# Why entry of retailers may drive up prices in a vertical industry: an application to the European natural gas market.

Bertrand CHARMAISON * †

June 18, 2010

**Abstract**

We consider a vertical industry where an upstream monopolist sells an homogenous good to competing retailers who serve the final market. Using an industrial organisation approach, we show that if at an initial stage the final market is supplied by an incumbent retailer holding long-term contracts with the upstream monopolist, then an excessive entry of firms on the retail market leads to a price increase for final consumers. Our model illustrates the existence of a trade-off between alleviating the double marginalisation issue thanks to additional competition at the retail level and limiting the market power of the upstream producer on the wholesale market through long-term contracts. Our results still hold if a dominant upstream producer faces a competitive fringe, provided firms of the fringe face substantially higher costs of production. The counter-intuitive outcome of our model could be of particular relevance for the European natural gas industry, in case the recently settled organisation grouping the largest gas exporters was to turn into a cartel of producers.

*Index Terms* - Long-term contracts, vertical industry, entry, European natural gas markets (L13, L42, L43, L95).

## 1 Introduction

The liberalisation of the European natural gas industry is progressing too slowly according to European authorities. Even though final consumers can now freely choose their gas supplier, incumbent retailers continue to hold significant market shares. Further, while wholesale market places for gas are developing and

*Toulouse School of Economics (LERNA), Allées de Brienne, F-31000 Toulouse, France. *E-mail: bertrand.charmaison@gmail.com*

†I would like to thank Laurent David and Laurent Percebois from the Research Department of GDF SUEZ for their ideas and remarks. The usual caveats apply. Any views expressed in this paper are those of the author and shall not be construed as positions from GDF SUEZ.

becoming more liquid, most volumes are still delivered through historical long-term take-or-pay contracts between incumbent retailers and producers. Meanwhile, Europe is becoming more and more dependent on natural gas imports, and EU initiatives to foster competition at the production level of the industry (i.e. outside Europe) have so far reached a limited success. On the contrary, the main suppliers of gas have recently formed the Gas Exporting Countries Forum (GECF), and some fear that this "discussion forum" might in the future turn into a cartel of producers (the "gas-OPEC")[1]. Leaving aside the key issue of security of supply, our motivation is to investigate whether final consumers will necessarily enjoy lower prices if more firms enter at the retail level of the European natural gas industry.

We propose an industrial organisation approach to address this issue. We depict a vertical industry where the production of an homogeneous good is made by a dominant upstream producer facing a competitive fringe whose production costs are higher. We further suppose that the dominant upstream producer initially holds long-term take-or-pay contracts with a downstream monopolist who serves the final market. We model liberalisation of the retail market though the following three stage game. At the first stage of the game, the monopoly of the incumbent retailer is lifted and a wholesale market for the good develops, which permits new firms to enter the retail market by paying a fixed cost of entry; the incumbent retailer and the dominant upstream producer react at the second stage by renegotiating the terms (price and quantities) of their long-term contracts; competition among firms in the industry occurs at the third stage and is depicted by a game inspired by the work of Neumann, Fell and Reichel (2005).

Our model shows that more entry at the retail level may lead to higher prices for final consumers, provided costs of the competitive fringe are substantially higher than those of the dominant upstream producer. This counterintuitive result stems from the fact that while more entry drives down margins at the retail level, it also induces contracting firms to reduce the size of the long-term contracts they hold and hence reduces their pro-competitive effect (as first described by Allaz and Vila (1993)). More entry at the retail level leads to an increase of the wholesale market price mitigated by the presence of the upstream competitive fringe. If the production of the fringe is large enough, this wholesale market price increase will be of second order compared to the gains induced by more competition at the retail level : we find the classical outcome that more entry benefits final consumers. But if the production of the fringe is limited, more entry at the retail level may induce higher retail prices for final consumers. Our model illustrates the existence of a trade-off between limiting the market power of an incumbent retailer through additional competition at the retail level and that of a dominant upstream producer through long-term take-or-pay contracts. This result could be of particular relevance for the European natural

[1] The motivations for GECF formation are discussed by Wagbara (2007) and Hallouche (2006). Massol and Tchung-Ming (2009) show that GECF members could collectively reduce the transportation costs they have to incur, but that it would be hard to find a scheme acceptable by all GECF members to share these savings; the authors claim therefore that the aim of the GECF cannot be to optimise costs but rather to exert market power.

gas industry, in case the GECF was to turn into a cartel of producers.

To our knowledge, the mechanism we depict has not been described in the literature. In a different context, Inderst (2002) has shown that increased competition could lead to higher prices for final consumers. In his model, an incumbent firm serves two categories of clients, some being captive and some others being able to change supplier by paying a switching cost. A more intense competition (i.e. a lower switching cost) will induce the incumbent firm to target more specifically its captive client base and lead to higher average prices for all consumers. It is however widely perceived that an increase of competition through the entry of new firms in a market leads to a reduction of the price paid by final consumers. In case of a vertical industry where an homogeneous good is produced by an upstream monopolist, it has been shown that entry of firms at the retail level alleviates the issue of double marginalisation and consequently reduces the price paid by final consumers. If perfect competition among downstream firms occurs, these firms do no more exert a negative externality on the upstream firm, which permits it to exert fully its monopoly power and pocket monopoly profit. Final consumers pay the monopoly price, which is lower than the price they would have paid assuming imperfect competition at the retail level. But it is also known that too much entry can lead to a decrease of social welfare through an excessive duplication of fixed costs. In the case of an homogenous good, Mankiw and Whinston (1986) have demonstrated that imperfect competition among firms leads to excessive entry compared to what would be socially optimal, because entrants do not internalise that they will induce incumbent firms to reduce their output. Ghosh and Morita (2007) have shown that such result does not necessarily hold for a vertical oligopoly. Assuming that entry at the upstream level of the industry is endogenous to the model whereas the number of downstream firms is fixed, they find out that the number of upstream entrants is socially insufficient when downstream firms hold significant market power. But in both models, even if excessive entry leads to social inefficiency, final consumers benefit from more entry as the price they pay decreases when the number of entrants increases[2]. Our model illustrates that excessive entry at the retail level of a vertical industry may lead to higher prices for final consumers.

Section 2 introduces a basic model which permits to capture the effects at stake in a simplified framework, assuming an upstream monopolist and an exogenous number of entrants at the downstream level of the vertical industry. Section 3 proposes a stylised representation of the European natural gas market, taking care of the presence of a competitive fringe of upstream producers and making the number of downstream entrants endogenous to the model. Section 3 concludes and gives some policy recommendations.

[2] Making the number of entrants endogenous at both levels of a vertical industry, Reisinger and Schnitzer (2008) illustrate that facilitating entry at one level has some ambiguous feedback effects at the other level. For example, reducing fixed entry costs at the downstream level may induce more or less upstream firms to enter, given the actual value of the entry cost. In their model, social welfare (which is by construction equal to consumer surplus) is however always increasing when the fixed cost of entry decreases.

# 2 A simplified model

## 2.1 Assumptions and notations

We consider a vertical industry where an homogeneous good is produced by a monopolist at the upstream level and delivered to final consumers by at least two retailers competing at the downstream level. We assume that the marginal cost of production of the upstream monopolist is constant, and for simplicity we set it equal to zero.

At an initial stage, the downstream level of the industry is not opened to competition and all final consumers are served by a monopolist retailer, hereinafter referred to as the "incumbent". Liberalisation of the retail market permits $N$ symmetric retailers ("the entrants") to enter. We suppose in this Section that the number of entrants $N$ is exogenously given and is at least equal to one. We assume further that the marginal cost for distributing the good is constant and equal for all retailers (including the incumbent), and set it to zero.

Demand from the final market is supposed to be deterministic and perfectly known by all firms active in the industry. It is assumed to be linear and aggregated by using the inverse demand function $p_f = D - q^I - Nq^E$, with $q^I \geq 0$ and $q^E \geq 0$ the quantities respectively offered by the incumbent and each entrant to final consumers.

The $N$ entrants supply themselves on the wholesale market only. Each of them buys the quantity $q^E$ at the price $p_w$, and is price taker from the wholesale market price. The upstream monopolist sell a quantity $s^M$ on the wholesale market, while the incumbent can be a net seller ($s^I > 0$) or a net buyer ($s^I < 0$) on that market. Indeed, the incumbent disposes from historical long-term take-or-pay contracts that were entered with the upstream monopolist prior to the liberalisation of the retail market. Contracts are defined by a maximum quantity $K$ that can be offtaken, a marginal price $P_x$ to be paid for each quantity $x^I \leq K$ of the good offtaken under the contracts and a fixed payment equal to $TK$[3], further assuming $P_x + T > 0$. Long-term take-or-pay contracts are then modelled as two-part tariffs with a cap on the quantity that can be offtaken.

We finally assume that all information is public and that all players are rationale. Figure 1 illustrates our setting.

## 2.2 Timing of the game

Liberalisation of the retail market and the development of a wholesale market induce the entry of firms at the downstream level of our industry. But contracting firms may have an incentive to react to the new structure of the industry and modify the terms of their long-term contracts. To depict such process, we adopt the following timing.

[3] This formulation is equivalent to state that long-term contracts consist of a take-or-pay quantity $K$ being also the maximum offtake quantity, a contract price $P_x + T$, and a take-or-pay penalty for quantities of the good not offtaken equal to a percentage $\frac{T}{P_x+T}$ of the contract price.

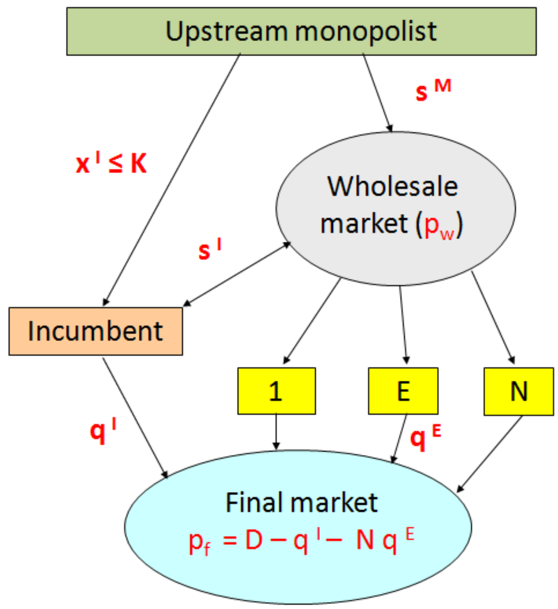


Figure 1: stylised representation of the industry

At date $t_1$ ("entry stage"), the downstream market is liberalised, which was not envisioned by the upstream monopolist and the incumbent retailer when they initially negotiated their long-term contracts. Downstream authorities are however not in position to challenge the monopoly structure at the upstream level of the industry, say for example the good is imported from foreign countries. A wholesale market develops, where the market price $p_w$ is set in accordance with offer and demand for the good, and $N$ entrants enter to compete with the incumbent on the retail market[4].

At date $t_2$ ("renegotiation stage"), the upstream monopolist and the incumbent retailer observe the entry of new firms (they know $N$) and react by renegotiating the terms (price and quantities) of their long-term contracts. We suppose that new entrants are not in position to enter into long-term contracts with the upstream monopolist, and that for regulatory reasons the upstream monopolist cannot integrate vertically nor use vertical restraints such as exclusivity contracts or resell price maintenance that would allow to restore its monopoly power. We assume further that if the upstream monopolist and the incumbent retailer do not manage to find a mutually satisfactory agreement long-term contracts are terminated[5].

[4] In this simplified approach, $N$ the number of entrants is deemed to be exogenous and the entry stage will therefore not be explicitly modelled. In the next Section, entry will be made endogenous to the model.

[5] This simplifying assumption will be lifted in the next Section, where we consider a more

At date $t_3$ ("competition stage"), the firms compete to maximise their profits, given the industry structure and long-term contracts features (even though contract prices remain confidential, we suppose that contracted quantities are perfectly known by all firms). In case they have failed to agree at date $t_2$, we assume that the upstream monopolist sells the good on the wholesale market to the incumbent and the $N$ entrants, which then compete in quantity to resell it to final consumers: this is a classical double marginalisation framework. If on the contrary they have found an agreement, we consider that the incumbent retailer holds a competitive advantage over the entrants on the retail market. Indeed, thanks to its take-or-pay contracts, it benefits from a marginal cost of supply $P_x$ below $p_w$ (at the expense of the fixed fee $TK$). The incumbent can then credibly commit to defend a certain market share on the retail market. In such case, we model competition between the firms by using a two-stage game inspired by the work of Neumann, Fell and Reichel (2005)[6]:

- at the first stage of the competition game, the upstream monopolist and the incumbent retailer simultaneously decide on the quantities that they will buy or sell on the wholesale market ($s^M$ and $s^I$), and, for the incumbent, quantities it will offtake under the long-term contracts ($x^I \leq K$).

- at the second stage of the competition game, given the wholesale market price $p_w$ and the quantities $q^I$ the incumbent proposes to final consumers, the $N$ entrants simultaneously decide the quantities $q^E$ they purchase and resell to final consumers on their residual share of the market[7].

Our game is solved by backward induction. We look for equilibrium quantities, prices and profits of the firms.

## 2.3 Results and interpretation

The resolution of the game is described in appendix n°1[8]. We show at first that the incumbent retailer cannot profitably foreclose the retail market: it will then accommodate entry and leave a share of the retail market to new entrants. Further, the incumbent retailer turns out to be a net buyer ($s^I < 0$) on the wholesale market at equilibrium, even if it does not fully offtake its long-term contracts, which occurs for $K$ larger than a certain threshold that we denote

realistic case where long-term contracts are binding and remain in full force if parties are to disagree.

[6] The model of Neumann, Fell and Reichel is derived from the work of Gaudet and Van Long (1996) but the timing of their game is different. In Gaudet and Van Long, downstream divisions of vertically integrated firms and non integrated retailers play simultaneously at the second stage of the game and take the wholesale market price as given. Neumann, Fell and Reichel make vertically integrated firms decide all their strategic variables simultaneously with non integrated upstream firms at the first stage of the game, arguing they have a structural advantage over non integrated downstream firms thanks to an unlimited access to the necessary good at the marginal cost of production.

[7] By announcing a large quantity $q^I$ (equivalently, by proposing a low price to final consumers), the incumbent retailer is then in position to foreclose the final market. Such strategy can however be sustained only if it makes a positive profit.

[8] A more detailed presentation of this simplified model and its full set of results can be found in Charmaison (2009).

by $K_{\lim}$. For $K \leq K_{\lim}$, the incumbent retailer does fully offtake its long-term contracts ($x^I = K$). In such case, the total quantity produced by the upstream monopolist is strictly increasing in $K$:

$$s^D + x^I = \frac{2N}{4N+3}D + \frac{2N+3}{4N+3}K$$

This result illustrates the pro-competitive effect of long-term contracts when firms compete in quantities, which was first described by Allaz and Vila (1993). The upstream monopolist having sold part of its production under long-term contracts (forward sales) behaves more aggressively on the additional quantities it can sell on the wholesale market (spot sales). More contracted quantities increase this effect and induce a lower price for final consumers. But in our model, when the contracted quantity $K$ is greater than the threshold $K_{\lim}$, the incumbent does not fully offtake its contracts ($x^I = K_{\lim}$ for any $K \geq K_{\lim}$). The pro-competitive effect of long-term contracts is then capped at the threshold quantity $K_{\lim}$.

We further observe that, provided that the marginal price $P_x$ under long-term contracts is not too high (so that the incumbent fully offtakes its take-or-pay quantity, i.e. $x^I = K$), the joint profit of the upstream monopolist and the incumbent retailer is concave in $K$ and maximised for:

$$K^* = \frac{1}{2}\frac{8N+9}{(4N+9)(N+1)}D$$

We show that there always exist a range of contract prices $P_x + T$ such that both contracting firms see their profit increasing when selecting $K^*$ compared to a case where contracts would terminate. Hence in the renegotiation stage the upstream monopolist and the incumbent retailer will always agree to pick the quantity $K^*$ that maximises their joint profit, and bargain on a contractual price within this range. For $K^*$, equilibrium prices are given by:

$$p_w(K^*) = \frac{2N+3}{4N+9}D$$

$$p_f(K^*) = \frac{1}{2}\frac{4N^2+12N+9}{4N^2+13N+9}D$$

We verify that $\frac{\partial(p_f(K^*)-p_w(K^*))}{\partial N} < 0$, $\frac{\partial K^*}{\partial N} < 0$, $\frac{\partial p_w(K^*)}{\partial N} > 0$, while the sign of $\frac{\partial p_f(K^*)}{\partial N}$ is ambiguous and depends on the number entrants $N$ (it has the same sign as $2N-3$). It turns out that the price paid by final consumers is minimised for $N = 2$. Further calculations from the model show that social welfare is also maximised for $N = 2$ as:

$$W(K^*) = \frac{1}{8}\frac{\left(48N^4+320N^3+748N^2+720N+243\right)}{(4N+9)^2(N+1)^2}D^2$$

This simplified approach permits to understand the effect of more entry (increase of $N$) at the retail level of our industry. As expected, more entry reduces the margins of retailers, which is beneficial to final consumers through an alleviation of the double marginalisation. But contracting firms react to more entry at the retail level of the industry by reducing the contracted quantity $K^*$. This decreases the pro-competitive effect exerted by long-term contracts, and permits the upstream monopolist to raise the wholesale market price $p_w$. The effect of entry for final consumers is therefore ambiguous. For $N \geq 2$, the gains induced by more competition at the retail level of the industry are more than confiscated by the upstream monopolist which is able to raise the wholesale market price $p_w$ by a higher amount. But conversely final consumers benefit from more competition at the retail level of the industry when there is only one firm competing with the incumbent retailer.

Our proposition 1 follows :

*In this simplified model, excessive entry leads to a decrease in social welfare and an increase of the price paid by final consumers. This stems from the fact that entry induces a decrease of the size of long-term contracts between the upstream monopolist and the incumbent and therefore permits the latter to increase the wholesale market price. This effect might be stronger than the gains induced by more competition at the retail level.*

Our results illustrate the existence of a trade-off between increasing competition at the retail level of a vertical industry and limiting the market power of an upstream monopolist through long-term contracts. Final consumers benefit from both effects, but those effects are somehow excluding each other. With this simple model, consumer surplus and social welfare are maximised when competition on the final market is not too strong[9], so that incumbent is able to support its take-or-pay commitments and hence to have significant volumes delivered under long-term contracts. Ironically, perfect competition at the retail level of the industry ($N \to +\infty$) and no competition at all both induce final consumers to pay the vertically integrated monopoly price $\frac{1}{2}D$. But the distribution of the rent within the industry is very different in both cases: all industry profits are shifted upwards in case of perfect competition, whereas the incumbent retailer may keep part of this rent when it holds a monopoly position downstream.

# 3 A model of the European natural gas industry

## 3.1 Specific assumptions

Based on the three-stages game we have presented in the previous Section, we will now depict a more specific framework that intends to be a stylised representation of competition in the European natural gas industry if members of the GECF were to form a cartel of producers (the "gas-OPEC").

[9] For $N = 2$ the retail market price equals $\frac{49}{102}D$ (4% below the one induced by a vertically integrated monopoly) while the social welfare at equilibrium is $\frac{8003}{20\,808}D^2$ (2,6% above).

For this, we depart from the upstream monopolist assumption and consider that the upstream level of the industry is characterised by competition between a dominant firm[10] and a competitive fringe. The dominant firm has some historical long-term take-or-pay contracts with an incumbent retailer at the downstream level of the industry and offers in addition a quantity $s^D$ on the wholesale market, whereas the competitive fringe is fully selling its production (quantity $s^F$) on the wholesale market. We suppose further that firms of the competitive fringe bear higher production costs than the dominant firm and face capacity constraints[11]. To depict it, we set the production costs of the dominant upstream firm equal to zero and assume increasing marginal costs of production for the fringe (we use a quadratic cost function defined by $\frac{1}{2}C_f(s^F)^2$ with $C_f > 0$).

We then make $n$ the number of entrants at the retail level of the industry endogenous to our model. For this, we suppose that each new entrant has to pay a fixed cost equal to a percentage $F > 0$ of the vertically integrated monopoly profit[12] during the entry stage (first stage of the game). The incumbent retailer, which is already active in the industry, does not have to pay such fee.

We further assume that long-term contracts were designed to maximise the profit of the industry prior to the liberalisation of the retail market. Contracting parties did not anticipate the impact of reorganisation of the industry and chose contractual terms that were then optimal for them. The initial contractual quantity was then $K_0 = \frac{1}{2}D$, the quantity that a vertically integrated monopoly would have proposed, leading final consumers to pay $p_{f0} = \frac{1}{2}D$. To avoid any double marginalisation problem, the marginal price of the contracts was set equal to the marginal cost of production, i.e. $P_{x0} = 0$ with our set of assumptions. Finally, the industry rent was shared between the upstream and downstream firms through the fixed fee. By taking $T_0 = \frac{\alpha}{2}D$ (with $0 \leq \alpha \leq 1$) we suppose that the dominant upstream producer received a percentage $\alpha$ of the rent, $1 - \alpha$ being kept by the incumbent retailer. Note that with this set of long-term contracts the incumbent retailer had no incentive to buy any

[10] In this framework, we assume that members of a cartel behave like a single firm. The dominant upstream producer will then be a representation of a "gas-OPEC" cartel that intends to maximise its profit, taking into account the existence of a competitive fringe.

[11] We argue that this set of assumption is consistent with a stylised representation of the upstream structure of the European natural gas market. Indeed, the closest non EU suppliers are all members or observers in the GECF. According to CEDIGAZ (2009), they should cover up to 96% of imports in 2020. Some alternative supplies are available but will have to come from remote producing countries (Australia...). As transportation distance has a huge impact on costs, it is reasonable to assume that production costs of the fringe will be significantly higher than those of GECF countries. This representation would also be relevant if significant deposits of non conventional gas (shale gas...) were to be discovered in Europe, as these fields turn out to be much more expensive to produce than conventional reserves.

[12] We think it is more informative to adopt such approach compared to a more traditional one which is to define fixed costs of entry through their absolute value $F$. Consider for example that the value of the fixed cost of entry in an industry is equal to 1; the implications of such value will be totally different if maximum industry profits are equal to 2 or to 100. Much more information is conveyed when we say that the fixed cost to enter represents 50% or 1% of the maximal profit the industry can make. It also turns out that such approach permits to dramatically simplify the analytical expressions we get at equilibrium.

quantity of the good to firms of the competitive fringe. It could however play on the existence of the fringe to bargain with the dominant upstream producer in order to get a higher share of the industry rent.

Finally, we suppose that in case contracting firms fail to agree when they renegotiate the long-term contracts at second stage of the game, the initial set of long-term contracts that we have just described remains in full force[13]. As we shall see now, this assumption does complexify the resolution of the game when the dominant upstream producer is in position to induce the exit of the incumbent retailer by sticking to the initial contractual provisions.

### 3.2 Non exclusion of the incumbent

The presence of the competitive fringe at the upstream level does not alter qualitatively the results of the competition game at date $t_3$ (see appendix n°2). We find that, provided the marginal contract price $P_x$ is not too high (so that $x^I = K$), the joint profit of the dominant upstream producer and the incumbent retailer is maximised for:

$$K'^*(n) = \frac{1}{2}\frac{(8n+9)C_f + 4n + 4}{((4n+9)C_f + 4n + 4)(n+1)}D > 0$$

Solving the renegotiation stage at date $t_2$ becomes slightly more complex. Indeed, we show that for $\alpha > \alpha_{\text{lim}}$[14] (i.e. when the dominant upstream producer enjoyed a strong bargaining power prior to the liberalisation of the retail market), the dominant upstream producer can exclude the incumbent retailer by refusing to renegotiate and sticking to the initial set of long-term contracts ($K_0 = \frac{1}{2}D$, $P_{x0} = 0$, $T_0 = \frac{\alpha}{2}D$). In such case, we will have at date $t_3$ a classical double marginalisation game with $m$ entrants and no more long-term contracts. The profit made by the dominant upstream producer is then:

$$\Pi^D_{I-exit}(m) = \frac{1}{4}\frac{m^2 C_f}{(m+1)(mC_f + m + 1)}D^2$$

The dominant upstream producer can also accept to renegotiate the long-term contracts at date $t_2$. For $\alpha > \alpha_{\text{lim}}$, it can make a take-it-or-leave-it offer to the incumbent and claim the entire joint profit $\Pi^D(K'^*(n)) + \Pi^I(K'^*(n))$ given by:

$$\frac{n(2n+3)^2 C_f^2 + (4n^3 + 12n^2 + 17n + 9)C_f + 4(n+1)^2}{4\,(n+1)\,(nC_f + n + 1)\,((4n+9)C_f + 4n + 4)}D^2$$

Expressions computing the profit of an entrant are not the same whether the incumbent is excluded or not, and the number of entrant $m$ will then in most

[13] This assumption is more realistic than the one we made in the previous Section, as we believe that long-term contracts in the European natural gas industry were initially signed to prevent the risk of ex-post opportunism by the parties. They must therefore be legally binding if a change of economic situation affects negatively one of the signing parties (the incumbent retailer here).

[14] With $0 < \alpha_{\text{lim}} = \frac{n(4n+9)C_f + 9(n+1)}{9(n+1)(nC_f + n + 1)} < 1$.

cases differ from $n$ (see appendix n°3). We find that for any strictly positive values of $n$ and $C_f$:

$$n \leq m \leq 2n + \frac{5}{2}$$

Exclusion of the incumbent permits more retailers to enter, which alleviates the double marginalisation and benefits the dominant upstream producer ($\Pi^D_{I-exit}(m)$ is strictly increasing in $m$). However, by renegotiating the long-term contracts, the upstream dominant producer can capture up to the entire joint profit. We verify that for any positive value of $n$ and $C_f$:

$$\Pi^D(K^{'*}(n)) + \Pi^I(K'^*(n)) - \Pi^D_{I-exit}(2n+4) > 0$$ [15]

Hence it is never the interest of the dominant upstream producer to have the incumbent excluded. It finds it more profitable to adapt the long-term contracts so that the incumbent continues to be the leader on the retail market, and to reap back all its profits through take-or-pay payments. The dominant upstream producer benefits then from a form of vertical integration, which is not the case when it sells on the wholesale market to non-integrated downstream retailers. The increased number of retailers induced by an exit of the incumbent, which alleviates the double marginalisation issue, is never enough for the dominant upstream producer to compensate for the loss of revenues from long-term contracts.

Our proposition 2 follows:

*In the vertical industry we have depicted, a dominant upstream producer has always an incentive to renegotiate the contracts it holds with the incumbent retailer, even if it could induce the exit of the latter by sticking to the contracts signed prior to the liberalisation of the retail market.*

### 3.3 Impact of entry

At date $t_1$, would-be entrants correctly anticipate that the dominant upstream producer and the incumbent retailer will renegotiate their long-term contracts after entry and agree on the quantity $K'^*$. They hence know the profit they will make given $n$, and compare it to the fixed cost of entry equal to $\frac{1}{4}FD^2$. For any $F$, the number of entrant at equilibrium will be given by the integer number immediately below the real number $n$ that solves:

$$\frac{n(2n+3)C_f^2 + 3(n+1)(2n+3)C_f + 4(n+1)^2}{(n+1)(nC_f+n+1)((4n+9)C_f+4n+4)} = \sqrt{F}$$

It turns out that it is not possible in the general case to get an analytical expression for $n$. We verify however that entry will not occur for any $F > F_{\lim}$[16],

[15] As the number of entrants $n$ and $m$ are necessarily given by integer values, we could have up to $2n+4$ entrants in the double marginalisation game (for example for $\tilde{n} = 1,99$ we verify $2\tilde{n} + \frac{5}{2} = 6,48$)

[16] We have $\left(\frac{5}{26}\right)^2 < F_{\lim} = \frac{1}{4}\frac{(5C_f^2+30C_f+16)^2}{(C_f+2)^2(13C_f+8)^2} < \frac{1}{4}$. Notice that $\frac{\partial F_{\lim}}{\partial C_f} < 0$ : an efficient competitive fringe upstream (low $C_f$) facilitates entry of one at least one retailer downstream.

as one single entrant is then not in a position to cover its fixed cost of entry. Large fixed entry costs at the retail level permit the dominant upstream producer and the incumbent to maintain the initial structure of the industry, with final consumers paying $\frac{1}{2}D$ the price offered by a vertically integrated monopoly.

Provided the fixed cost of entry is not too high, at least one competitor will enter the retail market at date $t_1$. The incumbent and the dominant upstream producer will react to entry at date $t_2$ by reducing the size of the long-term contracts they hold. This reduction will be stronger when more firms enter (i.e. for lower costs of entry). More entry at the retail level will then permit the dominant upstream producer to exert more market power at date $t_3$ on the wholesale market. This anti-competitive effect will however be mitigated at both levels of our vertical industry, downstream by the increased competition among retailers and upstream by the impact of additional sales from the competitive fringe on the wholesale market. As we have just indicated, it is in most cases not possible to have an analytical expression giving equilibrium prices in order to see whether the price paid by final consumers increases or decreases with more entry (lower value of $F$). To illustrate it, we will focus on two polar cases before moving to a numerical example.

If the competitive fringe is almost as efficient as the dominant upstream producer and is not constrained by its capacity of production ($C_f \to 0$), and further provided $F \leq \frac{1}{4}$, the equilibrium expressions for wholesale and final market prices are given by:

$$p_w^*\left(C_f \to 0\right) = 0$$

$$p_f^*\left(C_f \to 0\right) = \frac{1}{2}\sqrt{F}D$$

The competitive pressure exerted by the fringe is so strong that the dominant upstream producer is no more able to raise the wholesale market price above its marginal cost of production. The incumbent can exert some market power at the retail level, as entry of competing retailer is limited by the fixed cost of entry. The retail market price is then strictly increasing in the fixed cost of entry (it jumps to the vertically integrated monopoly price $\frac{1}{2}D$ for $F > \frac{1}{4}$). Consumers are then best off when entry costs are minimal so that a large number of new entrants compete with the incumbent on the retail market. We find the classical outcome that additional competition benefits final consumers.

Suppose now that the competitive fringe is just not relevant ($C_f \to +\infty$). This result is an extension to the one found in the previous Section by making the number of entrants endogenous to the model. We have here for any $F \leq (\frac{5}{26})^2$:

$$p_w^*\left(C_f \to +\infty\right) = \frac{1}{2}\left(1 - \frac{6\sqrt{F}}{\sqrt{25F - 4\sqrt{F} + 4} + 5\sqrt{F} + 2}\right)D$$

$$p_f^*(C_f \to +\infty) = \frac{1}{8}\left(2 - \sqrt{F} + \sqrt{25F - 4\sqrt{F} + 4}\right)D$$

We check that the wholesale market price strictly decreases in $F$ while the final market price decreases in $F$ up to $\left(\frac{4}{25}\right)^2$ and then increases in $F$. Low costs of entry induce many retailers to enter and compete with the incumbent. As a consequence, the size of long-term contracts will be reduced, which more than offsets the gains induced by increased retail competition. When costs of entry are too high, the incumbent is able to exert its market power at the retail level (it enjoys a monopoly position for $F > (\frac{5}{26})^2$) which induces higher prices for final consumers. We find the same trade-off as the one we depicted in the previous Section. Final consumers pay the lowest price for $n = 2$, i.e. when $F \in \left](\frac{3}{28})^2; (\frac{7}{51})^2\right]$. When the upstream level is fully cartelised, entry at the retail level might be excessive and induce higher prices for final consumers.

We will now illustrate the outcome of the model with a numerical example depicting a situation inbetween these two polar cases (we take $D = 1$ and $C_f = 10$). We have built for that purpose a numerical algorithm calculating the equilibrium number of entrants (necessarily an integer value). Figure 2 illustrates our results at equilibrium, by presenting the number of entrants, the long-term contracted quantity and the price paid by final consumers as a function of the fixed cost of entry.

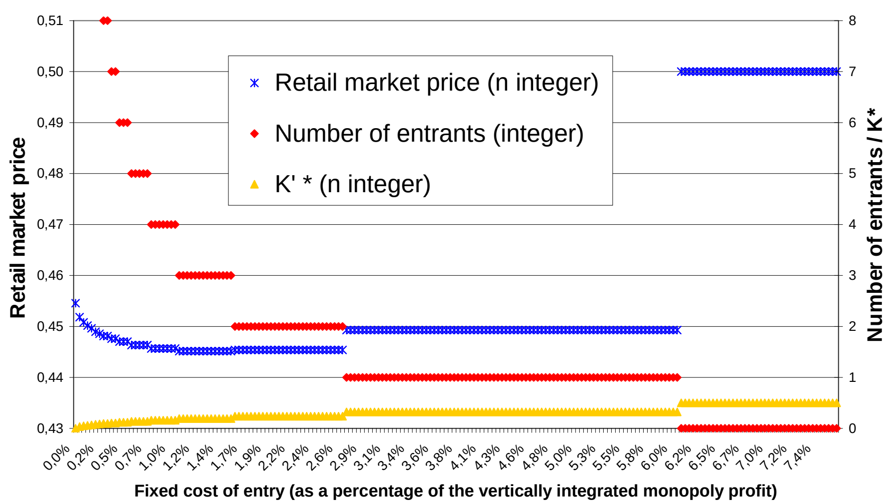


Figure 2

Figure 2 shows that final consumers do not necessarily benefit from additional entry at the retail level of the industry. They would favour a situation where only 3 newcomers compete with the incumbent, which occurs here when the fixed cost of entry is around 1.1% to 1.5% of the maximum industry profit. Lower cost levels induce excessive entry at the retail level, forcing the incumbent to reduce the size of its long-term contracts with the dominant upstream producer and therefore permitting the latter to exert more market power on the wholesale market, even though it is limited by the presence of the competitive fringe. Higher fixed costs of entry imply an insufficient level of competition at the retail level from a customer perspective. When these costs represent more than $6,1\%$ of the maximum industry profit, then no entry occurs at the retail level, which permits the incumbent and the dominant upstream producer to foreclose the wholesale market and to set the price paid by final consumers at the monopoly level. Note that in this example final consumers pay a higher price in case of perfect competition at the retail level ($F \to 0$ and $n \to +\infty$) compared to any situation characterised by a limited number of entrant (provided at least one new retailer enters and competes with the incumbent). We however have to stress that in this example the impact of the number of entrants on the price actually paid by final consumers is limited (provided there is at least one entrant) as equilibrium retail prices are within a range of approximately 2%.

We obtain qualitatively the same type of result for various values of $C_f$, provided they are sufficiently high. Indeed, when $C_f$ is small, the competitive pressure exerted by the competitive fringe on the dominant upstream producer is so strong that it becomes difficult for the latter to raise the wholesale market price significantly above its marginal cost of production. Even though additional entry at the retail level still reduces the long-term contract quantities and leads to a higher wholesale market price, final consumers do benefit in such cases from the decrease of margins at the retail level and would be better off in case of perfect competition among retailers. It turns out to be no longer verified as $C_f$ increases, as the dominant upstream producer is then able to raise the wholesale market price significantly above its marginal cost of production. Consumer surplus is then maximised when only a limited number of retailers enters.

Our proposition 3 follows:
*In the vertical industry we have depicted, excessive entry at the retail level leads to an increase of the price paid by final consumers when the dominant upstream producer faces a competitive fringe, provided the latter has substantially higher costs of productions.*

# 4 Conclusion

More competition at the retail level of a vertical industry does not *necessarily* reduce prices for final consumers. As we have shown, in case the upstream level of the industry is concentrated, excessive entry at the retail level can on the contrary raise the price paid by final consumers if it forces an incumbent retailer to reduce the size of long-term contracts it holds with a dominant upstream producer. Our model illustrates the existence of a trade-off between limiting the market power of an incumbent retailer through more competition on the retail market and that of a cartel of upstream producers trough long-term contracts.

By focussing solely on entry and competition at the retail level of a vertical industry, authorities may end up harming both final consumers and retailers profits, for the sole benefit of upstream producers. When authorities are not in a position to enhance competition between these producers, they should be careful in implementing policies that lead to threaten tools such as long-term contracts that do limit the market power of these firms.

In the European natural gas industry, long-term supply contracts have long been suspiciously scrutinised by the authorities, mainly concerned by the risk of foreclosure of the retail market by incumbent firms. They are now perceived as a key element to insure the security of supply, in particular since gas deliveries from Russia through Ukraine were twice interrupted in the recent years. We think that they should also be regarded as pro-competitive instruments that allows final consumers to benefit from lower prices on a long-term perspective[17], by limiting the potential exercise of market power by large upstream producers.

A way for future research would be to explicitly model entry at the upstream level of our vertical industry. We could also try to investigate whether the existence of historical long-term contracts makes collusion between upstream producers more likely or not.

**References**

ALLAZ, Blaise and VILA, Jean-Luc (1993): *Cournot Competition, Forward Markets and Efficiency*; Journal of Economic Theory Vol 59, pp. 1-16.

CEDIGAZ (2009): *European gas demand prospects: how to meet long-term needs?* Presentation made at the 24th World Gas Conference in Buenos Aires, available at www.wgc2009.com

CHARMAISON, Bertrand (2009): *Retail market liberalisation in a vertical industry: how excessive entry can raise the price paid by final consumers*; Presentation made at the 2009 annual meeting of the Association of Southern European Economic Theorists, available at www.econ.boun.edu.tr/asset2009/

GAUDET, Gérard and VAN LONG, Ngo (1996): *Vertical Integration, Foreclosure and Profits in the Presence of Double Marginalisation;* Journal of Economics and Management Strategy, Vol.16, pp. 367-384.

GHOSH, Arghya and MORITA, Hodaka (2007): *Free entry and social efficiency under vertical oligopoly;* The RAND Journal of Economics, Vol. 38, No 2, pp. 541-554.

HALLOUCHE, Hadi (2006): *The Gas Exporting Countries Forum; is it really a gas OPEC in the making?* Oxford Institute for Energy Studies, Working Paper NG 13.

INDERST, Roman (2002) : *Why competition may drive up prices;* Journal of Economic Behaviour and Organisation, Vol. 47, pp 451-462.

MANKIW, Gregory, and WHINSTON, Michael (1986): *Free entry and social inefficiency;* The RAND Journal of Economics, Vol. 17, No 1, pp. 48-58.

[17] European long-term contract prices for natural gas are currently way above wholesale market prices, following the drop in gas demand worldwide induced by the economic crisis and the rise in production capacity for LNG (in Qatar especially) and for unconventional gas in the United States. But in the coming years total gas demand is expected to rise again while numerous investments in new production facilities are currently frozen.

MASSOL, Olivier, and TCHUNG-MING, Stéphane (2009): *Cooperation among liquefied natural gas suppliers: is rationalization the sole objective?* Cahier de recherche du CREDEN No 06.03.64.

NEUMANN, Manfred, FELL, Uli and REICHEL, Richard (2005) : *Successive oligopolies, vertical downstream integration and foreclosure;* Journal of Industry, Competition and Trade, 5:1, pp. 59-77.

REISINGER, Markus, and SCHNITZER, Monika (2008): *A model of vertical oligopolistic competition*; Working Paper No. 2008-8; University of Munich.

WAGBARA, Obindah (2007): *How would the Gas Exporting Countries Forum influence gas trade?* Energy Policy, Vol 35, pp. 1224-1237.

# 5 Appendix

## 5.1 Appendix n°1

We assume that at date $t_2$ the upstream monopolist and the incumbent have agreed to keep their long-term contracts. The incumbent could foreclose the retail market by proposing a retail market price $p_f$ below the marginal cost of production of the upstream monopolist (zero with our set of assumptions). Any higher price would indeed induce the upstream firm to profitably sell some quantities on the wholesale market that could be bought by the entrants. Such policy is obviously not sustainable for $P_x$ greater than the marginal cost of production. If this is not the case, we verify that the incumbent profit would be strictly negative as $T + P_x > 0$:

$$\Pi^I = -TK - P_x x^I + p_f x^I \leq -(T + P_x)K < 0$$

Foreclosing the final market would then imply a negative profit for the incumbent and cannot be an equilibrium strategy. The incumbent will then leave a residual share of the final market to new entrants.

We then model the competition game as a static two-stage game with 1 upstream monopolist, 1 incumbent retailer and $N$ entrants.

At the second stage of the game, the $N$ entrant firms maximise their profit $\Pi_e^E = (D - q^I - q_e^E - \sum q_{-e}^E - p_w)q_e^E$ on the residual market by simultaneously choosing $q_e^E$. Given the wholesale market price $p_w$ and the quantity offered by the incumbent $q^I$, and further taking into account the symmetry of entrants, first order conditions yield immediately:

$$q^E = \frac{1}{N+1}(D - q^I - p_w)$$

The balance of quantities on the wholesale market imposes $s^M + s^I = Nq^E$. We further have $q^I = x^I - s^I$. Hence the derived demand addressed to the upstream monopolist and the incumbent retailer can be written as:

$$p_w = D - x^I - \frac{1}{N}s^I - \frac{N+1}{N}s^M$$

We have also:

$$p_f = D - x^I - s^M$$

Solving the first stage of the game needs to take care of the capacity constraint $x^I \leq K$, to which we associate the Lagrange multiplier $\lambda$. The upstream monopolist and the incumbent maximise their profits which are given by:

$$\Pi^M = TK + P_x x^I + p_w s^M$$

$$\Pi^I = -TK + (p_f - P_x)x^I - (p_f - p_w)s^I$$

This yields the following first order conditions:

$$D - x^I - \frac{1}{N}s^I - 2\frac{N+1}{N}s^M = 0$$

$$D - P_x - 2x^I - s^M - \lambda = 0$$

$$2s^I + s^M = 0$$

$$K - x^I \perp \lambda$$ [18]

The solution to this system is unique and given by:

| | $0 < K \leq K_{\text{lim}}$ | $K_{\text{lim}} \leq K$ |
|---|---|---|
| $s^M$ | $\frac{2N}{4N+3}(D-K)$ | $\frac{2N}{4N+3}(D-K_{\text{lim}})$ |
| $s^I$ | $\frac{-N}{4N+3}(D-K)$ | $\frac{-N}{4N+3}(D-K_{\text{lim}})$ |
| $x^I$ | $K$ | $K_{\text{lim}}$ |
| $\lambda$ | $\frac{2N+3}{4N+3}D - P_x - 6\frac{N+1}{4N+3}K \geq 0$ | $0$ |

where the threshold value for $K$ is:

$$K_{\text{lim}} = \frac{(2N+3)D - (4N+3)P_x}{6(N+1)}$$

This threshold takes a positive value for $P_x \leq \frac{2N+3}{4N+3}D$. If this assumption is not met, the variable price of the long-term contract is so high that the incumbent does not offtake any quantity under its long-term contracts. This would not be consistent with the description of our game where the incumbent retailer benefits from a low marginal cost of supply under its long-term contracts which permits that firm to play therefore before the entrants. We will assume that this condition over $P_x$ is met.

Equilibrium quantities and prices are given by:

| | $0 < K \leq K_{\text{lim}}$ | $K_{\text{lim}} \leq K$ |
|---|---|---|
| $q^E$ | $\frac{1}{4N+3}(D-K)$ | $\frac{1}{4N+3}(D-K_{\text{lim}})$ |
| $q^I$ | $\frac{N}{4N+3}D + 3\frac{N+1}{4N+3}K$ | $\frac{N}{4N+3}D + 3\frac{N+1}{4N+3}K_{\text{lim}}$ |
| $q$ | $\frac{2N}{4N+3}D + \frac{2N+3}{4N+3}K$ | $\frac{2N}{4N+3}D + \frac{2N+3}{4N+3}K_{\text{lim}}$ |
| $p_f$ | $\frac{2N+3}{4N+3}(D-K)$ | $\frac{2N+3}{4N+3}(D-K_{\text{lim}})$ |
| $p_w$ | $2\frac{N+1}{4N+3}(D-K)$ | $2\frac{N+1}{4N+3}(D-K_{\text{lim}})$ |

[18] This notation means that we jointly have $K - x^I \geq 0$, $\lambda \geq 0$ and $\lambda(K - x^I) = 0$.

Profits are then as follows:

| | $0 < K \leq K_{\text{lim}}$ |
|---|---|
| $\Pi^M$ | $(T + P_x)K + 4N\frac{N+1}{(4N+3)^2}(D - K)^2$ |
| $\Pi^I$ | $-(T + P_x)K + \frac{N}{(4N+3)^2}(D - K)^2 + \frac{2N+3}{4N+3}(D - K)K$ |
| $\Pi^E$ | $\frac{1}{(4N+3)^2}(D - K)^2$ |
| $\Pi^M + \Pi^I$ | $N\frac{4N+5}{(4N+3)^2}(D - K)^2 + \frac{2N+3}{4N+3}(D - K)K$ |

| | $K_{\text{lim}} \leq K$ |
|---|---|
| $\Pi^M$ | $TK + P_x K_{\text{lim}} + 4N\frac{N+1}{(4N+3)^2}(D - K_{\text{lim}})^2$ |
| $\Pi^I$ | $-TK - P_x K_{\text{lim}} + \frac{N}{(4N+3)^2}(D - K_{\text{lim}})^2 + \frac{2N+3}{4N+3}(D - K_{\text{lim}})K_{\text{lim}}$ |
| $\Pi^E$ | $\frac{1}{(4N+3)^2}(D - K_{\text{lim}})^2$ |
| $\Pi^M + \Pi^I$ | $N\frac{4N+5}{(4N+3)^2}(D - K_{\text{lim}})^2 + \frac{2N+3}{4N+3}(D - K_{\text{lim}})K_{\text{lim}}$ |

We notice that the expression giving the joint profit of the contracting firms is constant in $K$ for $K_{\text{lim}} \leq K$ and concave in $K$ over $0 < K \leq K_{\text{lim}}$. Over this interval, the profit is maximised for:

$$K^* = \frac{1}{2}\frac{8N + 9}{(4N + 9)(N + 1)}D$$

We verify that $K^*$ belongs to the interval $]0; K_{\text{lim}}]$ provided:

$$P_x \leq \frac{2N}{4N + 9}D$$ [19]

This maximum threshold for $P_x$ is strictly lower than $p_w(K^*) = \frac{2N+3}{4N+9}D$. Contracts maximising the joint profit of the contracting firms verify that the marginal cost of supply of the incumbent retailer is below the one of the entrants.

By picking $K^*$ and a contractual price $P_x$ that verifies the above inequality at the renegotiation stage, the upstream monopolist and the incumbent retailer will at the competition stage earn respectively:

$$\Pi^M(K^*) = \frac{1}{2}\frac{(8N + 9)}{(4N + 9)(N + 1)}(T + P_x)D + \frac{N}{N + 1}\frac{(2N + 3)^2}{(4N + 9)^2}D^2$$

$$\Pi^I(K^*) = -\frac{1}{2}\frac{(8N + 9)}{(4N + 9)(N + 1)}(T + P_x)D + \frac{9}{4}\frac{(2N + 3)^2}{(N + 1)(4N + 9)^2}D^2$$

If they do not agree to renegotiate their long-term contracts, those contracts will terminate and the firms will earn the reservation profit given by a classical double marginalisation framework ($\frac{N+1}{4(N+2)}D^2$ for the upstream monopolist and $\frac{1}{4(N+2)^2}D^2$ for the incumbent retailer). We verify that both parties have their

[19] This threshold value is strictly below $\frac{2N+3}{4N+3}D$ for which we have $x^I = 0$.

profits increasing by choosing $K^*$ and agreeing on a contractual price verifying $(P_x + T)_{\min} \leq P_x + T \leq (P_x + T)_{\max}$ where:

$$(P_x + T)_{\min} = \frac{1}{2} \frac{\left(24N^3 + 109N^2 + 162N + 81\right)}{(8N + 9)(N + 2)(4N + 9)} D$$

$$(P_x + T)_{\max} = \frac{1}{2} \frac{\left(36N^4 + 236N^3 + 569N^2 + 603N + 243\right)}{(4N + 9)(8N + 9)(N + 2)^2} D$$

It is therefore the interest of both parties to renegotiate their long-term contracts at the second stage of the game.

## 5.2 Appendix n°2

We assume that at date $t_2$ the upstream monopolist and the incumbent have agreed to keep their long-term contracts. The solution of second stage of the competition game at date $t_3$ is then identical to the one found previously:

$$q^E = \frac{1}{n+1}(D - q^I - p_w)$$

Balance of quantities on the wholesale market now writes down:

$$s^D + s^F + s^I = nq^E$$

As we further have $q^I = x^I - s^I$ and $s^F = \frac{1}{C_f} p_w$, the derived inverse demand function on the wholesale market is given by:

$$p_w = \frac{nC_f}{nC_f + n + 1}(D - (\frac{n+1}{n})s^D - x^I - \frac{1}{n}s^I)$$

The final market price is equal to $D - s^D - x^I - s^F$ which simplifies into:

$$p_f = \frac{nC_f + 1}{nC_f + n + 1}\left(D - \frac{nC_f}{nC_f + 1}s^D - x^I + \frac{1}{nC_f + 1}s^I\right)$$

At the first stage of the competition game, the dominant upstream producer and the incumbent retailer maximise their profits given by:

$$\Pi^D = p_w s^D + P_x x^I + TK$$

$$\Pi^I = (p_f - P_x)x^I - (p_f - p_w)s^I - TK$$

The incumbent is constrained by the quantity it can offtake under its long-term contracts ($x^I \leq K$) to which we associate the Lagrange multiplier $\lambda$. For the first stage of the competition game, first order conditions now write down:

$$D - 2(\frac{n+1}{n})s^D - x^I - \frac{1}{n}s^I = 0$$

$$\frac{nC_f+1}{nC_f+n+1}\left(D-\frac{nC_f}{nC_f+1}s^D-2x^I+\frac{1}{nC_f+1}2s^I\right)-P_x-\lambda=0$$

$$D+C_fs^D-2x^I+2(C_f+1)s^I=0$$

$$K-x^I\perp\lambda$$

The solution to this system is unique and given by:

| | $0<K\leq K'_{\text{lim}}$ | $K'_{\text{lim}}\leq K$ |
|---|---|---|
| $s^D$ | $\frac{2nC_f+2n+1}{(4n+3)C_f+4n+4}D-\frac{2nC_f+2n+2}{(4n+3)C_f+4n+4}K$ | $\frac{2nC_f+2n+1}{(4n+3)C_f+4n+4}D-\frac{2nC_f+2n+2}{(4n+3)C_f+4n+4}K'_{\text{lim}}$ |
| $s^I$ | $-\frac{nC_f+2n+2}{(4n+3)C_f+4n+4}D+\frac{nC_f+4n+4}{(4n+3)C_f+4n+4}K$ | $-\frac{nC_f+2n+2}{(4n+3)C_f+4n+4}D+\frac{nC_f+4n+4}{(4n+3)C_f+4n+4}K'_{\text{lim}}$ |
| $x^I$ | $K$ | $K'_{\text{lim}}$ |
| $\lambda$ | $\frac{(2n+3)C_f}{(4n+3)C_f+4n+4}D-\frac{6(n+1)C_f}{(4n+3)C_f+4n+4}K-P_x\geq 0$ | 0 |

where the threshold value for $K$ is:

$$K'_{\text{lim}}=\frac{2n+3}{6(n+1)}D-\frac{(4n+3)C_f+4n+4}{6(n+1)C_f}P_x$$

The description of our game is consistent only for $K'_{\text{lim}}\geq 0$ which induces that the marginal price of the long-term contracts must not exceed the following threshold:

$$P_x\leq\frac{(2n+3)C_f}{(4n+3)C_f+4n+4}D$$

We notice also that if the the initial set of long-term contracts is kept at the competition stage of the game ($K_0=\frac{1}{2}D$ and $P_{x0}=0$) then the incumbent will not be able to fully offtake its long term contract as we have $K'_{\text{lim}}<\frac{1}{2}D$.

Equilibrium quantities and prices are given by:

| | $0<K\leq K'_{\text{lim}}$ |
|---|---|
| $q^E$ | $\frac{1}{(4n+3)C_f+4n+4}\left(\frac{(C_f+1)(nC_f+2n+2)}{nC_f+n+1}D-C_fK\right)$ |
| $q^I$ | $\frac{nC_f+2n+2}{(4n+3)C_f+4n+4}D+\frac{3(n+1)C_f}{(4n+3)C_f+4n+4}K$ |
| $s^F$ | $\frac{n+1}{((4n+3)C_f+4n+4)(nC_f+n+1)}((2nC_f+2n+1)D-(2nC_f+2n+2)K)$ |
| $q$ | $\frac{1}{(4n+3)C_f+4n+4}\left(\frac{(2nC_f+2n+1)(nC_f+2n+2)}{nC_f+n+1}D+(2n+3)C_fK\right)$ |
| $p_f$ | $\frac{1}{(4n+3)C_f+4n+4}\left(\frac{(2n+3)nC_f^2+(2n^2+6n+3)C_f+2n+2}{nC_f+n+1}D-(2n+3)C_fK\right)$ |
| $p_w$ | $\frac{(n+1)C_f}{((4n+3)C_f+4n+4)(nC_f+n+1)}((2nC_f+2n+1)D-(2nC_f+2n+2)K)$ |

We do not reproduce results for $K'_{\text{lim}}\leq K$; as in appendix n°1 expressions are identical to the one obtained for $K\leq K'_{\text{lim}}$ except that $K$ must be replaced by $K'_{\text{lim}}$ in the formula.

Expressions of the firms profits are as follows:

| | $0 < K \leq K'_{\text{lim}}$ |
|---|---|
| $\Pi^D$ | $(T + P_x)K + \frac{(n+1)C_f}{(nC_f+n+1)((4n+3)C_f+4n+4)^2}((2nC_f + 2n + 1)D - (2nC_f + 2n + 2)K)^2$ |
| $\Pi^I$ | $-(T + P_x)K + \frac{1}{(4n+3)C_f+4n+4}(\frac{(2n+3)nC_f^2+(2n^2+6n+3)C_f+2n+2}{nC_f+n+1}D - (2n + 3)C_f K)K$ $+\frac{1}{(4n+3)C_f+4n+4}(\frac{(C_f+1)(nC_f+2n+2)}{nC_f+n+1}D - C_f K)(\frac{nC_f+2n+2}{(4n+3)C_f+4n+4}D - \frac{nC_f+4n+4}{(4n+3)C_f+4n+4}K)$ |
| $\Pi^E$ | $(\frac{1}{(4n+3)C_f+4n+4}(\frac{(C_f+1)(nC_f+2n+2)}{nC_f+n+1}D - C_f K))^2 - \frac{1}{4}FD^2$ |
| $\Pi^F$ | $\frac{1}{2}C_f(\frac{n+1}{((4n+3)C_f+4n+4)(nC_f+n+1)}((2nC_f + 2n + 1)D - (2nC_f + 2n + 2)K))^2$ |

For $K'_{\text{lim}} \leq K$, the profits are given by the above expressions and by taking $K = K'_{\text{lim}}$. However, for the dominant upstream producer profit, we must add the term $T(K - K'_{\text{lim}})$ that reflect additional take-or-pay payment from the incumbent, while such term must be deducted from the profit of the incumbent. We notice that the joint profit of the dominant upstream producer and of the incumbent retailer is constant in $K$ for $K'_{\text{lim}} \leq K$.

For $0 < K \leq K'_{\text{lim}}$, we verify that $\frac{\partial^2(\Pi^D+\Pi^I)}{\partial K^2} < 0$ for any strictly positive values of $C_f$ and $n$. The function is therefore concave in $K$ and reaches its maximum value for:

$$K'^* = \frac{1}{2}\frac{(8n + 9)C_f + 4n + 4}{((4n + 9)C_f + 4n + 4)(n + 1)}D > 0$$

We further have $K'^* \leq K'_{\text{lim}}$ for:

$$P_x \leq \frac{2nC_f}{(4n + 9)C_f + 4n + 4}D$$ [20]

Contracting firms will maximise their joint profit by choosing a quantity $K'^*$ and a marginal price $P_x$ that satisfies the above inequality. In such case, they will jointly earn:

$$\Pi^{jDI}(K'^*) = \frac{1}{4}\frac{n(2n + 3)^2C_f^2 + (n + 1)\left(8n + 4n^2 + 9\right)C_f + 4(n + 1)^2}{(n + 1)(nC_f + n + 1)((4n + 9)C_f + 4n + 4)}D^2$$

## 5.3 Appendix n°3

Liberalisation of the retail market drives down the profit of the incumbent; if its initial share of the industry rent is low, the dominant upstream producer can induce the exit of the incumbent by sticking to the initial long-term contracts. In such case, the dominant upstream producer is competing with the competitive fringe on the wholesale market where $m$ price-taker retailers supply themselves to resell the good to final consumers. We then have a double marginalisation framework whose equilibrium results are given by:

[20] Notice that this threshold is strictly below $\frac{(2n+3)C_f}{(4n+3)C_f+4n+4}D$ for which we have $x^I = 0$.

| | |
|---|---|
| $s^D$ | $\frac{1}{2}\frac{m}{m+1}D$ |
| $s^F$ | $\frac{1}{2}\frac{m}{mC_f+m+1}D$ |
| $q^E$ | $\frac{1}{2}\frac{mC_f+2m+2}{(m+1)(mC_f+m+1)}D$ |
| $q$ | $\frac{1}{2}\frac{m(mC_f+2m+2)}{(m+1)(mC_f+m+1)}D$ |
| $p_f$ | $\frac{1}{2}\frac{m(m+2)C_f+2m+2}{(m+1)(mC_f+m+1)}D$ |
| $p_w$ | $\frac{1}{2}\frac{mC_f}{mC_f+m+1}D$ |
| $\Pi^D$ | $\frac{1}{4}\frac{m^2C_f}{(m+1)(mC_f+m+1)}D^2$ |
| $\Pi^F$ | $\frac{1}{4}C_f(\frac{m}{mC_f+m+1})^2D^2$ |
| $\Pi^E$ | $\frac{1}{4}(\frac{mC_f+2m+2}{(m+1)(mC_f+m+1)})^2D^2-\frac{1}{4}FD^2$ |

For a given $F$, we will now compare the number of entrant retailers in this double marginalisation game and in the game where the incumbent is a leader on the retail market and has agreed on the contractual quantity $K'^*$ with the dominant upstream producer. We verify at first that we cannot have less entrants when the incumbent is excluded. Indeed, if we assume $n=m$ (both being integer numbers), we verify immediately that the profit of an entrant retailer is higher when the incumbent is excluded as:

$$\frac{nC_f+2n+2}{(n+1)(nC_f+n+1)}-\frac{n(2n+3)C_f^2+3(n+1)(2n+3)C_f+4(n+1)^2}{(n+1)(nC_f+n+1)((4n+9)C_f+4n+4)}>0$$

Therefore there will be always be more entrants (or at least the same number) when the incumbent is excluded. We can therefore write $m=n+y$, with $y\geq 0$. For a given $F$, the additional number of entrants that find it profitable to enter is bounded above by a value $\bar{y}$ that verifies:

$$\frac{(n+\bar{y})C_f+2(n+\bar{y})+2}{(n+\bar{y}+1)((n+\bar{y})C_f+n+\bar{y}+1)}-\frac{n(2n+3)C_f^2+3(n+1)(2n+3)C_f+4(n+1)^2}{(n+1)(nC_f+n+1)((4n+9)C_f+4n+4)}=0$$

We find:

$$\bar{y}=\frac{1}{2}\frac{(5n(n+1)+n(5n+6)C_f)C_f^2+\sqrt{z}}{(C_f+1)\left(C_f+1\right)\left(2n^2\left(C_f+2\right)\left(C_f+1\right)\right)}$$

where:

$$\begin{aligned} z \;=\;& 64\left(n+1\right)^6+32\left(10n+11\right)\left(n+1\right)^5C_f+4\left(352n+164n^2+153\right)\left(n+1\right)^4C_f^2+ \\ & 4\left(459n+550n^2+176n^3+81\right)\left(n+1\right)^3C_f^3+n\left(2005n+1672n^2+416n^3+648\right)\left(n+1\right)^2C_f^4 \\ & +2n^2\left(n+1\right)\left(475n+308n^2+64n^3+228\right)C_f^5+n^2\left(n+2\right)^2\left(4n+3\right)^2C_f^6 \end{aligned}$$

We can show that $\frac{\partial\bar{y}}{\partial n}>0$. We verify numerically that $\bar{y}$ is not monotonous in $C_f$, but that it reaches its maximum value for $C_f\rightarrow+\infty$ provided $n\geq 1$. We check also numerically that for any positive values of $n$ and $C_f$ we have $\bar{y}\leq n+\frac{5}{2}$ and therefore $m\leq 2n+\frac{5}{2}$.