Liberalizing the Gas Industry: Take-or-Pay Contracts, Market Segmentation and the Wholesale Market *

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Abstract

This paper examines competition in a liberalized natural gas market. Wholesale activities (buying gas from the producers under take-or-pay obligations) and retail activities (selling gas to final customers) are both run by retailers, whose marginal costs are zero up to their TOP obligations and positive for larger amounts. The market is decentralized and the firms decide which customers to serve, competing then in prices. In equilibrium each firm approaches a different segment of the market and sets the monopoly price, i.e. market segmentation. Gas release programs do not prevent such an outcome while the separation of wholesale and retail activities and the creation of a wholesale market induces generalized competition and low margins in the retail segment.

Keywords: Entry, Segmentation, capacity constraints, wholesale markets.

JEL Classification numbers: L11, L13, L95

1 Introduction

In this paper we analyze competition in a natural gas market, bearing in mind the liberalization process implemented in Europe. Since the second part of the

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Nineties the European Commission has promoted through several Directives the liberalization of the main public utility markets, such as telecommunications, electricity and natural gas; the framework adopted is by and large common to these industries, and rests on the open access to the network infrastructures, the unbundling of monopolistic from competitive activities and the opening of demand.

The natural gas Directives 1998/30 and 2003/55 have specified the lines of reform that the Member Countries have then followed in their national liberalization plans. Although the wording adopted is almost identical to the one in the electricity Directive 2003/54[1], the solutions adopted in the gas and in the electricity markets concerning the organization of wholesale trades are quite different. In electricity markets, some form of organized wholesale trade has been introduced throughout Europe, while the prevailing solution for the natural gas industry involves until recently a direct participation of producers and importers in the retail market or bilateral trades between wholesalers and retailers. The long term contracts adopted are typically characterized by take-or-pay (TOP) clauses.[2] The organization of trades between wholesalers and retailers and the role of TOP clauses will play a central role in our analysis.

A TOP obligation entails an unconditional fixed payment, which enables the purchaser to get up to a certain threshold quantity of gas. This payment is due whether or not the company actually decides to get (and resell) it, and further payments at a marginal price are due if the company wants to receive additional quantities. The very nature of this kind of contracts, therefore, is to substitute variable payments conditional on actual deliveries with a fixed unconditional payment up to a certain delivery threshold. With TOP clauses the structure of costs is affected, the marginal cost of gas being negligible up to the obligations and positive for larger amounts.

TOP clauses pre-exist the liberalization of European markets and are justified by risk-sharing and financial commitments when large investments in the extraction of gas and in the building of dedicated infrastructures are required. However, we argue that once the liberalization process starts, the existence of TOP obligations not only creates problems in the application of the TPA, but may introduce a natural strategic incentive for firms to avoid face to face competition for final customers, if wholesale and retail activities are not unbundled and no organized wholesale market is introduced. This concern was perceived in the early stages of the discussion on gas liberalization. In a document of the House of Lords, for instance, we read that “there was little or no gas-on-gas

[1] "In order to ensure effective market access for all market players including new entrants, non discriminatory and cost-reflective balancing mechanisms are necessary. As soon as the gas market is sufficiently liquid, this should be achieved through the setting up of transparent market-based mechanisms fot the supply and purchase of gas (electricity) needed in the framework of balancing requirements", EC 2003/54 (17) and EC 2003/55 (15).

[2] Another difference between the electricity and gas liberalization process concerns the implementation of the general *principle of Third Party Access (TPA).* In gas markets a relevant exception is admitted, allowing to restrict the release of transport capacity when giving access to the network would create technical or financial problems to the incumbent because of its take-or-pay (TOP) obligations.

competition since the few importers there were had divided the market between them through a series of long term contracts characterized by costly take or pay clauses and supply prices based on the price of competing fuels".[3]

Our paper shows that when retailers directly bear TOP obligations they tend to target different groups of customers with no competition nor benefits for the consumers. However, if wholesale and retail activities are unbundled and wholesale trades are realized in a centralized market, or the contracts are restricted to linear and non discriminating wholesale prices, competition in retailing can be obtained. Hence, our results suggest that there is still an element missing in the liberalization plans, and offer a solution to make the development of competition in the retail market more effective.

In a decentralized market organization as the one presently prevailing in Europe, retail activities require one to select which segments of demand to approach and serve (marketing strategy), then competing in prices, while wholesale activities entail buying gas from producers or importers under long term contracts with TOP clauses. When no unbundling is imposed, these activities are run by the same firm, as we observe in most cases in Europe. In this setting short run price competition leads to the following outcomes: if two firms with TOP obligations target the same customers, they have the same (zero) marginal costs, and in equilibrium they obtain positive sales (and low margins due to price competition). If instead only one of the two firms has TOP obligations, the high marginal cost competitor is unable to obtain positive sales and profits in a price equilibrium. This feature of price competition with TOP obligations drives the marketing strategies of the firms: entering the same market is never convenient because it gives low profits and leaves residual obligations to the two firms (fostering competing entries in other submarkets). Leaving a (sufficiently large) fraction of the customers to the rival, instead, induces this latter to exhaust its TOP obligations, making it a high cost (potential) rival with no incentive to compete on the residual demand. In a word, leaving the rival to act as a monopolist on a fraction of the market guarantees a firm to be a monopolist on the residual demand. In equilibrium, indeed, each firm enters a different submarket and serves the customers at the monopoly price.

According to our model, a more competitive outcome might instead be obtained if we unbundle wholesale and retail activities creating a centralized wholesale market, where the wholesalers (burdened by TOP obligations) sell gas and the retailers buy whatever amount they need at the wholesale price. In this case, all 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 obtain, contrary to the benchmark case, small but positive profits in any market they enter. Generalized entry becomes the dominant strategy, bringing in intense price competition and low margins in the retail market.[4]

[3] House of Lords, Select Committee on European Communities, Seventh Report, "EU Gas Directive", 7th Report, Session 1997-1998, HL Paper 35, p8, para 15.

[4] We discuss in the paper also an alternative measure, based on regulatory restrictions on the retailers-wholesalers contracts that impose linear wholesale prices and prohibit price dis-

The empirical evidence on the European markets supports the idea that the gas market is particularly problematic, more so than electricity. The EU Commission in 2005 noted that "Whilst the rates of larger electricity customers switching continue to rise, gas consumers ... remain reluctant to exercise their right to choose. ... Often competing offers are unavailable" (European Commission, 2005). The situation is not improving; as clearly pointed out more recently in Ergeg (2008), "Gas retail competition is almost non-existent in most member states". Switching rates (one of the few indicators of competition for final customers) are typically low. In 2007, only 3 to 4 EU countries have reported a switching rate above 1% per year. In Southern Australia, another country characterized by liberalized retail markets and take-or-pay wholesale contracts, analogous results emerge from several market surveys. For instance, in 2006 only 16% of small business gas customers received a competing offer, while the same figure rises to 54% in the electricity market (Escosa, 2006).

Going back to the EU situation, it is interesting to stress that switching rates are poorly correlated to concentration (Ergeg, 2008). For instance, in 2007 two of the relatively more fragmented markets[5], namely Germany and Italy, displayed switching rates of about 1%, a case of entry without competition. Higher switching rates were instead observed in markets which were even more concentrated, but which were characterized either by a major role of LNG (Spain) or by the existence of an organized wholesale hub (e.g., Belgium).[6]

We acknowledge that the existing evidence of a poor development of competition in the gas market may be explained in different ways, including the persisting constraints in accessing the transportation network. However, we notice that it is consistent with our model's predictions and many elements are quite reminiscent of our segmentation story.

Our results may have some interest in the policy debate on gas liberalization. The discussion so far has focussed on the development and access to international and national transport infrastructures and on the unbundling of activities of incumbent firms.[7] The recent Energy sector inquiry of the European Commission (2006) stresses that problems of access are still the main concern of policy makers. We add to this explanation a warning on additional obstacles in retail competition. Several countries have imposed gas release commitments on the incumbent, in order to ease the entry of new firms and promote competition in the retail markets.

crimination. Although simpler than the creation of a wholesale market in terms of institutional design, this alternative measure poses hard problems of transparency in its implementation.

[5] The report by Ergeg (2008) provides data on the cumulated market share of the three largest suppliers in each country. According to these data, in 2007 this figure was 26.3% in Germany and 66.5% in Italy.

[6] In recent years, wholesale markets have been introduced in some European markets in order to ease the balancing of transport activities by providing purchase or sales opportunities when inflows and outflows do not match. There is actually a wide variety of arrangements, from physical hubs, to electronic exchange platforms to actual gas exchanges (particularly developed in Belgium, the Netherlands, the UK and more recently Germany and partially France).

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

We show that these measures, successful in reducing the incumbent's market shares, do not avoid the segmentation outcome and are therefore unable to provide actual benefits to the customers. An effective role might instead be played by wholesale gas markets, which may help develop a more intense competition in the retail activities.

Relationship to the literature. The existing literature on TOP contracts (see Cretì and Villeneuve, 2004, for a broad survey) focusses almost entirely on the reasons which justify their existence. For instance, Crocker and Masten (1985) argue that a simple contract of this kind provides appropriate incentives to limit opportunistic behavior, while Hubbard and Weiner (1986) emphasize the risk sharing properties of such a contract. However, the consequences of these contracts on competition remain out of the scope of these analyses.

The relationship between spot markets and long term contracts has been studied in a number of papers (Allaz and Villa (1993), Mahenc and Salanié (2004), Bushnell J. (2008) among others), suggesting that forward contracts affect short run competition in spot markets. The original paper by Allaz and Villa showed that forward contracts increase short run competition in a Cournot setting, a result that is reversed in Mahenc and Salanié under price competition. Although our setting is partly different, we add to this debate a result that stresses potential anticompetitive effects of long term contracts, when they take the form of TOP clauses.

Another stream of literature which is relevant to our analysis is the one on price competition with capacity constraints or decreasing returns. Since the seminal work by Kreps and Scheinkman (1983) we know that capacity constraints may modify the incentives to cut-throat price competition, leading to an outcome equivalent to Cournot.[8] Vives (1986) shows that if marginal costs are flat up to capacity and then they are increasing, their steepness determines how the equilibrium ranges from Bertrand to Cournot. The literature on supply function equilibria (Klemperer and Meyer (1989)) has generalized this intuition showing that if firms can choose and commit to any supply function, all the individually rational outcomes can be implemented in equilibrium. Our paper adopts the same technology as Maggi (1996)[9], that introduces discontinuous marginal costs as those that emerge with TOP obligations. Maggi shows that the amplitude of the upward jump in the marginal cost determines the equilibrium outcomes, that range from Bertrand (no jump) to Cournot.

Finally, our paper shares many features with the analysis of dynamic price competition in Bertrand-Edgeworth settings[10]: Dubey (1992) shows that absolute capacity constraints and dynamic pricing over a sequence of consumers

[8] Davidson and Deneckere (1986) have shown that if we substitute the efficient rationing rule adoped in Kreps and Scheinkman with a proportional rationing rule, the market outcome is intermediate between Bertrand and Cournot.

[9] The same technology can be found in Dixit (1980): in this paper the incumbent has already sunk a given capacity and therefore has marginal costs deriving from variable inputs up to this capacity and a higher marginal cost, that includes the cost of installing additional capacity, for higher output.

[10] See also Ghemawat and McGahan (1998) on order backlogs for similar arguments.

avoids price cycles (or mixed strategy equilibria) and leads to almost monopoly prices. We show in our paper that similar results can be obtained with discontinuous marginal costs rather than absolute capacity constraints and with simultaneous pricing, provided that entry and pricing in the submarkets are taken sequentially.

The paper is organized as follows. In section 2 we describe the main assumptions of the model; section 3 analyzes the sequential entry case; section 4 considers the introduction of a wholesale market. Concluding remarks follow. Appendix I contains the proofs, Appendix II shows that the segmentation result holds also under simultaneous entry and Appendix III endogenizes the competitor's choice of TOP obligations.

2 The model

We maintain in our modeling strategy the general premise that justifies the liberalization of the natural gas industry: the retail markets are potentially competitive, meaning that the basic technologies and demand conditions may be consistent with two or more equally efficient firms competing for the final customers. The focus of our analysis is then on the effects of long term contracts and TOP clauses on the competitive process and the possible distortions they introduce by affecting the cost structure of firms, and the policy measures that can promote retail competition.

Our model reflects four main features of the gas industry in most European countries.

1. The wholesale activity involve buying gas from the producers under long term contracts with the producers including TOP obligations. Hence a wholesaler has zero marginal costs up to the output that fulfills these obligations, and can obtain additional gas from other sources, such as spot contracts or extensions of the main contract, at a (higher) marginal cost that reflects the marginal purchase price.

2. The retail activity entails selling gas to final customers and requires to buy gas, to select which submarkets to approach and to specify the commercial terms (price and ancillary clauses). The retail market is decentralized, in the sense that retailers have to select which submarkets they want to serve and to approach the potential customers accordingly. Submarkets can be identified by location (geographical submarkets) and/or by the type of customers (residential, business, specific industries, etc.). This marketing activity involves (limited) fixed costs.

3. Although the gas provided is a commodity at the wholesale level, the retail service includes some element of horizontal product differentiation and consumers' heterogeneity; hence, retailers may obtain in certain circumstances positive margin.

4. The wholesale and retail activities are not unbundled, e.g. they are run within the same firm ("retailer") and no wholesale market is open.

We assume that two retailers, the incumbent (I) and the competitor (C), are active in the retail market for natural gas provision. According to point 4 above, the firms purchase the natural gas from the producers under TOP obligations and resell it to the final customers transporting it through the pipeline network. Although third party access is far from established in the natural gas industry in many European countries, in this paper we want to study the features of competition in the retail market absent any (once removed) entry barriers to the transport infrastructures that might limit entry. Consequently, we assume that Third Party Access is fully implemented, implying that no bottleneck or abusive conduct prevents the access of the competitor to the transportation network at non discriminatory terms.

We now move on describing in detail preferences and demand, costs and the timing of the game.

Submarkets, preferences and demand

Consumers belong to a set of D identical submarkets, each of mass 1. Submarkets may be identified by geographical location ("areas") and/or according to certain characteristics of the customers (e.g. domestic v. industrial ones, heavy users, etc.). No matter how we interpret the different submarkets, an individual consumer belongs to just one of them and cannot move to another one.

Hence, our description of the demand side focusses on the features of preferences and demand in a given submarket, while we can obtain the demand of larger sets of customers simply by aggregation. In every submarket $d = 1, .., D$ the consumers have inelastic unit demand and they view the service provided as slightly differentiated due to the additional (commercial or locational) characteristics of the retailers, over which they have heterogenous preferences.

More specifically, we model the demand in each submarket d according to a Hotelling-type specification. Customers in submarket d are uniformly 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 $\psi \geq 0$ is a parameter describing the importance of the commercial services or the locational issues (horizontal product differentiation) for the client. Notice that our model, therefore, includes perfect substitutability and homogeneous products ($\psi = 0$) as a special case.

Each firm $i = I, C$ is exogenously 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 $x^C = 3/4$, i.e. the two firms have some (exogenous) difference in the service provided.[11] The firms do not observe the individual customer's tastes

[11] Since we already analyze an asymmetric model, with the incumbent selecting first the submarkets it is willing to serve, we do not endogenize the choice of variety, where the incumbent might obtain additional advantages by locating its variety more centrally.

(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 in submarket d. Let us define $\widehat{v}$ as the consumer indifferent between the offers of I and $C, \overline{v}^I$ as the consumer indifferent between the offer of the incumbent and buying nothing, and $\overline{v}^C$ as the consumer indifferent between buying from C or nothing. It is easy to check that:

$$\begin{aligned} \widehat{v} &= \frac{1}{2} + \frac{p^C - p^I}{\psi} \\ \overline{v}^I &= \frac{1}{4} + \left[\frac{u^* - p^I}{\psi}\right]^{\frac{1}{2}} \\ \overline{v}^C &= \frac{3}{4} - \left[\frac{u^* - p^C}{\psi}\right]^{\frac{1}{2}} \end{aligned}$$

Then, the demand for firm I in submarket d (of mass 1) is

$$D_d^I = \left[\max\left\{0, \min\left\{\widehat{v}, \overline{v}^I, 1\right\}\right\} - \max\left\{\frac{1}{2} - \overline{v}^I, 0\right\}\right] \tag{1}$$

and the demand for C corresponds to

$$D_d^C = \left[\min\left\{1, \overline{v}^C\right\} - \min\left\{1, \max\left\{0, \widehat{v}, \frac{3}{2} - \overline{v}^C\right\}\right\}\right] \tag{2}$$

The two expressions give the demand for the active firm(s) if one or both firms entered market d (and offer relevant prices to the customers): for instance, when both firms are active and the submarket is covered we obtain the usual demand system of the Hotelling model,

$$D_d^i = \frac{1}{2} + \frac{p_d^j - p_d^i}{\psi} \tag{3}$$

with $i, j = I, C$, $i \neq j$. When instead only the incumbent entered in submarket d and the market is not completely covered, due to the very high price set, the demand is $D_d^I = \overline{v}^I$, etc.

We have described so far the demand in a specific submarket d of size 1. Since all the submarket are identical, total demand is not larger than D, and it is indeed equal to D if all the consumers are served in the D submarkets. According to the entry and pricing decisions of the retailers, the consumers in the D submarkets may face no, one or two competing offers and will react in each of them as described in equations (1) and (2).

Costs

The (integrated) retailers's costs refer to the purchase, transport and sales of gas and to the marketing costs related to entering a given (set of) submarket(s).

Since we assume that transport services are offered at non discriminatory terms with a linear access charge, the network access costs are the same for C and I and, w.l.o.g., are set equal to zero. Variable sales costs are assumed to be (linear and) zero as well. Purchase costs depend on the nature of the upstream contractual arrangements. Each retailer $i = I, C$ has a portfolio of long term contracts with the producers[12], where the unit cost of gas w^i and a TOP obligation $\overline{q}^i$ per unit of time are specified: the retailer has to pay to the producer an amount $w^i\overline{q}^i$ no matter if the gas is taken or not. Retailers can obtain additional supply from secondary sources, as extensions of the main contract or spot contracts with other providers. In our setting what distinguishes the primary from the secondary source is the nature of the marginal purchase price: it is zero up to the TOP obligations $\overline{q}^i$ (primary source) while it is positive and (w.l.o.g.) equal to w^i for additional (secondary) supply[13]. Notice that in our model the firms have no absolute capacity constraint but a discontinuous marginal cost curve, that jumps from 0 to w^i once the TOP obligations are exhausted. For simplicity, we assume $w^C = w^I = w$.

We further assume that a retailer pays a fixed cost f for any submarket (of size 1) where it decides to operate. These fixed outlays can be due to the set-up costs of commercial offices and the cost of the dedicated personnel that runs the marketing activity in the submarket.

The cost function of firm $i = I, C$ is therefore:

$$C^i(q^i, \overline{q}^i, D^i) = \begin{cases} w\overline{q}^i + fD^i & \text{for } 0 \leq q^i \leq \overline{q}^i \\ w(q^i - \overline{q}^i) + w\overline{q}^i + fD^i & \text{for } q^i \geq \overline{q}^i \end{cases} \tag{4}$$

where D^i corresponds to the size of the submarkets in which retailer i has decided to enter.

Assumptions

From our description of preferences and costs, there are four key parameters in the model, u^*, w, f and ψ, whose values influence the equilibrium outcomes. The first, u^*, defines the maximum willingness to pay for gas; the second (w) corresponds to the marginal price for gas provisions beyond the TOP obligations and determines the jump in the marginal cost; the third (f) is related to the entry costs in a submarket and determines the minimum gross profits needed to expand the activities in a new submarket, while the fourth (ψ) gives the degree of service differentiation across retailers, influencing the equilibrium

[12] If the retailers purchase gas from the importers rather than from the producers, we maintain the assumption that their gas provision entails long term contracts with TOP obligations. The importers, indeed, obtain directly gas from the producers who impose such contractual framework. In turn, when reselling gas to the retailers, the importers require the same contractual features with these latter.

[13] Long term contracts usually include additional clauses, as a total annual capacity that can be 25-30% larger than TOP obligations, and rules to anticipate or postpone the fullfilment of TOP obligations across years. All these elements do not modify the key element in our analysis, a discontinuous marginal purchase price once TOP obligations are exhausted. Hence, we model the costs according to this essential feature.

margins. Although in general one may admit many different ranges of values of these parameters, we think that focussing on our industry case a particular combination of values is particularly relevant. Qualitatively, we claim that gas is an important input in many activities (u^* is high), it is costly (w is large as well), it is a commodity, with limited opportunities to differentiate the offers (ψ is low) and submarkets are potentially competitive (f is low). We translate these qualitative claims in the following assumptions:

$$u^* \geq w + \frac{33}{16}\psi \tag{5}$$

$$w > \frac{\psi}{2} \geq 0 \tag{6}$$

$$f < \frac{\psi}{4} \tag{7}$$

Assumption (5) is sufficient to ensure that a monopolist prefers to cover the entire market at the highest possible price rather than further rise it and ration the market, and that its equilibrium profits are non negative. Assumption (6) ensures that internal solutions give non negative prices in any subgame where the two firms compete in the same submarket (See Proposition 1's proof for details). Finally, assumption (7) is consistent with profitable entry when firms compete with symmetric marginal costs. Once derived our results under these assumptions we will discuss what changes if they do not hold.

TOP obligations and capacities

We assume that the incumbent and the competitor have a portfolio of long term contracts such that total TOP obligations equal total demand:

$$\overline{q}^I + \overline{q}^C = D. \tag{8}$$

In Appendix III we will endogenize the competitor's choice of obligations $\overline{q}^C$, showing that indeed the competitor selects obligations equal to the residual market $D - \overline{q}^I$ that is not covered by the incumbent's obligations.

Although (8) is all that is needed in our equilibrium analysis, from an empirical point of view it seems realistic to assume that the incumbent's obligations are larger than the competitor's, and they do not exceed the size of the market, $\overline{q}^C < \overline{q}^I \leq D$.

Entry, competition and timing

The market is decentralized, so that firms have to decide which submarkets to deal with, and propose a price to their potential customers. This marketing decision allows to target a particular group of customers, what we call a submarket, by deploying dedicated and specialized resources. For instance, the retailer can set up a network of agents that cover a specific geographical area, or that develop relationships with certain industrial clients. We assume that the decision to serve a submarket is observable by the competitors and irreversible in the short run, as it requires to sink some resources (e.g. local distribution networks, local offices and dedicated personnel) paralleled by the fixed outlay f.

Given the marketing decisions of the two firms, a given submarket may thus face no offer, one offer (by a firm that would then be a monopolist for those customers), or two offers from the two competing firms. Once received the offer(s) - if any - the customers decides whether to sign a contract or not. Once a contract is signed, the selected provider supplies all the gas demanded by the customer, since the technology does not imply absolute capacity constraints but simply a discontinuous marginal cost.

We further assume that the incumbent is always able to move first in approaching the customers, due to his pre-existing relationships with the clients, followed by the competitor. Submarkets are visited by the firms sequentially and, in each of them, once the marketing choices are taken, the active firms simultaneously propose their prices. In Appendix II we show that our segmentation result still holds also under simultaneous entry. Hence, sequential entry is not essential to our result, but allows to easily cope with the coordination problem that otherwise would arise in a simultaneous entry setting when firms, aiming at targeting different submarkets, may end up erroneously selecting the same ones.

When we analyze price competition in a single submarket, the crucial element that affects the equilibrium is the amount of residual TOP obligations of the firms, that enable them to serve the customers in that submarket at zero marginal cost. Since the incumbent moves first, we shall show in the equilibrium analysis that the firms face similar strategic issues when entering and pricing in each of the submarkets (of size 1) $d = 1, 2, .., D_1$, where $D_1 = \overline{q}^I$ delimits a subset of submarkets whose total demand equals the incumbent's obligations. In each of these submarkets, indeed, the incumbent has residual TOP obligations greater (or equal) than the submarket demand. Hence, if I decides to enter, C anticipates that by entering in its turn, it will face a competitor that can serve the submarket demand at zero marginal costs. Moreover, C anticipates that if it enters and competes for some customers, additional cross-market effects will arise, since I will not use all its TOP obligations in the first D_1 submarkets and will have incentives to enter and compete on the residual demand. The same strategic issues can be analyzed by grouping all the first D_1 submarkets together, that is by assuming that the incumbent decides first whether to enter or not a subset $D_1 = \overline{q}^I$ of submarkets whose demand may potentially exhaust its obligations, and then considers the residual submarkets $D_2 = D - D_1 = \overline{q}^C$. As this compact formulation lends itself to a shorter (but equivalent) equilibrium analysis, we will adopt it.

Summing up, we assume that the two firms decide sequentially at first whether or not to enter market 1, composed by submarkets $d = 1, .., D_1$, and market 2, that includes submarkets $d = D_1 + 1, .., D$. We thus define a variable $e_t^i = \{0, 1\}$, $i = I, C$, $t = 1, 2$, which refers to firm i's decision to enter ($e = 1$) or not ($e = 0$) in a particular submarket $t = 1, 2$.

From our discussion, the timing when $\overline{q}^I < D$ is as follows:

- at $t = 1$ the incumbent decides whether to enter ($e_1^I = 1$) or not ($e_1^I = 0$) in D_1; then, having observed whether or not I participates, the competitor chooses to enter ($e_1^C = 1$) or not ($e_1^C = 0$) in market D_1. Then the participating firm(s) (if any) set a price simultaneously.

- having the firms observed the outcome of stage $t = 1$, at $t = 2$ the incumbent decides whether to enter ($e_2^I = 1$) or not ($e_2^I = 0$) in D_2; then, having observed whether or not I participates, the competitor chooses to enter ($e_2^C = 1$) or not ($e_2^C = 0$) in market D_2. Then the participating firm(s) (if any) set a price simultaneously.

When $\overline{q}^I = D$ (and therefore $\overline{q}^C = D_2 = 0$) the timing is restricted to the first bullet.

Before moving to the equilibrium analysis, it appears convenient to anticipate the main result, and then to show (backwards) how this can be proven. The equilibrium of the game can be described as follows:

Result. *In any equilibrium configuration all the customers pay the monopoly price. If the incumbent's obligations are smaller than market demand, I and C enter as monopolists in different submarkets, while if the incumbent's obligations are as large as total demand I monopolizes all the submarkets.*

3 The sequential entry game

In this section we analyze the subgame perfect equilibria in the sequential entry game, where competition in the first and then in the second market takes place. Although the two markets are separate, a strategic link between them remains, because the residual TOP obligations in the second market depend on the sales (i.e. entry and pricing decisions) in the first market. Hence, when the firms decide their entry and price strategy in the first market they take into account the impact on profits in the first market and on the residual obligations left, anticipating how these latter will affect entry and price decisions in the second market. Therefore, even in our simplified two-markets setting, we are able to maintain all the within-market and cross-market effects that characterize competition.

3.1 Pricing and entry in the second market

We start our equilibrium analysis, according to backward induction, with the pricing and marketing decisions in market 2, that includes all the residual submarkets $d = D_1 + 1, .., D$, and corresponds to the last stage of the game. Hence, the firms design their strategies maximizing just their second market profits. The profits in market 2, and in particular the relevant marginal costs, are affected by the amount (if any) of residual TOP obligations not already committed to sales in market 1. Hence, we can parametrize the second stage subgames to

$(\overline{q}_2^I, \overline{q}_2^C)$, where $\overline{q}_2^i \leq \overline{q}^i$ is the residual TOP obligation of firm $i = I, C$ in the second market.

We proceed by identifying the best reply function when both firms enter in the second market and compete in prices. First of all, notice that the profit functions are continuous and concave, but kinked along the locus $\overline{p}_2^i(p_2^j, \overline{q}_2^i)$ that solves $D_2^i(p_2^i, p_2^j) = \overline{q}_2^i$. Hence, $\overline{p}_2^i(p_2^j, \overline{q}_2^i)$ is the price p_2^i that, for given p_2^j, makes firm i's demand equal to its residual obligations. For $p_2^i < \overline{p}_2^i$ firm i's demand exceeds its obligations and the marginal cost jumps up from 0 to w. Solving explicitly, we obtain:

$$\overline{p}_2^i(p_2^j, \overline{q}_2^i) = p_2^j - \frac{\psi}{2D_2}(2\overline{q}_2^i - D_2).$$

Let $\widehat{p}_2^i(p_2^j, c)$ be the price that maximizes profits for given p_2^j when the marginal cost is $c \in \{0, w\}$. It is implicitly defined by the first order condition $\frac{\partial \Pi_2^i(p_2^i, p_2^j, c)}{\partial p^i} = 0$. Solving explicitly we get:

$$\widehat{p}_2^i(p_2^j, c) = \frac{p_2^j + c}{2} + \frac{\psi}{4}.$$

The following Lemma characterizes the best reply for firm i.

Lemma 1 : *Let $BR_2^i(p_2^j)$ be firm i's best reply to p_2^j. Then*

$$BR_2^i(p_2^j) = \begin{cases} \widehat{p}_2^i(p_2^j, 0) & \text{for } p_2^j \in \left[0, \max\left\{0, \frac{\psi}{2D_2}(4\overline{q}_2^i - D_2)\right\}\right] \\ \overline{p}_2^i(p_2^j, \overline{q}_2^i) & \text{for } p_2^j \in \left[\max\left\{0, \frac{\psi}{2D_2}(4\overline{q}_2^i - D_2)\right\}, w + \frac{\psi}{2D_2}(4\overline{q}_2^i - D_2)\right] \\ \widehat{p}_2^i(p_2^j, w) & \text{for } p_2^j \in \left[w + \frac{\psi}{2D_2}(4\overline{q}_2^i - D_2), u^*\right] \end{cases}$$

Proof. See Appendix. ■

Figure 1 below shows the best reply $BR_2^i(p_2^j)$ that is piecewise linear and continuous, with the lower segment AB (if any) corresponding to $\widehat{p}_2^i(p_2^j, 0)$, the intermediate segment BC given by $\overline{p}_2^i(p_2^j, \overline{q}_2^i)$ and the upper segment CD equal to $\widehat{p}_2^i(p_2^j, w)$. Notice that when the residual obligation $\overline{q}_2^i$ increases, $\overline{p}_2^i(p_2^j, \overline{q}_2^i)$ decreases, shifting up the intermediate segment BC of the best reply.

Figure 1 about here

We can now proceed analyzing the price equilibria that occur in the different subgames depending on the marketing decisions of the two firms in the second market.

Proposition 1: *(Price equilibria)*

If only firm $i = I, C$ *enters in market 2, it sets price* $p_2^{i*} = u^* - \frac{9}{16}\psi$ *and serves the entire market for any residual obligation it has.*

If both firms enter in the second market, given the marketing and price strategies in the first market the residual obligations and the corresponding equilibrium prices fall in one of the three following cases:

a) $\overline{q}_2^I + \overline{q}_2^C = D_2$ *with* $0 \leq \overline{q}_2^i \leq D_2/2 \leq \overline{q}_2^j$, $i, j = I, C$, $i \neq j$. *Then, the (Pareto efficient) equilibrium prices are*

$$\begin{aligned} p_2^{i*} &= w + \psi \frac{\overline{q}_2^i}{D_2} \\ p_2^{j*} &= w + \psi \frac{4\overline{q}_2^i - D_2}{2D_2} \end{aligned} \tag{9}$$

Each firm sells all its residual TOP obligation.

b) $\overline{q}_2^I + \overline{q}_2^C > D_2$ *with* $0 \leq \overline{q}_2^i \leq D_2/2 < \overline{q}_2^j$, $i, j = I, C, i \neq j$. *Then, the equilibrium prices are*

$$\begin{aligned} p_2^{i*} &= \psi \frac{3D_2 - 4\overline{q}_2^i}{2D_2} \\ p_2^{j*} &= \psi \frac{D_2 - \overline{q}_2^i}{D_2} \end{aligned} \tag{10}$$

Only firm i*, with the smaller residual obligations, sells all of them while firm* j*, with the larger residual obligations, covers the residual demand.*

c) $\overline{q}_2^I + \overline{q}_2^C > D_2$ *with* $\overline{q}_2^i > D_2/2,$ *,* $i = I, C$. *Then, the equilibrium prices are*

$$\begin{aligned} p_2^{i*} &= \frac{\psi}{2} \\ p_2^{j*} &= \frac{\psi}{2} \end{aligned} \tag{11}$$

and each firm serves half of the market.

Proof. See Appendix. ■

The equilibrium prices in the second market depend first of all on the number of firms that enter: if only one retailer decides to serve market 2, it will set the monopoly price covering the entire demand. If, however, both firms enter market 2, the prices set and the sales realized in equilibrium depend on the residual obligations, which in turn derive from the marketing and price decisions in the first market. Case (a) refers to a situation where total residual obligations equal demand: in this case each firm sells exactly its residual obligations and the equilibrium prices never exceed $w + \psi/2$. In this case we select the prices that are Pareto efficient for firms. If residual TOP obligations are larger than D_2, we have two additional cases, labelled (b) and (c). In both of them, competition leads to prices lower than in case (a), but above the zero marginal cost due to product differentiation (parameter ψ). When one of the two firms has limited residual obligations (case (b)) it still sells all of them, while in case (c) both firms have very large residual obligations and they split evenly the market without exhausting them, and gaining a small margin over the marginal cost 0. In this latter case, TOP obligations do not affect the equilibrium prices and sales, and the market equilibrium corresponds to what emerges when two firms with zero marginal costs compete.

Notice that the price configurations described in Proposition 1 include also the case of perfectly homogeneous offers and Bertrand competition, when the differentiation parameter ψ tends to zero. When we converge to the homogeneous products case ($\psi \to 0$), indeed, prices fall to w in case (a) and to 0 in case (b) and (c), in line with the Bertrand result.

Figure 2 shows the three cases a), b) and c) in which both firms are active in market 2 and the different points of intersection of the two best reply functions.

Figure 2 about here

We can now move to the marketing decisions of the two firms in the subgames of the second market, having characterized the equilibrium prices in any subgame. When choosing whether to serve market 2 or not, the firms compare the gross profits associated to the equilibrium prices and sales described in Proposition 1 with the fixed marketing costs fD_2 in case of entry in market 2.

The following Proposition identifies the entry equilibrium in all possible cases.

Proposition 2: *(Entry equilibria) The equilibrium marketing strategies of the two firms are:*

a) when $\overline{q}_2^I + \overline{q}_2^C = D_2$ *and* $\overline{q}(a) < \overline{q}_2^i \leq D_2/2 \leq \overline{q}_2^j$, $i, j = I, C$, $i \neq j$, *where*

$$\overline{q}(a) \equiv \frac{-w + \sqrt[2]{w^2 + 4f\psi/D_2}}{2\psi/D_2}$$

both firms enter in market 2 while when $0 \leq \overline{q}_2^i \leq \overline{q}(a)$ *only firm* j *enters in market 2;*

b) when $\overline{q}_2^I + \overline{q}_2^C > D_2$ *and* $\overline{q}(b) \leq \overline{q}_2^i \leq D_2/2 < \overline{q}_2^j$, $i, j = I, C, i \neq j$, *where*

$$\overline{q}(b) \equiv \frac{3\psi - \sqrt[2]{9\psi^2 - 16f\psi/D_2}}{8\psi/D_2}$$

both firms enter in market 2, while when $0 \leq \overline{q}_2^i \leq \overline{q}(b)$ *only firm* j *enters in market 2;*

c) when $\overline{q}_2^I + \overline{q}_2^C > D_2$ *with* $\overline{q}_2^i > D_2/2$, , $i = I, C$, *both firms enter in market 2.*

Proof. See Appendix. ■

The intuition behind the equilibrium entry pattern is straightforward. At the second stage, the price equilibria give positive sales and gross profits as long as a firm has positive residual obligations; entry is then profitable if the gross profits enable to cover the fixed marketing costs fD_2. In cases a) and b) the firm with the smaller residual obligations (firm i in our notation) sells exactly $\overline{q}_2^i$ in equilibrium, and therefore its sales and gross profits decrease the lower the obligations still pending. In these two cases, therefore, there is a minimum level of residual obligations, $\overline{q}(a)$ or $\overline{q}(b)$, that allows repaying the fixed marketing costs once entered. In case c), instead, the margin obtained is always sufficient to make entry profitable. Notice that when the marketing cost vanishes, i.e. $f \to 0$, the equilibrium marketing strategies boil down to a very simple rule: each firm enters as long as it retains positive residual obligations.

3.2 Equilibrium

Once obtained the marketing and price equilibria in the second market, 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 $\overline{q}^C$. The more relevant difference between the two phases, that we label as market 1 and market 2, rests on the different strategic implications of the marketing and price decisions. The strategies in market 2, being referred to the last stage of the game, are aimed at maximizing just the market 2 profits. When instead we consider market 1's choices, the firms realize that their marketing and price strategies have a direct effect on the profits realized in market 1, but they also exert a strategic effect on the equilibrium strategies and profits in market 2, through the determination of the residual obligations.[14] Notice that this cross-market strategic effect is relevant in the determination of both the optimal marketing and pricing strategies: how much of the initial obligations is used in market 1 depends first on the decision to serve it on not, and then, if entered, on the sales induced by the pricing strategies.

These additional effects apply in case only one firm enters market 1 as well as when both firms compete for the first market's customers. In the first case we have to check whether the optimal price entails covering the entire demand D_1 (as shown for the second stage in Proposition 1) or it prescribes to ration the first market (through a price higher than p_m) retaining some residual obligations that will induce entry in the second market. When instead both firms enter,

[14] This different feature of the strategies in market 1 and market 2 would occur also in a more disaggregated setting, in which the firms would enter sequentially each of the D submarkets: the strategies in submarket $d = D$ would involve only the maximization of the (last) submarket profits while those taken in submarkets $d = 1, .., D - 1$ would depend on their impact on both the submarket profits and the continuation of the game.

each firm might have the incentive to price in such a way to leave a substantial part of the sales to the rival. This way the latter would indeed exhaust (almost) all its obligations, finding then unprofitable to enter in market 2, that the former firm would monopolize. The following proposition analyses the different cases.

Proposition 3: *The following price equilibria occur in the first market:*

a) If only firm i enters in the first market, it sets the price $p_m = u^* - \frac{9}{16}\psi$ and supplies the entire market D_1.

b) If both firms enter in the first market:

1. *there is no price equilibrium in pure strategies,*
2. *an equilibrium in mixed strategies μ_1^{I*}, μ_1^{C*} exists.*
3. *in the mixed strategy equilibrium both firms obtain positive expected profits and the expected total profits of the competitor in the two markets are $E\Pi^C(\mu_1^I, \mu_1^C) < (u^* - \frac{9}{16}\psi)D_2$.*

Proof. See Appendix. ■

Some comments are in order.

Part (a) of Proposition 3 shows that the strategic link between the two markets is insufficient to distort the first market pricing decisions when only one firm enters. In this case the active firm faces two alternatives: extract the monopoly rents from the consumers in the first market, or ration some customers and retain some residual obligations for the second market by overpricing above p_m. In this latter case, however, the firm cannot extend its monopoly to the second market (where the rival will enter being still endowed with large TOP obligations) and it will obtain competitive, rather than monopoly, returns on its residual obligations. Hence, renouncing to some monopoly rents by overpricing in the first market and shifting some obligations to the second (competitive) market is not convenient, and the firm sets the monopoly price and covers the entire market D_1 renouncing to enter market 2.

When both firms enter in the first market, total equilibrium profits as a function of p_1^i (given p_1^j) have the following pattern. When firm i's offer is much cheaper than firm j's, the former sells most or all its obligations in the first market and does not enter the second one, as shown in Proposition 2. When the prices of the two firms are closer both use only part of their TOP obligations in market 1, and therefore both firms enter the second market. Finally, when firm i's offer is much more expensive than firm j's, this latter exhausts its obligations in market 1, and only firm i enters as a monopolist in market 2. Inducing the rival to sell all its obligations in the first market becomes the dominant strategy for both firms, since it secures monopoly rents in the second market; and this is why we do not have a price equilibrium in pure strategies in the first market.[15]

A crucial feature of the mixed strategy equilibrium (that arises when both firms enter in market 1, so that both firms enter market 2 as well) is that the total expected profits the competitor C can earn in both markets are below the monopoly profits that it can earn with certainty in market 2 by staying out of market 1: gaining competitive profits in both markets is worse than obtaining monopoly profits in just one of them. This inequality is key to understand the optimal marketing decisions in the first stage. We have concentrated so far our analysis on the case when the incumbent has TOP obligations short of total demand. Our analysis, however, allows us to easily consider also the case of incumbent's obligations that match market demand. The following Proposition - in line with the claim expressed at the beginning of the section - establishes our main segmentation result.

Proposition 4: *Depending on the amount of TOP obligations of the incumbent, we can have two possible outcomes:*

- *Segmentation: when $\overline{q}^I < D$, the incumbent enters in the first market, while the competitor enters in the second market. Both firms charge to their customer(s) the monopoly price $p_m = u^* - \frac{9}{16}\psi$.*
- *Monopolization: when $\overline{q}^I = D$, the incumbent enters in the market and charges the monopoly price $p_m = u^* - \frac{9}{16}\psi$, while the competitor does not enter.*

Proof. See Appendix. ■

3.3 Comments to the result

Proposition 4 suggests two possible unsatisfactory outcomes of liberalization, depending on the amount of TOP obligations of the incumbent. If they fall short of market demand, segmentation occurs, that is entry without competition, while entry would be completely prevented if the incumbent can supply the entire market with its TOP obligations. In both cases, consumers do not receive any benefit. Our result therefore suggests that third party access is a necessary but not a sufficient condition to create competition in the retail markets. In the next section we shall discuss possible solutions that allow one to enrich the liberalization plans leading to competition in retailing.

[15] This sort of outcome would occur also in case of sequential entry in the different submarkets $d = 1, .., D - \overline{q}^C$, whenever we do not aggregate all of them into a single market 1: if both firms enter in any of these submarkets, the pricing strategies may contribute to make the residual obligations of either firm insufficient to motivate its entry in the remaining submarkets. Leaving sufficient sales to the rival would therefore secure monopoly profits in some of the residual submarkets.

The basic intuition behind our segmentation result (case $\overline{q}^I < D$) is quite simple: when a firm has to meet TOP clauses, 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 capacities are used in a competitive price game obtaining low returns; moreover, both firms remain with positive residual obligations, that induce them to enter in the second market as well, again with competitive low returns. On the other hand, leaving a fraction of the market to the rival turns out to be a mutually convenient and credible strategy. The other firm, indeed, once exhausted its TOP obligations serving the 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 enough sales and profits to cover the fixed marketing costs. By leaving the rival in a monopoly position on a part of the market, a firm acquires a monopoly position on the residual customers.

The two institutional features behind this result are decentralized retail markets, that require firms to select which customers to approach, and the absence of a wholesale market, that forces the retailers to buy gas directly from the producers under long term contracts, bearing TOP obligations. The liberalization process in the European countries, as it has developed so far, matches precisely these features.

The monopolization result (case $\overline{q}^I = D$) is easily explained as well: the asymmetry in marginal costs when only the incumbent has TOP obligations makes entry unattractive for the competitor, who would face an aggressive low cost incumbent and would obtain no sales and profits. We show in Appendix III that even endogenizing the competitor's choice of TOP obligations, it is always optimal for C to contract obligations $\overline{q}^C$ equal to the residual demand (if any) not covered by the incumbent's obligations. Hence, in this latter case the competitor does not contract any gas provision and remains out of the market.

Some countries, such as Spain, UK and Italy have included in their liberalization plans some measures that can be rationalized with the concern that entry is blockaded by the huge amounts of gas provisions in the incumbent's portfolio. More precisely, they have introduced gas release programs that force the incumbent to sell to the competitors certain amounts of gas. Similar measures have been used as commitments in antitrust cases in Italy (see case A329B - Blugas-Snam of June 2004). Gas release programs, if they include TOP clauses on the receiving firm or take the form of annual auctions on certain amounts of gas, affect the net TOP obligations of the incumbent, reducing $\overline{q}^I$ and increasing $\overline{q}^C$ accordingly. These measures, therefore, can create opportunities for entry (if initially $\overline{q}^I = D$) or they can increase the competitor's market share, but they are not sufficient to avoid segmentation and to create competition.

Our result of segmentation and monopolization is not just an example of the well known result that with high fixed costs a market with intense price competition becomes a monopoly in a free entry equilibrium. To clarify this point let us define $\Pi^i(c^i, c^j; \psi)$ as firm i's profits when its own marginal cost is

c^i and the rival's is c^j, with parameter ψ describing how much price competition is relaxed. In our setting the marginal cost can assume one of two relevant levels, 0 or w, creating an environment of symmetric or asymmetric costs firms. Let us assume the following inequalitites:

$$\Pi^i(0, w; \psi) > \Pi^i(0, 0; \psi) \geq \Pi^i(w, w; \psi) > \Pi^i(w, 0; \psi),$$

that hold in a wide series of oligopoly models including Cournot or Hotelling, the one we adopt in this paper.[16] Competing with a high marginal cost rival creates an advantage with respect to a symmetric cost setting, with the high marginal cost competitor worse off. In this environment, we can have different outcomes of the entry process according to the level the fixed costs f, that correspond in our model to the marketing costs.

When f is very high, that is $f > \Pi^i(0, 0; \psi)$, no duopoly configuration can emerge in a free entry equilibrium: even a competitor as efficient as the incumbent would make losses by entering, once the first firm is in the market. Hence, in this case the market is a monopoly with no possibility for a second firm to enter, the traditional case of blockaded entry. When the fixed costs are lower, namely

$$\Pi^i(w, w; \psi) > f > \Pi^i(w, 0; \psi), \tag{12}$$

entry occurs if firms are symmetric, while an inefficient competitor would not enter once a low cost firm is already in the market. Notice that the condition $\Pi^i(w, w; \psi) > f$ is consistent with the premise of a liberalization plans: the market can sustain more than one (equally efficient) firm. Moreover, the inequality $f > \Pi^i(w, 0; \psi)$ explains the entry pattern in the second market: entry occurs as long as a firm retains a minimum amount of residual obligations, that allow it to compete on equal footing with the rival, while it does not enter if residual obligations are exhausted, with a cost disadvantage for any level of output. It should be stressed that $\Pi^i(w, 0; \psi)$, and the minimum marketing cost f, may be very low, in particular if w is high and/or ψ is low: a significant cost disadvantage and/or intense competition reduce the profits of the firm that has exhausted its obligations, supporting the segmentation result. In this case even small entry costs f will determine market segmentation, extending significantly the occurrence of monopoly prices far beyond what the traditional blockaded entry result would suggest.[17]

Finally, inequality (12) explains why focussing just on the homogeneous product price competition setting is not well suited to analyze our case: in the Bertrand model ($\psi \to 0$) $\Pi^i(0, 0; 0) = \Pi^i(w, w; 0) = \Pi^i(w, 0; 0) = 0$ and no competitive outcome occurs even with symmetric firms if $f > 0$ (blockaded entry), a result quite in contrast with the idea that retail markets are potentially competitive. In other words, in the Bertrand setting liberalization and

[16] The inequalities are consistent with the following effects: $\partial\Pi^i/\partial c^i < 0$, $\partial\Pi^i/\partial c^j > 0$ and $\partial\Pi^i/\partial\psi > 0$.

[17] More generally, the condition $f \geq \Pi^i(w, 0; \psi)$ identifies a region in the (w, ψ, f) space in which segmentation occurs, that is much wider than the region of blackaded entry, implicitly defined by $f \geq \Pi^i(0, 0; \psi)$.

retail competition are justified only if we have strictly zero fixed entry costs, while monopolization would arise otherwise. However, if we assume that $f = 0$ to guarantee that competition is feasible, firms would obtain zero net profits entering or not, and even entering when they have exhausted their obligations. Since firms are indifferent in all these outcomes, the entry pattern would depend entirely on the assumptions we make regarding the way these ties are broken, quite an artificial result.[18] With some degree of imperfect competition ($\psi > 0$), instead, the entry choices are clearly determined.

A result close to our segmentation outcome can be found in Dubey (1992) on dynamic pricing with (absolute) capacity constraints. Dubey's paper modifies the standard Edgeworth-Bertrand setting assuming that consumers enter in the market sequentially and purchase during the period; the firms, endowed with a fixed capacity, compete in prices in each period to attract the current consumer. In this setting, pricing in different periods is the key ingredient that allows firms to avoid cut-throat competition or Edgeworth-cycling, exhausting their capacity sequentially and serving consumers at monopoly prices. We obtain similar results with a more flexible technology, that exhibits discontinuous marginal cost rather than absolute capacity constraints, without dynamic pricing and also admitting some degree of product differentiation. Moreover, in Appendix II we prove that segmentation occurs even when both firms decide simultaneously to enter in the different submarkets and then, having observed the entry choices, set simultaneously a price in each of the submarket where they entered. In our setting, indeed, the key ingredient is the different timing in entry and pricing decisions. rather than a full dynamic pricing environment.

4 Restoring retail competition

The inequality (12) suggest that the segmentation outcome can occur when firms have asymmetric marginal costs, but generalized entry and competition would prevail in a symmetric cost environment. We have argued that asymmetric costs in the natural gas market do not arise from the features of technology, but they occur due to the TOP obligations that create a discontinuity in the marginal costs of the retailers. In this section we consider two ways of restoring flat and symmetric marginal costs in retail activity, a condition that removes the incentives to segment the market. In both cases, unbundling of wholesale and retail activities is needed. The first solution then entails the creation of a compulsory wholesale market where the wholesalers bearing TOP obligations sell gas and where the retailers buy whatever amount they need at a (linear) wholesale price. Alternatively, we may maintain bilateral trades of wholesalers

[18] For instance, to replicate the segmentation result in a homogeneous product setting we have to *assume* what instead would be strictly optimal with product differentiation, namely that firms enter (and get zero profits) when they have symmetric costs while they stay out (getting zero profits as well) if they have a cost disadvantage.

and retailers for the provision of gas, imposing regulatory constraints on the contracts in the form of linear wholesale prices and non discrimination clauses.[19]

Let us consider in more detail the creation of a wholesale compulsory market once the wholesale and retail activities have been unbundled. We try to model this alternative environment keeping the structure of the model as close as possible to the benchmark case.

The wholesale market. On the supply side of the wholesale market, we have two large operators (our firms I and C). They obtain gas from the producers on the basis of long term contracts with TOP clauses as described in the benchmark model, up to output levels $\overline{q}^I$ and $\overline{q}^C$ with $\overline{q}^I + \overline{q}^C = D$. On the demand side we have the retail firms, which buy gas from the wholesale market and resell it to final consumers. Since gas is a commodity, wholesale transactions entail perfectly homogenous supplies by the two wholesalers. The equilibrium wholesale price p_w clears the market.

The retail market. The retailers buy at the (linear) wholesale price and therefore are free from TOP obligations, and each of them has the same constant marginal cost, equal to the gas wholesale price p_w, for any amount of gas demanded. As in the benchmark model, final demand can be decomposed into D submarkets of size equal to 1, and the retailers have to decide which submarkets to serve. The customers in each submarket considers the retailers' supplies as differentiated according to service or location elements. In order to keep the structure of the model as similar as possible to the benchmark case, we maintain the assumption that also the retail market is a duopoly[20], with firm a offering variety $x^a = \frac{1}{4}$ and firm b offering variety $x^b = \frac{3}{4}$ in each submarket.

To sum up, the final demand is the same as in the benchmark model, and the same is true for the wholesale supply of gas and the costs of TOP contracts. However, once a wholesale market is introduced, we obtain a separation between the wholesalers I and C bearing TOP obligations and the retailers a an b, that select the submarkets they will serve at a constant marginal cost p_w.

Since the retailers in this setting have always the same marginal cost p_w, when analyzing their entry and price decisions the problem faced by the two firms in each submarket is the same, and no strategic effect across markets occur since the marginal cost in a given submarket does not depends on the decisions in other submarkets. Moreover, since the number of submarkets D is finite, the subgame perfect equilibrium involves the repetition in every submarket of the same strategy configurations that maximize the submarket's profits. These

[19] An alternative solution might be to prohibit TOP clauses in the contracts. However, this measure does not seem easy to implement since most of the gas imported by member countries comes from outside the European Union, and international contracts are out of the jurisdiction of national (or even Community) authorities. We recognize that the European Commission has been able to impose some revisions of the international contracts, for instance abolishing the destination clauses. However we argue that eliminating TOP clauses would be much harder, if we consider that these restrictions, beyond thier impact on retail competition, have a genuine reasons of risk sharing between producers and users when huge transport infrastructures must be realized.

[20] The extension to the N retailers case using the circular road version of the Hotelling model (Salop (1979)) is however straightforward.

features allow us to adopt a very simple time structure, in which firms first and simultaneously select which of the $d = 1, .., D$ submarkets to enter and then, being the entry choices public information, simultaneously post prices in each of the submarkets entered. This simple timing gives the same results as the one we might adapt from the benchmark model, i.e. grouping the submarkets in two subsets D_1 and D_2 and assuming sequential entry.

Entering and setting prices allows the two retailers a and b to collect the orders. The expected demand for firm $i = a, b$ from customers in submarket d , D_d^i, can be derived according to the same logic of the benchmark model (expressions (1) and (2)). In particular, if both firms a and b enter in submarket d (of size 1) the demand for firm j, $i = a, b$, $i \neq j$, is given by (3).

Total demand for retailer $i = a, b$ is therefore $D^i(p^a, p^b) = \sum_{d=1}^{D} D_d^i(p_d^a, p_d^b)$ where p^a and p^b are the vectors of prices set by the two firms in the D submarkets. Finally, $D(p^a, p^b) = D^a(p^a, p^b) + D^b(p^a, p^b)$ is total demand from the retailers in the wholesale market. The two wholesalers I and C compete in prices given total demand.

The timing of the game is:

- (*marketing*) at $t = 1$ the retailers $i = a, b$ decide simultaneously whether to enter submarkets $d = 1, .., D$ (with total demand D); the entry choices become public information once taken;
- (*retail price*) at $t = 2$ the retailers set simultaneously the price vectors p^a and p^b and collect the orders in the submarket where they entered;
- (*wholesale price*) at $t = 3$ the wholesalers I and C compete in prices in the (wholesale) market, given the demand from the retailers $D(p^a, p^b)$. The retailers purchase at the equilibrium wholesale price p_w and serve the final customers at the contracted prices p^a and p^b.

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

Proposition 5: *When total wholesale demand equals retail market demand, i.e.* $D(p^a, p^b) = D$, . *When* $D(p^a, p^b) = D$, *the equilibrium wholesale prices are* $p^I = p^C = p_w = w$. *When* $D(p^a, p^b) < D$ *the equilibrium wholesale prices are* $p^I = p^C = p_w \in [0, w)$ *and if the sharing rule adopted when the firms set the same price requires that* $\frac{\partial D^i}{\partial D(p^a, p^b)} \geq 0$, $i = I, C$, *the wholesale price is increasing in* $D(p^a, p^b)$.

Proof. See Appendix. ■

The wholesale equilibrium prices described in Proposition 5 are equal to the unit cost of gas w if $D(p^a, p^b) = D$ $(= \overline{q}^I + \overline{q}^C)$, i.e. if the retailers serve all the consumers, while $p_w < w$ if the retail market is rationed, i.e. $D(p^a, p^b) < D$. Moreover, under the reasonable assumption that when the wholesalers set the same price the individual demand is increasing in total demand, the wholesale price is increasing in total sales. Hence, although the wholesalers have a stepwise marginal cost curve, the equilibrium wholesale price is an increasing function of total wholesale supply of gas. We can now conclude our analysis considering the equilibrium in the retail market.

Proposition 6: *(Generalized entry and retail competition) In the retail market, each firm $j = a, b$ enters in all submarkets $d = 1, ..D$, and sets a price $p_d^j = p_w + \frac{\psi}{2}$. The subgame perfect equilibrium of the game is therefore characterized by wholesale prices $p^I = p^C = w$ and retail prices $p_a^d = \widehat{p}_b^d = w + \frac{\psi}{2}$.*

Proof. See Appendix. ■

A wholesale market, determining a flat marginal cost curve at p_w, eliminates the strategic links among the marketing decisions in the different submarkets: the marginal cost of the retailers is always the same, and it does not depend on the entry and price strategies in the other submarkets. Then, the entry decisions are determined by the (positive) contribution to total profits of the additional segment that is served.

Unbundling wholesale and retail activities and introducing a compulsory wholesale market[21] allows avoiding the segmentation outcome of the retail market and leads to generalized competition and lower retail margins (prices). The wholesale firms, on the other hand, are able to cover their TOP obligations with no losses. In this setting, the competitive bias deriving from long term supply contracts and take-or-pay clauses is avoided, because when the retailers purchase the gas in a liquid wholesale market they have flat and symmetric marginal costs independently of individual output levels. 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 any additional submarket a firm would always have the same costs as the rivals and would always gain margins over the wholesale price that are sufficient to

[21] Unbundling and the restriction that all the transactions should be realized in the wholesale market (compulsory wholesale market) are crucial. If we maintain integrated wholesale-retail activities and simply add a non compulsory wholesale market, we would not avoid the segmentation result. Since spending TOP obligations in the provision of its retailing unit allows a wholesaler to monopolize the final market, it is profitable for each operator to sell in the wholesale market only additional output that may be required beyond the TOP obligations. For instance, a wholesale market used only for balancing services would fit this case.

cover the fixed marketing costs, since $\Pi^i(p_w, p_w; \psi) > f$. Hence, generalized entry and competition replace selective entry and monopoly pricing.[22]

It should be stressed that competition in the upstream segment, where the wholesale suppliers sell to the market, may 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[23] has shown that the Bertrand equilibrium corresponds to the case when the firms use a supply curve equal to their true marginal costs; but if firms are able to commit to a supply curve that includes a mark-up over marginal costs, the equilibrium wholesale 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 p_w might be much higher than w if the wholesalers use more complex strategies, increasing accordingly the price for the final customers.

The separation of wholesalers and retailers and the creation of a wholesale market, therefore, ensure to squeeze retail margins, but has no effect on the kind of competition in the wholesale market. Even in this case, however, the outcome in the present setting cannot be worse for customers than that of the benchmark model: if the wholesalers collude they will find it profitable to set a wholesale price $\overline{p}^w$ such that all the final customers purchase given the equilibrium retail prices, i.e. $\overline{p}^w + \frac{\psi}{2} = u^* - \frac{9}{16}\psi$. In this case, we have no improvement with respect to the case of decentralized markets. Any wholesale price below $\overline{p}^w$, however, will increase final customers surplus by decreasing retail prices. In this sense, introducing a wholesale market makes customers (weakly) better off.

Once understood why flat marginal costs lead to generalized entry, it is easy to consider the alternative solution to the segmentation result, based on the unbundling of wholesale and retail activities, bilateral contracting of wholesalers and retailers and regulatory restrictions on the gas provision contracts. The first restriction refers to the commitment to use linear wholesale prices in order to avoid any discontinuity in the retailers' marginal costs. However, this restriction is not sufficient. Suppose that the wholesalers agree on a linear wholesale price p_w^a with retailer a that is higher than the wholesale price p_w^b contracted with the other retailer. In this case retailer a would have a cost disadvantage that limits its ability to compete, and if the difference in the two wholesale prices is sufficiently large, as for instance $p_w^a - p_w^b > \frac{3}{2}\psi$, retailer b would be unable to profitably enter any submarket.[24] Hence, we should add to the linear price

[22] Notice that sequential entry in each submarket would determine the same result, since there is no strategic link among submarkets and it is a dominant strategy for both firms to enter in each submarket.

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

[24] In this case the equilibrium prices would be

$$p_d^a = \frac{3\psi + 4p_w^a + 2p_w^b}{6}$$

$$p_d^b = \frac{3\psi + 4p_w^b + 2p_w^a}{6}$$

restriction a prohibition to price discriminate between retailers, a principle that we often find in the European Directives on energy markets . Unbundling together with linear and non discriminating wholesale price would determine the same cost structure of the retailers that we obtain with a wholesale market. Notice that if the wholesalers have market (bargaining) power, even in this alternative setting we might have a (common) wholesale price that is above the true cost of gas w.[25] While this alternative solution may appear simpler than the construction of a wholesale market, we should consider that there is a serious issue of transparency that emerges if we want to implement the linear and non discriminating wholesale price restrictions: usually the long term supply contracts are not public and they often involve non-EU firms. Then it would be hard to obtain precise information on the specific terms in order to check their consistency with the restrictions introduced. All these transparency issues would be avoided in case of a centralized and compulsory wholesale market.

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 properly designing and regulating wholesale and retail markets and of promoting competition seems the next step that the liberalization policies need to address.

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and therefore

$$D_d^a = \frac{1}{2} + \frac{p_d^b - p_d^a}{\psi} = 0$$

if

$$p_w^a - p_w^b > \frac{3}{2}\psi.$$

[25] Notice that in this case we obtain a trade-off that is often mentioned in the debate on gas liberalization: fragmenting the retail segment may enhance competition, squeezing retail margins, but in turn might weaken the bargaining position of the retails when they contract with the wholesalers, leading to higher wholesale prices.

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5 Appendix I: proofs

Proof of Lemma 1.

Proof. Notice at first that for given p_2^j any $p_2^i \leq \overline{p}_2^i(p_2^j, \overline{q}_2^i) \rightarrow D_2^i(p_2^i, p_2^j) \geq \overline{q}_2^i$ $\rightarrow c = w$ and any $p_2^i > \overline{p}_2^i(p_2^j, \overline{q}_2^i) \rightarrow D_2^i(p_2^i, p_2^j) < \overline{q}_2^i \rightarrow c = 0$. Let us consider the three following cases:

- if for a given p_2^j we have $D_2^i(\widehat{p}_2^i(p_2^j, 0), p_2^j) < \overline{q}_2^i$, then, $BR_2^i(p_2^j) = \widehat{p}_2^i(p_2^j, 0)$. We have in fact $\overline{p}_2^i(p_2^j, \overline{q}_2^i) < \widehat{p}_2^i(p_2^j, 0)$, the profits are maximized at $\widehat{p}_2^i(p_2^j, 0)$ for any $p_2^i > \overline{p}_2^i(p_2^j, \overline{q}_2^i)$, they are increasing (from above) at $\overline{p}_2^i(p_2^j, \overline{q}_2^i)$ and become steeper for lower p_2^i as the marginal costs switches from 0 to w. Solving explicitly the condition $D_2^i(\widehat{p}_2^i(p_2^j, 0), p_2^j) = \overline{q}_2^i$ in terms of p_2^j gives us the boundary of this region. If $\frac{\psi}{2D_2}(4\overline{q}_2^i - D_2) > 0$ this region is nonempty.

- if for a given p_2^j we have $D_2^i(\widehat{p}_2^i(p_2^j, w), p_2^j) \geq \overline{q}_2^i, \rightarrow \overline{p}_2^i(p_2^j, \overline{q}_2^i) \geq \widehat{p}_2^i(p_2^j, w)$, then, $BR_2^i(p_2^j) = \widehat{p}_2^i(p_2^j, w)$. Indeed, the profits are maximized at $\widehat{p}_2^i(p_2^j, w)$ for any $p_2^i \leq \overline{p}_2^i(p_2^j, \overline{q}_2^i)$, they are decreasing and continuous at $\overline{p}_2^i(p_2^j, \overline{q}_2^i)$ and decreasing for higher p_2^i when we enter into the region where the marginal costs switches from w to 0, since $\widehat{p}_2^i(p_2^j, 0) < \widehat{p}_2^i(p_2^j, w)$. Solving explicitly the condition $D_2^i(\widehat{p}_2^i(p_2^j, w), p_2^j) = \overline{q}_2^i$ in terms of p_2^j gives us the boundary of this region.

- for intermediate values of p_2^j we have $D_2^i(\widehat{p}_2^i(p_2^j,0),p_2^j) > \overline{q}_2^i \geq D_2^i(\widehat{p}_2^i(p_2^j,w),p_2^j)$, $\rightarrow \widehat{p}_2^i(p_2^j,0) < \overline{p}_2^i(p_2^j,\overline{q}_2^i) \leq \widehat{p}_2^i(p_2^j,w)$. Hence, at $\overline{p}_2^i(p_2^j,\overline{q}_2^i)$ the profits are kinked, $\Pi_2^i(p_2^i,p_2^j,w)$ is non-decreasing from below and $\Pi_2^i(p_2^i,p_2^j,0)$ is non-increasing from above, implying that $BR_2^i(p_2^j) = \overline{p}_2^i(p_2^j,\overline{q}_2^i)$. If $\frac{\psi}{2D_2}(4\overline{q}_2^i - D_2) > 0$, when $p_2^j = \frac{\psi}{2D_2}(4\overline{q}_2^i - D_2)$ we have $\widehat{p}_2^i(p_2^j,0) = \overline{p}_2^i(p_2^j,\overline{q}_2^i)$, i.e. the best reply $BR_2^i(p_2^j)$ is continuous moving from the first to the second region. For $p_2^j = w + \frac{\psi}{2D_2}(4\overline{q}_2^i - D_2)$ we have $\widehat{p}_2^i(p_2^j,w) = \overline{p}_2^i(p_2^j,\overline{q}_2^i)$ and the best reply $BR_2^i(p_2^j)$ is continuous moving from the second to the third region.

■

Proof of Proposition 1

Proof. Let us consider first the case when only one firm enters market 2. The demand is described above by (1) or (2). The highest price at which every consumer buys one unit of the good is $p_m = u^* - \frac{9}{16}\psi$. As long as $u^* \geq \frac{33}{16}\psi$, any price above p_m implies a fall in the monopolist's profit. Moreover, we require that $p_m \geq w$. The two conditions are met under assumption (5). The profits are maximized at p_m for any level of the marginal cost, and therefore, the equilibrium price if only one firm enters in the market is $p_2^{i*} = p_m = u^* - \frac{9}{16}\psi$ for any possible level of the residual obligations of the competitor.

Turning to the case of both firms entering market 2, we start by identifying precisely the combinations of residual obligations $(\overline{q}_2^I, \overline{q}_2^C)$ that can occur in the second market for any possible entry and pricing decision of the two firms in the first market. This allows us to restrict our analysis of the equilibrium in the second market to the relevant cases, that are described in the Proposition.

Let's consider first all the possible cases in which the firm(s) set a price that induce *all the consumers* in the first market to purchase. Since $\overline{q}^I + \overline{q}^C = D_1 + D_2$ if only I enters then $\overline{q}_2^I = 0$ and $\overline{q}_2^C = D_2$ (case a). If only C enters $\overline{q}_2^I = D_1 > D_2$ and $\overline{q}_2^C = 0$ (case b). If both enter in the first market and $D_1^C(p_1^I,p_1^C) \leq \overline{q}^C$ then $\overline{q}_2^I + \overline{q}_2^C = D_2$ (case a). If both enter and $D_1^C(p_1^I,p_1^C) > \overline{q}^C$ then $\overline{q}_2^I > D_2$ and $\overline{q}_2^C = 0$ (case b).

We turn now to all the cases in which the price(s) set by the firm(s) induce *only a fraction of consumers* in the first market to purchase. If only I enters then $\overline{q}_2^I + \overline{q}_2^C > D_2$ with $\overline{q}_2^I > 0$ and $\overline{q}_2^C = D_2$ (case b or c). If only C enters $\overline{q}_2^I = D_1 > D_2$ and $\overline{q}_2^C \geq 0$ (case b or c). If both enter in the first market and $D_1^C(p_1^I,p_1^C) \leq \overline{q}^C$ then $\overline{q}_2^I + \overline{q}_2^C > D_2$ with $\overline{q}_2^I > 0$ and $\overline{q}_2^C \geq 0$ (case b or c). If both enter and $D_1^C(p_1^I,p_1^C) > \overline{q}^C$ then $\overline{q}_2^I > D_2$ and $\overline{q}_2^C = 0$ (case b). Finally, if no firm enters in the first market, both retain their initial obligations: $\overline{q}_2^I = D_1$ and $\overline{q}_2^C = D_2$ (case c).

We can now turn to identify the price equilibria when both firm enter in the second market, falling in one of the three cases above. The best reply functions in these subgames differ for the position of the intermediate segments

$$\begin{aligned}
\overline{p}_2^i(p_2^j, \overline{q}_2^i) &= p_2^j - \frac{\psi}{2D_2}(2\overline{q}_2^i - D_2) \\
\overline{p}_2^j(p_2^i, \overline{q}_2^j) &= p_2^i - \frac{\psi}{2D_2}(2\overline{q}_2^j - D_2).
\end{aligned}$$

If $\overline{q}_2^i + \overline{q}_2^j = D_2$ the two segments overlap, i.e. $\overline{p}_2^i(\overline{p}_2^j(p_2^i, \overline{q}_2^j), \overline{q}_2^i) = p_2^i$ while if $\overline{q}_2^i + \overline{q}_2^j > D_2$ then $\overline{p}_2^i(p_2^j, \overline{q}_2^i)$ lies to the left (above) $\overline{p}_2^j(p_2^i, \overline{q}_2^j)$ in the (p_2^i, p_2^j) space. Let us now consider the three cases in the statement of the Proposition.

In case a), $\overline{q}_2^i + \overline{q}_2^j = D_2$, the two best reply functions overlap along the intermediate segments giving a continuum of Nash equilibria. Among them, we select the Pareto dominant (for firms) price pair. If $\overline{q}_2^i \leq D_2/2$ the two best reply functions overlap below or at the locus $p_2^i = p_2^j$ and the Pareto dominant price pair is identified - see figure 2.a - by the intersection of $\overline{p}_2^j(p_2^i, \overline{q}_2^j)$ and $\widehat{p}_2^i(p_2^j, w)$, i.e. $p_2^{i*} = \widehat{p}_2^i(p_2^{j*}, w)$ and $p_2^{j*} = \overline{p}_2^j(p_2^{i*}, \overline{q}_2^j)$. The solution is given in the statement of the Proposition. Notice that the two firms sell exactly their residual obligations and that $p_2^{i*} > p_2^{j*} > 0$ due to assumption (6).

In case b) we have $\overline{q}_2^i + \overline{q}_2^j > D_2$ and $\overline{q}_2^i \leq D_2/2 < \overline{q}_2^j$. Hence, the intermediate segments of both best reply functions are below the locus $p_2^i = p_2^j$, with $\overline{p}_2^i(p_2^j, \overline{q}_2^i)$ above $\overline{p}_2^j(p_2^i, \overline{q}_2^j)$. Then, the two best reply functions intersect - see figure 2.b - at $p_2^{i*} = \overline{p}_2^i(p_2^{j*}, \overline{q}_2^i)$ and $p_2^{j*} = \widehat{p}_2^i(p_2^{i*}, 0)$: the explicit solutions are in the statement. Notice that at the equilibrium prices only firm i, the one with the smaller residual obligations, sells all of them ($p_2^{j*} > \overline{p}_2^j(p_2^{i*}, \overline{q}_2^j)$).

In case c) $\overline{q}_2^i + \overline{q}_2^j > D_2$ and $\overline{q}_2^i, \overline{q}_2^j > D_2/2$ the intermediate segment $\overline{p}_2^i(p_2^j, \overline{q}_2^i)$ lies above the locus $p_2^i = p_2^j$ while $\overline{p}_2^j(p_2^i, \overline{q}_2^j)$ lies below it. Then, the two best reply functions intersect - see figure 2.c - at $p_2^{i*} = \widehat{p}_2^i(p_2^{j*}, 0)$ and $p_2^{j*} = \widehat{p}_2^j(p_2^{i*}, 0)$ and in the symmetric equilibrium each firm covers half of the market. ■

Proof of Proposition 2.

Proof. According to Proposition 1, if only one firm enters in market 2, it obtains monopoly profits and covers the fixed marketing costs fD_2. Hence, if C observes that I does not enter, it is always optimal to enter market 2. Proposition 1 has also identified the prices, sales and gross profits when both firms enter in the second market, distinguishing three cases. In case a) both firms sell their residual obligations and therefore sales and gross profits decrease the lower the obligations left to fulfill. In our notation firm i is the one with the lower residual obligations: when $\overline{q}_2^i$ is sufficiently small, the gross profits do not allow covering the marketing costs fD_2. The same argument applies to case b), where only the firm (firm i in our notation) with the smaller residual obligations, cover them in equilibrium. We can therefore define a threshold on the residual obligations, $\overline{q}(a)$ or $\overline{q}(b)$, above which entry is profitable in the two cases a) and b) and below which the firm with the smaller residual obligations does not enter. In case c) the gross profits obtained, $\psi D_2/4$, are larger than the fixed marketing costs fD_2 by assumption (7) and both firms enter. ■

Proof of Proposition 3.

Proof. In the following we denote as Π^i, Π_1^i and Π_2^i, respectively, the overall profits of firm i and the profits it gains in the first and second market.

Point (a). We consider the incentives to overpricing of the incumbent, that has a larger TOP obligations. I has two alternatives. Set $p_m = u^* - \frac{9}{16}\psi$ and maximize Π_1^I, cover market 1 and don't enter market 2, having exhausted its obligations; alternatively, set $p_1^I > p_m$ with lower Π_1^I, retain some obligations in market 2 and enter and price accordingly in the second market, with profits $\Pi^I = p_1^I D_1^I(p_1^I) + \min\left\{\psi\frac{D_2}{2}, (3\psi - 4\psi\overline{q}_2^I/D_2)\overline{q}_2^I\right\}$. Then the derivative of the profit function evaluated at $p_1^I \longrightarrow^+ u^* - \frac{9}{16}\psi$ is

$$\frac{\partial \Pi^I}{\partial p_1^I} = 1 - \frac{2}{3\psi}(u^* - \frac{9}{16}\psi) - \frac{9D_1 - 12D_2}{12\psi D_2} < 0$$

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

Point (b). Let us define the following subsets of the strategy space $P = \left\{(p_1^I, p_1^C) \in [0, u^*]^2\right\}$:

$$P^I = \left\{(p_1^I, p_1^C) \middle| p_1^I \in [0, u^*], p_1^C \in [0, \min\left\{p_1^I + \psi\widetilde{D}, u^*\right\}]\right\} \tag{13}$$
$$P^{IC} = \left\{(p_1^I, p_1^C) \middle| p_1^I \in [0, u^* - \psi\widetilde{D}], p_1^C \in (p_1^I + \psi\widetilde{D}, \min\left\{p_1^I + \frac{\psi}{2}\widehat{D}, u^*\right\})\right\}$$
$$P^C = \left\{(p_1^I, p_1^C) \middle| p_1^I \in [0, u^* - \frac{\psi}{2}\widehat{D}], p_1^C \in [p_1^I + \frac{\psi}{2}\widehat{D}, u^*]\right\}$$

where $\widetilde{D} = (D_1 - 2(D_2 - \overline{q}(a))/2D_1$ and $\widehat{D} = (D_1 - 2\overline{q}(a))/2D_1$. When $(p_1^I, p_1^C) \in P^I$ firm C exhausts almost its obligations in the the first market ($D_1^C(p_1^I, p_1^C) \geq D_2 - \overline{q}(a)$ that implies $\overline{q}_2^I > D_2$ and $\overline{q}_2^C \leq \overline{q}(a)$) and therefore C does not enter in market 2, while firm I will enter as a monopolist. Conversely, when $(p_1^I, p_1^C) \in P^C$ firm I covers most of market 1 demand and almost exhausts its capacity ($D_1^I(p_1^I, p_1^I) \geq D_1 - \overline{q}(a)$ that implies $\overline{q}_2^I \leq \overline{q}(a)$); therefore only C will enter in the second market. Finally, for $(p_1^I, p_1^C) \in P^{IC}$ both firms retain sufficient residual obligations and will enter also in the second market. Hence, the three sets imply different entry patterns in the second stage. Notice, for future reference, that $P^I$and P^C are closed sets while P^{IC} is open. From the previous discussion, the incumbent's profits jump up at the boundary of P^I since the monopoly profits in market 2 are added, while the competitor's profits have a similar pattern at the boundary of P^C. Finally, the industry profits $\Pi = \Pi^I + \Pi^C$ are discontinuous at the boundaries of P^I and P^C, since the joint profits when the second market is a duopoly (region P^{IC}) are strictly lower than those obtained when it becomes a monopoly. Once introduced this notation we can prove part (b) proceeding in the three steps.

Step 1. We start proving that no price equilibrium in pure strategies exists if both firms enter in the first market.

We shall show that firm I's optimal reply requires to choose always a price in P^I while firm C optimally selects a price at the boundary of P^C or, for low $\overline{q}^C$, internal to P^I when p_1^I is sufficiently high. In any case, the optimal replies never intersect.

Let us consider the incumbent's optimal reply. For $D_2 < \frac{3}{4}D_1$ and $p_1^C \leq \psi\frac{3D_1-4D_2}{2D_1}$ the price that maximizes firm I's profits in the first market producing at zero marginal cost, $\widehat{p}_1^I(p_1^C, 0) = \frac{p_1^C}{2} + \frac{\psi}{4}$, belongs to P^I. This is clearly the optimal reply for I: this price maximizes the incumbent's profits Π_1^I in the first market and, being consistent with competitor's sales not lower than $D_2 - \overline{q}(a)$, it secures to the incumbent also the monopoly profits in the second market. For $p_1^C \geq \psi\frac{3D_1-4D_2}{2D_1}$, by moving along $\widehat{p}_1^I(p_1^C, 0)$ we enter in region P^{IC} where both firms enter both markets. Then, for $p_1^C > \psi\frac{3D_1-4D_2}{2D_1}$, the optimal reply for the incumbent would be to corner firm C making it almost exhausting its obligations and preventing its later entry, i.e. setting $p_1^I = p_1^C - \psi\widetilde{D}$, the price at the boundary of region P^I. That way the incumbent continues to sell (at increasing prices) $D_1 - D_2 + \overline{q}(a)$ in the first market but secures the monopoly profits in the second market. For $D_1 > D_2 > \frac{3}{4}D_1$ the incumbent's optimal reply is at the boundary of P^I that is $p_1^I = \overline{p}_1^I(p_1^C) = p_1^C - \psi\widetilde{D}$ for any price of the competitor, since $\widehat{p}_1^I(p_1^C, 0)$ never belongs to P^I.

Hence, the best reply of the incumbent is always included in P^I and the incumbent maximizes always its profits by preventing firm C's entry in the second market.

Turning to firm C, for $p_1^I \geq w + \psi\frac{4(D_2-\overline{q}(a))-D_1}{2D_1}$ firm C's optimal reply when maximizing market 1's profits, $\widehat{p}_1^C(p_1^I, w) = \frac{p_1^I}{2} + \frac{w}{2} + \frac{\psi}{4}$, lies in region P^I: firm C sells more than its obligations in market 1 and does not enter the second market. If market 2 is very small, this strategy may dominate that of letting the incumbent covering almost all market 1's demand and securing market 2's monopoly profits. For lower prices p_1^I, $\widehat{p}_1^C(p_1^I, w)$ would imply lower sales at lower prices in market 1 and entry and competitive prices in market 2, i.e. a fall in profits. At some point, before reaching the boundary of P^I, it becomes preferable to set a price at the boundary of P^C letting the incumbent covering almost all market 1's demand and securing market 2's monopoly profits. If instead firm C's obligations (and market 2) are sufficiently large, setting the price at the boundary of P^C is always the optimal reply. Hence, for large competitor's obligations each firm $i = I, C$ wants to corner the rival by picking up the price in P^i, while in case of small obligations and market 2's demand the incumbent finds it profitable to let the competitor sell more than its obligations (pick up a price inside P^I) for low prices p_1^C, while C find it profitable to follow the same pattern for high prices p_1^I. Hence, in both cases, the two best reply functions never intersect. Consequently, there is no price equilibrium in pure strategies. 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 is a compact and convex subset of R^+ and the discontinuity set for the incumbent is (using Dasgupta and Maskin notation)

$$P^{**}(I) = \left\{ (p_1^I, p_1^C) \middle| p_1^I \in [0, u^* - \psi \widetilde{D}], p_1^C = p_1^I + \psi \widetilde{D} \right\},$$

i.e. the boundary of P^I. Analogously, the discontinuity set for the competitor is

$$P^{**}(C) = \left\{ (p_1^I, p_1^C) \middle| p_1^I \in [0, u^* - \frac{\psi}{2} \widehat{D}], p_1^C = p_1^I + \frac{\psi}{2} \widehat{D} \right\},$$

i.e. the boundary of P^I. 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 $\Pi^i(p_1^I, p_1^C)$ is continuous elsewhere. Second, $\Pi = \Pi^I + \Pi^C$ is upper semi-continuous (see Definition 2 in Dasgupta and Maskin (1986)): since Π^I, Π^C and Π are continuous within the three subsets P^I, P^{IC} and P^C, for any sequence $\{p^n\} \subseteq P^j$ and $p \in P^j$, $j = I, IC, C$, 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^{IC}, i.e.$\{p^n\} \subseteq P^{IC}$ and $p \in P^{**}(i)$, $i = I, C$, such that $p^n \longrightarrow p$, then $\lim_{n \longrightarrow \infty} \Pi(p^n) < \Pi(p)$, i.e. the joint profits jump up. Third, $\Pi^i(p_1^I, p_1^C)$ is weakly lower semi-continuous in p_1^i according to Definition 6 in Dasgupta and Maskin (1986). At $(\overline{p}_1^I, \overline{p}_1^C) \in P^{**}(I)$, if we take (see Dasgupta and Maskin (1986) $\lambda = 0$, $\lim_{p_1^I \longrightarrow^+ \overline{p}_1^I} \Pi^I(p_1^I, \overline{p}_1^C) = \Pi_1^I(\overline{p}_1^I, \overline{p}_1^C)$. Analogously, at $(p_1^I, \overline{p}_1^C) \in P^{**}(C)$, if we take $\lambda = 1$, $\lim_{p_1^C \longrightarrow^- \overline{p}_1^C} \Pi^C(p_1^I, \overline{p}_1^C) = \Pi_1^C(\overline{p}_1^I, \overline{p}_1^C)$. Then all the conditions required in Theorem 5 are satisfied and a mixed strategy equilibrium (μ_1^{I*}, μ_1^{C*}) exists.

Point 3. Finally, we prove that $E\Pi^I(\mu_1^{I*}, \mu_1^{C*}) > 0$ and $E\Pi^C(\mu_1^{I*}, \mu_1^{C*}) < (u^* - \frac{9}{16}\psi)D_2$. The first inequality simply follows from the fact that $\Pi^i(p_1^i, p_1^j) > 0$ for any admissible price pair. To establish the second inequality we can proceed by contradiction. Suppose that the equilibrium mixed strategies μ_1^{I*}, μ_1^{C*} are such that $p \in P^C$ occurs with probability 1, with an expected profit for firm C equal to $E\Pi^C(\mu_1^{I*}, \mu_1^{C*}) = (u^* - \frac{9}{16}\psi)D_2$. From point 1, we know that the best reply of the incumbent is always included in P^I for any price $p_1^C \in [0, u^*]$; therefore, Π^I is always increasing in p_1^I moving from region P^C to P^{IC} to P^I. Then, the incumbent can profitably deviate by giving more weight μ_1^I (or choose with probability 1) to prices such that $p \in P^I$ and $p \in P^{IC}$ occur with positive probability. Hence, in a mixed strategy it cannot be that $p \in P^C$ occurs with probability 1, and P^I and P^{IC} have to occur with positive probability. The competitor obtains profits lower than $(u^* - \frac{9}{16}\psi)D_2$ when $p \in P^{IC}$ and, for D_2 sufficiently large, for $p \in P^I$, since its best reply is always at the boundary of region P^C. Hence, the expected profits in a mixed strategy equilibrium must be $E\Pi^C(\mu_1^{I*}, \mu_1^{C*}) < (u^* - \frac{9}{16}\psi)D_2$. When D_2 is small, for very high prices of the incumbent the competitor's optimal reply is in P^I: the competitor optimally sets $\widehat{p}_1^C(p_1^I, w)$ and covers a very large fraction of the (large) first market, renouncing to enter in the (small) second market as a monopolist. However, it cannot be that in a mixed strategy equilibrium this outcome occurs with a probability sufficiently high to make $E\Pi^C(\mu_1^{I*}, \mu_1^{C*}) \geq (u^* - \frac{9}{16}\psi)D_2$. In this case, indeed, the incumbent, would induce the competitor to almost exhaust its obligations (obtaining to enter as a monopolist in the small second market) in a too generous way, by leaving a large fraction of the large first market to the competitor and making it selling more than its obligations. Remind that in the region where the competitor sets $\widehat{p}_1^C(p_1^I, w)$, the profits of the incumbent are decreasing in p_1^I. By putting more weight on lower prices the incumbent would be better off. Then, $E\Pi^C(\mu_1^{I*}, \mu_1^{C*}) < (u^* - \frac{9}{16}\psi)D_2$. ■

Proof of Proposition 4.

Proof. Let us analyze first the case when $\overline{q}^I < D$. 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:

- $e_1^I = 1, e_1^C = 1$: in the mixed strategy equilibrium $E\Pi^I > 0$ and $0 < E\Pi^C < (u^* - \frac{9}{16}\psi)D_2$.
- $e_1^I = 1, e_1^C = 0$: the incumbent uses all its obligations and stays out of the second market. The profits are therefore $\Pi^I = (u^* - \frac{9}{16}\psi - w - f)D_1$ and $\Pi^C = (u^* - \frac{9}{16}\psi - w - f)D_2$.
- $e_1^I = 0, e_1^C = 1$: in this case it is the competitor that covers all the first market demand at the monopoly price staying out at the second stage, that is monopolized by the incumbent. We have therefore $\Pi^I = (u^* - \frac{9}{16}\psi - f)D_2 - wD_1$ and $\Pi^C = (u^* - \frac{9}{16}\psi - w - f)D_1$.
- $e_1^I = 0, e_1^C = 0$: if no firm enters in the first market, both will enter in the second with profits $\Pi^I = (\frac{\psi}{4} - f)D_2 - wD_1$ and $\Pi^C = (\frac{\psi}{4} - f - w)D_2$.

Since the incumbent moves first, and makes positive profits entering the first market for any reaction of the competitor, I enters. Since $E\Pi^C(\mu_1^{I*}, \mu_1^{C*}) < (u^* - \frac{9}{16}\psi)D_2$ the competitor is better off staying out of the first market and becoming a monopolist in the second market. Uniqueness simply follows by construction.

In the case $\overline{q}^I = D$ (and $\overline{q}^C = 0$) the incumbent has enough obligations to cover the entire demand. In this case we have to analyze the marketing and price decisions in just one market, and the firms are driven by the aim of maximizing the market profits, with no further strategic consideration, exactly as it was when we analyzed market 2 equilibria in Propositions 1 and 2. If C enters the price equilibrium corresponds to case a) in Proposition 1, and C sells nothing. Then, given the marketing costs fD_1, firm C has no incentive to enter.[26] ■

[26] Notice that the same outcome would occur also if we disaggregate the marketing and price decisions in the different submarkets $d = 1, .., D$: given the incumbent obligations $\overline{q}^I = D$ there is no way for firm C to enter in an earlier submarket and price in such a way that the incumbent exhausts its residual obligations, creating room for entry in a later stage. Hence, the complete monopolization of the market by the incumbent occurs even in a disaggregated analysis.

Proof of Proposition 5.

Proof. First notice that wholesale demand is $D(p^a, p^b) \leq D$. The wholesalers are not capacity constrained, as they can purchase from the producers at unit cost w any quantity exceeding their obligations $\overline{q}^i$. Hence, as long as the rival is pricing above w, setting a price above the rival leaves with no sales and no profits, and it is never an optimal reply. Considering the price pairs $p^i = p^j \leq w$, $i, j = I, C, i \neq j$, firm i's profits are $\Pi^i = p^j D^i$, where D^i are firm i sales according to a sharing rule that respects the following properties: if $D(p^a, p^b) = \overline{q}^I + \overline{q}^C$, then $D^i = \overline{q}^i$ while if $D(p^a, p^b) < \overline{q}^I + \overline{q}^C$, 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 $\Pi^i = p^j D(p^a, p^b) - w(D(p^a, p^b) - \overline{q}^i)$, i.e. firm i supplies the entire demand and purchases additional gas $D(p^a, p^b) - \overline{q}^i$ at unit price w. Then, comparing the two profits firm i will profitably undercut if:

$$p^j > w \frac{D(p^a, p^b) - \overline{q}^i}{D(p^a, p^b) - D^i} \equiv \underline{p}^j$$

Since overpricing is never profitable, the equilibrium prices will be $p^i = p^j = \min\left\{\underline{p}^i, \underline{p}^j\right\}$. If $D(p^a, p^b) = \overline{q}^I + \overline{q}^C$, then $D^i = \overline{q}^i$ and $\min\left\{\underline{p}^i, \underline{p}^j\right\} = w$. If instead $D(p^a, p^b) < \overline{q}^I + \overline{q}^C$, $\min\left\{\underline{p}^i, \underline{p}^j\right\} < w$. 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. Then we have no explicit solution without choosing a precise rule. However, assuming that $\frac{\partial D^i}{\partial D(p^a, p^b)} \geq 0$, i.e. that if total demand falls individual demand cannot increase when firms set the same price, we obtain

$$\frac{\partial \underline{p}^i}{\partial D(p^a, p^b)} = w \frac{\overline{q}^i - D^i + \frac{\partial D^i}{\partial D(p^a, p^b)}(\min\left\{\underline{p}^i, \underline{p}^j\right\} - \overline{q}^i)}{(\min\left\{\underline{p}^i, \underline{p}^j\right\} - D^i)^2} > 0$$

Hence, even without choosing an explicit sharing rule we are able to show that under reasonable conditions the equilibrium wholesale price p_w is increasing in total demand and sales $D(p^a, p^b)$. ■

Proof of Proposition 6.

Proof. Let us first consider the retail market equilibrium prices. The marginal costs of the two firms is $p_w = w$ if $D(p^a, p^b) = D$ and $p_w < w$ if $D(p^a, p^b) < D$. If both firms enter in submarket d, firm i's profits, $i, j = a, b$, $i \neq j$, are

$$\Pi_d^i = \left[\frac{1}{2} + \frac{p_d^j - p_d^i}{\psi}\right]\left(p^d - p_w\right)$$

If we consider submarket d in isolation, the unique symmetric equilibrium in prices is $p_d^{*i} = p_d^{*j} = p_w + \frac{\psi}{2}$, with the two firms covering half of demand $D_d = 1$. The profits in this submarket are $\Pi_d^i = \frac{\psi}{4}$, independently of the level of the marginal cost p_w. Since the marginal cost of the two firms is flat for any level of output and the profits add-up a margin $\frac{\psi}{2}$ over (any) marginal cost p_w, there is no strategic link among submarket and with total demand in the wholesale market, and this pricing strategy is the symmetric equilibrium in all submarkets where the two firms enter. 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 ($\frac{\psi}{4} - f > 0$ if also the other firm enters and $u^* - \frac{9}{16}\psi - p_w - f > 0$ if the rival stays out).

Since entering in each submarket is the dominant strategy for each firm, both firms will enter in all submarkets setting a price $p_w + \frac{\psi}{2}$ and serving all the customers. Summing up across submarkets, total demand equals D and the wholesale price (marginal cost) is w. ■

6 Appendix II: Simultaneous entry

In this Appendix we briefly discuss the case of simultaneous entry, showing that the segmentation result persists even in this setting. In order to check for robustness, we adopt a completely symmetric framework in which the two firms have the same obligations equal to half of the market D, i.e. $\overline{q}^I = \overline{q}^C = D/2$; then we group the submarkets in two markets $D_n = D/2$, $n = 1, 2$ of equal size. The timing of the game is therefore:

1. At $t = 1$ the two firms decide simultaneously which of the submarkets D_1 and D_2 to enter;
2. At $t = 2$, having observed the entry choices in the previous stage, the two firms set a price simultaneously in the submarket(s) they entered

In terms of notation, we define as $\{0; 1\}$ the subgame when I stays out of any market and C enters the first market, $\{1, 2; 2\}$ as the subgame in which I enters both markets and C enters the second one, etc. For each subgame we consider the price equilibria in the second stage.

We start by a general argument: although prices are chosen simultaneously in the last stage, a link among market 1 and 2 persists since the optimal price in each market requires to equate the marginal (market) revenue to (overall) marginal costs, that depend on the (prices and) sales in both markets.

With a slight abuse of terminology, let us continue to define as "residual obligations" in a given market the obligations not covered by the sales in the other market. Let us briefly reconsider the different cases.

1) Both firms enter both markets: $\{1, 2; 1, 2\}$. In each market (say, market 1) the equilibrium requires each firm to set a price p_1^i that maximizes the profits given its equilibrium price p_2^{i*} in the other submarket and the two prices p_1^{j*} and p_2^{j*}set by the rival. The prices in the other submarket p_2^{i*}

and p_2^{j*} imply sales $D_2^i(p_2^{i*}, p_2^{j*})$ and "residual obligations" $\overline{q}^i - D_2^i(p_2^{i*}, p_2^{j*})$ to be covered in market 1. For a given allocation of obligations between the two markets we have a continuum of equilibrium prices, as in Proposition 1, case a), and we pick up the one that is Pareto dominant for firms, corresponding to the highest price pair along the overlapping segments BC of the two firms (see figure 2. case 1). Moreover, the allocation of sales that maximizes the price in the two markets is the one in which both firms set the same price in each market sharing equally each market demand: in this case the two intermediate segment (BC in figure 1) overlap along the locus $p_n^i = p_n^j$ (having therefore in each submarket $n = 1, 2$ a "residual obligation" equal to $D_n/2$). Hence:

$$\begin{aligned} p_n^{i*} &= \widehat{p}_n^i(p_n^{j*}, w) = w + \frac{\psi}{2} \\ p_n^{j*} &= \overline{p}_n^j(p_n^{i*}, D_n/2) = w + \frac{\psi}{2} \end{aligned}$$

with gross overall profits in the two markets $\Pi^i = (w + \frac{\psi}{2})\frac{D}{2}$.

2) One firm enters both markets and the other only one market: $\{1, 2; 1\}$, $\{1, 2; 2\}$,$\{1; 1, 2\}$ and $\{2; 1, 2\}$. Let us call m the monopoly market and d the duopoly market. Firm i entering both markets sets $p_m^i = u^* - \frac{9}{16}\psi$ in the monopoly market committing all its TOP obligations. The price equilibrium in the duopoly market entails firm j still endowed with all its obligations (equal $D/2$) and firm i with no obligations left. Since total obligations in the duopoly market are equal to the submarket demand, we are still in case a), Proposition 1, and the same arguments developed in case 1) above apply. Hence, in the duopoly market we have:

$$\begin{aligned} p_d^{i*} &= \widehat{p}_d^i(p_d^{j*}, w) = w \\ p_d^{j*} &= \overline{p}_d^j(p_d^{i*}, D/2) = w - \frac{\psi}{2} \end{aligned}$$

and firm i sells nothing in market d. The gross profits are $\Pi^i = (u^* - \frac{9}{16}\psi)\frac{D}{2}$ and $\Pi^j = (w - \frac{\psi}{2})\frac{D}{2}$

3) If both firms enter one and the same market, $\{1; 1\}$ and $\{2; 2\}$, each is endowed with obligations equal to the submarket demand. Hence we are in case c), Proposition 1 and the equilibrium prices are:

$$\begin{aligned} p_n^{i*} &= \widehat{p}_n^i(p_n^{j*}, 0) = \frac{\psi}{2} \\ p_n^{j*} &= \widehat{p}_n^j(p_n^{i*}, 0) = \frac{\psi}{2} \end{aligned}$$

with gross profits $\Pi^i = \frac{\psi D}{8}$.

We can summarize the price equilibria in the second stage by this table, reporting the gross profits in the different price subgames.

E/I	1	2	1,2
1	$\frac{\psi D}{8}, \frac{\psi D}{8}$	$(u^* - \frac{9}{16}\psi)\frac{D}{2}, (u^* - \frac{9}{16}\psi)\frac{D}{2}$	$(w - \frac{\psi}{2})\frac{D}{2}, (u^* - \frac{9}{16}\psi)\frac{D}{2}$
2	$(u^* - \frac{9}{16}\psi)\frac{D}{2}, (u^* - \frac{9}{16}\psi)\frac{D}{2}$	$\frac{\psi D}{8}, \frac{\psi D}{8}$	$(w - \frac{\psi}{2})\frac{D}{2}, (u^* - \frac{9}{16}\psi)\frac{D}{2}$
1,2	$(u^* - \frac{9}{16}\psi)\frac{D}{2},(w - \frac{\psi}{2})\frac{D}{2}$	$(u^* - \frac{9}{16}\psi)\frac{D}{2},(w - \frac{\psi}{2})\frac{D}{2}$	$(w + \frac{\psi}{2})\frac{D}{2}, (w + \frac{\psi}{2})\frac{D}{2}$

Since the fixed marketing costs when entering market n are $fD/2$, from the table we can easily identify the equilibrium entry choices in the following:

Proposition 7: *In the simultaneous entry game there are types of two subgame perfect equilibria:*
- $\{1,2;1,2\}$ *in which both firms enter both submarkets and set the price* $w + \frac{\psi}{2}$
- $\{1;2\}$ *and* $\{2;1\}$ *with each monopolist setting the price* $u^* - \frac{9}{16}\psi$ *in its submarket; this equilibrium is Pareto dominant for firms.*

7 Appendix III: The competitor's choice of TOP obligations

In this Appendix we show that if the competitor can choose its obligations $\overline{q}^C$, it will indeed choose exactly $\overline{q}^C = D - \overline{q}^I$. To prove this result we add an initial stage where the competitor signs its long term contract deciding the amount of TOP obligations.

We already know that if the competitor chooses TOP obligations equal to the residual demand, $\overline{q}^C = D - \overline{q}^I$, in equilibrium its profits can be written as $(u^* - \frac{9}{16}\psi - w)(D - \overline{q}^I)$.

Let us first consider a subgame where the competitor chooses obligations lower than the residual demand, i.e. $\overline{q}^C < D - \overline{q}^I$. Having discussed in detail the pricing and entry decisions in the benchmark case, we just sketch the analysis, which remains quite similar. Maintaining the sequential contracting structure, this is equivalent to considering all the contracting stages $d = 1,..,D$ in a sequence or to group them in *three* submarkets of sizes equal to $\overline{q}^I$, $\overline{q}^C$ and $D - \overline{q}^I - \overline{q}^C$. Then we can 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 C chooses as well and finally the active firms price simultaneously. The equilibrium analysis of the benchmark model points to the following conclusions:

- in market 1, only the incumbent enters and sets the monopoly price;
- in market 2, only the competitor enters and sets the monopoly price;
- for the residual submarket of size $D - \overline{q}^I - \overline{q}^C$, both firms would have marginal cost equal to w having exhausted their obligations. If they both enter, the equilibrium is symmetric with a price equal to $w + \frac{\psi}{2}$, and the two firms serve half of the residual demand gaining, given the fixed

marketing costs $f(D-\overline{q}^I-\overline{q}^C)$, positive profits $(\frac{\psi}{4}-f)(D-\overline{q}^I-\overline{q}^C)>0$. Hence, both firms enter.

The total profits obtained by the competitor are now $(u^*-\frac{9}{16}\psi-w)\overline{q}^C+\frac{\psi}{4}(D-\overline{q}^I-\overline{q}^C)<(u^*-\frac{9}{16}\psi-w)(D-\overline{q}^I)$. Hence, the competitor[27] does not gain from having obligations lower than $D-\overline{q}^I$.

Second, consider the subgame if $\overline{q}^C>D-\overline{q}^I$, 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. From the previous analysis, going through the same steps, it is easy to see that the equilibrium entry and price decisions are the same as in Proposition 4, with I entering the first market, and C the second one, with sales $D_2<\overline{q}^C$. Although the competitor C has TOP obligations exceeding residual demand $D-\overline{q}^I$, it prefers not to enter until the incumbent has exhausted its own obligations. In fact, if C decides to enter 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 C would gain otherwise. Hence, the competitor would prefer to maintain its residual obligations idle, although it is paying for it.

Therefore, going to the stage in which the competitor chooses the amount of obligations to sign, it will choose obligations equal to the residual demand $D-\overline{q}^I$, as assumed in the benchmark model.

Finally, notice that if $\overline{q}^I=D$, adding its own obligations and entering market 1 the competitor would induce a price equilibrium corresponding to Proposition 1, cases b) or c): in both cases the price is below w and the competitor would be unable to cover the TOP payments with the gross profits gained. We summarize this discussion in the following Proposition.

Proposition 8: *If the competitor chooses its obligations $\overline{q}^C$ at time 0, given the incumbent's obligations $\overline{q}^I$, and then the game follows as in the benchmark model, C chooses obligations equal to the residual demand, i.e. $\overline{q}^C=D-\overline{q}^I$.*

The discussion on the different configurations developed above highlights also the outcomes of an alternative situation in which the firms are still endowed with exogenous TOP obligations $\overline{q}^I$ and $\overline{q}^C$, but market demand D may be larger or smaller than their obligations, for instance due to cyclical fluctuations. If total obligations fall short of total demand, i.e. $\overline{q}^C+\overline{q}^I<D$ we would observe segmentation of a relevant part of the market $\overline{q}^I+\overline{q}^C$ and generalized entry in the residual part $D-\overline{q}^I-\overline{q}^C$. If instead the two firms have obligations in excess of market demand, $\overline{q}^C+\overline{q}^I>D$, the segmentation result occurs, with some obligations that are not fulfilled with actual deliveries. Hence, we can

[27] Alternatively, in the spirit of our entry model, we can notice that if $D>\overline{q}^I+\overline{q}^C$ there is room for a third firm with obligations $D-\overline{q}^I-\overline{q}^C$ to enter and monopolize the residual demand. The first competitor then would obtain profits $(u^*-\frac{9}{16}\psi-w)\overline{q}^C<(u^*-\frac{9}{16}\psi-w)(D-\overline{q}^I)$ if installing $\overline{q}^C<D-\overline{q}^I$.

conclude that when demand fluctuates and firms have exogenous obligations, segmentation would involve volumes of gas corresponding to $\min\left\{\overline{q}^C + \overline{q}^I, D\right\}$.

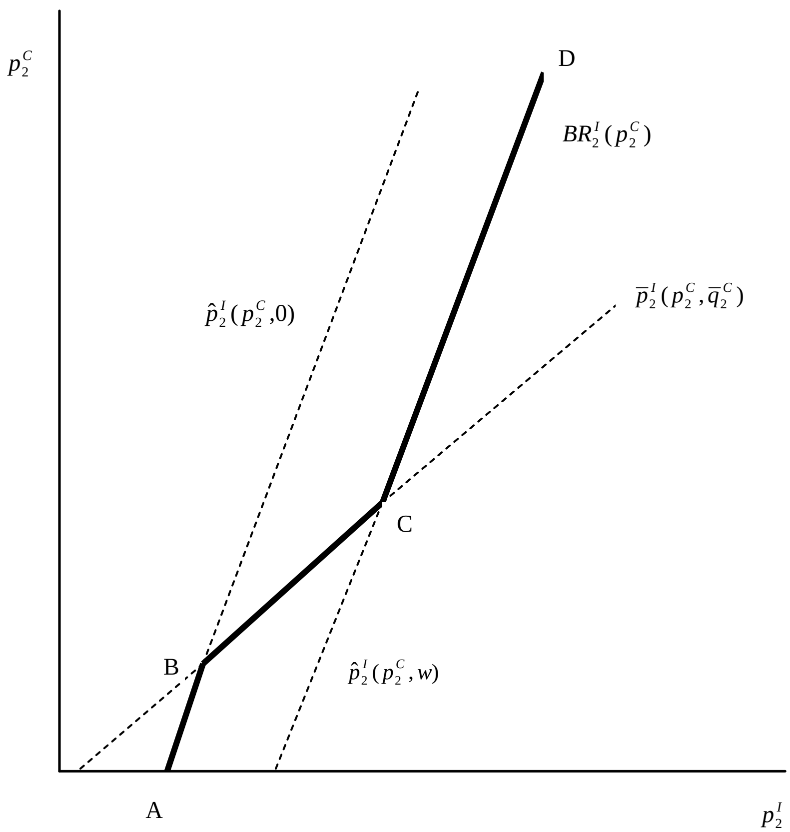

Figure 1: Best Reply: $BR_2^I(p_2^C)$

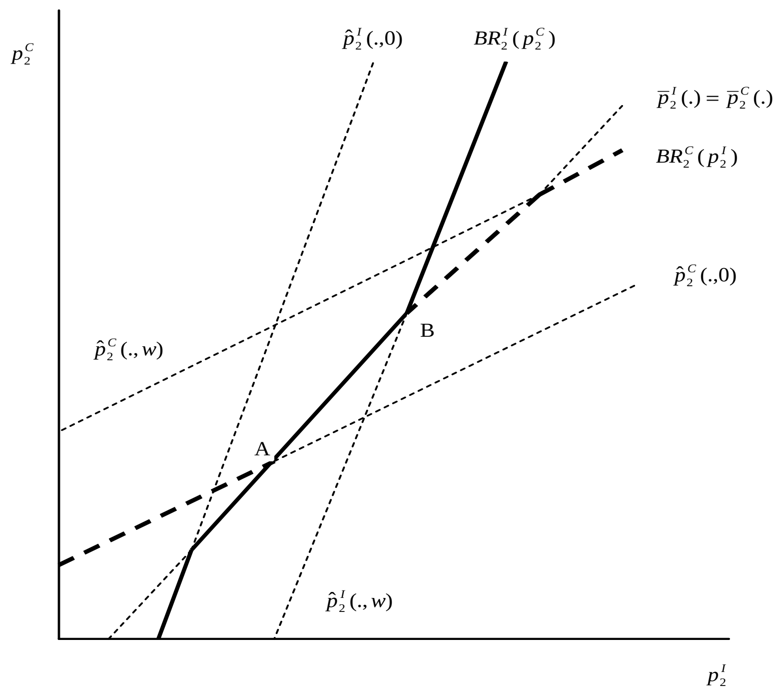

Figure 2: Equilibrium Prices: segment A-B (case a)

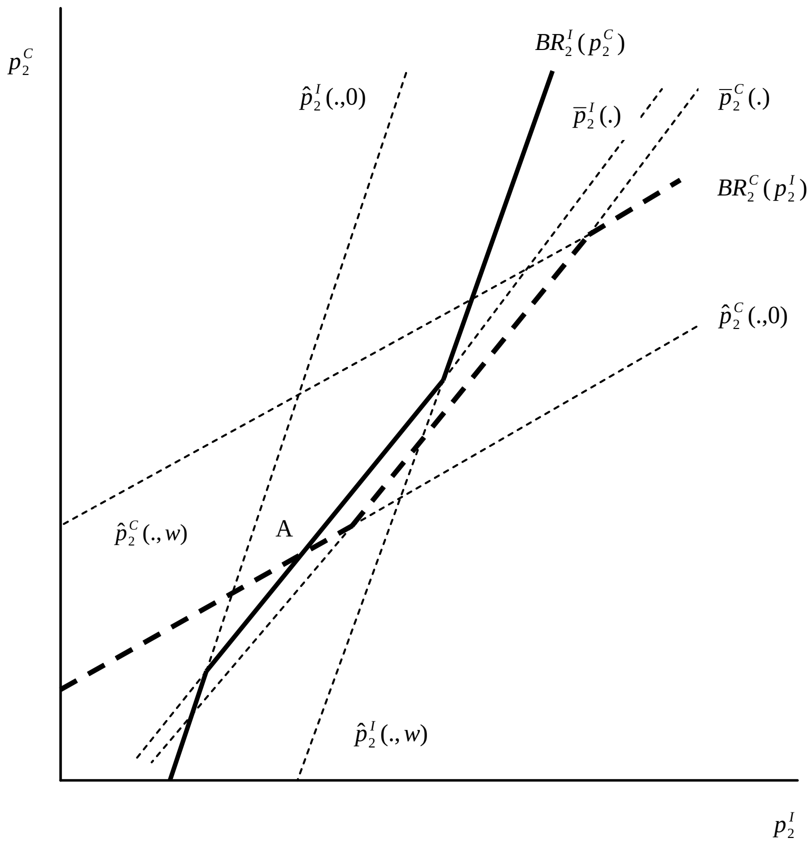

Figure 2: Equilibrium Price: point A (case b)

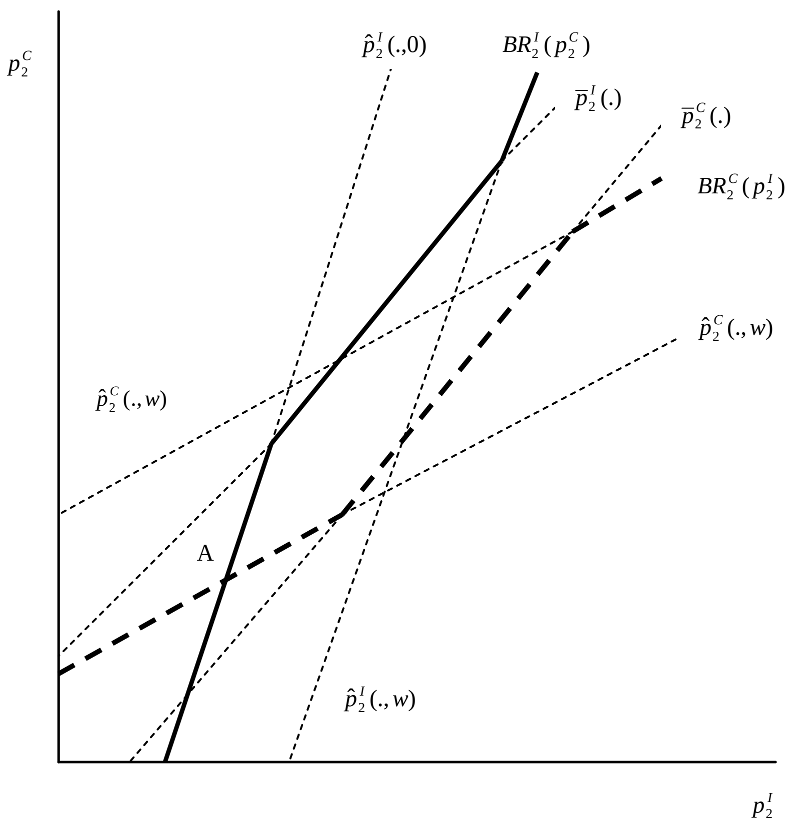

Figure 2: Equilibrium Price: point A (case c)