$, *i.e.* i *is the smaller and* j *the larger firm.*

Proof. We consider first the case in which in equilibrium each firm exactly covers its TOP obligations; in this case, we can identify a continuum of equilibrium prices that are Pareto ranked, and we pick up the highest ones (associated to the highest profits). Finally, we check that no price equilibrium exists, in which one firm produces more and the other one less than its TOP obligations.

If $\overline{q}_I^2 \geq 0, \overline{q}_E^2 \geq 0, \overline{q}_I^2 + \overline{q}_E^2 = D^2$, if in equilibrium each firm uses its obligations it must be that:

$$\begin{aligned}
\left.\frac{\partial \pi_I^2}{\partial p_I}\right|_{p^-} &\equiv \frac{1}{2} + \frac{p_E - w}{\psi} - \frac{2p_I}{\psi} \geq 0 \\
\left.\frac{\partial \pi_I^2}{\partial p_I}\right|_{p^+} &\equiv \frac{1}{2} + \frac{p_E}{\psi} - \frac{2p_I}{\psi} \leq 0 \\
\left.\frac{\partial \pi_E^2}{\partial p_E}\right|_{p^-} &\equiv \frac{1}{2} + \frac{p_I - w}{\psi} - \frac{2p_E}{\psi} \geq 0 \\
\left.\frac{\partial \pi_E^2}{\partial p_E}\right|_{p^+} &\equiv \frac{1}{2} + \frac{p_I}{\psi} - \frac{2p_E}{\psi} \leq 0 \\
& \quad \frac{1}{2} + \frac{p_E - p_I}{\psi} = \frac{\overline{q}_I^2}{D^2}
\end{aligned}$$

The first four conditions correspond to the left- and right-hand derivatives of the incumbent's and the entrant's profits while the last one specifies that each firm covers its obligations (since $\overline{q}_I^2 + \overline{q}_E^2 = D^2$ an analogous condition on $\overline{q}_E^2$ would be redundant). Figure 1 graphically represents the above conditions, and allows one to easily identify equilibrium prices. For $\overline{q}_I^2 \in [0, D^2/2]$ and $\overline{q}_E^2 \in [D^2/2, D^2]$ (which imply $i = I$ and $j = E$ in the notation of the statement), the first and the last expressions characterize equilibrium prices, assuming that, among those prices that satisfy the five conditions the firms pick up the highest ones. For $\overline{q}_I^2 \in [D^2/2, D^2]$ (which implies $i = E$ and $j = I$ in the notation of the statement) equilibrium prices are determined by the third and the fifth expression above. The segments ABC in figure 1 correspond to the Pareto efficient equilibrium prices for different values of the TOP obligations.

Let us now remove the assumption that firms sell exactly their TOP obligations, and calculate the equilibrium prices when one firm (say, firm I) produces more and the other (say, firm E) less than their respective obligations. We'll see that no such equilibrium exists. Notice that given the linear demand system at such a price pair the two profit functions are smooth, and the equilibrium requires the first derivatives of profits to be zero; in the case considered, the relevant derivatives are the first one (since I produces more than $\overline{q}_I^2$ its marginal cost is w) and the fourth one (since E is not using all its obligations, it has zero marginal costs). Solving for the price pair we get: $p_I = \frac{2}{3}w + \frac{\psi}{2}$ and $p_E = \frac{1}{3}w + \frac{\psi}{2}$. However, this price pair would be such, that I produces nothing and E supplies the whole market, which is a contradiction, as if this were true, E would have marginal cost equal to w and not to 0 and I would have marginal cost equal to 0 and not to w. Point D in Figure 1 corresponds to this case, and clearly implies that E is covering the entire market.

The complementary case of $D_I^2(\cdot) < \overline{q}_I^2$ and $D_E^2(\cdot) > \overline{q}_E^2$ works exactly in the same way (point E in Figure 1) and another contradiction would be established. Hence, the only possible price equilibria imply that each firm exactly covers its obligations. ■

The case considered above is relevant if both firms entered in the first market, or if only firm I entered, using all its obligations. In either case, in fact, the total residual TOP obligations in market 2 equal D^2: if both firms entered in market 1, no matter how the demand was allocated, the residual obligations amount to D^2 since $\overline{q}_I^1 + \overline{q}_E^1 - D^1 = D - D^1 = D^2$; if only firm I entered, using all its TOP obligations in market 1, then $\overline{q}_I^2 = 0, \overline{q}_E^2 = D^2$ and $\overline{q}_I^2 + \overline{q}_E^2 = D^2$.

Let us now consider the price equilibria when residual TOP obligations in the second market exceed demand. Although total residual obligations would allow to serve the market at zero marginal cost, the equilibrium prices depend on the allocation of residual obligations between the two firms. If one of the two firms has residual obligations lower than half of market demand, the (contrained) equilibrium prices will depend on the smaller firm obligations. Once both firms are endowed with obligations larger than half of the market, the symmetric (unconstrained) price equilibrium occurs, with total demand equally split between the two firms.

Proposition 3 *Assume that both firms enter the second market. If* $\overline{q}_j^2 \in [0, D^2]$ *and* $\overline{q}_i^2 > \max\left\{D^2/2, D^2 - \overline{q}_j^2\right\}$ *(and therefore* $\overline{q}_i^2 + \overline{q}_j^2 > D^2$*)* $i = I, E$, $i \neq j$ *the equilibrium prices are*

$$\begin{aligned} \widehat{p}_i^2 &= \psi \frac{\max\left\{D^2/2, D^2 - \overline{q}_j^2\right\}}{D^2} \\ \widehat{p}_j^2 &= \psi \frac{\max\left\{D^2/2, 3D^2/2 - 2\overline{q}_j^2\right\}}{D^2} \end{aligned} \tag{7}$$

Proof. Since $\overline{q}_i^2 > D^2/2$, its marginal cost is 0 over the relevant range of output and its profit function is smooth at equilibrium: firm i's equilibrium conditions require the first derivative to be zero (with zero marginal costs). For firm j we have to distinguish two cases, whether $\overline{q}_j^2$ is lower or larger than $D^2/2$. In the first case, the equilibrium prices will be such that firm j sells exactly its obligations: hence, we have to consider both left and right first derivatives. When instead $\overline{q}_j^2 > D^2/2$ a symmetric equilibrium will occur, and in equilibrium we'll have firm j's first derivative equal to zero (with zero marginal cost).

Let's consider the two cases in turn. When $\overline{q}_i^2 > D^2/2$ and $\overline{q}_j^2 < D^2/2$, $\overline{q}_i^2 + \overline{q}_j^2 > D^2$, the necessary and sufficient equilibrium conditions are:

$$\begin{aligned} \frac{1}{2} + \frac{p_j}{\psi} - \frac{2p_i}{\psi} &= 0 \\ \frac{1}{2} + \frac{p_i - w}{\psi} - \frac{2p_j}{\psi} &\geq 0 \\ \frac{1}{2} + \frac{p_i}{\psi} - \frac{2p_j}{\psi} &\leq 0 \\ \frac{1}{2} + \frac{p_i - p_j}{\psi} &= \frac{\overline{q}_j^2}{D^2} \end{aligned}$$

Figure 2 shows the relevant curves associated to these conditions and allows one to identify equilibrium prices. The first and the last conditions are binding and it is easy to check that the prices obtained also satisfy the second and the third inequality. Solving we obtain

$$\widehat{p}_i^2 = \psi \frac{D^2 - \overline{q}_j^2}{D^2}$$
$$\widehat{p}_j^2 = \psi \frac{3D^2 - 4\overline{q}_j^2}{2D^2}$$

Finally, no price equilibrium exists in which firm j produces less than its obligations: in this case, the equilibrium prices should be identified by the first and the third conditions as equalities (point A in Figure 2) and $D_j^2(\cdot) = D^2/2 \geq \overline{q}_j^2$, which contradicts the assumption of the statement.

When $\overline{q}_i^2 > D^2/2$ and $\overline{q}_j^2 > D^2/2$ the residual obligations are so large that, in a symmetric equilibrium, the marginal cost is zero for both firms. The price equilibrium simply requires the first order conditions to be met. Hence,

$$\frac{1}{2} + \frac{p_E}{\psi} - \frac{2p_I}{\psi} = 0 \qquad (8)$$
$$\frac{1}{2} + \frac{p_I}{\psi} - \frac{2p_E}{\psi} = 0$$

Solving for the equilibrium prices we obtain $\widehat{p}_I^2 = \widehat{p}_E^2 = \frac{\psi}{2}$. Each firm sells half of D^2 and the marginal cost is 0 as implicit in the equilibrium conditions. ■

Proposition 3 describes the price equilibria if either (a) both firms enter in the second market when in the first market a single firm entered but did not cover all the demand, retaining some obligations, (b) only the entrant was active in market 1 exhausting all its obligations, (c) no firm entered in the first market.

Figure 2 about here

3.2 Entry decisions in the second market

We have argued that, depending on the residual TOP obligations which have not been committed in the first market, four different cases may arise, and we have analyzed equilibrium prices in each of these cases in Propositions 1-3. We can now move to the entry decisions of the two firms in the four subgames of the second market. We remind that Proposition 1 describes the optimal price when only one firm enters in the second market for any previous entry choices in the first market. When both firms enter in stage 2, instead, Proposition 2 or 3 apply, depending on the entry and price equilibrium in the first market, which determines the residual obligations of the two firms. In the entry decision we assume that if a firm by entering expects zero profits (zero sales in our setting), that firm will remain out (no frivolous entry).

The following Proposition identifies the entry equilibrium in the four cases.

Proposition 4 *In the second market, a firm enters if and only if its residual TOP obligations are positive. More precisely:*

- *Consider the case where both firms entered in market 1. If* $\overline{q}_I^2 > 0, \overline{q}_E^2 > 0$, *then* $\widehat{e}_I^2 = \widehat{e}_E^2 = 1$, *i.e. both enter also in market* 2, *while if* $\overline{q}_i^2 = 0, \overline{q}_j^2 > 0$ *then* $\widehat{e}_i^2 = 0$ *and* $\widehat{e}_j^2 = 1$, *i.e. only the firm with residual obligations enters in market* 2.
- *Consider the case where only firm* i $(i, j = I, E, i \neq j)$ *entered market 1. If* $\overline{q}_i^2 > 0$, *then* $\widehat{e}_i^2 = \widehat{e}_j^2 = 1$, *i.e. if firm* i *retains some obligations both firms enter in the second market, while if* $\overline{q}_i^2 = 0$, *then* $\widehat{e}_i^2 = 0$ *and* $\widehat{e}_j^2 = 1$, *i.e. if firm* i *already exhausted its obligations it does not enter in market* 2;
- *If neither firm entered market 1, then they both enter market 2.*

Proof. Consider first the subgame following the decision of the two firms to enter in the first market ($e_I^1 = e_E^1 = 1$): since we have not yet solved for the price equilibrium in market 1 we have to analyze the second stage for any combination of residual capacities such that $\overline{q}_I^2 \geq 0, \overline{q}_E^2 \geq 0, \overline{q}_I^2 + \overline{q}_E^2 = D^2$. The corresponding price equilibrium has been shown in Proposition 2 and the associated profits are $\Pi_i^2 = (w + \psi \overline{q}_i^2 / D^2)\overline{q}_i^2$ and $\Pi_j^2 = (w + \psi(3D^2 - 4\overline{q}_j^2)/2D^2)\overline{q}_j^2$, where i and j are such that $\overline{q}_i^2 \in [0, D^2/2]$ and $\overline{q}_j^2 \in [D^2/2, D^2]$: notice that the profits are positive if the residual obligations of the firm are positive. Since not entering gives zero stage profits, a firm will enter if it has some residual obligation and stays out otherwise.

Consider now the two subgames following the entry of a single firm in the first market ($e_I^1 = 1, e_E^1 = 0$ and $e_I^1 = 0, e_E^1 = 1$): although covering all the first market exhausts the obligations of either firm ($D^1 = \overline{q}_I > \overline{q}_E$) we cannot exclude that the entrant in the first market has priced so high to serve only a fraction of D^1, retaining some residual capacity in the second market. Hence, $\overline{q}_I^2 \geq 0, \overline{q}_E^2 \geq 0, \overline{q}_I^2 + \overline{q}_E^2 \geq D^2$. Let's analyze the different cases. If the incumbent entered the first market using all its obligations (pricing according to Proposition 1) then $\overline{q}_I^2 = 0, \overline{q}_E^2 = D^2$. Proposition 2 describes the price equilibrium if both enter: since the entrant makes positive profits it will enter in any case, while the incumbent, entering the second market realizes no profits since $D_I^2 = 0$ being $\overline{q}_I^2 = 0$; thus, I will stay out. Hence, $\widehat{e}_I^2 = 0$ and $\widehat{e}_E^2 = 1$. If I entered the first market but rationed the demand retaining some obligations, $\overline{q}_I^2 > 0, \overline{q}_E^2 = D^2$. Since $\overline{q}_I^2 + \overline{q}_E^2 > D^2$ Proposition 3 applies. The equilibrium profits if both firms enter are therefore $\Pi_I^2 = \psi \min\left\{\frac{D^2}{4}, \frac{(3D^2/2 - 2\overline{q}_I^2)}{D^2}\overline{q}_I^2\right\}$ and $\Pi_E^2 = \psi \max\left\{\frac{D^2}{4}, \frac{(D^2 - \overline{q}_I^2)^2}{D^2}\right\}$. Since both are positive for $\overline{q}_I^2 > 0$, both firms will enter if the incumbent has retained some capacity from the first stage. Hence, we conclude that a firm will enter in the second market if it has some residual obligation to cover. The same arguments apply to the complementary case in which only E entered in the first market ($e_I^1 = 0, e_E^1 = 1$), showing that if the entrant used all its obligations in the first market it stays out of the second market, that will be monopolized by the incumbent, while if $\overline{q}_E^2 > 0$ both firms enter in stage 2.

Finally, if no firm enters in the first market each firm has residual obligations sufficient to cover D^2: if both enter Proposition 3 applies and both firms obtain positive profits. Hence, they will enter. ■

The intuition of the equilibrium entry pattern is straightforward. At the second stage, the price equilibria give positive sales and profits as long as a firm has positive residual obligations, while if a firm with TOP obligations competes with one that already exhausted them, the latter at the equilibrium price sells nothing. Hence, there is an incentive to enter only if a firm has still obligations to be covered.

3.3 Equilibrium

Once obtained the entry and price equilibria in the second market in the four subgames, we can turn our attention to the analysis of the entry and price subgames in the first market, when the two firms have still all their obligations $\overline{q}_I$ and $\overline{q}_E$. We already observed that there is a strategic link between the two markets, due to the residual obligations in stage 2 as determined by the first market choices. Both the decision to enter the first market and the price strategy determine in fact the residual obligations in the second market, and therefore the optimal strategy in the continuation of the game. In market 1 firm i takes an entry and a price decision in order to maximize its overall profits $\Pi_i = e_i^1 \cdot \Pi_i^1(p_i^1, p_j^1; e_i^1, e_j^1) + \widehat{e}_i^2(p_i^1, p_j^1; e_i^1, e_j^1) \cdot \widehat{\Pi}_i^2(p_i^1, p_j^1; e_i^1, e_j^1)$, where $\widehat{e}_i^2$ and $\widehat{\Pi}_i^2$ are respectively the second stage equilibrium entry choices and the second stage profits evaluated at the equilibrium entry and price decisions.

We start our analysis of the first market by considering the price games. If a single firm enters in the first market, we have to check whether the optimal price entails covering the entire market (as shown for the second stage in Proposition 1) or prescribes to ration the first market (through a higher price) retaining some obligations in the second market. Since TOP obligations (with zero marginal cost) imply a more aggressive pricing behaviour, this choice might be justified if it leads to exclude the rival from the second market, a sort of leveraging effect. The following proposition shows that this is not the case.

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Proposition 5 *If only firm i enters in the first market, it sets the price $\widehat{p}_i^1 = u^* - \frac{9}{16}\psi$ and supplies the entire market D^1.*

Proof. From Proposition 1 we know that firm i's profits in market 1 are maximized by setting $\widehat{p}_i^1 = u^* - \frac{9}{16}\psi$. If firm i sets a price $p_i^1 > u^* - \frac{9}{16}\psi$, $D_i^1 < D^1$, leaving some residual obligation $\overline{q}_i^2 > 0$. Proposition 4 has shown that if the firm active in the first market retains some residual obligations $\overline{q}_i^2 > 0$, both firms will enter in the second market (no foreclosure realized). If, for example, firm I has entered in the first market, its overall profits if it does not cover D^1 are $\Pi_I = p_I^1 D_I^1(p_I^1) + \min\left\{\psi\frac{D^2}{2}, (3\psi - 4\psi\overline{q}_I^2/D^2)\overline{q}_I^2\right\}$ where $D_I^1(p_I^1)$ is the demand when only one firm (I) is active in market 1 and $\overline{q}_I^2 = D^1 - D_I^1(p_I^1)$. Then the derivative of the profit function evaluated at $p_I^1 \longrightarrow^{+} u^* - \frac{9}{16}\psi$ is

$$\frac{\partial \Pi_I}{\partial p_I^1} = 1 - \frac{2}{3\psi}(u^* - \frac{9}{16}\psi) - \frac{9D^1 - 12D^2}{12D^2\psi} < 0$$

that is, the second market profit gains do not compensate the reduced profits in the first market. The same holds true if only firm E enters in the first market. ■

Proposition 5 shows that the strategic link between the two markets is insufficient to distort the first market pricing decisions when only one firm enters: since this firm is in a position to extract monopoly rents from those consumers, while it cannot extend its monopoly to the second market by retaining part of its obligations, this firm sets the monopoly price and covers all the market.

We move now to the price game when both firms enter in the first market. Proposition 4 has shown that the second stage entry and price equilibrium following the decision of the two firms to enter in the first market crucially depends on the pricing decisions in the first stage: if, in fact, firm i exhausts its obligations in the first market, i.e. $D_i^1(p_i^1, p_j^1) \geq \overline{q}_i$, it will not enter in the other market, while positive residual obligations of the two firms lead to a duopoly in the second stage. Since the first market profits $D_i^1(p_i^1, p_j^1)p_i^1$ are continuous and concave in the two prices, while the second stage equilibrium profits are zero when the firm does not enter, positive and depending on the residual obligations $\overline{q}_i^2$ when both enter, and jump up when the firm remains as a monopolist in market 2, the overall firm profits are discontinous at the prices where the firm becomes a monopolist in the second market. This occurs for the incumbent if the entrant sells all its obligations in the first market, i.e. $D_E^1(p_I^1, p_E^1) \geq D^2 = \overline{q}_E$ (hence $\overline{q}_E^2 = 0$), while the entrant will monopolize market 2 if, although entered in the first market, it sells nothing (and the incumbent therefore exhausts its obligations, $\overline{q}_I^2 = 0$), i.e. $D_E^1(p_I^1, p_E^1) = 0$.

Let us define the following subsets of the strategy space $P = \left\{(p_I^1, p_E^1) \in [0, u^*]^2\right\}$:

$$P^A = \left\{(p_I^1, p_E^1) \middle| p_I^1 \in [0, u^*], p_E^1 \in [0, \min\left\{p_I^1 + \psi\widetilde{D}, u^*\right\}]\right\} \tag{9}$$
$$P^B = \left\{(p_I^1, p_E^1) \middle| p_I^1 \in [0, u^* - \psi\widetilde{D}], p_E^1 \in (p_I^1 + \psi\widetilde{D}, \min\left\{p_I^1 + \frac{\psi}{2}, u^*\right\})\right\}$$
$$P^C = \left\{(p_I^1, p_E^1) \middle| p_I^1 \in [0, u^* - \frac{\psi}{2}], p_E^1 \in [p_I^1 + \frac{\psi}{2}, u^*]\right\}$$

where $\widetilde{D} = \frac{D^1 - 2D^2}{2D^1}$. When $(p_I^1, p_E^1) \in P^A$ firm E exhausts its obligations in the the first market ($D_E^1(p_I^1, p_E^1) \geq D^2 = \overline{q}_E$) and does not enter in the second. Conversely, when $(p_I^1, p_E^1) \in P^C$ firm E doesn't sell anything in the first market and I exhausts its capacity; therefore in the second market only E will enter. Finally, for $(p_I^1, p_E^1) \in P^B$ no firm exhausts its obligations in the first market and therefore both will enter also in the second. Notice, for future reference, that P^A and P^C are closed sets while P^B is open. From the previous discussion, the incumbent profits jump up at the boundary of P^A while the entrant profits have a similar pattern at the boundary of P^C. Finally, the industry profits $\Pi = \Pi_I + \Pi_E$ are discontinous at the boundaries of P^A and P^C, since the joint profits when the second market is a duopoly in P^B are strictly lower than those obtained when it becomes a monopoly. Given these discontinuities, an equilibrium in pure strategies may fail to exist, as we show in the following proposition, and we will use Dasgupta and Maskin's (1986) results to characterize a mixed strategy equilibrium.

Proposition 6 *If both firms enter in the first market,*

1. *there is no price equilibrium in pure strategies,*
2. *an equilibrium in mixed strategies μ_I^*, μ_E^* exists.*
3. *in the mixed strategy equilibrium both firms obtain positive expected profits and the expected overall profits of the entrant are $E\Pi_E(\mu_I^*, \mu_E^*) < (u^* - \frac{9}{16}\psi)D^2$.*

Proof. Point 1. First we prove that no price equilibrium in pure strategies exists if $e_I^1 = e_E^1 = 1$. The incumbent profit function in the first market is $\Pi_I^1 = D_I^1(p_I^1, p_E^1)p_I^1$. If $(p_I^1, p_E^1) \in P^C$, it corresponds to the overall profits Π_I since the incumbent does not enter in the second market; at the boundary of P^B with P^C (where the two firms enter in the second market) the residual capacity of the incumbent $\overline{q}_I^2$, and the second market profits, tend to zero. Hence, Π_I is continous moving from P^C to P^B. At the boundary of P^B and P^A the entrant exhausts all its obligations in market 1, and I becomes monopolist in market 2, adding $(u^* - \frac{9}{16}\psi)D^2$ to the first market profits. Hence, since I produces in the first market in all the three regions Π_I has a global maximum at the boundary of P^A where the market 2 monopoly profits are added, and the incumbent best reply is $p_I^1 = p_E^1 - \psi\widetilde{D}$. Turning to the entrant's profits, a similar pattern occurs, with a discrete jump in the profit function entering region P^C, where $\Pi_E = (u^* - \frac{9}{16}\psi)D^2$. The entrant's profits has a global maximum at the boundary of P^C and its best reply is $p_E^1 = p_I^1 + \frac{\psi}{2}$. Hence, there is no price pair that satisfies the two best reply functions simultaneously. Each firm wants the rival to sell all its obligations in the first market, in order to monopolize the second market. This proves point 1.

Point 2. Now we turn to proving the existence of a mixed strategy equilibrium in prices, relying on Dasgupta and Maskin (1986) Theorem 5. First notice that firm i's strategy space $P_i \subseteq R^1$ and the discontinuity set for the incumbent is $P^{**}(I) = \left\{ (p_I^1, p_E^1) \middle| p_I^1 \in [0, u^* - \psi\widetilde{D}], p_E^1 = p_I^1 + \psi\widetilde{D} \right\}$, i.e. the boundary of P^C. Analogously, the discontinuity set for the entrant is $P^{**}(E) =$

$\left\{(p_I^1, p_E^1) \middle| p_I^1 \in [0, u^* - \frac{\psi}{2}], p_E^1 = p_I^1 + \frac{\psi}{2}\right\}$, i.e. the boundary of P^A. Hence, the discontinuities occur when the two prices are linked by a one-to-one relation, as required (see equation (2) in Dasgupta and Maskin (1986)), while $\Pi_i(p_i^1, p_j^1)$ is continuous elsewhere. Second, $\Pi = \Pi_I + \Pi_E$ is upper semi-continuous (see Definition 2 in Dasgupta and Maskin (1986)): since Π_I, Π_E and Π are continuous within the three subsets P^A, P^B and P^C, for any sequence $\{p^n\} \subseteq P^j$ and $p \in P^j$, $j = A, B, C$, such that $p^n \longrightarrow p$, $\lim_{n \longrightarrow \infty} \Pi(p^n) = \Pi(p)$. In other words, at any sequence that is completely internal to one of the three subsets P^j the joint profits are continuous. If instead we consider a sequence $\{p^n\}$ converging to the discontinuity sets from the open set P^B, i.e.$\{p^n\} \subseteq P^B$ and $p \in P^{**}(i)$, $i = I, E$, such that $p^n \longrightarrow p$, then $\lim_{n \longrightarrow \infty} \Pi(p^n) < \Pi(p)$, i.e. the joint profits jump up. Third, $\Pi_i(p_i^1, p_j^1)$ is weakly lower semi-continuous in p_i^1 according to Definition 6 in Dasgupta and Maskin (1986). At $(\overline{p}_I^1, \overline{p}_E^1) = \overline{p}^1 \in P^{**}(I)$, if we take (see Dasgupta and Maskin (1986) $\lambda = 0$, $\lim_{p_I^1 \longrightarrow^+ \overline{p}_I^1} \Pi_I(p_I^1, \overline{p}_E^1) = \Pi_I(\overline{p}_I^1, \overline{p}_E^1)$. Analogously, at $(\overline{p}_I^1, \overline{p}_E^1) = \overline{p}^1 \in P^{**}(E)$, if we take $\lambda = 1$, $\lim_{p_E^1 \longrightarrow^- \overline{p}_E^1} \Pi_E(\overline{p}_I^1, p_E^1) > \Pi_E(\overline{p}_I^1, \overline{p}_E^1)$. Then all the conditions required in Theorem 5 are satisfied and a mixed strategy equilibrium (μ_I^*, μ_E^*) exists.

Point 3. Finally, we prove that $E\Pi_i(\mu_I^*, \mu_E^*) > 0$ and $E\Pi_E(\mu_I^*, \mu_E^*) < (u^* - \frac{9}{16}\psi)D^2$. The first inequality simply follows from the fact that $\Pi_i(p_i^1, p_j^1) > 0$ for any $p \in P$. To establish the second inequality, notice that $\max_{p \in P} \Pi_E(p_I^1, p_E^1) = (u^* - \frac{9}{16}\psi)D^2$, occurring when $p \in P^C$. Let the support of the mixed strategy μ_i^* be M_i^*. Suppose that the mixed strategies μ_I^*, μ_E^* are such that in the mixed strategy equilibrium $p \in P^C$ occurs with probability 1: since μ_I^* and μ_E^* are independent, it means that $M_I^* \subseteq [0, (u^* - \frac{\psi}{2})/2]$ and $M_E^* \subseteq [(u^* + \frac{\psi}{2})/2, u^*]$. But then the incumbent can profitably deviate from μ_I^* while E plays μ_E^* by setting a price $\overline{p}_I^1 \notin M_I^*$ sufficiently high to be in P^A with positive probability, a contradiction. Hence, in a mixed strategy equilibrium it cannot be that P^C (and, for the same argument, P^A) occur with probability 1. Then, $E\Pi_E(\mu_I^*, \mu_E^*) < (u^* - \frac{9}{16}\psi)D^2$. ■

We have completed our analysis of the price games in the first market, obtaining all the ingredients to address the entry decisions in the first stage. The following Proposition establishes our main segmentation result.

Proposition 7 *In the unique subgame perfect equilibrium, the incumbent enters in the first market only, while the entrant enters only in the second market. Both firms charge to their customer(s) the monopoly price* $u^* - \frac{9}{16}\psi$.

Proof. Consider, for different entry choices in the first market, the profits of the two firms evaluated at the equilibrium price in the first stage and at the entry and price equilibrium in the second stage:

- $e_I^1 = 1, e_E^1 = 1$: we have seen that in the mixed strategy equilibrium the two firms obtain expected gross profits $E\Pi_I(\mu_I^*, \mu_E^*) > 0$ and $0 < E\Pi_E(\mu_I^*, \mu_E^*) < (u^* - \frac{9}{16}\psi)D^2$.

- $e_I^1 = 1, e_E^1 = 0$: the first market equilibrium price implies that the incumbent uses all its obligations and stays out of the second market. The profits are therefore $\Pi_I = (u^* - \frac{3}{4}\psi - w)D^1$ and $\Pi_E = (u^* - \frac{3}{4}\psi - w)D^2$.
- $e_I^1 = 0, e_E^1 = 1$: in this case it is the entrant that covers all the first market demand at the monopoly price staying out at the second stage. We have therefore $\Pi_I = (u^* - \frac{3}{4}\psi)D^2 - wD^1$ and $\Pi_E = (u^* - \frac{3}{4}\psi)D^1 - wk_E - w'(D^1 - k_E)$.
- $e_I^1 = 0, e_E^1 = 0$: if no firm enters in the first market, both will enter in the second with profits $\Pi_I = \psi\frac{D^2}{2} - wD^1$ and $\Pi_E = \psi\frac{D^2}{2} - wD^2$.
- Since the incumbent moves first, and makes positive profits entering the first market for any reaction of the entrant, I enters. Since $E\Pi_E(\mu_I^*, \mu_E^*) < (u^* - \frac{9}{16}\psi)D^2$ the entrant is better off staying out of the first market and becoming a monopolist in the second market. Uniqueness simply follows by construction.

■

The result obtained shows that when entry is allowed, the incumbent serves a fraction of the market equal to its TOP obligations and leaves the rest to the entrant. Liberalization, in this setting, allows the entry of new firms but does not bring in competition, inducing segmentation and monopoly pricing.. When a firm has TOP clauses, in fact, its cost structure is characterized by zero marginal costs up to the obligations and higher marginal cost for larger quantities. If both firms enter in the first market, we have two consequences: the low marginal cost capacity is used in a competitive price game obtaining low profits; moreover, both firms remain with positive residual obligations, that induce them to enter also in the second market, with competitive low profits again. On the other hand, leaving a fraction of the market to the rival comes out to be a mutually convenient strategy: the other firm, once exhausted its TOP obligations serving its customers in a monopoly position, becomes a high (marginal) cost competitor with no incentives to enter the residual fraction of the market, since even entering it will not obtain any sales in the price equilibrium. Leaving the rival in a monopoly position on a part of the market guarantees to be monopolist on the residual customers.

The key ingredients of this result are decentralized trades and a core low cost capacity, as induced by TOP obligations, two central features of the natural gas industry. Decentralized trades implies that the firms can decide which customers they want to serve. The gas provision contracts give the incentive to selective entry. First, long term contracts are a natural commitment device, since they cannot be renegotiated or modified at will. Secondly, although the market is apparently very liquid, since overall capacity is unbounded, what matters to determine the basic market interaction is the amount of low marginal cost capacity, i.e of TOP obligations. Once a firm has exhausted its obligations (although having still unbounded capacity at the marginal cost w) it is not able, in a price equilibrium, to sell anything if competing with a rival bearing sufficient residual obligations. This is the reason why, by leaving the rival to act as a monopolist in a submarket (equal to its obligations) a firm is sure to obtain the same treatment by the rival in the residual markets.

Finally, it should be stressed that the large amount of fixed costs implied by TOP obligations play no role in our entry and segmentation result. Hence, it is not the fixed outlays of the obligations that suggest to enter different submarkets, but the low (zero) marginal cost of the TOP obligations that drives the equilibrium. Consequently, the segmentaion outcome requires simply low cost core capacity and decentralized markets, and in this sense it is not specific to the gas industry.

4 Endogenizing entrant's obligations

So far we have assumed that the entrant, facing an incumbent endowed with TOP obligations of $\overline{q}_I$, has a long term contract with obligations equal to $D-\overline{q}_I$, implying that total obligations equal total demand. Here we want to show that if the entrant chooses $\overline{q}_E$ in order to maximize profits, it will actually choose exactly $\overline{q}_E = D - \overline{q}_I$. In this section therefore we add an initial stage where the entrant signs its long term contract deciding the amount of TOP obligations.

We already know that if the entrant chooses TOP obligations equal to the residual demand, $\overline{q}_E = D - \overline{q}_I$, in equilibrium its profits would be $(u^* - \frac{9}{16}\psi - w)(D - \overline{q}_I)$.

Consider now the equilibrium if the entrant chooses obligations lower than the residual demand, i.e. $\overline{q}_E < D-\overline{q}_I$: having discussed in detail the pricing and entry decisions in the benchmark case, we just sketch the lines of the analysis, that is quite similar to the case already analyzed. In this case, maintaining the sequential contracting structure, it is equivalent to consider all the contracting episodes $d = 1, .., D$ in a sequence or to group them in three submarkets equal to $\overline{q}_I$, $\overline{q}_E$ and $D - \overline{q}_I - \overline{q}_E$ and study the entry and pricing decisions according to the timing of the benchmark case: in each of the three submarkets, that are opened sequentially, I decides whether to enter, then E chooses as well and finally the active firms price simultaneously. The equilibrium analysis of the benchmark model suggests the following conclusions[6]:

- in the first submarket, $\overline{q}_I$, only the incumbent enters and sets the monopoly price;
- in the second submarket, equal to $\overline{q}_E$, the roles are reversed and the entrant is monopolist in this segment;
- for the residual customers, $D - \overline{q}_I - \overline{q}_E$, both firms would have marginal cost equal to w having exhausted their obligations. If they both enter, the price equilibrium is symmetric with $\widehat{p}_I = \widehat{p}_E = w + \frac{\psi}{2}$, and the two firms

[6] To save space we leave a formal proof, which is basically the same as the benchmark model, to the reader.

serve half of the residual demand gaining positive profits. Hence, both firms will enter the residual market $D - \overline{q}_I - \overline{q}_E$.

The profits obtained by the entrant are now $(u^* - \frac{9}{16}\psi - w)\overline{q}_E + \frac{\psi}{4}(D - \overline{q}_I - \overline{q}_E) < (u^* - \frac{9}{16}\psi - w)(D - \overline{q}_I)$. Hence, the entrant[7] does not gain from having obligations lower than $D - \overline{q}_I$.

Finally, let us analyze the case $\overline{q}_E > D - \overline{q}_I$, where total obligations are larger than total demand. The arguments are quite similar to the benchmark case. We can analyze the equilibrium distinguishing the two submarkets $\overline{q}_I = D^1$ and $D - \overline{q}_I = D^2$ as before. The residual obligations in market 2 are now larger than the residual demand, i.e. $\overline{q}_I^2 + \overline{q}_E^2 > D^2$. Hence, if both firms enter in the second market Proposition 3 applies and both obtain positive profits as long as each of them has positive residual obligations. We have therefore a pattern of equilibrium entries in market 2 that replicates what we found in the benchmark model: a firm enters as long as it has residual obligations. Moving to the first market, if both enter no price equilibrium in pure strategies exists since each firm wants the rival to exhaust its obligations. Moreover, the mixed strategy equilibrium expected overall profits of the entrant are lower than the monopoly profits in the second market. Hence, if the incumbent enter in the first market, E will stay out monopolizing the second market. We conclude that the equilibrium is unchanged if the entrant chooses obligations in excess to the residual demand $D - \overline{q}_I$. However, this choice implies larger TOP payments to the extractors and is therefore unprofitable. Therefore, the entrant will choose to sign obligations equal to the residual demand $D - \overline{q}_I$, as assumed in the benchmark model. We summarize this discussion in the following proposition.

Proposition 8 *If the entrant chooses its obligations $\overline{q}_E$ at time 0, given the incumbent obligations $\overline{q}_I$, and then the game follows as in the benchmark model, the entrant will choose obligations equal to the residual demand, i.e. $\overline{q}_E = D - \overline{q}_I$.*

The discussion above has shown that even if the entrant has obligations larger than the residual demand, it would not use them in equilibrium (although it pays the contracted gas according to the TOP clauses). The intuition of this result is the following. Let's imagine that E, anticipating that it will not use some of its obligations, would try to use this residual obligations entering the first market. It would share D^1 with the incumbent and, as a consequence, I would not exhaust its obligations $\overline{q}_I$ in the first market. Hence, the incumbent would enter the second market as well, destroying the monopoly profits that E would gain otherwise. Hence, the entrant would prefer to maintain its residual obligations idle (and therefore does not choose excessive obligations).

The allocation of demand between the incumbent and the entrant in our model depends on the amount of TOP obligations held by I when liberalization

[7] Alternatively, in the spirit of our entry model, we can notice that if $D > \overline{q}_I + \overline{q}_E$ there is room for a third firm with obligations $D - \overline{q}_I - \overline{q}_E$ to enter and monopolize the residual demand.

starts. The market share of the incumbent after entry therefore can be very large if $\overline{q}^I \cong D$, with a very limited scope for new comers. To avoid such an outcome, the liberalization plans in some European countries, as Italy, Spain and UK, have introduced constraints on the incumbent marke share, as antitrust ceilings or release of import contracts. In the following section we consider whether this instrument can help to promote competition in the market.

5 Antitrust ceilings and the persistence of segmentation

In this section we enrich the benchmark model, introducing a further restriction in line with the gas release decisions of a few countries following liberalization: we assume that the incumbent cannot supply more than a certain amount of gas, $\widehat{q}_I < \overline{q}_I$.

On the other hand, I can sell (or it is forced to sell, in some cases) its TOP obligations exceeding $\widehat{q}_I$ to other operators at the unit cost w, i.e. it can resell its long run contracts exceeding the ceiling. Consequently, defining as $\overline{q}_E^0$ the TOP obligations of the entrant in the benchmark model, its overall obligations when antitrust ceilings are introduced become $\overline{q}_E = \overline{q}_E^0 + (\overline{q}^I - \widehat{q}_I)$. The main difference relative to the previous case rests on the fact that TOP obligations introduce a jump up in marginal costs but do not prevent the incumbent from producing more than $\overline{q}^I$.

We can analyze the sequential entry game assuming that the two markets are $D_1 = \widehat{q}_I$ and $D_2 = D - D_1$ and that they are opened sequentially. As in the previous case, I decides first whether to enter the first (and then, the second) market, followed by E. Once in each market the customers have been approached, simultaneous pricing strategies are set. Considering second stage price equilibria, if only one firm enters and has residual obligations at least as large as market demand D_2, the analysis remains completely unchanged. However, the introduction of (absolute) capacity contraints instead of (milder) TOP obligations changes the nature of equilibrium price when both firms enter in the second market. In this case, when the residual antitrust ceilings of the incumbent and the residual obligations of the entrant add up to market demand, i.e. $\widehat{q}_I^2 + \overline{q}_E^2 = D_2$, no price equilibrium in pure strategies exists. However, a mixed strategy equilibrium with positive profits exists, as the following Proposition establishes.

Proposition 9 *When both firms enter in the second market and* $\widehat{q}_I^2 + \overline{q}_E^2 = D^2$, $\widehat{q}_I^2 > 0$ *and* $\overline{q}_E^2 > 0$, *there is no pure strategy equilibrium. An equilibrium in mixed strategies* μ_I^*, μ_E^* *exists. The expected profits of the two firms in the mixed strategy equilibrium are positive but lower than the monopoly profits in market* 2, *i.e.* $E\Pi_E^2(\mu_I^*, \mu_E^*) \in (0, (u^* - \frac{9}{16}\psi - w)D_2)$.

Proof. From the analysis of the benchmark case, we know that an equilibrium, if any, must entail the two firms selling their residual obligations or ceilings. Consider a price pair (p_I^2, p_E^2) with $p_E^2 < u^* - \frac{\psi}{16}$, such that $D_I^2(p_I^2, p_E^2) = \widehat{q}_2^I$ and $D_E^2(p_I^2, p_E^2) = \overline{q}_E^2$. As long as $\frac{\partial \Pi_I^2(c_I=0)}{\partial p_I^2} \leq 0$, this price pair is a maximum for the incumbent: I does not gain from raising the price (producing less that the ceiling at a marginal cost $c_I = 0$), as the derivative is stating, and does not gain from reducing price, since it cannot sell more than $\widehat{q}_I^2$. On the other hand, E can profitably raise p_E^2, because the antitrust ceilings, contrary to the TOP obligations, prevent the incumbent from serving the increased demand, that will be served by the entrant as long as the price is not too high ($p_E^2 < u^* - \frac{\psi}{16}$). But once the price is very high and the two firms set prices such that $D_2^I(p_I^2, p_E^2) = \widehat{q}_I^2$, it is easy to see that $\frac{\partial \Pi_E^2(c_E=w)}{\partial p_E^2} > 0$, i.e. the entrant is better off by reducing its price and serving (at a marginal cost $c_E = w$) a fraction of the market larger than its residual obligations, i.e.$D_E^2(p_I^2, p_E^2) > \overline{q}_E^2$. Hence, no price equilibrium in pure strategies exists.

From the discussion above it is clear that the entrant profit function (not surprisingly) is not quasi-concave in its price when the incumbent has antitrust ceilings (capacity contraints). However, it is continuous and the strategy space $p_i \in [0, u^*]$ is compact and convex. Hence, we can apply Glicksberg (1952) Theorem establishing that a mixed strategy equilibrium (μ_I^*, μ_E^*) exists.

Finally, $E\Pi_E^2(\mu_I^*, \mu_E^*) = 0$ would occur only if in the mixed strategy equilibrium $p_E^2 = 0$ with probability 1, since any other price pair, given that $\widehat{q}_I^2 < D^2$, would leave at least $D^2 - \widehat{q}_I^2$ sales and positive profits to the entrant. But then E might probably deviate setting a higher price with certainty and gaining positive profits. Secondly, $E\Pi_i^2(\mu_I^*, \mu_E^*) = (u^* - \frac{9}{16}\psi - w)D^2$ would be the case only if the support of the incumbent mixed strategy would include only prices so high that I does not sell anything when the entrant is pricing at $p_E^2 = u^* - \frac{9}{16}\psi$. But this cannot occur in a mixed strategy equilibrium since the incumbent would be better off by setting with probability one a lower price, selling its residual ceilings and making profits. ■

We can now turn to the entry decisions in the second market, that largely correspond to those of the benchmark model: if I entered in the first market while E did not, $\widehat{q}_I^2 = 0$ and the incumbent cannot enter the second market, which is therefore supplied by the entrant at the monopoly price. Conversely, if the entrant alone approached the first D^1 consumers, the second group of customers is served by the incumbent at $u^* - \frac{9}{16}\psi$. The same outcome arises, due to the incumbent first mover advantage, if no firm approaches the first customer. Finally, if both firms entered in the first market, the entry and pricing decisions in the second market depend on the overall residual ceilings and. obligations $\widehat{q}_I^2 + \overline{q}_E^2$. Building on the benchmark model analysis here we focus on the case $\widehat{q}_I^2 + \overline{q}_E^2 = D^2$, $\widehat{q}_I^2 > 0$ and $\overline{q}_E^2 > 0$ analyzed in the Proposition above. Since the entrant expects positive profits whenever $\overline{q}_E^2 > 0$, it will follow the incumbent in the second market. Hence, the entry pattern replicates the one of the benchmark model: a firm enters if it has still residual obligations or ceilings. Moving to the first market price equilibria, notice that the incumbent capacity contraints never bind because $\widehat{q}_I = D^1$. Consequently, it is easy to check that the same price equilibria and entry decision already analyzed in the benchmark model still apply, even taking into account the different second market price equilibrium analyzed in the Proposition above. The following Proposition summarizes the results.

Proposition 10 *In the subgame perfect equilibrium of the game with antitrust ceilings, the incumbent enters in the first market D^1 while the entrant enters in the second market D^2. Both firms charge to their customer(s) the reservation price $u^* - \frac{9}{16}\psi$.*

The only effect of antitrust ceilings is therefore to shift market shares and profits from the incumbent to the entrant[8]. Customers do not benefit from gas release programs of this type, as the segmentation result and monopoly pricing still hold.

6 The introduction of a wholesale market

Antitrust ceilings are not able to prevent the segmentation of the market, because even in this regime the retailers are selecting their customers while bearing TOP obligations according to long run contracts. Their marginal costs are therefore zero up to a predetermined amount of obligations (or ceilings), and higher for larger deliveries. Since no firm has obligations equal to the total market, there is room for entry, but still no incentive to compete for the same customers exists. The driving forces of the segmentation outcome, low marginal cost core capacity and decentralized markets, suggest a possible way out of this unsatisfactory result.

Suppose a wholesale market is created, such that

- the gross providers of gas, which bear TOP obligations and long run contracts with the extractors, must sell "to the market" while
- final sales may only be done by retail traders, which buy the gas they need "from the market" at the wholesale market price p^w.

In this case, we obtain two relevant effects. First, the firms that select the final customers to deal with are not bearing TOP obligations, and each of them will always have the same marginal cost, equal to the wholesale gas price. Secondly, the retailers buy in a liquid market where they can purchase all the gas they need, given the contracts they sign with the final customers. As a result, the retailers have a flat marginal cost p^w for any quantity they want to sell. When deciding whether to enter an additional segment of the market or

[8]Notice that, since we assumed that both firms have unbounded additional capacity at unit price w once exhausted the obligations, the incumbent cannot sell its contract at a price higher than w. If we add capacity constraints to the contract and a spot market with unit price $w' > w$, the incumbent might resell its contracts to a price w', keeping back some additional profits from the entrant.

not, they will have symmetric cost structures and will enter if expecting positive margins.

Once a wholesale market is introduced, we obtain a separation between the gross provision of gas, where the commodity traded is perfectly homogeneous, and the retail trade, where the service and location elements introduce a horizontal differentiation flavour. Hence, we have an upstream segment with large operators (our firms I and E) and a downstream segment which can be fragmented. In order to maintain the structure of the model as similar as possible to the benchmark case, we will maintain the assumption that the retail market is a duopoly, with firm a offering variety $x_a = \frac{1}{4}$ and firm b offering variety $x_b = \frac{3}{4}$. The extension to the N retailers case using the circular road version of the Hotelling model (Salop (1979)) is however straightforward.

When the retail traders have a flat marginal cost p^w for any quantity they want to purchase, each of them is potentially able to serve the market at the same marginal cost, contrary to what happened in the benchmark case where the TOP obligations $\overline{q}_i$, creating a discontinuity in the marginal cost, created a kink in the cost and profit functions.

In this setting, all the negotiations with (groups of) customers $d = 1, .., D$, each of mass 1, are similar, with the active firms endowed with marginal costs p^w facing a customer drawn from the same uniform distribution over her preferred variety v. The expected demand for firm $j = a, b$ from customer d , D_j^d, correspond to the expressions (2) and (3), setting the mass of consumers $D^d = 1$.

Given that now both sellers have a flat marginal cost, there is no reason to group the consumers in two subsets D^1 and D^2 as we did before. For reasons that will be clear in a moment, we prefer to discuss the entry and price strategies assuming that the firms decide sequentially to approach each (group of) customer separately. Total demand for retailer j is therefore $D_j(p_a, p_b) = \sum_{d=1}^{D} D_j^d$ where p_a and p_b are the vectors of prices set by the two firms in the D submarkets. The timing of the game is now:

- at $t = 1$ the retail firms $j = a, b$ decide sequentially whether to deal with the customers $d = 1, .., D$ (with total demand D); the entry choices become public information once taken. Once every firm has decided which customers to approach, they set simultaneously the prices and collect the orders.

- at $t = 2$ the gross suppliers of gas I and E compete in prices in the wholesale market, given the demand from the retail traders $D_a + D_b$.

Let us consider the equilibrium of the game, starting from the second stage, where the two wholesale suppliers I and E compete in prices, each endowed with TOP obligations $\overline{q}_I$ and $\overline{q}_E$, $\overline{q}_I + \overline{q}_E = D$. Since the wholesale market is a commodity trade, Bertrand competition describes the basic interaction between the two firms: the two firms post simultaneously their price, the demand is allocated and each firm supplies its notional demand. In case of equal prices, the allocation of demand is indeterminate and we'll assume that the two firms decide how to share total demand among them. The following Proposition establishes the wholesale price equilibrium.

Proposition 11 *Let total wholesale demand be $D^w = D_a(p_a, p_b) + D_b(p_a, p_b)$. If $D^w = D$ the equilibrium wholesale prices are $p_I = p_E = p^w = w$. If $D^w < D$ the equilibrium wholesale prices are $p_I = p_E = p^w \in [0, w)$ and they are increasing in total sales D^w.*

Proof. First notice that wholesale demand is $D^w \leq D$. The firms are not capacity constrained, as they can purchase from the extractors at unit cost w any quantity exceeding their obligations. Hence, setting a price above the rival leaves with no sales and no profits, and is never an optimal reply. If firm i sets the same price as the rival, i.e. $p_i = p_j$, its profits are $\Pi_i = p_j D_i$, where D_i are firm i sales: if $D^w = \overline{q}_I + \overline{q}_E$, then $D_i = \overline{q}_i$ while if $D^w < \overline{q}_I + \overline{q}_E$, then $D_i \leq \overline{q}_i$, with strict inequality for at least one firm. If firm i undercuts firm j, setting $p_i = p_j - \varepsilon$, taking the limit for $\varepsilon \to 0$ the profits are $\Pi_i = p_j D^w - w(D^w - \overline{q}_i)$, i.e. firm i supplies the entire demand and purchases additional gas $D^w - \overline{q}_i$ at unit price w. Then, comparing the two profits we can identify the condition that makes undercutting profitable:

$$p_j > w \frac{D^w - \overline{q}_i}{D^w - D_i} \equiv \underline{p}_j$$

Hence, firm i will undercut firm j if $p_j > \underline{p}_j$ and firm j will undercut firm i if $p_i > \underline{p}_i$. Since overpricing is never profitable, the equilibrium prices will be $p_i = p_j = \min\left\{\underline{p}_i, \underline{p}_j\right\}$. Notice that $\underline{p}_i$ and $\underline{p}_j$ depend on the allocation of demand between the two firms, D_i and D_j. If $D^w = \overline{q}_I + \overline{q}_E$, then $D_i = \overline{q}_i$ and $\min\left\{\underline{p}_i, \underline{p}_j\right\} = w$. If instead $D^w < \overline{q}_I + \overline{q}_E$, $\min\left\{\underline{p}_i, \underline{p}_j\right\} < w$. Since $\min\left\{\underline{p}_i, \underline{p}_j\right\}$ depends on the rule the firms follow in allocating total demand when they set the same price, i.e. on the way D_i and D_j are determined, we have no explicit solution without choosing a precise rule. However, assuming that any reasonable rule should require $\frac{\partial D_i}{\partial D^w} \geq 0$, i.e. that if total demand falls individual demand cannot increase when firms set the same price, we obtain

$$\frac{\partial \underline{p}_i}{\partial D^w} = w \frac{\overline{q}_i - D_i + \frac{\partial D_i}{\partial D^w}(D^w - \overline{q}_i)}{(D^w - D_i)^2} > 0$$

Hence, even without choosing an explicit allocation rule we are able to show that the equilibrium wholesale price p^w is increasing in total sales D^w. ■

The wholesale equilibrium prices described in the Proposition above are equal to the unit cost of gas w if $D^w = D$ $(= \overline{q}_I + \overline{q}_E)$, i.e if the retailers serve all the consumers, while $\underline{p} < w$ if the retail market is rationed, i.e. $D^w < D$. Hence, although the wholesale gas providers have a stepwise marginal cost curve, the equilibrium wholesale price is an increasing function of total gross provision of gas. We can now conclude our analysis considering the equilibrium in the retail market.

Proposition 12 *In the retail market, each firm $j = a, b$ approaches all groups of customers $d = 1, ..D$, and sets a price $\widehat{p}_j^d = p^w + \frac{\psi}{2}$. The subgame perfect equilibrium of the game is therefore characterized by $\widehat{p}_I = \widehat{p}_E = w$ and $\widehat{p}_a^d = \widehat{p}_b^d = w + \frac{\psi}{2}$.*

Proof. Let us first consider the retail market equilibrium prices. The marginal costs of the two firms is $p^w = w$ if total demand for gas D^w is equal to D and $p^w < w$ if total demand of gas is lower than D. If both firms enter in submarket $\widetilde{d}$, firm i's profits are

$$\Pi_j^d = \left[\frac{1}{2} + \frac{p_i^d - p_j^d}{\psi}\right]\left(p_j^d - p^w\right)$$

If we consider submarket $\widetilde{d}$ in isolation, the unique simmetric equilibrium in prices is $\widehat{p}_i^d = \widehat{p}_j^d = p^w + \frac{\psi}{2}$ and the profits in this submarket are $\widehat{\Pi}_j^d = \frac{\psi}{2}$, independently of the level of the marginal cost p^w. We conclude that if we look at submarket $\widetilde{d}$ profits only, there is no incentive to ration the demand setting a price such that $D_a^d + D_b^d < 1$. But there is no incentive to ration the submarket demand even if we consider the overall effect on the wholesale price (marginal costs) c applied to the overall purchase of gas. If by rationing submarket d total demand becomes lower than D, the wholesale price falls to $p^w < w$, the final prices reduce accordingly to $p^w + \frac{\psi}{2}$, with no effects on the firm profits. Hence, the price equilibrium entails setting a margin $\frac{\psi}{2}$ over the relevant marginal costs p^w. Turning to the entry decisions, no matter how large is total demand for gas (and therefore the wholesale price and the marginal cost p^w), the entry in each submarket increases overall profits by a positive amount ($\frac{\psi}{2}$ if also the other firm enters and $u^* - \frac{9}{16}\psi - p^w$ if the rival stays out).

Since entering in each submarket is the dominant strategy for each firm, both firms will enter in all submarkets and will set a price such that all the submarket demand is covered. Total demand equals D and the wholesale price (marginal cost) is w. ■

A wholesale market, determining a flat marginal cost curve at p^w , eliminates the strategic links among the entering decisions in the different submarkets, that with a decentralized market are driven by the residual low cost capacity still available. Then, the entry decisions are determined by the contribution to total profits of the additional segment that is served.

It is important to stress that although in our setting proving that there is no incentive to restrict entry (or rationing demand through pricing) is easy, because the equilibrium mark-up is additive over the relevant marginal cost, there is a more general argument that can be used in settings where the margin itself depends on the marginal cost. Suppose that the retail market model is such that the mark-up is decreasing in the marginal cost p^w. In this case it may be convenient for the firms to enter all the submarkets but 1, so that total demand is $D-1$ and the marginal cost is below w: in this case the firms are trading off the profits in the last submarkets with the higher profits in the inframarginal markets, and might find it convenient to restrict entry. However, if entry is allowed, as in the spirit of a competitive retail market, a new comer, that has no inframarginal profits to consider, would enter and serve the last submarket, making the marginal cost increasing to w.

A wholesale market allows to avoid the segmentation of the market and to obtain generalized competition and lower retail margins (prices). The gross prividers, on the other hand, are able to cover their TOP obligations with no losses. In this institutional setting, the competitive bias deriving from long term provision contracts and take or pay clauses is avoided, because when the retailers purchase the gas in a liquid wholesale market they have a flat marginal cost reflecting the true cost of gas. The basic mechanism of the benchmark model, such that by leaving a submarket to the rival a firm would secure to be monopolist on the residual demand, does not work anymore: by entering the additional submarkets a firm would have the same costs as the rivals and would gain margins over the true cost of gas. Hence, generalized entry and competition replace selective entry and monopoly pricing.

It should be stressed that competition in the upstream segment, where the gross providers sell to the market, does not necessarily lead to a wholesale price equal to the unit cost of gas w, according to the Bertrand equilibrium. The literature on supply function equilibria[9] has shown that the Bertrand equilibrium corresponds to the firms using a supply curve equal to their true marginal costs; but if firms are able to commit to a supply curve that includes margins over marginal costs, the equilibrium prices may be much higher that the competitive ones. In our case, while the downstream margins $\frac{\psi}{2}$ are low, due to competition and the limited scope for product differentiation, the wholesale price might be much higher than w if the gross providers use more complex strategies, increasing accordingly the price for the final customers.

7 Simultaneous entry and market segmentation

So far we have focussed on a sequential entry game in which the incumbent decides first whether to contract or not with a sequence of customers. This setting seems appropriate to model the initial phase after the liberalization, when I can exploit its long lasting relations with the customers acting as a leader. We move now to a simultanous entry game where both firms decide the customers to contract with, and then compete in prices. In a sense, this second case might represent a more mature phase of the market, in which the initial asymmetries have disappeared.

[9]See Klemperer and Meier (1989) and, on the electricity market, Green and Newbery (1992).

We adapt the framework of the sequential entry model of the previous section to a more symmetric environment, in which both firms $i = I, E$ have the same TOP obligations $\overline{q}_i = D/2$ and neither of them has an advantage in approaching the customers. In this case, it is equivalent to consider the two firms approaching each customer d separately, or proposing two prices to two subsets of the customers that we call market 1 and 2, with demand $.D^1 = D^2 = D/2$. The timing of the game is modified as follows:

- At time $t = 1$ both firms decide simultaneously which market(s) (if any) to enter;
- At time $t = 2$, having observed the entry decisions of the two firms, each firm sets its price simultaneously in each market where it entered.

Hence, each firm will choose whether to stay out, enter the first, the second or both markets, while the market configurations (which markets are served and by which operator) will derive from the combination of the entry choices of the two firms. In terms of notation, we define as $\{\emptyset; 2\}$ the case in which the incumbent stays out while the entrant serves only the second market, $\{1, 2; 2\}$ the situation when I enters both market and E only the second, etc. For each market configuration we consider now the corresponding price equilibria.

Some cases are rather trivial: when only firm i enters in a market, the equilibrium price is $\widehat{p}_i = u^* - \frac{9}{16}\psi$ and the corresponding gross profits $\Pi_i = (u^* - \frac{9}{16}\psi)D/2$. The cases in which, at least in one market, both firms enter are more interesting. In the following Propositions we establish the price equilibria.

Proposition 13 *If both firms enter in both markets , i.e.* $\{1, 2; 1, 2\}$*, equilibrium prices are* $\widehat{p}_I^1 = \widehat{p}_I^2 = \widehat{p}_E^1 = \widehat{p}_E^2 = w + \frac{\psi}{2}$*. The profits (gross of the TOP obligations) for firm* i *are* $\widehat{\Pi}_i = (w + \frac{\psi}{2})\frac{D}{2}$*.*

Proof. The equilibrium conditions in this case are

$$\left.\frac{\partial \Pi_i}{\partial p_i^k}\right|_{p^-} = D_i^k + p_i^k \frac{\partial D_i^k}{\partial p_i^k} - \frac{\partial C_i(D_i^1 + D_i^2)}{\partial q_i^k}\frac{\partial D_i^k}{\partial p_i^k} \geq 0$$

$$\left.\frac{\partial \Pi_i}{\partial p_i^k}\right|_{p^+} = D_i^k + p_i^k \frac{\partial D_i^k}{\partial p_i^k} - \frac{\partial C_i(D_i^1 + D_i^2)}{\partial q_i^k}\frac{\partial D_i^k}{\partial p_i^k} \leq 0$$

for $i = I, E$ and $k = 1, 2$. Let us consider a pair of prices such that $D_i^1(p_i^1, p_j^1) + D_i^2(p_i^2, p_j^2) = \overline{q}_i = D/2$. This latter condition, once substituted for $D_i^t(p_i^t, p_j^t) =$

$\frac{D}{2}\left[\frac{1}{2}+\frac{p_j^1-p_i^1}{\psi}\right]$, reduces to $p_E^1 - p_I^1 = p_I^2 - p_E^2$. The derivatives give for firm i:

$$\begin{aligned} \frac{1}{2}+\frac{p_j^1-w}{\psi}-\frac{2p_i^1}{\psi} &\geq 0 \\ \frac{1}{2}+\frac{p_j^1}{\psi}-\frac{2p_i^1}{\psi} &\leq 0 \\ \frac{1}{2}+\frac{p_j^2-w}{\psi}-\frac{2p_i^2}{\psi} &\geq 0 \\ \frac{1}{2}+\frac{p_j^2}{\psi}-\frac{2p_i^2}{\psi} &\leq 0 \end{aligned}$$

and the same for firm j. Taken as equalities, the conditions above are linear in prices and intersect only once. As in Proposition 2, the binding constraints are the first and the third. They are solved at the prices in the statement and satisfy also the condition that all the obligations are used in the two markets. ■

The following Proposition addresses the case in which one market is a duopoly and the other is a monopoly.

Proposition 14 *If firm i enters in market m (monopoly) and market d (duopoly) while firm j enters only in one market d, i.e. $\{1,2;2\}$, $\{2;1,2\}$, $\{1,2;1\}$ and $\{1;1,2\}$, the equilibrium prices are $\widehat{p}_i^m = u^* - \frac{9}{16}\psi$ in the monopoly market and $\widehat{p}_i^d = \frac{3}{2}\psi$, $\widehat{p}_j^d = \psi$ in the duopoly market, where firm i sells nothing. The gross profits are $\widehat{\Pi}_i = (u^* - \frac{9}{16}\psi)\frac{D}{2}$ and $\widehat{\Pi}_j = \psi\frac{D}{2}$.*

Proof. Since in market m firm i is a monopolist, the optimal price is $u^* - \frac{9}{16}\psi$ for any price in the other market. Then, firm i exhausts its obligations in market m. Suppose that in the other market the prices are such that all the demand is covered by firm j. In this case the equilibrium conditions require $D_i^d = \frac{D}{2}(\frac{1}{2}+\frac{p_j^d-p_i^d}{\psi}) = 0$,

$$\left.\frac{\partial \Pi_i}{\partial p_i^d}\right|_{p^-} = \frac{1}{2}+\frac{p_j^d}{\psi}-\frac{2p_i^d}{\psi}+\frac{w}{\psi} \geq 0$$

(the right derivative is irrelevant because $D_i^d(\cdot) = 0$) and

$$\left.\frac{\partial \Pi_j}{\partial p_j^d}\right|_{p^+} = \frac{1}{2}+\frac{p_i^d}{\psi}-\frac{2p_j^d}{\psi} \leq 0$$

(the left derivative is irrelevant because $D_j^d(\cdot) = D/2$). Solving we obtain the equilibrium prices. It is easy to see, with the same arguments used in proof of Proposition 2, that no equilibrium exists in which $D_i^d > 0$ and $D_j^d < D/2$. ■

Finally, we have to consider the case when both firms enter the same and single market.

Proposition 15 *When both firms enter only one and the same market t, i.e.* $\{1;1\}$ *and* $\{2;2\}$*, the equilibrium price is* $\widehat{p}_I^t = \widehat{p}_I^t = \frac{\psi}{2}$ *and the gross profits are* $\widehat{\Pi}_i = \psi\frac{D}{4}$.

Proof. The price equilibrium corresponds to the case considered in Proposition 3 when both firms have large obligations. ■

The table below summarized the equilibrium profits in the price games following the entry decisions of the two firms: the first expression in each cell corresponds to the profits of the entrant and the second to those of the incumbent.

$E \setminus I$	1	2	1, 2
1	$\psi\frac{D}{4}$ $\psi\frac{D}{4}$	$(u^* - \frac{9}{16}\psi)\frac{D}{2}$ $(u^* - \frac{9}{16}\psi)\frac{D}{2}$	$\psi\frac{D}{2}$ $(u^* - \frac{9}{16}\psi)\frac{D}{2}$
2	$(u^* - \frac{9}{16}\psi)\frac{D}{2}$ $(u^* - \frac{9}{16}\psi)\frac{D}{2}$	$\psi\frac{D}{4}$ $\psi\frac{D}{4}$	$\psi\frac{D}{2}$ $(u^* - \frac{9}{16}\psi)\frac{D}{2}$
1, 2	$(u^* - \frac{9}{16}\psi)\frac{D}{2}$ $\psi\frac{D}{2}$	$(u^* - \frac{9}{16}\psi)\frac{D}{2}$ $\psi\frac{D}{2}$	$(w + \frac{\psi}{2})\frac{D}{2}$ $(w + \frac{\psi}{2})\frac{D}{2}$

We can now easily derive the subgame perfect equilibrium in the simultaneous entry game.

Proposition 16 *In the simultaneous entry game there are three subgame perfect equilibria.*

- $\{1,2;1,2\}$ *with each duopolist in each market setting the price* $w + \frac{\psi}{2}$.
- $\{1;2\}$ *and* $\{2;1\}$*, with the monopolist in each submarket setting the price* $u^* - \frac{9}{16}\psi$*; this latter equilibria are Pareto dominant.*

Proof. The three equilibria can be easily established looking at the payoff matrix that summarizes the equilibrium prices in the different subgames. As before, we assume that if a firm is not able to improve its profits entering a market, it doesn't enter (no frivolous entry). ■

Even when entry is simultaneous and the market is perfectly simmetric, we are able to replicate the segmentation result previously obtained in an asymmetric setting, where entry was sequential and the incumbent had a first mover advantage in approaching the customers and larger TOP obligations. The only difference between the results obtained in these two settings relies on the multiplicity of equilibria in the simultaneous entry symmetric game analyzed in this section, which suggests an underlying coordination problem that was naturally solved in the sequential entry asymmetric game. Hence, a crucial ingredient of our segmentation result is that in decentralized markets deciding which customers to serve and propose a price occur in different stages, while the sequential marketing structure of the benchmark model is inessential. This setting seems appropriate to describe firms strategies when some sunk decision, as for instance setting up local commercial structures, is needed in order to contract with the clients.

8 Conclusions

We have considered in this paper entry and competition in the liberalized natural gas market. The model rests on three key assumptions, that correspond to essential features of the gas industry but that can be found also in other markets: the firms are endowed with low marginal cost core capacity, with higher marginal costs for additional supply, as it is in the gas industry due to long term contracts with TOP obligations. The market is decentralized and the marketing decision on which customers to serve is medium term and not completely flexible once taken. Once chosen the submarkets to enter, firms compete in prices, with slight differentiation in the commercial service.

Our main finding is that entry can lead to segmentation and monopoly pricing rather than competition. The key mechanism, that holds under sequential as well as simultaneous entry (contracting) works as follows: in a decentralized market each firm has to choose which customers to approach; since both firms have TOP obligations, if both compete for the same customer(s) the equilibrium price gives very low margins. However, if a firm exhausts its obligations acting as a monopolist in a segment of the market, it looses any incentive to further enter in the residual part of the market, because it would be unable to obtain positive sales and profits competing with a low cost rival. Hence, leaving a fraction of the market to the competitor ensures to remain monopolist on the residual demand, maximizing the rents over the low cost capacity. The equilibrium entry pattern requires to select different submarkets and pricing as a monopolist. The outcome is therefore one of entry without competition.

This result persists even when antitrust ceilings or forced divestiture of import contracts are imposed, with the only effect of shifting market shares and profits from the incumbent to the entrant. Introducing a wholesale market, instead, can have positive effects on competition. If the gross importers, burdened with TOP obligations, sell "to the market" and the retailers, that select the final customers to serve, buy "from the market", those latter have the same flat marginal cost equal to the wholesale price for any amount of gas, and obtain positive profits in any submarket they enter. Generalized entry and low retail margins therefore follow. The level of the wholesale price (and competition in the pool market) becomes crucial in this perspective. With intense competition the final price of gas becomes very low, although we might imagine more complex strategies, e.g. competition in supply functions, that can implement high (wholesale and final) prices.

These results suggest that the liberalization plans, focussed so far on the task of creating opportunities of entry and a level playing field for new comers, should not take as granted that entry will bring in competition in the market. The issue of promoting competition seems the next step that the liberalization policies need to address.

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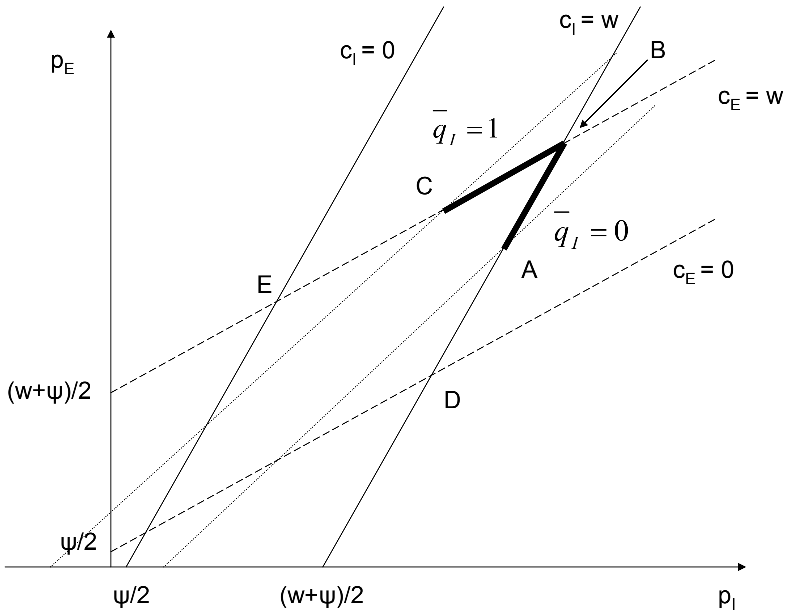

Figure 1: Equilibrium conditions and prices, Proposition 2.

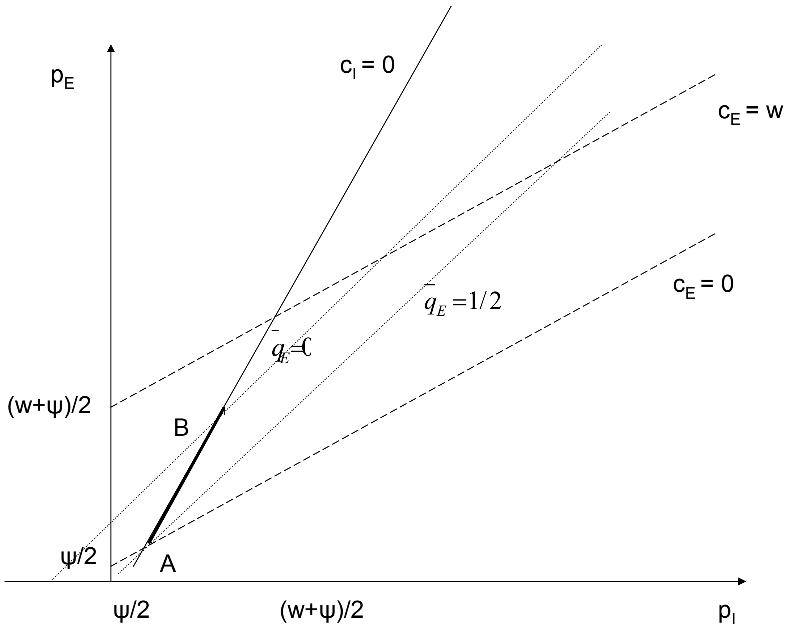

Figure 2: Equilibrium conditions and prices, Proposition 3.