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WORKING PAPER NO. 522

Dynamic Vertical Foreclosure

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January 2019

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ISSN: 2240-9696

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Abstract
This paper shows that vertical foreclosure can have a dynamic rationale. By refusing to supply an efficient downstream rival, a vertically integrated incumbent sacrifices current profits but can exclude the rival by depriving it of the critical profits it needs to be successful. In turn, monopolizing the downstream market may prevent the incumbent from losing most of its future profits because: (a) it allows the incumbent to extract more rents from an efficient upstream rival if future upstream entry cannot be discouraged; or (b) it also deters future upstream entry by weakening competition for the input and reducing the post-entry profits of the prospective upstream competitor.

Keywords: Inefficient foreclosure, Refusal to supply, Scale economies, Exclusion, Monopolization

JEL Classification: K21, L41

Acknowledgement: Comments by Luis Cabral, Claire Chambolle, Philippe Choné, Joe Farrell, Laurent Linnemer, Jorge Padilla, Fiona Scott Morton, Patrick Rey, Nicolas Schutz, David Spector, Christian Wey, Ralph Winter, as well as by participants to the 2nd Workshop on Advances in Industrial Organization (Bergamo), EARIE 2018 (Athens), MaCCI Summer Institute 2018, CRESSE 2018 Conference, Annual Conference of MaCCI 2018, Bergen Competition Policy Conference 2017, 10th Annual Competition Law Conference (Cape Town), Workshop on Competition and Bargaining in Vertical Chains (Toulouse), the Competition and Markets Authority (London), Jornadas de Economia Industrial (Alicante), the UBC Summer Conference on Industrial Organization (Vancouver), and by seminar audiences at the Paris School of Economics (Paris) and at Pontificia Universidad Católica de Chile are gratefully acknowledged. Chiara Fumagalli acknowledges financial support from Baffi-Carefin Centre and IGIER (Università Bocconi), Massimo Motta acknowledges funding from the Spanish Agencia Estatal de Investigación (AEI/FEDER) Project ECO2016-76998-P. This is a thoroughly revised version of the working paper bearing the same title and published as CEPR Discussion Paper DP12498 in December 2017.

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1 Introduction

Vertical foreclosure refers to situations in which a vertically integrated firm that dominates one market acts in such a way to exclude (or marginalize) rivals in vertically related markets. For example, a monopoly owner of a necessary input may refuse to sell it to the downstream competitors and reserve it all for its own downstream affiliate. The upstream monopolist may also resort to more subtle ways to foreclose the activity of the downstream rivals, for instance by reducing the quality of the input supplied to rivals, by degrading interconnection, or by delaying the input provision.[1]

The rationale for vertical foreclosure has long been contested. In particular, the so-called Chicago School critique pointed out that while the owner of an essential input may have the *ability* to exclude downstream rivals, it would rarely have the *incentive* to do so, especially in the presence of more efficient downstream rivals: this is because the control of the bottleneck input enables the upstream monopolist to earn higher profits by serving efficient downstream rivals, and extracting rents from them, rather than by excluding them.

Modern industrial organization and antitrust scholars have been struggling to find a rationale for anti-competitive vertical foreclosure. The common explanation behind these theories, that we will discuss more in detail at the end of this Section, is that they all rely on imperfect rents extraction: they have identified some circumstances under which the upstream monopolist is able to extract too little from the downstream rivals and for this reason it may find it more profitable to foreclose them and to monopolise the final market through the own, though less efficient, affiliate.

These theories share a static perspective. This paper identifies instead a dynamic rationale for anti-competitive vertical foreclosure. We consider a vertically integrated incumbent that faces the threat of entry in the downstream market in the current period and in the upstream market in the following period. (The same mechanism would apply if the scope for current entry was upstream and future entry may take place in the downstream market.) In this setting, we show that the upstream monopolist may have an incentive to foreclose a more efficient downstream rival even though it sacrifices current profits.

In the current period, in which only downstream entry can take place, the incumbent would find it more profitable to accommodate downstream entry and to supply the more efficient downstream competitor, because it would be able to extract sufficient rents from it. However upstream entry may also occur in the future, and with entry in both markets the incumbent will make fewer profits. Instead, if it engages in refusal to supply, it will affect the future market structure and will earn higher future profits.

Refusal to supply affects the future market structure because lack of access to the input may deprive the downstream rival of the critical profits it needs to be viable. Then refusal to supply excludes the independent rival from the downstream market. Monopolisation of the downstream market will in turn allow the vertically integrated incumbent to increase its future profits, via either of the following mechanisms.

If future entry cannot be discouraged (for instance because upstream entry entails very low fixed setup costs) the incumbent knows that it will lose the upstream monopoly in any event. However, it may find it optimal to foreclose the downstream competitor in the current period so as to obtain

[1] Alternatively, the vertically integrated firm could set a combination of high upstream (or wholesale) prices and low downstream (or retail) prices such that competitors cannot profitably operate in the downstream market, a practice known as margin squeeze.

a downstream monopoly in the future and use such position to extract rents from the more efficient upstream entrant. (If a more efficient downstream rival was in the market, the incumbent would be able to extract fewer rents from future contracting.) In this case foreclosure is motivated by the incumbent's intent to protect monopoly power downstream so as to gain a better position when contracting with the upstream rival in the future.

If upstream entry costs are large enough, future upstream entry may also be deterred, because foreclosure of the downstream rival will weaken competition for input procurement, and hence reduce the post-entry profits of the prospective upstream competitor. In this case foreclosure protects the incumbent's monopoly position in *both* vertically related markets. Note that the incumbent's incentive to engage in vertical foreclosure is weaker in this case: once the incumbent dominates the downstream market, its future profits are higher when the more efficient independent firm operates in the upstream market, because it can extract some of its rents. However, monopolising both markets is more profitable than facing competition in both of them, and the incumbent may benefit from vertical foreclosure also in this case, although to a lower extent.

Whether at equilibrium the incumbent will have an incentive to engage in refusal to supply will depend on whether future gains (obtained via the mechanisms just described) outweigh losses from not supplying the more efficient downstream entrant in the current period.

The reader familiar with the literature on exclusionary practices will have noticed that the latter mechanism (but not the former) is reminiscent of Carlton and Waldman (2002)'s model of exclusionary tying between a primary product and a complementary one. In Carlton and Waldman (2002) tying discourages current entry in the complementary market, thereby making future entry in the primary market unprofitable (which fits well the Microsoft case, which inspired the paper). We will discuss in detail in Section 2.2.4 the differences between our analysis and Carlton and Waldman's (2002) — beyond the fact that we deal with vertical foreclosure (which raises some different formal challenges) and not tying. However let us anticipate that a contribution of our paper is to show that vertical foreclosure can have a new rationale: it can be aimed not only at protecting the incumbent's monopoly power in both the vertically related markets (or in both the primary and the complementary market as for tying in Carlton and Waldman (2002)), but also – if future efficient entry in the upstream is inevitable – at protecting the incumbent's monopoly power in the downstream market so as to gain the ability to extract more rents in the future from the more efficient entrant. Moreover, the incentives to engage in vertical foreclosure are stronger in this case than in the case where vertical foreclosure discourages entry in both markets. A policy implication of this result is that downstream entry needs not be a pre-condition for upstream entry to build a theory of harm for vertical foreclosure. Indeed, a crucial ingredient for a theory of harm is that future entry in the upstream market is likely, irrespective of whether it would occur anyway or it depends on entry in the vertically related market.

Another contribution of our paper is to show that the ownership structure of the entrants affects the incumbent's ability and incentive to exclude (we study this issue in Section 4.3). Indeed, if fixed costs in the downstream market are moderate, refusal to supply manages to exclude when the entrants are independent but not when they are integrated. The reason for this result is that each vertically integrated entrant takes into account that its decision to enter a market, by intensifying competition, increases the post-entry profits of the entrant in the other market. This makes the vertically integrated entrant more prone to enter both markets, thereby making it more difficult for the incumbent to exclude.

Our paper is also related to the literature on vertical foreclosure.[2] As we mentioned earlier, in this literature it is the inability of the upstream monopolist to extract sufficient rents from downstream competitors that may generate an incentive to foreclose their activity. This inability to extract rents may be due, for instance, to the presence of sectoral regulation which restricts the upstream monopolist's freedom to contract with downstream rivals.[3]

Another source of imperfect rent extraction is the so called 'commitment problem', first proposed by Hart and Tirole (1990) and recently applied by Reisinger and Tarantino (2014) to a context in which a vertically integrated incumbent faces a more efficient downstream rival.[4]

Finally, if the incumbent faces some competition in the provision of the input, then the incentive to deny the input to an independent downstream firm may come from the so-called *raising rivals' cost* argument, due to Ordover et al. (1990): the incumbent's withdrawal from the wholesale market will make the downstream rival pay a higher price for its input requirements, because such inputs will be bought from the independent upstream firm, which will enjoy stronger market power over the independent downstream firm. In this case the downstream competitor is not completely excluded from the market, but it faces higher input costs, which makes it less competitive and aggressive in the downstream market, to the benefit of the incumbent's downstream profits.[5,6]

As we emphasized earlier, we depart from this literature because in our paper the incentive to engage in vertical foreclosure does not stem from static imperfect rent extraction. Indeed, in the *current* period, when entry occurs only in one of the vertically related market, the incumbent does sacrifice profits by engaging in refusal to deal. However, vertical foreclosure affects the future market structure and allows the incumbent to make larger profits in the *future*.[7] This result suggests that one should look not only at the current market structure but also, and possibly more importantly, at how the market is likely to evolve in the future in order to properly assess whether a vertically integrated firm has an incentive to engage in vertical foreclosure.

The paper continues in the following way. In Section 2 we study a model with minimal structure on demand and on the contracting game among upstream and downstream firms, and we show that as long as some properties on post-entry payoffs are satisfied, there may exist conditions for anti-competitive vertical foreclosure to occur at equilibrium. In Section 3 we give more structure to the model by assuming a particular (non-cooperative) contracting game. After checking that in this contracting environment the assumed payoff properties hold, we study the conditions at which vertical foreclosure emerges at equilibrium, as well as its effects on consumer and total surplus. In

[2] See Fumagalli et al (2018) for an extensive discussion of the literature on vertical foreclosure.

[3] See Jullien et al. (2014) and Fumagalli et al. (2018), for models that study the conditions under which regulation of the wholesale price induces a vertically integrated incumbent to engage in refusal to supply and in margin squeeze.

[4] See also the work by O'Brien and Shaffer (1992), McAfee and Schwartz (1994), Rey and Vergé (2004). See also Rey and Tirole (2007) for an insightful review of this literature.

[5] In both cases, there is a reduction in the competition for the input. However, in Ordover and al.'s paper the market structure is given (neither downstream nor upstream entry can be deterred), and the aim of refusal to supply is to relax downstream competition; in doing so, however, the upstream rival actually benefits from it. In our paper instead, due to the lack of downstream independent entry the upstream rival can actually be harmed - and its entry may be deterred - by refusal to supply.

[6] Another paper in which there is an incentive to exclude even in a static perspective is Comanor and Rey (2000). They consider non-integrated established firms, and each of them (be it an upstream or a downstream firm) benefits from increased competition at the other stage of production. However, since competition dissipates industry profits, entry at one stage of production lowers the *joint* profits of the established firms. This gives them the incentive to discourage entry by engaging in exclusive dealing.

[7] The incumbent would find it more profitable to accommodate entry rather than to engage in vertical foreclosure if it could also extract sufficient period-2 efficiency rents. We will discuss this issue in Section 5.2. We could say that, in our setting, the incentive to engage in vertical foreclosure stems from *future* imperfect rents extraction.

Section 4 we discuss the robustness of the results with respect to different assumptions on the length of the commitment not to supply, to different "bargaining" weights in the contracting game, and when assuming that entrants are vertically integrated. In Section 5 we look at possible alternatives to refusal to supply. First, we show that refusal to supply may still be optimal even when the incumbent has the possibility to engage in exclusive dealing with the downstream rival so as to exclude the upstream entrant. However, when exclusive dealing is possible, refusal to supply is less likely to arise at the equilibrium. Second, we show what assumptions would be necessary for the incumbent to accommodate both entrants and extract sufficient efficiency rents rather than engaging in vertical foreclosure. Finally, Section (6) concludes the paper by discussing under which circumstances one may apply this theory of harm to actual antitrust cases.

2 The Baseline Model

In this Section we describe a model that makes general assumptions on the contracting game and on the demand function, and we shall show that as long as some properties (that we regard as reasonable and general enough) of the post-entry payoffs hold, a vertically integrated incumbent that faces downstream entry today and upstream entry in the future may have both the ability and the incentive to engage in refusal to supply.

2.1 Description of the game

An indispensable input is sold by a monopolist seller, I_U, which is the upstream affiliate of the vertically integrated firm I. Firm I also operates in a downstream market through its downstream affiliate I_D which uses one unit of the input to produce one unit of a final product. Upstream and downstream production are characterised by constant marginal costs. Market demand is given by a generic function $Q = Q(p)$ with $Q(p)$ continuous, decreasing in p, concave and twice differentiable.

We analyse a two-period game. In period 1 a rival firm D considers entry in the downstream market, while an upstream competitor U can enter at the subsequent period 2. For the time being we assume that the two entrants are not vertically integrated, but in Section 4.3 we consider the case where they are integrated and we discuss how this will impact upon the conditions for vertical foreclosure.[8]

Upstream firms and (respectively) downstream firms sell perfectly homogeneous inputs and (respectively) outputs. Potential entrants are more efficient than the incumbent both upstream - where U's constant marginal cost is lower than I_U's marginal cost: $0 < c$ - and downstream - where D's marginal cost is lower than I_D's marginal cost: $\gamma_E < \gamma_I$. We make the standard assumption that the efficiency gap between the incumbent and the independent entrants is not too large, so that $c + \gamma_I < p^m(\gamma_E)$, which guarantees that entrants are not so much more efficient that they could behave as monopolists in the final market.

Upstream and downstream entry entail fixed costs F_U and F_D respectively, which satisfy the following restrictions:

$$0 \leq F_U \leq \Pi_U(D, U) \equiv \overline{F}_U \tag{A1}$$

$$0 \leq F_D \leq \Pi_D(D, \emptyset) + \Pi_D(D, U) \equiv \overline{F}_D \tag{A2}$$

[8] All the results are valid if in period 1 entry is possible only upstream while a downstream competitor can enter in period 2.

where $\overline{F}_U$ corresponds to the post-entry profits of firm U when firm D is also active; $\overline{F}_D$ corresponds to the total post-entry profits of firm D (earned in period 1 and in period 2) when it enters the downstream market in period 1 and the incumbent did not engage in refusal to supply.

Note that we use the notation $\Pi_j(D, U)$ to indicate post-entry profits of firm $j = I, D, U$, gross of the entry cost, in the market configuration where both D and U are active, $\Pi_j(D, \emptyset)$ those where D is active and U is not (recall also that in period 1 U can never operate by assumption) and so on. These upper bounds on the fixed costs ensure that, absent refusal to supply, entry (in the downstream and upstream market respectively) is profitable. These assumptions make the analysis meaningful.

The timing of the game is as follows:

1. Period 0: The incumbent decides whether to commit to 'refusal to supply' or, alternatively, to deal with the downstream rival. The commitment value of the decision to engage in refusal to supply lasts until the end of period 1.[9]

2. Period 1, stage 1: Firm D, after observing the incumbent's choice, decides whether to enter (and pay the fixed sunk cost F_D) or not;

3. Period 1, stage 2: If D is active, I and D contract upon the terms of sale of the input.

4. Period 1, stage 3: Active downstream firms choose final prices p_E and p_I, firm D orders the input to satisfy demand, paying accordingly, and transforms one unit of the input into one unit of the final product.

5. Period 2, stage 1: Firm U decides whether it wants to enter the upstream market; D can still enter if it did not enter in period 1.

6. Period 2, stage 2: Active upstream and downstream firms contract upon the terms of sale of the input.

7. Period 2, stage 3: The active downstream firms set final prices p_I and p_E, orders are made, payments take place and payoffs are realized.

All firms discount future profits at a factor $\delta = 1$. The timing of the game is summarised by Figure 1.

In this Section we do not specify in detail the contracting game. We limit ourselves to assuming that it is a non-cooperative game in which firms can offer non-linear tariffs and all offers and acceptance decisions are publicly observed. We assume, though, that the contracting game results in payoffs – associated to the different post-entry market configurations – that satisfy the properties that we illustrate below. We do not claim that these properties will hold for any possible contracting game, but they seem reasonable and general enough to be satisfied in many instances. In Section 3 we will show that they are valid under a specific contracting game, but we have looked at different versions of the game (which vary depending on the restrictions imposed on the set of feasible contracts) in which these properties also turn out to be satisfied.[10]

[9]To simplify the exposition we do not allow the incumbent to engage again in refusal to supply at the beginning of period 2, once period-0 decision has expired and before period-2 entry decisions are taken. In Section 4.1 we discuss this assumption and argue that allowing the incumbent to engage again in refusal to supply at the beginning of period 2 would not alter the results. Another possibility is that the commitment value of refusal to supply lasts forever. As we also discuss in Section 4.1, in that case refusal to supply is more likely to arise at the equilibrium.

[10]See also our CEPR Discussion Paper no. 12498.

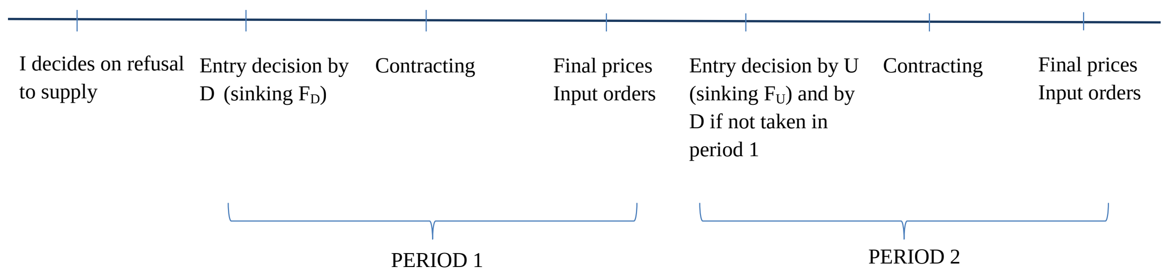

Figure 1. Timeline

Properties of the post-entry payoffs

$$min\{\pi_I(\emptyset, U), \pi_I(D, \emptyset)\} > \pi_I(\emptyset, \emptyset) > \pi_I(D, U) \tag{P1}$$

$$\Pi_D(D, U) > \Pi_D(D, \emptyset) \tag{P2}$$

$$\Pi_U(D, U) > \Pi_U(\emptyset, U) \tag{P3}$$

Property $P1$ states that the vertically integrated incumbent will obtain higher profits (a) when only one entrant is active than when none is; and (b) when neither entrant is active than when both are.

Underlying inequality (a) is the assumption that factors that may limit rents extraction (such as regulation of the input price or scope for opportunistic behavior; see the discussion in the Introduction) do not play an important role in our setting; then, consistently with the Chicago School intuition, a vertically integrated incumbent earns higher profits when dealing with a more efficient independent firm than when that independent firm is excluded from the market. Property (a) ensures that imperfect rents extraction in period 1 is not the rationale for vertical foreclosure and allows us to focus on a new rationale for vertical foreclosure.

Property (b) states that facing competition from more efficient rivals both upstream and downstream makes the vertically integrated incumbent worse off relative to the case in which it is a monopolist in both vertically related markets.

Properties P2 and P3 state that an entrant (whether downstream or upstream) will make higher profits when the other entrant is also active than when it will have to contract only with the incumbent to procure the input or to sell it downstream. Intuitively, having to deal with a bottleneck monopolist is harmful: a downstream firm benefits from choosing among more (and more efficient) input providers, and an upstream firm from having more (and more efficient) buyers that can distribute its product to the final consumers.

We shall now identify the conditions under which, if these properties on the post-entry payoffs hold, the vertically integrated incumbent has an incentive to engage in refusal to supply.

2.2 Refusal to Supply in the Base Model

We now derive the equilibria of the game, by backward induction.

2.2.1 Entry decisions in period 2

From properties (P1)-(P3) above, the following Lemma can be trivially derived:

Lemma 1. ***Entry decisions in Period 2.***
Entry decisions in period 2 depend on whether firm D decided to enter in period 1 and on the level of fixed costs:

(i) If D entered in period 1, then U enters in period 2.

(ii) If D did not enter in period 1, then the continuation of the game exhibits:

- *A unique equilibrium in which both U and D enter iff either $F_U \leq \Pi_U(\emptyset, U)$ and $F_D \leq \Pi_D(D, U)$ or $F_U \in (\Pi_U(\emptyset, U), \overline{F}_U]$ and $F_D \leq \Pi_D(D, \emptyset)$.*
- *A unique equilibrium in which only firm U enters the market iff $F_U \leq \Pi_U(\emptyset, U)$ and $F_D \in (\Pi_D(D, U), \overline{F}_D]$.*
- *A unique equilibrium in which no independent firm enters the market iff $F_U \in (\Pi_U(\emptyset, U), \overline{F}_U]$ and $F_D \in (\Pi_D(D, U), \overline{F}_D]$.*
- *Multiple equilibria in which either both firms enter the market or none of them does iff $F_U \in (\Pi_U(\emptyset, U), \overline{F}_U]$ and $F_D \in (\Pi_D(D, \emptyset), \Pi_D(D, U))$.*

Proof. The equilibrium entry decision at (i) follows from assumption A1. The equilibrium entry decisions at (ii) follow trivially from (P2)-(P3) above. □

2.2.2 Entry decision in period 1.

The entry decision taken by D in the first period is illustrated by Lemma 2. It shows that refusal to supply discourages downstream entry when downstream entry costs are sufficiently large. In that case, second period profits *alone* are insufficient to make downstream entry profitable. Then refusal to supply, by preventing D from earning profits in period 1, deprives D of the profits that are crucial to cover the entry costs, and discourages entry altogether.

Lemma 2. ***Entry decision at period*** *1:*

(i) If the incumbent did not engage in refusal to supply, D enters the downstream market in period 1. Upstream entry in period 2 follows.

(ii) If the incumbent engaged in refusal to supply, D does not enter the downstream market in either period if (and only if) $F_D \in (\Pi_D(D, U), \overline{F}_D]$ (and enters otherwise). In that case, refusal to supply discourages also upstream entry in period 2 if (and only if) upstream entry costs are sufficiently large: $F_U \in (\Pi_U(\emptyset, U), \overline{F}_U]$.

Proof. (i) If the incumbent did not engage in refusal to supply, D anticipates that the total profits it makes by entering the market in period 1 will cover the fixed entry cost: D earns $\Pi_D(D, \emptyset)$ in period 1 and $\Pi_D(D, U)$ in period 2 (by Lemma 1 we know that U will enter in period 2 if D entered in period 1). By assumption A2, entry is profitable. There is no reason to delay the entry decision until period 2 because even if a continuation equilibrium with entry arises, D would lose period 1 profits.
(ii) If the incumbent engaged in refusal to supply, by entering the downstream market D does not

make profits in period 1. Then, it will enter if (and only if) period 2 profits alone are sufficient to cover the entry cost, i.e. iff $F_D < \Pi_D(D, U)$.
Note that when $F_D \in (\Pi_D(D, \emptyset), \Pi_D(D, U)]$ and $F_U \in (\Pi_U(\emptyset, U), \overline{F}_U]$, D strictly prefers to enter in period 1 so as to avoid coordination failures in period-2 entry decisions. Otherwise, it is indifferent between entry in period 1 and in period 2. □

2.2.3 Refusal to supply in equilibrium

We can now build on the results obtained so far to examine the vertically integrated incumbent's ability and incentive to exclude. First, the following corollary establishes whether and when by engaging in refusal to supply (RtoS) I will have the *ability* to foreclose.

Corollary 1. ***Ability to exclude***

- *If $F_D \leq \Pi_D(D, U)$ refusal to supply will not exclude.*
- *If $F_D > \Pi_D(D, U)$ refusal to supply will exclude D. Two cases arise under this condition:*
  - *If $F_U \leq \Pi_U(\emptyset, U)$ then refusal to supply excludes only D.*
  - *If $F_U > \Pi_U(\emptyset, U)$ then refusal to supply excludes both D and U.*

Next, we shall examine whether I has an *incentive* to exclude. Payoff property (P1) states that the vertically integrated incumbent obtains a higher payoff when one independent firm is active than when neither is, because it extracts a sufficiently large amount of the efficiency rents that the independent firm brings into the market. This implies that refusing to supply D sacrifices the incumbent's profits in period 1 - which is the usual Chicago School argument. Then, when firm D enters the market anyway, even if the incumbent engaged in refusal to supply (i.e. when post-entry profits in period 2 are large enough to cover the downstream entry cost: $F_D < \Pi_D(D, U)$) the incumbent cannot but lose from refusal to supply, and it would never engage in it at the equilibrium. Instead, when refusal to supply discourages downstream entry – which occurs for $F_D \in \left(\Pi_D(D, U), \overline{F}_D\right)$ – there is a trade-off: in the current period refusing to supply is costly, but it is beneficial in the future period.

Refusal to supply increases the incumbent's future (period-2) profits through the two following mechanisms. When upstream entry costs are sufficiently low (i.e. $F_U \leq \Pi_U(\emptyset, U)$), upstream entry occurs in period 2 even in the absence of downstream entry. In this case, by discouraging downstream entry, refusal to supply allows the incumbent to *protect its monopoly power downstream*, and use such position to extract rents from the more efficient upstream entrant when contracting with it in the second-period: being the unique buyer of the input will allow the incumbent to extract some of the efficiency rents produced by the more efficient upstream supplier. Instead, if it did not engage in refusal to supply, downstream entry would occur, and the incumbent would face competition from D when contracting for the input and would obtain lower second period profits.

When, instead, upstream costs are sufficiently large (i.e. $F_U > \Pi(\emptyset, U)$), lack of downstream entry, by reducing the post-entry profits of the upstream independent firm, discourages also future upstream entry. In this case refusal to supply allows the incumbent to increase period-2 profits because it *protects its monopoly power* in *both* vertically related markets. Note that once downstream entry is discouraged, the incumbent's profits would be higher if upstream entry occurred, since the incumbent could extract some rents from the more efficient independent upstream firm. However, entry in neither market is more profitable for the incumbent than entry in both of them. Then, refusal to supply is beneficial in period 2 also in this case, even though to a lower extent than in the case in which upstream entry occurs anyway.

The following Proposition summarises this discussion.

Proposition 1. ***Incentive to exclude (Refusal to supply at equilibrium)***

(i) $F_D \leq \Pi_D(D, U)$*: refusal to supply will not be able to exclude.*

(ii) $F_D > \Pi_D(D, U)$ *and* $F_U \leq \Pi_U(\emptyset, U)$*: I will engage in refusal to supply (and exclude D) if* $\pi_I(\emptyset, \emptyset) + \pi_I(\emptyset, U) \geq \pi_I(D, \emptyset) + \pi_I(D, U)$*; otherwise, it will choose not to engage in refusal to supply.*

(iii) $F_D > \Pi_D(D, U)$ *and* $F_U > \Pi_U(\emptyset, U)$*: I will engage in refusal to supply (and exclude both D and U) if* $\pi_I(\emptyset, \emptyset) + \pi_I(\emptyset, \emptyset) \geq \pi_I(D, \emptyset) + \pi_I(D, U)$*; otherwise, it will choose not to engage in refusal to supply.*

(iv) When refusal to supply excludes both D and U (case (ii)) the incentive of the incumbent to engage in vertical foreclosure is weaker than when refusal to supply excludes only D (case (iii)).

2.2.4 Discussion

Proposition 1 shows that refusal to supply may occur because of a *dynamic rationale* and may emerge at the equilibrium when the sacrifice of profits in the first period (choosing not to contract with a more efficient firm reduces profits) is dominated by the second period beneficial effect (instead of having competition *both* upstream and downstream, the incumbent gains from keeping a monopoly at both levels or, even better, from extracting surplus from *one* more efficient rival, either upstream or downstream).

Let us make a few comments on the result obtained.

Existence of the incentive to exclude, and welfare effects of foreclosure. Proposition 1 gives us, within a fairly general model, the conditions under which refusal to supply may occur at equilibrium. In Section 3 we shall study the model under specific assumptions on the contracting game (and, when needed, we shall also specify the demand function) and we will show that those conditions can indeed be satisfied, and that they will depend among other things on the efficiency gap between the incumbent and the entrants. There are other reasons why it makes sense to impose more structure to the model: firstly, it will allow us to show that there exist reasonable settings in which the payoff properties (P1)-(P3) are satisfied. Secondly, it will also allow us to investigate the effects of vertical foreclosure (when it occurs at equilibrium) upon consumer surplus and total surplus.[11]

[11] Within the general framework of this Section, in which we do not specify the contracting game, we can show that refusal to supply leads to higher prices and is detrimental to consumers when it excludes both the downstream and the upstream entrant. (See Appendix A.1.1.) To show that the same result holds when refusal to supply excludes only the downstream rival we would need to impose more structure on the contracting game and specify that firms can offer contracts that commit to exclusive distribution or exclusive purchase.

A comparison with Carlton and Waldman's model. As we have seen, vertical foreclosure in our model may take two different forms: (a) the vertically integrated incumbent I will always have to coexist with an upstream entrant, but refusal to supply will protect its downstream monopoly; (b) deterring entry downstream will also prevent upstream entry, and refusal to supply will protect the incumbent's monopoly both upstream and downstream. (Recall that ceteris paribus I would prefer to find itself in case (a), because it can use upstream monopoly power to extract profits from the more efficient downstream entrant.)

The underlying mechanism in case (b), in which refusal to supply discourages entry *both* in the downstream and in the upstream market, is similar to the one proposed by Carlton and Waldman (2002) in the context of exclusionary tying.[12] In their model tying a primary product and a complementary one discourages current entry in the complementary market which in turn discourages future entry in the primary market.

To appreciate the difference between our model and Carlton and Waldman (2002) one has to note that, in their setting, entry in the primary market (which is equivalent to the upstream market in our model) would never occur (i) in the absence of entry in the complementary market and (ii) unless the entrants are part of the same company. This follows from their assumptions that the incumbent and the competitor engage in Bertrand competition and have the same marginal cost for producing homogeneous primary products. Given the existence of fixed entry costs, in their setting entry in the primary market is unprofitable *per se*.[13]

Therefore, an important difference between our model and theirs is that, in the setting proposed by Carlton and Waldman (2002), our case (a) — where vertical foreclosure is motivated by the intent to protect the downstream monopoly in the future (with upstream entry which cannot be impeded) — cannot arise. Our model, therefore, unveils a new rationale for vertical foreclosure, for which the incentives to exclude the rival are indeed stronger than in the case in which vertical foreclosure protects the incumbent's dominant position in both the vertically related markets. A further implication of this analysis is that it is not necessary that downstream entry opens the way to upstream entry to build a theory of harm for vertical foreclosure. Indeed a crucial ingredient for a theory of harm is that future entry in the upstream market is likely, irrespective of whether upstream entry would occur anyway or it depends on the success of entry in the vertically related market.

A second important difference is that in our model the entrants do not need to be vertically integrated. This allows us to study how the ownership structure of the entrants affects the scope for vertical foreclosure. In Section 4.3 we study the case of vertically integrated entrants, and show how this impacts upon the incumbent's ability and incentive to exclude relative to the baseline model where U and D are independent firms.

[12] Note that, despite similarities with tying, dealing with a model of vertical foreclosure involves some additional complexity since firms also have to contract with each other, and not only with consumers.

[13] More precisely in Carlton and Waldman (2002) entry in the primary market, even though unprofitable *per se*, increases the post-entry profits in the complementary market (where the independent firm is more efficient than the incumbent) by preventing the incumbent from engaging in price-squeeze: when there is entry in the complementary market *only*, the incumbent can set a below-cost price for the complementary product – thereby squeezing the margin of the more efficient rival – while increasing the price of the primary product; price-squeeze is not possible when entry occurs *also* in the primary market, which allows the independent firm to earn higher profits in the complementary market. If the entrants are part of the same firm, the positive externality that entry in the primary market exerts on profitability of the complementary market is internalised, and the integrated company finds it profitable to enter also the primary market. If the entrants are independent firms, entry in the primary market would never occur.

Commitment value of refusal to supply The commitment value of refusal to supply is crucial for foreclosure to arise in the model. If that decision was reversible at *any* moment, then the downstream entrant would always enter in period 1, even if it observed that the incumbent engaged in refusal to supply. Indeed, firm D would anticipate that the incumbent would undo its decision once firm D is in the market, in order to extract some of its efficiency rents. Refusal to supply would never emerge at the equilibrium.

One possible way to credibly commit to refusal to supply may be to design the input in such a way that it is compatible with the downstream affiliate only (see Choi and Yi, 2000 and Church and Gandal, 2000). To the extent that this is a technological feature that cannot be changed, this would correspond to the assumption that the commitment value of the refusal to supply lasts forever, a case is which vertical foreclosure is more likely to arise at the equilibrium than in the base-line model in which the commitment value expires after one period. We will discuss this issue in Section 4.1.

In the working paper version of this work we have also considered another avenue to deal with the commitment issue: we allow for refusal to supply to be reversible, while considering a setting where the incumbent faces successive downstream entry (followed by upstream entry) in separate geographic markets and where there is incomplete information: the downstream entrants do not know whether the incumbent's affiliates are inefficient like in the base model or they are at least as efficient as the entrants. In that setting the incumbent may want to refuse to supply downstream firms that enter the market in the early periods in order to build up a reputation to be very efficient and discourage future entrants.

3 Specifying the contracting stage: a non-cooperative game with menu offers

We have so far not fully specified the game that firms play when they contract upon the input, and simply assumed that payoffs under the different market configurations satisfy certain general properties. In this Section, we give more structure to the game by assuming that contracting takes place in a particular fashion. After describing the contracting assumptions, we proceed as follows. Firstly, we shall show that the payoff properties assumed in Section 2.1 hold under these contracting assumptions. Secondly, we check that indeed vertical foreclosure may emerge at equilibrium, and analyse what variables play a role in determining whether or not foreclosure occurs. Thirdly, we shall study the effects of (equilibrium) foreclosure upon consumer and total surplus.

3.1 The contracting assumptions

Contracting upon the input takes place in two distinct periods of our game, and we model it as a non-cooperative game with ex-ante uncertainty about who makes the offers. In the first period, if D has entered, we assume that with probability $1/2$, the incumbent makes a take-it-or-leave-it offer to D. With probability $1/2$, it is D that makes a take-it-or-leave-it offer to the incumbent. Likewise, in period 2 we assume that active upstream firms (either I only, or also U if it has entered) make offers to active downstream firms with probability $1/2$. With probability $1/2$, it is active downstream firms (I and, if it is in the market, also D) that make a take-it-or-leave-it offer to active upstream firms.[14]

[14] Assuming that the offers are made with probability $1/2$ makes things simpler. We do not need to specify a particular value for the probabilities of making offers, but for our analysis to be meaningful we need to exclude the extreme case in

Feasible contracts. As for the content of the offers, we allow firms to offer "rich" enough contracts. The incumbent can make offers that commit to "withdrawal", i.e. to stop operating the downstream affiliate if the offer is accepted. Downstream firms can make offers that commit to exclusive purchase, i.e. not to buy the input from upstream sellers other than the one involved in the contract. Moreover, we allow firms to offer menus of contracts that specify different terms of trade depending on whether the relationship is exclusive or not. Consider the case in which upstream firms make the offer. Each upstream firm, say I_U, can offer a contract that specifies different terms of trade (i.e. marginal price w and fixed fee T) when the downstream firm D accepts only I_U's offer (thereby purchasing in exclusivity from I_U) or when D accepts the offers of both upstream suppliers. Similarly, when downstream firms make the offer: each downstream firm, say I_D, can offer a contract that specifies different terms of trade when the upstream firm U accepts only I_D's offer (thereby selling in exclusivity to I_D) or when U accepts the offers of both downstream firms.[15]

It turns out that such rich set of feasible contracts allow firms to sustain the maximal industry profits in period 2, when both D and U are active. (See Section 3.2 and Appendix A.1.2.) Furthermore, among the equilibria that sustain maximal industry profits, we will focus on the one that attributes the highest payoff to the incumbent. This set of assumptions allows us to focus on the least favourable environment for vertical foreclosure, since the higher the profits that the incumbent makes when all rivals are in the market, the weaker its incentive to engage in refusal to supply. Then, if vertical foreclosure emerges as an equilibrium behavior in this case, it will *a fortiori* emerge in other environments in which the set of feasible contracts is more restricted and the incumbent's payoff is lower.[16]

3.2 Post-entry payoffs under different market configurations

The following Lemma summarises the post-entry payoffs of the incumbent and of the independent firms depending on the configurations of active firms. The post-entry profits are indicated in Table 1 according to the following notation: we indicate with $\pi^m(c_i)$ the monopoly profits of a firm with marginal cost c_i and facing market demand $Q(p)$, while with $\pi^d(c_i, c_j)$ we indicate the duopoly profits obtained by a firm with marginal cost c_i competing à la Bertrand in the final market (with demand $Q(p)$) with a firm with marginal cost c_j and $p^m(c_i) > c_j$. Also recall that we denote by (D, U) the configuration where both entrant firms D and U are in the market, $(D, \emptyset)$, $(\emptyset, U)$ and $(\emptyset, \emptyset)$ those where respectively only D is in the market, only U is in the market, and neither entrant is in the market. The equilibria producing those payoffs are discussed in detail in Appendix A.1.2.

which I can extract all of D's rents in period 1, otherwise D makes no profits at all in that period, and whatever occurs in period 1 does not affect its entry decision. Once that extreme case where upstream firms always make the offers is excluded, our results remain qualitatively valid, under the caveat that the lower the probability that upstream firms make the offers the stronger the incumbent's incentive to engage in refusal to supply. (See the discussion in Section 4.2).

[15]Contracts contingent on the relationship being exclusive (or not) are allowed for, among the others, in Bernheim and Whinston (1998) and Miklós-Thal, Rey and Vergé (2011). In particular, the latter shows that contracts contingent on exclusivity allow to sustain maximal industry profits in a setting in which downstream retailers make take-it-or-leave-it offers to a single manufacturer.

[16]We do not allow firms to make offers contingent on the acceptance decision of another firm or on how much it would sell. For instance, an upstream firm, say U, cannot offer a contract to a downstream firm, say D, which depends on whether the other downstream firm I_D accepts or rejects U's offer. Maximal industry profits can be sustained even though the set of feasible contracts does not include those contracts.

Lemma 3. ***Post-entry payoffs, with menu offers***

The payoffs of the incumbent and of the independent firms (gross of any entry costs), in the different configurations of active firms are as follows:

Table 1. Post-entry payoffs with menu offers, under different market configurations.

$D\backslash U$	Active	Not Active
Active	$\pi_I(D,U) = \pi^m(\gamma_E) - \pi^d(\gamma_E, c+\gamma_I)$ $\Pi_D(D,U) = \frac{\pi^d(\gamma_E,c+\gamma_I)-[\pi^m(\gamma_I)-\pi^m(c+\gamma_E)]}{2}$ $\Pi_U(D,U) = \frac{\pi^d(\gamma_E,c+\gamma_I)+[\pi^m(\gamma_I)-\pi^m(c+\gamma_E)]}{2}$	$\pi_I(D,\emptyset) = \frac{\pi^m(c+\gamma_I)+\pi^m(c+\gamma_E)}{2}$ $\Pi_D(D,\emptyset) = \frac{\pi^m(c+\gamma_E)-\pi^m(c+\gamma_I)}{2}$ $\Pi_U(D,\emptyset) = 0$
Not Active	$\pi_I(\emptyset,U) = \frac{\pi^m(\gamma_I)+\pi^m(c+\gamma_I)}{2}$ $\Pi_D(\emptyset,U) = 0$ $\Pi_U(\emptyset,U) = \frac{\pi^m(\gamma_I)-\pi^m(c+\gamma_I)}{2}$	$\pi_I(\emptyset,\emptyset) = \pi^m(c+\gamma_I)$ $\Pi_D(\emptyset,\emptyset) = 0$ $\Pi_U(\emptyset,\emptyset) = 0$

Proof. See Appendix A.1.2. □

It may be useful to give some intuition behind these payoffs also in the text. Consider first the case where no independent firm is active: $(\emptyset,\emptyset)$. In this case, the incumbent monopolises the final market by using its own *less efficient* upstream and downstream technologies, thereby making profits $\pi^m(c+\gamma_I)$.

When one independent firm is active, say the downstream firm D — market configuration $(D,\emptyset)$ — the incumbent is left with its outside option payoff, $\pi^m(c+\gamma_I)$, if take-it-or-leave-it offers are made downstream; however, if I_U makes the take-it-or-leave-it offer, the incumbent manages to extract from D the monopoly profits associated with the more efficient downstream technology: $\pi^m(c+\gamma_E) > \pi^m(c+\gamma_I)$ from $\gamma_I > \gamma_E$.[17] In expected terms the incumbent earns higher profits than in the case in which firm D is not active. The logic is similar when only the upstream firm is active: $(\emptyset, U)$. There again, the incumbent appropriates part of firm U's efficiency rents and earns higher profits than in the case in which firm U is not active.

When both independent firms are active (D,U), maximal industry profits are sustained by way of contracts that pay the inefficient incumbent not to compete downstream: the efficient independent firms D and U are the only ones to produce and sell, making the monopoly profits $\pi^m(\gamma_E)$; the incumbent is remunerated at its marginal contribution for not competing downstream, receiving the difference between the monopoly profits $\pi^m(\gamma_E)$ and the duopoly profits $\pi^d(\gamma_E, c+\gamma_I)$. Note also that, when offers are made downstream, the use of menus of contracts, whose terms of trade depend of whether U sells in exclusivity, is crucial to sustain the maximal industry profits. Essentially, at the equilibrium the incumbent's downstream affiliate I_D offers to buy in exclusivity from U at a very high marginal price w and a negative fixed fee (i.e. a payment from U), while firm D offers to pay U a positive fee and a marginal price w equal to U's marginal cost. If U accepts both offers, I_D will not exert competitive pressure in the downstream market and maximal monopoly profits $\pi^m(\gamma_E)$ will be sustained. Without menus of contracts, though, U would never accept also I_D's offer, as it does not internalise the benefit of lack of competition in the final market and it is not willing to pay for that.

[17]In our setting the possibility to offer two-part tariffs or to commit to exclusive distribution removes the scope for opportunistic behavior through the downstream affiliate and allows the vertically integrated incumbent to sustain and extract the maximal profits $\pi^m(c+\gamma_E)$.

With menus of contracts, instead, the terms of trade offered by D if the upstream entrant accepts only D's offer can be adjusted in such a way to make U indifferent between accepting both offers or only one. Menus of contracts might allow to sustain multiple equilibria with different distribution of maximal industry profits. The equilibrium we have focused on attributes to the incumbent the highest possible profits. This allows us to focus on the least favourable environment for vertical foreclosure.[18]

Once found the payoffs of the game under these specific contracting model, we can show they satisfy properties (P1)-(P3).

Corollary 2. *The payoffs obtained under our contracting game satisfy properties (P1)-(P3).*

Proof. The first part of (P1) says that the incumbent is better off when *one* independent firm is active than when none is active: $\min\{\pi_I(\emptyset, U), \pi_I(D, \emptyset)\} > \pi_I(\emptyset, \emptyset)$. These comparisons follow from noting that $\pi^m(\gamma_I) > \pi^m(c + \gamma_I)$ and that $\pi^m(c + \gamma_E) > \pi^m(c + \gamma_I)$ since $c > 0$ and $\gamma_E < \gamma_I$. The second part of (P1), $\pi_I(\emptyset, \emptyset) > \pi_I(D, U)$, follows from noting that the Arrow replacement effect (which is satisfied under regular demand functions) implies $\pi^d(\gamma_E, c + \gamma_I) > \pi^m(\gamma_E) - \pi^m(c + \gamma_I)$. Similarly for (P2) — $\Pi_D(D, U) > \Pi_D(D, \emptyset)$ — and (P3) — $\Pi_U(D, U) > \Pi_U(\emptyset, U)$ — after noting that the following inequalities hold: $\pi^d(\gamma_E, c + \gamma_I) > \pi^m(\gamma_E) - \pi^m(c + \gamma_I) > \pi^m(\gamma_I) - \pi^m(c + \gamma_I)$ and $\pi^d(\gamma_E, c + \gamma_I) > \pi^m(\gamma_E) - \pi^m(c + \gamma_I) > \pi^m(c + \gamma_E) - \pi^m(c + \gamma_I)$.

□

3.3 Refusal to supply at equilibrium

Next, we show that under this contracting game vertical foreclosure will arise at equilibrium, and under which conditions it will be so.

Proposition 2. ***Profitability of refusal to supply***

(i) ***Refusal to supply protects the downstream monopoly***

When it discourages only downstream entry (i.e. when $F_D > \Pi_D(D, U)$ and $F_U \leq \Pi_U(\emptyset, U)$), a sufficient condition for refusal to supply to be profitable is that $\gamma_I \leq c + \gamma_E$.

In the linear demand case (i.e. $Q(p) = 1 - p$) there exist threshold levels γ_I^P and c^P such that:

- *if $c \geq c^P \equiv \frac{1-\gamma_E}{12}$, refusal to supply is always profitable for the incumbent.*
- *if $c < c^P$, refusal to supply is profitable for the incumbent if (and only if) $\gamma_I \leq \gamma_I^P \equiv \frac{1}{5}(1 - 6c + 4\gamma_E + \sqrt{c^2 + 18c(1 - \gamma_E) + (1 - \gamma_E)^2})$.*

(ii) ***Refusal to supply protects monopoly power in both markets***

When it discourages entry in both markets (i.e. when $F_D > \Pi_D(D, U)$ and $F_U > \Pi_U(\emptyset, U)$), refusal to supply is less likely to be profitable for the incumbent. A sufficient condition for refusal to supply to be profitable is that γ_I is close enough to γ_E.

[18] In a previous version of the paper (CEPR Discussion Paper 12498) we did not allow to remunerate a firm, I in our case, not to compete downstream. Under those restrictions the equilibria emerging in period 2, when both D and U are active, do not sustain maximal industry profits and the incumbent's payoff is lower than in the case we analyse in this version, making vertical foreclosure more likely.

In the linear demand case (i.e. $Q(p) = 1 - p$) there exist threshold levels c^{PP} and γ_I^{PP} such that:

- *if $c \geq c^{PP} \equiv (1 - \frac{\sqrt{3}}{2})(1 - \gamma_E)$, refusal to supply is always profitable for the incumbent, with $c^{PP} > c^P$.*
- *if $c < c^{PP}$, refusal to supply is profitable for the incumbent if (and only if) $\gamma_I \leq \gamma_I^{PP} \equiv \frac{1}{5}\left(1 - 5c + 4\gamma_E + \sqrt{-5c^2 + 10c(1-\gamma_E) + (1-\gamma_E)^2}\right)$, with $\gamma_I^{PP} < \gamma_I^P$.*

Proof. Case (i): Refusal to supply discourages only downstream entry.
The incumbent's change in profits when it engages in refusal to supply (that is, $\pi_I(\emptyset, \emptyset) + \pi_I(\emptyset, U) - \pi_I(D, \emptyset) - \pi_I(D, U)$) can be written as:

$$\Delta\pi_I = \pi^d(\gamma_E, c + \gamma_I) - [\pi^m(\gamma_E) - \pi^m(c + \gamma_I)] - \frac{1}{2}[\pi^m(c + \gamma_E) - \pi^m(\gamma_I)] \tag{1}$$

where $\pi^d(\gamma_E, c + \gamma_I) - [\pi^m(\gamma_E) - \pi^m(c + \gamma_I)] > 0$ by the Arrow's replacement effect. If $\gamma_I \leq c + \gamma_E$ then $\frac{1}{2}[\pi^m(c + \gamma_E) - \pi^m(\gamma_I)] \leq 0$ and $\Delta\pi_I > 0$.

See Appendix A.1.3 for the analysis of the linear case.

Case (ii): Refusal to supply discourages entry in both markets.
The incumbent's change in profits when it engages in refusal to supply (that is, $\pi_I(\emptyset, \emptyset) + \pi_I(\emptyset, \emptyset) - \pi_I(D, \emptyset) - \pi_I(D, U)$) can be written as:

$$\Delta\pi_I = \pi^d(\gamma_E, c + \gamma_I) - [\pi^m(\gamma_E) - \pi^m(c + \gamma_I)] - \frac{1}{2}[\pi^m(c + \gamma_E) - \pi^m(c + \gamma_I)] \tag{2}$$

Note that $\pi^m(\gamma_I) > \pi^m(c + \gamma_I)$. Then in this case $\Delta\pi_I$ is lower than in Case (i). Note also that if $\gamma_I = \gamma_E$ then $\frac{1}{2}[\pi^m(c+\gamma_E) - \pi^m(c+\gamma_I)] = 0$ and $\Delta\pi_I > 0$. By continuity, $\Delta\pi_I > 0$ if γ_I is sufficiently close to γ_E.

See Appendix A.1.3 for the analysis of the linear case.

□

There are two points affecting the likelihood of vertical foreclosure which are worth stressing and which go beyond the linear demand example. The first one is that refusal to supply is the more likely the closer the efficiency levels between the downstream affiliate of I and the downstream rival (that is, the lower γ_I). This is because (equilibrium) the lower the efficiency gap between the own downstream affiliate and the downstream rival the lower the sacrifice of profits in the first period, when the incumbent supplies the final market through the own affiliate, rather then relying on the independent firm D and extracting part of D's efficiency rents.

The second one, that we have already mentioned in the discussion of the general model, is that the incumbent benefits less from refusal to supply when it deters entry of *both* rivals. Indeed, the thresholds identified in the proposition for the linear case are such that $c^{PP} > c^P$ and $\gamma_I^P > \gamma_I^{PP}$, implying that vertical foreclosure is less likely to occur when it results in the incumbent maintaining the monopoly on both markets.

3.4 Welfare effects of refusal to supply

In this section we analyse the impact of vertical foreclosure on welfare, something we were unable to determine in the general model. First, we look at the effect on consumer surplus, later on total surplus.

When the incumbent engages in refusal to supply consumers pay a higher price (relative to the case in which there is no refusal to supply) both in period 1, when the inefficient incumbent monopolises the market, and in period 2 when, in the best-case scenario, only the independent upstream firm enters the market. Then, refusal to supply is detrimental for consumers, as stated in following lemma.

Lemma 4. ***Effect of refusal to supply on consumers.***
Refusal to supply harms consumers when it emerges at the equilibrium.

Proof. Absent refusal to supply consumers pay the price $p^m(c + \gamma_E)$ in period 1, when only downstream entry occurs and the price $p^m(\gamma_E)$ in period 2 when also upstream entry occurs. When the incumbent engages in refusal to supply consumer pay the price $p^m(c + \gamma_I) > p^m(c + \gamma_E)$ in period 1, since downstream entry is discouraged and the incumbent monopolises the final market with the own affiliates. In period 2 consumers pay the price $p^m(\gamma_I) > p^m(\gamma_E)$ when upstream entry occurs in period 2 (Case (i)). They pay the price $p^m(c + \gamma_I) > p^m(\gamma_E)$ when refusal to supply discourage also upstream entry (Case (ii)). □

Refusal to supply is detrimental also for total welfare as long as it discourages efficient entry, i.e. when entry costs are not too high; otherwise, refusal to supply is welfare beneficial. The latter case refers to the well-known possibility that there may be excess entry in a market. (See e.g. Mankiw and Whinston (1986).) Lemma 5 below identifies the threshold levels of fixed costs F_D^W and F_{D+U}^W that distinguish between welfare detrimental and welfare beneficial refusal to supply, and highlights that the condition for refusal to supply to be welfare detrimental is more likely to be satisfied the higher the efficiency gap between the incumbent downstream affiliate and the independent downstream firm. However, with generic demand functions it is not possible to establish whether such threshold levels of fixed costs fall within or outside the feasible interval of the fixed costs F_D and F_U identified by assumptions A1 and A2. However, we show in Appendix $A.1.2.2$ that for the specific case of linear demand $Q(p) = 1 - p$, different configurations of parameters can give rise to situations where F_D^W (or F_{D+U}^W) is: (a) above the upper bound, implying that refusal to supply is always welfare detrimental when it arises; (b) below the lower bound, implying that refusal to supply is always welfare beneficial, or (c) falls within the interval.

Lemma 5. ***Effect of refusal to supply on total welfare.***

Case (i): Refusal to supply that discourages downstream entry is welfare detrimental iff $F_D \leq F_D^W \equiv \Delta CS(p^m(c+\gamma_I), p^m(c+\gamma_E)) + \Delta\pi^m(c+\gamma_I, c+\gamma_E) + \Delta CS(p^m(\gamma_I), p^m(\gamma_E)) + \Delta\pi^m(\gamma_I, \gamma_E)$.

Case (ii): Refusal to supply that discourages entry in both markets is welfare detrimental iff $F_D + F_U \leq F_{D+U}^W \equiv \Delta CS(p^m(c + \gamma_I), p^m(c + \gamma_E)) + \Delta\pi^m(c + \gamma_I, c + \gamma_E) + \Delta CS(p^m(c + \gamma_I), p^m(\gamma_E)) + \Delta\pi^m(c + \gamma_I, \gamma_E)$.

$\Delta CS(x, y)$ *indicates the change in consumer surplus when the price varies from* x *to* y *and* $\Delta\pi^m(x, y)$ *indicates the change in monopoly profits when the marginal cost of production varies from* x *to* y.

Both inequalities are the more likely to be satisfied the lower γ_E and the higher γ_I. Therefore, if refusal does occur at equilibrium, it will be more likely to be detrimental the higher the efficiency gap between I and D.

Proof. Case (i).
Absent refusal to supply total welfare amounts in the two periods amount to:

$$W^T = CS(p^m(c+\gamma_E)) + \pi^m(c+\gamma_E) + CS(p^m(\gamma_E)) + \pi^m(\gamma_E) - F_D - F_U$$

When the incumbent engages in refusal to supply (that discourages only downstream entry) total welfare is given by:

$$W^R = CS(p^m(c+\gamma_I)) + \pi^m(c+\gamma_I) + CS(p^m(\gamma_I)) + \pi^m(\gamma_I) - F_U$$

Refusal to supply is welfare detrimental iff $F_D \leq F_D^W$.
Case (ii).
When the incumbent engages in refusal to supply (that discourages entry in both markets) total welfare is given by:

$$W^{RR} = CS(p^m(c+\gamma_I)) + \pi^m(c+\gamma_I) + CS(p^m(c+\gamma_I)) + \pi^m(c+\gamma_I)$$

Refusal to supply is welfare detrimental iff $F_D + F_U \leq F_{D+U}^W$.

□

4 Extensions

In this Section we show the robustness of the results with respect to different assumptions on the length of the commitment not to supply (Section 4.1), to different bargaining weights in the contracting game (Section 4.2), and when assuming that entrants are vertically integrated (Section 4.3).

4.1 Commitment to refusal to supply

So far we have not allowed the incumbent to engage again in refusal to supply at the beginning of period 2 (that is, once period-0 decision has expired). Imagine, instead, that before period-2 entry decisions are taken the incumbent can renew its decision concerning refusal to supply. If the independent firm D has already entered the downstream market in period 1, the incumbent has no incentive to engage again in refusal to supply. Imagine it does. Given that D has entered, U will also enter: since the incumbent cannot deal with D, D will be more dependent on U for the provision of the input and post-entry profits of U will increase. The incumbent, instead, will be disadvantaged when contracting for the input as refusal to supply limits its possibility to make offers. Anticipating this, when D is in, the incumbent prefers not to engage in refusal to supply at the beginning of period 2. In turn, firm D will enter the market in period 1, irrespective of what the incumbent chose in period 0, if $F < \Pi_D(D,U)$, i.e. if the post-entry profits of firm D (when both independent firms are in the market and the incumbent does not engage in refusal to supply) are higher than the entry cost. This will induce the incumbent not to engage in refusal to supply at the beginning of the game, as we discussed in Section 2.2.3. If, instead, $F > \Pi_D(D,U)$, D would not enter in either period if the incumbent engaged in refusal to supply in period 0. In this case the possibility to renew the decision at the beginning of period 2 is irrelevant. Therefore, if we allowed for the possibility to engage again in refusal to supply at the beginning of period 2, the analysis would not change.

An alternative assumption is that the commitment value of refusal to supply, decided in period 0, never expires. In that case refusal to supply would be more likely to discourage downstream entry. Indeed, refusal to supply would not only prevent the independent downstream firm to make profits in period 1, as in the baseline model, but it would also reduce the post-entry profits of D in period 2. As mentioned above, if the incumbent commits not to deal with D, D will be more dependent on U for the provision of the input and its profits cannot but decrease. As a result, the threshold level of the downstream entry costs such that refusal to supply discourages downstream entry would decrease, and vertical foreclosure would be more likely to emerge at the equilibrium. Therefore, by focusing on the case in which the commitment value lasts for one period, we are focusing on the least favorable scenario for vertical foreclosure to arise.

4.2 Probability to make take-it-or-leave-it offers

We have assumed that the upstream and downstream firms have equal probability to make take-it-or-leave-it offers when contracting the terms of trade. In other words, denoting as β the probability that upstream firms make take-it-or-leave-it offers, we have been focusing on the case in which $\beta = 1/2$. For our analysis to be meaningful we have to exclude the extreme case is which upstream firms always make the offers (i.e. in which $\beta = 1$). In that case, in period 1, the incumbent would extract all the profits from D. The downstream entrant would not earn any profit in period 1, even though the incumbent does not engage in refusal to supply, and the upper bound of downstream entry costs such that entry is feasible absent refusal to supply, $\overline{F}_D$, would coincide with period-2 post-entry profits of D, $\Pi_D(D, U)$. As a consequence, as we discussed in Section 2.2.3, for any feasible value of the downstream entry costs ($F_D < \overline{F}_D$) refusal to supply would not discourage downstream entry and the incumbent would have no incentive to engage in it. Consider now a generic $\beta < 1$. As β decreases, the incumbent extracts lower profits from D in period 1 when it does not engage in refusal to supply. Then the lower β the lower the profit sacrifice of the incumbent in period 1 if it engages in refusal to supply. Let us consider now period 2. Absent refusal to supply, the incumbent's payoff in period 2 does not depend on β: irrespective of who makes the offers, the incumbent obtains its marginal contribution $\pi^m(\gamma_E) - \pi^d(\gamma_E, c + \gamma_I)$. Then, when refusal to supply discourages entry in both markets, the incumbent's benefit in period 2 does not depend on β. When, instead, refusal to supply discourages only downstream entry, the incumbent's benefit in period 2 increases as β decreases. Indeed, the higher the probability that downstream firms make the offer, the higher the profits that the incumbent extracts in period 2 when only the upstream independent firm has entered the market. We can, then, conclude that the lower the probability β that upstream firms make the offers the stronger the incumbent's incentive to engage in refusal to supply.

4.3 Vertically Integrated Entrants

Consider the case where D and U are vertically integrated, and call E the vertically integrated entrant.

Let us look at the general case where the contracting stage of the game is not specified, and simply assume that D and U will be able to extract at least the same profits when they are integrated as when they are independent of each other (and that firm I will obtain weakly lower profits when the independent firms are integrated than when they are not):

$$\Pi_E^{vie}(D,U) \geq \Pi_D(D,U) + \Pi_U(D,U) \tag{P4}$$

$$\pi_I^{vie}(D,U) \leq \pi_I(D,U) \tag{P5}$$

where the index *vie* stands for the configuration where there is a vertically integrated entrant.[19]

We keep the assumptions (A1) and (A2) on fixed costs F_D and F_U, and note that they imply:

$$0 \leq F_D + F_U \leq \Pi_D(D,\emptyset) + \Pi_D(D,U) + \Pi_U(D,U) \tag{A3}$$

Lemma 6 shows that, when the entrants are vertically integrated, there exist values of the fixed downstream costs – namely $F_D \in (\Pi_D(D,U), F_D^{vie}]$ – such that refusal to supply would discourage entry under vertical separation but not under vertical integration. To see the intuition consider the entry decisions at period 2, when no entry occurred in period 1. Under vertical separation, the downstream firm takes its entry decision comparing own post-entry profits to the fixed entry cost. If those profits are insufficient to cover the entry cost (i.e. if $F_D > \Pi_D(D,U)$), it will decide not to enter. In that situation the vertically integrated entrant might, instead, decide to enter the downstream market. This is because the vertically integrated entrant internalises the beneficial effect that downstream entry exerts on the post-entry profits in the upstream market. Then, entering both markets may become a profitable strategy, even though downstream entry *per se* is not. Moreover, entry in both markets by a vertically integrated firms might be strictly more profitable than entry by two independent firms (property P4). This is a further reason why vertical integration might make exclusion less likely.

Lemma 6. ***Ability to exclude under vertical integration***
The ability *to engage in vertical foreclosure is more limited when entrants are vertically integrated (it is easier to exclude under vertically separated entrants): there exists a threshold level of the downstream entry cost – that is,* $F_D^{vie} \equiv \min\{\Pi_E^{vie}(D,U) - F_U, \Pi_E^{vie}(D,U) - \Pi_U(\emptyset,U)\}$*, with* $F_D^{vie} > \Pi_D(D,U)$ *– such that if* $F_D \in (\Pi_D(D,U), F_D^{vie}]$ *refusal to supply does not discourage entry in either market when the entrants are vertically integrated, whereas it discourages downstream entry (and upstream entry if* $F_U > \Pi_U(\emptyset,U)$ *) when the entrants are separated.*

Proof. See Appendix A.2.1. □

After studying I's ability to exclude, we still have to check its *incentive* to do so. It is straightforward to check that, as long as the profits that I makes when the vertically integrated entrants are active in period 2 are (weakly) lower than when they are vertically separated (that is, $\pi_I^{vie}(D,U) \geq \pi_I(D,U)$, as assumed by property (P5)), then the incentive to exclude is (weakly) stronger. This is because, when the entrants are vertically integrated, the incumbent has more to lose from the presence of both independent firms in period 2.

[19] This assumption can be justified considering that D and U, when integrated, could at least replicate the contractual offers and the outcome in the final market that arise when they are independent; they might also do better by internalizing the effect of their choices on the vertically related firm. Moreover, one could assume that the decision to integrate vertically is taken at an earlier stage, and would not be made if it is not (weakly) profitable.

Proposition 3. ***Incentive to exclude. (Refusal to supply at equilibrium with vertically integrated entrants)***

(i) When the entrants are vertically integrated, $F_U \leq \Pi_U(\emptyset, U)$ and $F_D > \Pi_E^{vie}(D, U) - \Pi_U(\emptyset, U)$, I will engage in refusal to supply (and exclude D) iff $\pi_I(\emptyset, \emptyset) + \pi_I(\emptyset, U) > \pi_I(D, \emptyset) + \pi_I^{vie}(D, U)$.

(ii) When the entrants are vertically integrated, $F_U > \Pi_U(\emptyset, U)$ and $F_D > \Pi_E^{vie}(D, U) - F_U$, I will engage in refusal to supply (and exclude both D and U) iff $\pi_I(\emptyset, \emptyset) + \pi_I(\emptyset, \emptyset) > \pi_I(D, \emptyset) + \pi_I^{vie}(D, U)$.

(iii) Conditional on being able to deter entry, the incumbent has a (weakly) stronger incentive to engage in refusal to supply when the entrants are vertically integrated.

Proof. See Appendix A.2.2 . □

Corollary 3 compares the equilibrium outcomes under vertically integrated and independent entrants.

Corollary 3. ***Equilibrium comparison: vertically integrated entrants v. vertically separated entrants.***

(i) If $F_D \leq \Pi_D(D, U)$, refusal to supply does not arise at equilibrium under either independent or integrated entrants.

(ii) If $\Pi_D(D, U) < F_D \leq F_D^{vie}$, refusal to supply does not exclude when the entrants are integrated whereas it has the ability to exclude under independent entrants. Refusal to supply arises at equilibrium under independent entrants if the incumbent has the incentive to engage in it, as established by Proposition 1.

(iii) If $F_D > F_D^{vie}$, refusal to supply has the ability to exclude in both cases, but the incentive of the incumbent to engage in it is (weakly) stronger when the entrants are independent.

Note that the result that vertical integration of the entrants limits the incumbent's ability to exclude relies exclusively on the fact that a vertically integrated entrant take its entry decision based on total profits. Even if the profits that the vertically integrated entrant obtains from period-2 contracting are simply the sum of the individual profits of the independent entrants, vertical integration makes the entrant more willing to enter both markets in period 2, simply because it internalizes the increase in the upstream post-entry profits caused by downstream entry. Instead, for vertical integration to strictly increase the incumbent's incentive to exclude, properties $P4$ and $P5$ should hold with strict inequality, i.e. vertical integration should enable the entrant to extract strictly higher rents from period-2 contracting – so that the scenario in which both entrants are active is even less profitable for the incumbent – something that is likely to depend on the way the contracting game is specified and on the set of feasible contracts.

5 Alternatives to refusal to supply

In this section we look at two alternatives to refusal to supply (but there may be others). Given that what hurts I is the presence of both entrants, the first alternative is that the incumbent, instead of excluding D by using refusal to supply, may want to exclude U by using exclusive dealing arrangements with D. The second alternative is that, instead of excluding either entrant, the incumbent may want to accommodate both of them and resort to some contracts to extract their efficiency rents. We discuss each of these alternatives in what follows.

5.1 Exclusive dealing v. refusal to supply

The purpose of this section is to explore whether the possibility to engage in exclusive dealing arrangements still leaves scope for refusal to supply, and under which circumstances.

The game we analyse is one in which the incumbent has to decide first whether to engage in refusal to supply or not. If not, and if the downstream firm has entered the market, at the end of period 1 the incumbent and the downstream firm can sign an exclusive dealing contract whereby the downstream entrant commits not to purchase from other suppliers.[20] For simplicity, we assume that along with the obligation of D not to deal with U, it also comes a commitment of I not to deal with U. So, effectively, the exclusive dealing amounts to a commitment by both I and D to deal only with each other and not with U.[21]

We solve the game by backward induction. If the incumbent choose to engage in refusal to supply, the continuation of the game is the same as the one analysed in the baseline model. If the incumbent did not engage in refusal to supply and firm D entered the market in period 1, I and firm D may decide to sign an exclusive dealing contract. The next section analyses under which conditions they have an incentive to do so.

5.1.1 Decision on exclusivity

If D entered the market in period 1 and no exclusive dealing contract has been signed, the entry decision in period 2 is the same as in the baseline model: U will enter the market. In this case the incumbent and D make profits $\pi_I(D,U)$ and $\Pi_D(D,U)$ respectively, in period 2. If instead, exclusivity has been agreed upon, U cannot profitably enter the market in period 2. In this case the incumbent and D make profits $\pi_I(D,\emptyset)$ and $\Pi_D(D,\emptyset)$. From property P1 it follows that the incumbent benefits from exclusivity, whereas D is harmed by it (from property P2). The incumbent and D will have an incentive to agree on exclusivity if exclusivity increases their joint profits: in that case the incumbent can offer a compensation to D in exchange for exclusivity that makes both D and the incumbent (weakly) better off. Then, the exclusive dealing contract is signed if the following condition is satisfied:

$$\Pi_{I+D}^{ED} = \pi_I(D,\emptyset) + \Pi_D(D,\emptyset) > \pi_I(D,U) + \Pi_D(D,U) = \Pi_{I+D}^{NoED}. \tag{3}$$

[20] To simplify the exposition, we are assuming that the incumbent and D cannot contract on exclusivity if the incumbent has committed to refusal to supply. Relaxing this assumption would not alter the qualitative results of the analysis. Moreover, we are assuming that exclusivity is contracted upon at the end of period 1. It would be equivalent if we assumed that, at stage 2 of period 1, firms contract not only on the terms of sale of the input but also on exclusive dealing.

[21] One may consider situations where the incumbent may want to keep the freedom to use its downstream affiliate, I_D, to buy from the more efficient entrant U and then resell the cheaper input to D. When one allows for this possibility, the exclusive dealing contract can be used to extract efficiency rents from U. We do not study this possibility here, as we explicitly study it in Section 5.2 where the incumbent and firm D are allowed to write long-term contracts – including price commitments or exclusivity clauses with liquidated damages – which aim at extracting U's efficiency rents.

In what follows we shall see that, under the contracting assumptions made in the Section 3 (a non-cooperative game with menu offers), we can establish under which conditions the exclusive dealing contract is signed in equilibrium. For consistency with the contracting game specified there, we assume that, when exclusivity is contracted upon, with probability 1/2 the incumbent makes the exclusive dealing offer to D (i.e. the incumbent offers a lump sum compensation to D in exchange for exclusivity), and with probability 1/2 D makes the offer (i.e. it indicates the compensation that it requires to agree on exclusivity). Therefore, I and D share evenly the increase in joint profits caused by exclusivity.

Lemma 7. ***Exclusivity decision, with menu offers.***

(i) At the end of period 1 *a sufficient condition for the incumbent and the independent downstream firm to agree on exclusivity is* $c \to 0$ *or* $\gamma_E \to \gamma_I$.

(ii) With linear demand $Q = 1 - p$*, exclusivity is always agreed upon.*

(iii) When the exclusive dealing contract is signed, the incumbent and firm D *obtain the following payoffs:*

$$\pi_I^{ED} = \pi_I(D,U) + \frac{1}{2}[\Pi_{I+D}^{ED} - \Pi_{I+D}^{NoED}];\ \Pi_D^{ED} = \Pi_D(D,U) + \frac{1}{2}[\Pi_{I+D}^{ED} - \Pi_{I+D}^{NoED}]$$

Proof. See Appendix A.2.3. □

The result according to which the incumbent and the downstream entrant may decide to sign an exclusive deal may appear to be inconsistent with the Chicago School critique, which states that a buyer and a seller will never find it profitable to sign an exclusive contract which excludes a more efficient seller. In our setting, though, differently from the standard Chicago setting firm D (the buyer) has to compete with the incumbent's downstream affiliate in order to get the input from the upstream entrant (the more efficient seller). Competition between D and I_D may allow U to appropriate a sufficiently large share of industry profits to make I and D willing to sign the exclusive dealing contract.

Recall that under the contracting assumptions made in the Section 3 firms always maximise total industry profits – in any market configuration arising in period 2. Under exclusivity the more efficient supplier is excluded from the market and the overall industry profits are lower than in the case in which the contract is not signed. However all of the "pie" is shared between I and D, whereas when the exclusive dealing contract is not signed the higher industry profits have to be shared with U.

As long as U obtains its marginal contribution when no exclusive contract is signed – i.e. $\pi^m(\gamma_E) - \pi^m(c + \gamma_E)$, the increase in total industry profits due to the use of its more efficient technology – the incumbent and D jointly obtain $\pi^m(c + \gamma_E)$, which is exactly the same payoff they earn when they agree on exclusivity and U is excluded from the upstream market. Hence in this case I and D do not strictly gain from exclusivity. If instead U obtains more than its marginal contribution, the coalition formed by I and D obtains less than $\pi^m(c+\gamma_E)$ when no exclusive contract is in place, and it is better off agreeing on exclusivity and excluding U.

In our contracting game (see the proof of Lemma 3.2) U obtains its marginal contribution when take-it-or-leave-it offers are made upstream. When instead take-it-or-leave-it offers are made downstream, U's payoff is $\pi^m(\gamma_I) - \pi^m(\gamma_E) + \pi^d(\gamma_E, c+\gamma_I)$. The latter payoff is larger than U's marginal contribution $\pi^m(\gamma_E) - \pi^m(c + \gamma_E)$ precisely when condition (10) is satisfied. In other words, when offers are made downstream, competition among those that make the offers may allow U to obtain more than its marginal contribution. In that case I and D find it more profitable to exclude U and share a smaller pie.[22]

5.1.2 Entry decision in period 1

Let us start from the case in which no refusal to supply has been committed to. When D anticipates that no exclusive dealing will be signed (i.e. when condition (3) is satisfied), assumption $A1$ ensures that D enters the market in period 1. When D anticipates that an exclusive dealing contract will be signed, entry in period 1 *a fortiori* takes place because D will make higher profits in period 2 than in the no-exclusive-dealing scenario, as it will extract half of the increase in the coalition $I + D$ joint profits caused by exclusivity. When refusal to supply has been committed to, downstream entry occurs if (and only if) $F_D \leq \Pi_D(D, U)$.

5.1.3 Refusal to supply vs. exclusive dealing in equilibrium

This Section studies the incumbent's decision to engage in refusal to supply. To streamline the exposition we will focus on the specific contracting game with menu offers described in Section 3 and on the specific case of linear demand $Q = 1 - p$.

Proposition 4. ***Refusal to supply vs. exclusive dealing in equilibrium, with menu offers and linear demand.***

Case I: $F_D \leq \Pi_D(D, U)$. The incumbent does not engage in refusal to supply in period 0. The exclusive dealing contract is always signed in period 1.

Case II: $F_D \in (\Pi_D(D, U), \overline{F}]$ and $F_U \leq \Pi_U(\emptyset, U)$. There exist threshold levels γ_I^R and c^R such that:

- *if $c \geq c^R \equiv \frac{7-\sqrt{43}}{4}(1 - \gamma_E)$, refusal to supply is chosen over exclusive dealing for any feasible value of γ_I.*
- *if $c < c^R$, refusal to supply is chosen over exclusive dealing if (and only if) $\gamma_I \leq \frac{1+6\gamma_E-8c+\sqrt{-13c^2+54c(1-\gamma_E)+(1-\gamma_E)^2}}{7} \equiv \gamma_I^R$, with γ_I^R increasing in c.*

Other things being equal, the more inefficient the incumbent's upstream affiliate the more likely that refusal to supply is chosen over exclusive dealing.

Case III: $F_D \in (\Pi_D(D, U), \overline{F}]$ and $F_U > \Pi_U(\emptyset, U)$.

- *if $c \geq c^{RR} \equiv \frac{5-\sqrt{13}}{8}(1 - \gamma_E)$, refusal to supply is chosen over exclusive dealing for any feasible value of γ_I.*
- *if $c < c^{RR}$, refusal to supply is chosen over exclusive dealing if (and only if) $\gamma_I \leq \frac{1+6\gamma_E-6c+\sqrt{-27c^2+30c(1-\gamma_E)+(1-\gamma_E)^2}}{7} \equiv \gamma_I^{RR}$.*

[22] This result is related to Ulsaker (2018) that, in a different setting, also finds that the more efficient seller can appropriate more than its marginal contribution, thereby generating the incentive for the incumbent seller and the buyer to agree on exclusivity.

Since refusal to supply discourages both upstream and downstream entry, it is chosen over exclusive dealing for a more limited range of parameters' values as compared to the case in which refusal to supply discourages only the downstream firm (Case II): $\gamma_I^{RR} < \gamma_I^R$ and $c^{RR} > c^R$.

Proof. See Appendix A.2.4. □

The intuition behind case II is fairly clear. Refusal to supply deters downstream entry whereas under exclusive dealing the downstream entrant is accommodated and the incumbent appropriates a share of its efficiency rents. The more efficient the downstream incumbent, i.e. the lower γ_I, the less detrimental is refusal to supply in period 1. However, exclusive dealing discourages upstream entry in period 2, whereas the upstream independent firm enters the market even though the incumbent engages in refusal to supply (recall that in case II $F_U \leq \Pi_U(\emptyset, U)$). The more inefficient the upstream incumbent, i.e. the higher c, the stronger the detrimental effect of exclusive dealing in period 2. The interaction between these two effects determines the result obtained.

In case III upstream entry costs are higher and refusal to supply discourages also upstream entry. Recall that the incumbent earns lower profits when it discourages both entrants rather than only one. Then it will be less likely that refusal to supply is more profitable than exclusive dealing as compared to the previous case in which refusal to supply deters only downstream entry (i.e. $\gamma_I^{RR} < \gamma_I^R$ and $c^{RR} > c^R$). The role of the parameter c is not clear any longer because both conducts discourage more efficient upstream entry.

When it chooses whether to engage in refusal to supply or not, the incumbent compares its payoff under refusal to supply with the payoff it obtains in the alternative scenario without refusal to supply. In that alternative scenario the payoff of the incumbent is higher when I and D sign an exclusive dealing contract in period 2, relative to the case in which exclusive dealing is not a possibility. Indeed, in period 1 the payoff of the incumbent is the same (i.e. $\pi_I(D, \emptyset)$), but it period 2 it is higher: when the incumbent and D agree on exclusivity, they share evenly the increase in their joint period-2 profits caused by exclusivity. Then, each of them in period 2 is better off as compared to the case in which no exclusive dealing contract is signed, and both D and U are active (see Lemma 7 (iii)). In particular, for the incumbent it holds that, in period 2:

$$\pi_I^{ED} = \pi_I(D, U) + \frac{1}{2}[\Pi_{I+D}^{ED} - \Pi_{I+D}^{NoED}] \geq \pi_I(D, U)$$

Since the alternative to refusal to supply is more profitable for the incumbent when exclusive dealing is a possibility, in that case it is less likely that refusal to supply arises at the equilibrium.

Corollary 4. *The condition for refusal to supply to arise at the equilibrium is more stringent when the incumbent and D have the possibility to sign an exclusive dealing contract in period* 1.

Proof. It can be easily shown that $\gamma_I^R < \gamma_I^P$ and $c^R > c^P$; similarly $\gamma_I^{RR} < \gamma_I^{PP}$ and $c^{RR} > c^{PP}$. □

5.2 Long-term contract with commitment on future prices

Our results have showed that if market structure is going to change in the future, the incumbent may want to foreclose downstream entry in order to protect rents that would be lost otherwise when more efficient entrants appear. However, one may wonder whether the incumbent could resort to more sophisticated instruments in order to extract the efficiency rents, rather than simply deter entry which would destroy industry profits.

The first possibility which springs to mind is that in period 1 the incumbent might impose conditions on D so as to extract profits that D will make in period 2, perhaps by threatening not to supply it if D did not agree to give (some of its) future profits to I in exchange for supplying the input. Another possibility is that – instead of excluding D – firm I would sign a contract with D which allows to extract rents from the upstream entrant.

But such a rent extraction by the incumbent will not be possible if we keep the same setting as in the base model, where contract negotiations take place *after* the entry decision by D. To see why, imagine D has entered and that I tries to impose a fixed fee or other terms aimed at extracting (also) second period rents from D. The latter could simply reject the offer, sell nothing in the first period, and wait until the second period, when U enters (recall that if D enters, U will always enter) and D can rely on more competition on input provision and get positive profits.

The objective of this section is to show that there may exist contracts which could indeed be more profitable than refusal to supply, but they may have to rely on strong assumptions (for instance, about the power of the incumbent to commit to certain actions) and a different timing of the game.

To fix ideas, it is convenient to focus on the simpler case where upstream entry will take place for sure, that is, $F_U = 0$ and where parameter values are such that in the base model refusal to supply would occur at equilibrium (we are interested in showing that there may be superior options to refusal to supply). Let us consider the following game:

- At period 0, I and D negotiate a contract which specifies the wholesale price at which they will trade the input in respectively periods 1 and 2, as well as the total fixed fee T to be paid in case of acceptance of the contract. If the contract is not signed, the game goes on exactly as in the base model, including the possibility for I to engage in refusal to supply. If the contract is signed, the game will proceed in the following way.

- At period 1, stage 1, the downstream entrant decides whether to enter (if affirmative it will pay its entry cost F_D).

- At period 1, stage 2, active firms set final prices, produce and sell.

- At period 2, stage 1, U enters (since we assume $F_U = 0$ entry will always take place), and D may have a second chance if it did not do it before (but under our assumptions on costs it will not enter in one period only).

- At period 2, stage 2, U will will contract with downstream firms.

- At period 2, stage 3, final prices are set and transactions take place.

Given this game, it is straightforward to see that the equilibrium would be given by I and D choosing a contract at which I sells the input at wholesale prices $w_{I1} = c$ and $w_{I2} = 0$ and commits to withdraw its subsidiary from the market. In period 1 D buys the input from I and sells at the final price $p^m(c + \gamma_E)$ (it can set the monopoly price because of I's commitment to withdraw its subsidiary). In period 2, U will enter (recall that its costs are zero), and it would offer its input at the wholesale price $w_U = 0$ (since I and D have committed on the input price $w_{I2} = 0$ it is the only feasible price at which U can sell), D would buy from it and sell to consumers at the monopoly price $p^m(\gamma_E)$ (again, since I has committed not to operate downstream, it has no possibility to behave opportunistically). Therefore, I and D will be able to extract all the efficiency rents from both periods. It is straightforward that I prefers to sign this contract rather than engaging in refusal to supply. Indeed, if I makes the contract offers at period 0, it will set the fixed fee so as to extract the first-best profits of both periods (if D rejected the offer, refusal to supply will follow and D would have zero profits). If D makes the offers, it will have to leave I with at least the same payoff as the one that I obtains if it engaged in refusal to supply. Thus, there will always be a fixed fee which makes both I and D better off than under refusal to supply.[23]

Probably the most heroic assumption in the game above consists in the incumbent's ability to commit to the second-period price ($w_{I2} = 0$). Note that this is critical for the mechanism of rents extraction: U is obliged to set such a low price for its input to D just because I and D have committed to exchange I's input at that price. An alternative way to extract U's rents may rely on I's using exclusive dealing and liquidated damages (see Aghion and Bolton, 1987): that is, I could negotiate an exclusive dealing arrangement with D according to which the latter could be released from exclusivity behind the payment of contractually-agreed damages to the former. After upstream entry, U and D will be able to trade but U will have to transfer all of its efficiency rents to I in the form of a payment of damages.[24]

6 Conclusions and competition policy implications

In this paper we provide a dynamic rationale for vertical foreclosure. We consider a situation where a vertically integrated incumbent faces current potential competition in the downstream market, and future competition in the upstream market. (But we would arrive at identical conclusions if we considered current competition in the upstream market, and future competition downstream.) In a static perspective (that is, if future market conditions did not change, and upstream entry were not a concern), and in line with the Chicago School insights, the incumbent would prefer to deal with the more efficient downstream rival and extract its rents. However, dealing with the downstream entrant today may imply that the incumbent will end up facing efficient rivals both downstream and upstream tomorrow, thereby losing (all or most of) its future market profits. More particularly, we have identified two circumstances in which the vertically integrated incumbent may prefer to engage in refusal to supply the downstream rival.

If future upstream entry cannot be deterred (that is, the incumbent cannot protect its upstream monopoly) then refusing the input to the downstream rival now may allow the vertically integrated dominant firm to protect its downstream monopoly, and use such position to extract rents from the more efficient upstream entrant when contracting with it. (If a more efficient downstream rival was also in the market, the incumbent would be able to extract fewer - or no - rents from the upstream entrant.)

Instead, if the downstream rival's success is a pre-condition for an upstream rival's entry, the incumbent may deny the input to the downstream rival today thereby maintaining its monopoly power in both vertically related markets tomorrow. (If a more efficient downstream rival was in the

[23]If the contract took place not at period 0 but after D's entry in period 1, the coalition between D and I would still appropriate U's efficiency rents, but I would have to leave D at least the same profits $\Pi_D(D, U)$ it would get in period 2. Therefore, I may not necessarily prefer the contract to refusal to supply.

[24]As showed by Aghion-Bolton (1987)'s model, of course, the rent-extracting mechanism may not work (among other things) if there is some uncertainty over the upstream entrant; for instance, if U turned out to have higher production costs than expected, it may be unable to pay the required liquidated damages (or, in the previous example, it may be unable to offer zero wholesale price for the input) and would not operate, resulting in the exclusive dealing to have welfare-detrimental inefficient deterrence.

market, the upstream rival would make more profits and its entry would be more likely. In turn, the incumbent would lose part of its profits when facing two efficient upstream and downstream rivals.) Interestingly, we have showed that the incumbent would prefer to discourage only downstream entry (because it could extract part of the upstream entrant efficiency rents). However in this case lack of downstream entry discourages upstream entry, and having no rivals at both levels is better than facing competition in both.

Cases This paper suggests that it is important to consider the expected evolution of a market when analysing incentives for vertical foreclosure in competition cases. It is worth asking more in detail which sort of cases may fit the dynamic vertical foreclosure theory of harm presented in this paper. In general, they must concern markets where a vertically integrated firm is facing competition both upstream and downstream.

As for the situation where foreclosure takes place in order to "protect" a downstream monopoly, possible candidates for this theory of harm might include industries where a vertically integrated incumbent derives most of its market power either from a patent which is about to expire or from some assets whose monopoly is about to lose, due for instance to technological or regulatory changes which makes it easier for an upstream rival to successfully enter the market. As the upstream monopoly becomes closer to the end, there may be an incentive not to sell through downstream rivals, so as to enjoy a downstream monopoly - and be able to extract more rents - when upstream rivals will be in the market.

For instance, a firm which holds a monopolistic position of broadcasting rights of sports events and packages them into a sports TV channel, may anticipate that in the future it will not be able to continue to monopolise such rights (say, because regulation prevents them from being bundled in a single package and sold to the same company). In such circumstances, it may have the incentive not to supply its sports broadcasting rights to a potential competing TV channel, so as to prevent it from being more competitive, in order to enjoy a stronger contracting position with upstream competitors in the future. Similarly, a vertically integrated media company which owns "must-have" content such as TV channels and distributes them through a downstream affiliate - say a cable operator - may refuse to license its channels to competing TV distributors, if it expects that changes in demand pattern or successful introduction of competing content will jeopardise its upstream market position.[25]

The other situation covered in this paper deals with vertical foreclosure which maintains (or protect) overall monopoly power both upstream and downstream. This theory of harm may apply to industries where success in downstream activities is a necessary condition for entering the upstream market successfully. A case in point may have been *Telefónica*, where the European Commission (EC) found that the eponymous Spanish telecoms incumbent abused its dominant position by excluding downstream competitors (through a margin squeeze) in the Spanish broadband market.[26]

Telefónica was the unique operator having a local access network, i.e. a network that reaches final users. Alternative operators wishing to provide services throughout Spain had no other option than

[25] There have been several cases where competition authorities have investigated vertical foreclosure concerns in the case of media mergers. See for instance the Liberty Global/De Vijver Media merger, EC Decision of 24 February 2015 and the more recent AT&T/Time Warner case in the US.

[26] Decision 2008/C 83/05 [2007] OJ C 83/06, upheld by the General Court and then the Court of Justice (Cases T-336/07 and C-295/12 P. Note that in many EU member states there were similar cases against the national telecom incumbent, accused of exclusionary practices against broadband rivals.

buying wholesale services from Telefónica. The dynamic theory proposed in this paper seems well aligned with the story proposed by the EC, and provides a possible rationale for Telefónica's vertical foreclosure strategy. Only if it obtained a critical size in the retail market, an alternative producer would be able to make the investment necessary to reach customers directly (through local loop unbundling in this case) and to gain independence from the services provided by the incumbent.[27] By engaging in vertical foreclosure (here taking the form of margin squeeze)[28], the incumbent is preventing alternative operators from achieving the critical size that would justify investment in their own infrastructure, thereby discouraging them from investing upstream. Vertical foreclosure can therefore be interpreted as a defensive strategy adopted by the incumbent to protect its dominant position in the both the upstream and downstream markets.

Arguably, our dynamic model also fits the facts of *Genzyme*,[29] a well-known UK abuse of dominance case. Genzyme was the only producer of Cerezyme, which at the time was the only drug available for the treatment of Gaucher disease (a rare metabolic disorder).[30] Another company, TKT, may have entered the market with a competing drug, although not in the short-run.

For home patients, the drug needed to be administered by specialised nurses or doctors. Initially, Genzyme used Healthcare at Home as its exclusive distributor and provider of home-care services for Cerezyme, but it later opened its own home-care service. After the contract was terminated, Healthcare at Home, in order to continue to offer the delivery/home-care service, had to purchase Cerezyme from Genzyme first, and Genzyme sold the drug to it at a price identical to its final downstream price. The OFT concluded that Genzyme had engaged in an anti-competitive margin squeeze, leaving no scope for downstream competition (i.e. in home delivery service).[31]

The OFT noted that in addition to restricting the extent of competition in Cerezyme delivery/homecare services, Genzyme's behaviour - by preventing viable independent provision of delivery/homecare services for Cerezyme (and potentially other drugs) - also raised barriers to entry into the (upstream) market for the supply of drugs for the treatment of Gaucher disease: "As a result of Genzyme's conduct it is more difficult for competitors to enter the upstream market for the supply of drugs for the treatment of Gaucher disease. Since the supply of homecare services is effectively tied to Genzyme Homecare, a new competitor would face the additional hurdle of persuading the patient to switch not only to a new drug, but also to a new homecare services provider." (Paragraph 331 of the OFT decision)[32]

[27] According to the EC, "[...]alternative operators [i.e. the entrants in the broadband market] are likely to follow a step-by-step approach to continuously expanding their customer base and infrastructure investments. In particular, when climbing up the "investment ladder", alternative operators seek to obtain a minimum critical mass, in order to be able to make further investments. (Para. 392 of the Decision)." "[...] The first step of the "investment ladder"is occupied by an operator whose strategy consists in targeting a mass market (thus involving considerable marketing and advertising expenditure), but who is merely acting as a reseller of the ADSL access product of the vertically integrated provider (the incumbent). As its customer base increases, then the alternative operator makes further investment. In a further step, it may even seek to connect its customers directly (local loop unbundling). Thus the progressive investments take the alternative operator progressively closer to the customer, reduce the reliance on the wholesale product of the incumbent, and increasingly enable it to add more value to the product offered to the end-user and to differentiate its service from that of the incumbent." (Para. 178 of the Decision)

[28] Telefónica could not flatly engage into a refusal to supply, since it was subject to regulatory obligations.

[29] Decision No. CA98/3/03 - Exclusionary behaviour by Genzyme Limited.

[30] One drug, Zavesca, had just received marketing authorisation but, according to the Office of Fair Trading (OFT, the UK competition authority at the time) would likely have provided only limited competition to Cerezyme.

[31] The Competition Appeal Tribunal (CAT) confirmed the finding of margin squeeze by the Office of Fair Trading. Case No: 1016/1/1/03, [2004] CAT 4.

[32] Experts are reported to explain that the presence in the downstream market is key for upstream success: "Professor Cox [...] expresses the view that changing homecare provider in circumstances where he was considering switching treatment could definitely affect the choice of treatment, especially in the case of vulnerable patients requiring infusion

The OFT decision might have provided more information about the real chances of successful upstream entry, but the narrative of the case does appear to be consistent with the dynamic leveraging model illustrated in this paper.

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assistance, particularly since "a very intense relationship can be built up between patients and their homecare providers".

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A Appendix

A.1 Proofs of the baseline model

A.1.1 Proof that refusal to supply increases retail prices when it excludes both D and U.

Let us consider case (iii) in which RtoS excludes both D and U. In that case, the vertically integrated incumbent sets in both periods the monopoly price $p^m(c+\gamma_I)$ (determined by the upstream and downstream cost of the own affiliates).

Without RtoS the incumbent and firm D are in the market in period 1. Can the final equilibrium price be $p \geq p^m(c+\gamma_I)$? Imagine that at the equilibrium the incumbent does not trade with D and supplies the final market through the own downstream affiliate, setting the final price $p^m(c+\gamma_I)$. Since we allow for two-part tariffs, I and D could take advantage of D's more efficient technology and set the final price $p^m(c+\gamma_E)$. For instance, D might buy the input from the incumbent's upstream affiliate at the wholesale marginal price $w = p^m(c+\gamma_E) - \gamma_I$. Then, D would set the final price $p = w + \gamma_I = p^m(c+\gamma_E)$, i.e. the highest price that the vertically integrated incumbent has no incentive to undercut through the own downstream affiliate. Total profits would amount to $\pi^m(c+\gamma_E)$, the maximal industry profits in this market configuration, and a fixed fee could be used to allocate these profits between the incumbent and D in such a way that are both (weakly) better off relative to the case in which they do not trade. The logic is similar if I and D trade but D sets $p \geq p^m(c+\gamma_I)$.

Without RtoS, in period 2 both U and D are in the market. We can show that the final equilibrium price cannot be $p \geq p^m(c+\gamma_I)$. Imagine that at the candidate equilibrium I_D buys from the upstream affiliate and supplies the final market at $p \geq p^m(c+\gamma_I)$ whereas and U and D do not trade (or they trade with each other but at a very high marginal price so that D does not sell downstream; or D buys from I_U at a very high marginal price). At that candidate equilibrium U and D earn zero profits. They would have an incentive to trade at a marginal price $w' = 0$. Competition with the vertical integrated incumbent would result in U and D earning total profits $(c+\gamma_I-\gamma_E)Q(c+\gamma_I) > 0$. Such profits can be shared through the fixed fee in such a way that they are both better off relative to the candidate equilibrium. Then the deviation would be profitable. Imagine now that at the candidate equilibrium I_D buys the input from U and supplies the final market at $p \geq p^m(c+\gamma_I)$ while D is not supplied (or it is supplied at a high marginal price so that it does not sell downstream). U and I_D could trade at the marginal price $w' = 0$ and set the final price $p' = p^m(\gamma_I)$ thereby increasing their total profits; they could share those profits through the fixed fee in such a way that they would be both better off. Imagine now that at the candidate equilibrium D buys the input from U and supplies the market at $p \geq p^m(c+\gamma_I)$, while the vertically integrated incumbent does not sell downstream (for instance it might buy the input from U at a very high marginal price and receive a lump-sum compensation). U and D would have an incentive to trade at the marginal price $w' = 0$ and set the final price $p^m(\gamma_E)$ that maximises industry profits. The fixed fees could be used to share those profits between U, D and I in such a way that they are all better off. Finally, imagine that at the candidate equilibrium D buys from I_U at a marginal price such that D supplies the final market at $p \geq p^m(c+\gamma_I)$. I_U and D could trade at the marginal price $w' = p^m(c+\gamma_E) - \gamma_I$ that allows D to set the final price $w' + \gamma_I = p^m(c+\gamma_E) < p^m(c+\gamma_I)$. That price would allow I and D to increase their total profits, earning $\pi^m(c+\gamma_E)$. They could use the fixed fee to share such profits in such a way that they would be both better off.

A.1.2 Proof of Lemma 3

In what follows, $\pi^m(c_i)$ indicates the monopoly profits of a firm with marginal cost c_i and facing market demand $Q(p)$, while $\pi^d(c_i, c_j)$ indicates the duopoly profits obtained by a firm with marginal cost c_i competing ï¿½ la Bertrand in the final market (with demand $Q(p)$) with a firm with marginal cost c_j and $p^m(c_i) > c_j$. Also recall that, by the Arrow's replacement effect, $\pi^m(c_i) - \pi^m(c_j) < \pi^d(c_i, c_j)$, with $c_i < c_j$.
Let us consider different cases depending on the active independent firms.

(1) Both D and U are active
Upstream firms make the offer
Consider menu contracts whereby I can offer to D the contract: $\{w, \widehat{T}_I, T_I\}$. $\widehat{T}_I$ is the fixed fee that D will pay in case of "exclusive purchase", namely when it accepts only I's offer and T_I is the franchise fee requested when D accepts both I and U's offer and deals with both upstream firms. Following the terminology used in Bernheim and Whinston (1998), we will denote this case as the case of *common representation.* Similarly, U offers D the contract of type: $\{w, \widehat{T}_U, T_U\}$.

In what follows, we shall focus on a common representation equilibrium that implements the maximal industry profits by way of contracts whereby the most efficient firms U and D are the only ones producing and selling, whereas the less efficient incumbent is paid not to compete. However, multiple equilibria may sustain different distributions of the maximal industry profits. Since the paper aims at showing that the incumbent has an incentive to refusal to supply, this vertical foreclosure outcome will be the less likely the higher the profits the incumbent makes when all rivals are in the market. Accordingly, we will select the equilibria in which the incumbent obtains the highest possible payoff, i.e. it is remunerated at its marginal contribution for not selling downstream. Among those equilibria, we will select the one in which firm U also receives the highest possible payoff. [33]

Lemma 8. *(Upstream offers) The following is the common representation equilibrium which sustain maximal industry profits and gives I and U the highest payoff:*

- *The incumbent offers D:* $\{w = c, Withdrawal, \widehat{T}_I = \pi^m(\gamma_E) - \pi^d(\gamma_E, c+\gamma_I), T_I = \widehat{T}_I\}$.
- *The upstream entrant offers D:* $\{w = 0, \widehat{T}_U = \pi^m(\gamma_E) - \pi^m(c+\gamma_E), T_U = \widehat{T}_E\}$.
- *D accepts both offers*

Equilibrium profits are: $\pi_I = \pi^m(\gamma_E) - \pi^d(\gamma_E, c+\gamma_I)$, $\Pi_U = \pi^m(\gamma_E) - \pi^m(c+\gamma_E)$, $\Pi_D = \pi^d(\gamma_E, c+\gamma_I) - [\pi^m(\gamma_E) - \pi^m(c+\gamma_E)]$

[33] The selection of the equilibrium payoff of firm U does not alter the results qualitatively.

Proof. First, note that at the candidate equilibrium firm D is indifferent between accepting both offers and accepting either one and that it obtains a positive payoff:

$$\pi^m(\gamma_E) - T_I - T_U = \pi^m(c + \gamma_E) - \widehat{T}_I = \pi^d(\gamma_E, c + \gamma_I) - \widehat{T}_U > 0 \tag{4}$$

Let us consider whether upstream suppliers have an incentive to offer alternative contracts. Can firm i (with $i = I, U$) deviate to a more profitable exclusive purchase arrangement with D? Since D obtains the same payoff accepting both contracts and either one, firm i should increase the joint profits with D in order to benefit from such a deviation. But at the candidate equilibrium $\pi_{D+I} = \pi^m(c + \gamma_E)$, which are the highest joint profits that I and D can produce by trading in exclusivity. Hence, I cannot induce D to accept a more profitable exclusive purchase arrangement. Similarly, at the candidate equilibrium $\pi_{D+U} = \pi^d(\gamma_E, c + \gamma_I)$, which are the highest joint profits that U and D can produce by trading in exclusivity. Hence, U cannot induce D to accept a more profitable exclusive purchase arrangement.

Can firm i deviate to a more profitable common representation (CR) contract? Consider I. If I makes a deviation offer and D accepts both contracts – we are focusing on a common representation scenario – then U would obtain the candidate equilibrium fee, which corresponds to its marginal contribution $\pi^m(\gamma_E) - \pi^m(c + \gamma_E)$. Since under CR total profits cannot exceed $\pi^m(\gamma_E)$, in any alternative common representation scenario the joint profits of I and D cannot exceed $\pi^m(\gamma_E) - \pi^m(\gamma_E) + \pi^m(c + \gamma_E) = \pi^m(c + \gamma_E)$. But this is what I and D already jointly achieve in the candidate CR equilibrium. Hence, I cannot deviate to a more profitable CR contract. Likewise, consider U. If U makes a deviation offer and D accepts both contracts then I would obtain the candidate equilibrium fee, which corresponds to its marginal contribution $\pi^m(\gamma_E) - \pi^d(\gamma_E, c + \gamma_I)$. Since under CR total profits cannot exceed $\pi^m(\gamma_E)$, in any alternative common representation scenario the joint profits of U and D cannot exceed $\pi^m(\gamma_E) - \pi^m(\gamma_E) + \pi^d(\gamma_E, c + \gamma_I) = \pi^d(\gamma_E, c + \gamma_I)$. But this is what U and D already jointly achieve in the candidate CR equilibrium. Hence, I cannot deviate to a more profitable CR contract.

I cannot profitably deviate and abstain from making offers, as it would earn zero profits.

It remains to check whether U has an incentive to deviate either making an exclusive purchase offer to I or an exclusive purchase offer both to I and D. Let us consider the former case first. Following U's deviation offer and the standing offer of I to D, it is a dominant strategy for D to accept I's offer. Since such an offer involves a commitment not to operate I_D, no positive profits can be generated by the deal between I and U, and the deviation cannot be profitable. Let us consider the case now in which U deviates and offers the contract $\{w' = 0, EP, T'_U\}$ with $T'_U \in (\pi^m(\gamma_E) - \pi^m(c + \gamma_E), 2\pi^m(\gamma_E) - \pi^m(c + \gamma_E) - \pi^d(\gamma_E, c + \gamma_I)]$ to D and the contract $\{w' > p^m(c + \gamma_I), EP, T_U = -\varepsilon\}$. There are two continuation equilibria to the offers on the table (the standing offer by the incumbent, and the deviation offer by firm U): one in which I rejects U's offer and D accepts I's offer (while rejecting U's); the other equilibrium in which I accepts U's offer and D accepts U's offer too (while rejecting I's).[34] Our candidate equilibrium is sustained by continuation equilibria in which I rejects

[34]The incumbent's standing offer involves the commitment to withdrawal. Then, if the incumbent expects D to accept its standing offer, the downstream affiliate will stop operating. Even though I accepts U's deviation offer, there

U's offer (because in those cases the deviation is not profitable).

This analysis shows that the one we propose above is indeed an equilibrium. There might be other common representation equilibria that implement the maximal industry profits but a different distribution of total surplus. To see this, note that at an equilibrium in which D deals with both suppliers the following conditions must be satisfied:

$$\pi^m(\gamma_E) - T_I - T_U = \pi^m(c+\gamma_E) - \widehat{T}_I = \pi^d(\gamma_E, c+\gamma_I) - \widehat{T}_U \tag{5}$$

Let us reason a contrario and let us suppose that

$$\pi^m(\gamma_E) - T_I - T_U < \max\left\{\pi^m(c+\gamma_E) - \widehat{T}_I, \pi^d(\gamma_E, c+\gamma_I) - \widehat{T}_U\right\}.$$

Then a common representation equilibrium would not exist because D would prefer to buy from the firm which offers the higher exclusive representation payoff.

Let us suppose now that $\pi^m(\gamma_E) - T_I - T_U > \max\left\{\pi^m(c+\gamma_E) - \widehat{T}_I, \pi^d(\gamma_E, c+\gamma_I) - \widehat{T}_U\right\}$. Then - given the fees $\widehat{T}_{-i}$ and T_{-i} of the rival - upstream supplier i (with $i = I, U$) could slightly increase the fee T_i: firm D would still prefer common representation to exclusivity and supplier i would earn higher profits.

Finally, let us suppose that $\pi^m(\gamma_E) - T_I - T_U = \pi^m(c+\gamma_E) - \widehat{T}_I > \pi^d(\gamma_E, c+\gamma_I) - \widehat{T}_U$. Then firm I would have an incentive to slightly increase both T_I and $\widehat{T}_I$ so that $\pi^m(\gamma_E) - T_I' - T_U = \pi^m(c+\gamma_E) - \widehat{T}_I'$ is still larger than $\pi^d(\gamma_E, c+\gamma_I) - \widehat{T}_U$. Firm D would still prefer common representation (or exclusivity with I) to exclusivity with U, and firm I would earn higher profits. (Likewise, if it was $\pi^m(\gamma_E) - T_I - T_U = \pi^d(\gamma_E, c+\gamma_I) - \widehat{T}_U > \pi^m(c+\gamma_E) - \widehat{T}_I$.)

Furthermore, at a common representation equilibrium fees must also satisfy the following conditions:

$$\widehat{T}_I \leq T_I; \quad \widehat{T}_U \leq T_U. \tag{6}$$

Otherwise upstream firm i would have an incentive to slightly decrease $\widehat{T}_i$ and sell in exclusivity to D. For instance, if at the candidate equilibrium (that is, in a situation where (5) holds) upstream firm i's fees were $\widehat{T}_i > T_i$, then firm i could slightly reduce its exclusivity fee so that $\widehat{T}_i - \varepsilon > T_i$. D would then choose exclusive representation by U_i and the deviation would be profitable.

There exist different combinations of fees that satisfy conditions (5) and (6) and that allow to identify candidate equilibria that implement different distributions of the maximal industry profits.[35] The equilibrium that we have found above is the one that gives to I and U the highest payoffs. Indeed, an equilibrium in which the incumbent obtains more than $\pi^m(\gamma_E) - \pi^d(\gamma_E, c+\gamma_I)$ does not exist. If it existed, the joint profits of D and U would be lower than $\pi^d(\gamma_E, c+\gamma_I)$. Then U could profitably deviate offering an exclusive purchase contract to D. Likewise, an equilibrium in which U obtains more than $\pi^m(\gamma_E) - \pi^m(\gamma_E + c)$ does not exist. If it existed, the joint profits of D and I would be lower than $\pi^m(\gamma_E + c)$. Then I could profitably deviate offering an exclusive purchase contract to D. $\square$

Downstream firms make the offers.

will be no downstream affiliate that can deal with U and I cannot earn any positive profit from that offer.

[35] Obviously, to show that they are indeed equilibria one should also check that no profitable deviation is possible.

Let us consider now the case of downstream offers. Also in this case we shall focus on a common representation equilibrium which implements the maximal industry profits and gives the highest payoffs to the downstream firms. In this equilibrium, like in the one with upstream offers, the most efficient firms U and D are the only ones producing and selling. Exactly as with upstream offers, firm I is remunerated at its marginal contribution for not selling downstream, and receives the difference between $\pi^m(\gamma_E)$ and $\pi^d(\gamma_E, c+\gamma_I)$. D also receives its marginal contribution, that is the difference between $\pi^m(\gamma_E)$ and $\pi^m(\gamma_I)$, with U receiving the remaining rents. Note that while in the case of upstream offers contracts contingent on exclusivity were not necessary to sustain maximal industry profits – indeed the contracts proposed in Lemma 8 feature $T_i = \widehat{T}_i$ – in this case in which offers are downstream, contingent contracts are key to sustain maximal industry profits.

Lemma 9. *(Downstream offers) The following is the common representation equilibrium which sustains maximal industry profits and gives I and D the highest payoff:*

- *I offers U: $\{w = 0, \widehat{T}_I = \pi^m(\gamma_I) - \pi^m(\gamma_E) + \pi^d(\gamma_E, c+\gamma_I)\}$ if U accepts only I's offer; $\{w = p^m(\gamma_E), excl.purchase, T_I = -[\pi^m(\gamma_E) - \pi^d(\gamma_E, c+\gamma_I)]\}$ if U accepts both I and D's contracts.*
- *D offers U: $\{w = 0, \widehat{T}_D = \pi^m(\gamma_I) - \pi^m(\gamma_E) + \pi^d(\gamma_E, c+\gamma_I), T_D = \pi^m(\gamma_I)\}$, where $\widehat{T}_D$ is the fee that D commits to pay to U if U accepts only D's offer, and T_D is the one when U accepts both I and D's contracts.*
- *U accepts both offers*

Equilibrium profits are: $\pi_I = \pi^m(\gamma_E) - \pi^d(\gamma_E, c+\gamma_I)$, $\Pi_U = \pi^m(\gamma_I) - \pi^m(\gamma_E) + \pi^d(\gamma_E, c+\gamma_I)$, $\Pi_D = \pi^m(\gamma_E) - \pi^m(\gamma_I)$.

Proof. First, note that by accepting both offers, U receives a positive fee from D but has to pay I, so we need to check that it makes a net positive profit. Indeed, $T_D + T_I = \pi^m(\gamma_I) - \pi^m(\gamma_E) + \pi^d(\gamma_E, c+\gamma_I) > 0$, because by the Arrow replacement effect $\pi^d(\gamma_E, \gamma_I) > \pi^m(\gamma_E) - \pi^m(\gamma_I)$, and $\pi^d(\gamma_E, c+\gamma_I) > \pi^d(\gamma_E, \gamma_I)$. Moreover, one can also check that if U accepts either only D's offer or only I's, it obtains the same payoff.

Let us consider whether downstream firms have an incentive to offer alternative contracts. Can firm i (with $i = I, D$) deviate to a more profitable exclusivity arrangement with U? Since U obtains the same payoff accepting both contracts and either one, firm i should increase the joint profits with U in order to benefit from such a deviation. But at the candidate equilibrium $\pi_{U+I} = \pi^m(\gamma_I)$, which are the highest joint profits that U and I can produce by trading in exclusivity. Hence, I cannot induce U to accept a more profitable exclusivity arrangement. Likewise, at the candidate equilibrium $\pi_{D+U} = \pi^d(\gamma_E, c+\gamma_I)$, which are the highest joint profits that U and D can produce by trading in exclusivity. Hence, D cannot induce U to accept a more profitable exclusivity arrangement.

Can firm i deviate to a more profitable CR contract? Consider D. Given the standing offer of I (that U must accept in a CR scenario), I secures $\pi^m(\gamma_E) - \pi^d(\gamma_E, c+\gamma_I)$. Since total profits cannot exceed $\pi^m(\gamma_E)$, in any CR scenario the bilateral profits of U and D cannot exceed $\pi^d(\gamma_E, c+\gamma_I)$, which is what they already obtain in the candidate equilibrium. Hence D cannot profitably deviate to a different CR contract.

Let us consider I. In a CR scenario U accepts the standing offer of D and earns $\pi^m(\gamma_I)$. Then, if I deviates and makes an offer to U, the highest bilateral profits that I and U can rely upon is $\pi^m(\gamma_I)$: if the deviation offer involves I competing in the downstream market, then I makes zero profits in the final market (at best, it has marginal cost γ_I and faces a rival whose marginal cost is $\gamma_E < \gamma_I$); likewise if the deviation involves I not competing in the final market, then I does not make downstream profits. But in the candidate equilibrium the joint profit of I and U is already $\pi^m(\gamma_I)$. Hence I cannot profitably deviate to a different CR contract.

Can D deviate and make an offer to I? It cannot be profitable to make an offer that both U and I accept. Imagine instead that D makes an offer to I which involves exclusive distribution at $w = 0, T'$. Irrespective of whether I accepts or rejects the deviation offer, given the standing offer of I to U, the incumbent has to pay the fee $\widehat{T}_I$ to U (since U receives no offer from D, then it is the 'exclusive' offer which is accepted by U, and this entails the payment of the fee $\widehat{T}_I$ to U). Then, if I rejects the deviation offer, D will be unable to sell downstream, I will monopolise the market and get $\pi^m(\gamma_I) - \widehat{T}_I$. If I accepts D's deviation offer, the incumbent can obtain the input at $w = 0$ through the contract between I and U and sell it to D. The incumbent's payoff is the fee T' minus the exclusivity fee $\widehat{T}_I$ that it has to pay to U. Therefore, the lowest deviation fee that D can offer and that induces I to accept is $T' = \pi^m(\gamma_I)$. But D's net deviation profit will then be $\pi^m(\gamma_E) - \pi^m(\gamma_I)$, which is exactly what D earns at the candidate equilibrium. Hence the deviation is not profitable.

The above analysis shows that the one we propose is indeed an equilibrium. There might exist other common representation equilibria that implement the maximal industry profits but a different distribution of total surplus. To see this note that at an equilibrium in which U deals with both downstream suppliers, it must be indifferent between accepting both contracts or dealing with exclusively with one of them, which translates in the following conditions:

$$T_I + T_D = \widehat{T}_I = \widehat{T}_D. \tag{7}$$

Like in the proof of Lemma 5 we can reason a contrario. Let us suppose that $T_I + T_D < \max\left\{\widehat{T}_I, \widehat{T}_E\right\}$. Then a common representation equilibrium would not exist because U would prefer to buy from the firm which offers the highest exclusive representation fee.

Let us suppose now that $T_I + T_D > \max\left\{\widehat{T}_I, \widehat{T}_E\right\}$. Then - given the fees $\widehat{T}_{-i}$ and T_{-i} of the rival - firm i (with $i = I, D$) could slightly decrease T_i: U would still prefer common representation and firm i would make higher profits.

Finally, let us suppose that $T_I + T_D = \widehat{T}_I > \widehat{T}_D$. Then firm I could deviate and slightly decrease T_I and $\widehat{T_I}$ so that $T_I' + T_D = \widehat{T}'_I > \widehat{T}_D$: U still prefers to deal with both, but I raises its profit because it pays a lower fee. (Likewise, if it was $T_I + T_D = \widehat{T}_D > \widehat{T}_I$, then D would have an incentive to deviate.)

Note also that at a common representation equilibrium (in which therefore condition 7 is satisfied), it must be that each downstream firm is weakly better off under CR than under exclusive representation. Otherwise, downstream firm i would have an incentive to slightly increase $\widehat{T}_i$. Firm U would choose to sell in exclusivity to i and i would still make higher profits than under CR. This implies that at a common representation equilibrium that sustains maximal industry profits the following conditions must be satisfied:

$$\pi^m(\gamma_E) - T_D \geq \pi^d(\gamma_E, c+\gamma_I) - \widehat{T}_D \quad \Rightarrow T_D - \widehat{T}_D \leq \pi^m(\gamma_E) - \pi^d(\gamma_E, c+\gamma_I) \tag{8}$$

and

$$T_I \geq \pi^m(\gamma_I) - \widehat{T}_I \quad \Rightarrow \widehat{T}_I - T_I \geq \pi^m(\gamma_I). \tag{9}$$

There might exists different combinations of fees that satisfy conditions (7), (8) and (9), and that allow to identify candidate equilibria that implement different distributions of the maximal industry profits. The equilibrium that found above is the one that gives to I and D the highest profits. As shown for the case of upstream offers, an equilibrium in which the incumbent obtains more than $\pi^m(\gamma_E) - \pi^d(\gamma_E, c+\gamma_I)$ does not exist. If it existed, the joint profits of D and U would be lower than $\pi^d(\gamma_E, c+\gamma_I)$. Then D could profitably deviate offering an exclusive purchase contract to D. Likewise, an equilibrium in which D obtains more than $\pi^m(\gamma_E) - \pi^m(\gamma_E + c)$ does not exist. If it existed, the joint profits of U and I would be lower than $\pi^m(\gamma_E + c)$. Then I could profitably deviate offering an exclusive purchase contract to U.

Considering the probabilities that offers are made upstream and downstream, the expected post-entry profits of the incumbent and the upstream rival (gross of the entry costs) are the following:

$$\begin{aligned}
\pi_I(D,U) &= \pi^m(\gamma_E) - \pi^d(\gamma_E, c+\gamma_I) \\
\Pi_U(D,U) &= \frac{1}{2}\pi^d(\gamma_E, c+\gamma_I) + \frac{1}{2}[\pi^m(\gamma_I) - \pi^m(c+\gamma_E)] \\
\Pi_D(D,U) &= \frac{1}{2}\pi^d(\gamma_E, c+\gamma_I) - \frac{1}{2}[\pi^m(\gamma_I) - \pi^m(c+\gamma_E)].
\end{aligned}$$

(2) Only downstream independent firm is active.

Upstream firm makes the offer.
The incumbent offers firm D the contract $\{w = c, Withdrawal, T_I = \pi^m(c+\gamma_E)\}$. Since the commitment not to operate the downstream affiliate removes the scope for opportunistic behavior, firm D accepts the contract and the incumbent extracts all the rents from the more efficient downstream competitor.[36]

Downstream firms make the offer.
Firm D offers the incumbent to pay the wholesale price $w = c$ for the input and to pay the fee $T_I = \pi^m(c+\gamma_I)$ under the commitment of the incumbent to withdrawal. The incumbent accepts the offer. Firm D extracts the increase in monopoly profits due to its more efficient production process.[37]. Firm I's payoff would be $\pi^m(c+\gamma_I)$ while firm D would earn $(p^m(c+\gamma_E) - w - \gamma_E)q^m(c+\gamma_E) - T_I = \pi^m(c+\gamma_E) - \pi^m(c+\gamma_I)$.

[36] Two-part tariffs are indeed sufficient to remove the scope for opportunistic behavior. Firm I could offer the contract $\{w = p^m(c+\gamma_E) - \gamma_I, T_I = (\gamma_I - \gamma_E)q^m(c+\gamma_E)\}$. Firm D would anticipate that, if it accepts the contract, the highest retail price that the incumbent has no incentive to undercut through the own affiliate is $\widehat{p} = w + \gamma_I = p^m(c+\gamma_E)$. Then firm D would anticipate that it would earn $(p^m(c+\gamma_E) - w - \gamma_E)q^m(c+\gamma_E) = (\gamma_I - \gamma_E)q^m(c+\gamma_E) - T_I = 0$ and would accept the offer. The incumbent's payoff would be $(w-c)q^m(c+\gamma_E) + T_I = \pi^m(c+\gamma_E)$.

[37] Also in this case two-part tariffs would suffice. Firm D could offer the contract $\{w = p^m(c+\gamma_E) - \gamma_I, T_I = \pi^m(c+\gamma_I) - (p^m(c+\gamma_E) - \gamma_I - c)q^m(c+\gamma_E)\}$

Expected post-entry profits of the incumbent and the downstream rival (gross of the entry costs) are the following:

$$\begin{aligned}
\pi_I(D,\emptyset) &= \frac{1}{2}\left[\pi^m(c+\gamma_E)\right]+\frac{1}{2}\left[\pi^m(c+\gamma_I)\right]\\
\Pi_D(D,\emptyset) &= \frac{1}{2}\left[\pi^m(c+\gamma_E)-\pi^m(c+\gamma_I)\right]\\
\Pi_U(D,\emptyset) &= 0
\end{aligned}$$

(3) Only the independent upstream firm is active.

Upstream firms make the offer.
Firm U offers the incumbent the contract $\{w=0, T_U=\pi^m(\gamma_I)-\pi^m(c+\gamma_I)\}$. The incumbent accepts the offer. Firm U extracts the increase in monopoly profits due to the use of its cheaper input.

Downstream firm makes the offer.
The incumbent offers firm U to pay the wholesale price $w=0$ for the input. U accepts.

Expected post-entry profits of the incumbent and the upstream rival are the following:

$$\begin{aligned}
\pi_I(\emptyset,U) &= \frac{1}{2}\left[\pi^m(c+\gamma_I)\right]+\frac{1}{2}\left[\pi^m(\gamma_I)\right]\\
\Pi_U(\emptyset,U) &= \frac{1}{2}\left[\pi^m(\gamma_I)-\pi^m(c+\gamma_I)\right]\\
\Pi_D(\emptyset,U) &= 0
\end{aligned}$$

(4) No independent firm is active.

In this case $\pi_I(\emptyset,\emptyset)=\pi^m(c+\gamma_I)$; $\Pi_U(\emptyset,\emptyset)=0=\Pi_D(\emptyset,\emptyset)$.

□

A.1.3 The case with linear demand

When the demand function is given by $Q(p)=1-p$, $\pi^m(c_i)=\frac{(1-c_i)^2}{4}$ and $\pi^d(c_i,c_j)=(c_j-c_i)(1-c_j)$. The restrictions we have to impose on the parameters are $\gamma_I<1$ and $c+\gamma_I<p^m(\gamma_E)$ that translates into $c+\gamma_I<\frac{1+\gamma_E}{2}<1$ (the second inequality following from $\gamma_E<\gamma_I<1$).

A.1.2.1 Profitability of refusal to supply

Case (i): Refusal to supply discourages only downstream entry.

The incumbent's change in profits from refusal to supply can be expressed as follows:

$$\Delta\pi_I=(c+\gamma_I-\gamma_E)(1-c-\gamma_I)-[\frac{(1-\gamma_E)^2}{4}-\frac{(1-c-\gamma_I)^2}{4}]-\frac{1}{2}[\frac{(1-c-\gamma_E)^2}{4}-\frac{(1-\gamma_I)^2}{4}]$$

Note that the feasible values of γ_I are such that $\gamma_I \in (\gamma_E, \frac{1+\gamma_E}{2} - c]$. We also know that $\Delta\pi_I > 0$ if $\gamma_I \leq c + \gamma_E$. Hence if $c + \gamma_E \geq \frac{1+\gamma_E}{2} - c$, i.e. if $c \geq \frac{1-\gamma_E}{4}$, $\Delta\pi_I > 0$ for any feasible value of γ_I.

Let us consider now $c < \frac{1-\gamma_E}{4}$. One can the check that the inequality $\Delta\pi_I \geq 0$ is solved for $\gamma_I \leq \frac{1}{5}\left(1 - 6c + 4\gamma_E + \sqrt{c^2 + 18c(1-\gamma_E) + (1-\gamma_E)^2}\right) \equiv \gamma_I^P$.[38] One can check that $\gamma_I^P > \gamma_E$ for any feasible γ_E (to do so, recall that $\gamma_E < \gamma_I < 1 - c$). One can also check that $\gamma_I^P \geq \frac{1+\gamma_E}{2} - c$ if and only if $\gamma_E \geq 1 - 12c$. Hence, if $c \geq (1 - \gamma - E)/12 \equiv c^P$ then refusal to supply is always profitable. If $c < c^P$ then refusal to supply is profitable if and only if $\gamma_I \leq \gamma_I^P$.

Case (ii): Refusal to supply discourages entry in both markets.

The incumbent's change in profits from refusal to supply can be expressed as follows:

$$\Delta\pi_I = (c + \gamma_I - \gamma_E)(1 - c - \gamma_I) - [\frac{(1-\gamma_E)^2}{4} - \frac{(1-c-\gamma_I)^2}{4}] - \frac{1}{2}[\frac{(1-c-\gamma_E)^2}{4} - \frac{(1-c-\gamma_I)^2}{4}]$$

When $\gamma_I = \gamma_E$ then $\Delta\pi_I > 0$. By solving the inequality $\Delta\pi_I > 0$ one can see it holds for: $\gamma_I < \frac{1}{5}\left(1 - 5c + 4\gamma_E + \sqrt{-5c^2 + 10c(1-\gamma_E) + (1-\gamma_E)^2}\right) \equiv \gamma_I^{PP}$.[39] One can show that $\gamma_I^{PP} > \gamma_E$ for all feasible parameter value. Further, $\gamma_I^{PP} > \frac{1+\gamma_E}{2} - c$ amounts to $c > (1 - \frac{\sqrt{3}}{2})(1-\gamma_E) \equiv c^{PP}(> c^P)$. One can also check that $\gamma_I^P > \gamma_I^{PP}$.

A.1.2.2 Effect of refusal to supply on total welfare

Case (i): Refusal to supply discourages only downstream entry

The difference in welfare between trade and refusal to supply is given by:

$$W^T - W^R = \frac{3(1-\gamma_E)^2}{8} + \frac{3(1-c-\gamma_E)^2}{8} - F_D - F_U - [\frac{3(1-\gamma_I)^2}{8} + \frac{3(1-c-\gamma_I)^2}{8} - F_U]$$

implying that refusal to supply is welfare detrimental iff:

$$F_D \leq \frac{3(2 - c - \gamma_E - \gamma_I)(\gamma_I - \gamma_E)}{4} \equiv F_D^W,$$

and beneficial to total welfare otherwise.

We know that for refusal to be feasible it must be $F_D > \Pi_D(D, U)$, since otherwise the downstream entrant could simply enter in the second period; and that it must be $F_D \leq \overline{F}_D$, else firm D would not enter independently of the incumbent's conduct. This means we have potentially three situations, according as to whether F_D^W lies (a) to the left of $\Pi_D(D, U)$, (b) between $\Pi_D(D, U)$ and $\overline{F}_D$, or (c) to the right of $\overline{F}_D$.

(a) If $\gamma_I < 3 + c - 2\gamma_E - \sqrt{4c^2 + 4c(1-\gamma_E) + 9(1-\gamma_E)^2} \equiv \gamma_I^w$, then $F_D^W < \Pi_D(D, U)$ and — whenever it occurs — refusal to supply raises welfare;

(c) if $\gamma_I > -1 - 3c + 2\gamma_E + \sqrt{6c^2 + 8c(1-\gamma_E) + (1-\gamma_E)^2} \equiv \gamma_I^W$ then $F_D^W > \overline{F}_D$ and —

[38] The lower root of the associated second degree inequality is lower than γ_E, and therefore can be disregarded.
[39] The other root which solves the inequality is lower than γ_E and can be disregarded.

whenever it occurs — refusal to supply is always detrimental;

(b) if $\gamma_I \in [\gamma_I^w, \gamma_I^W]$, then $F_D^W \in [\Pi_D(D,U), \overline{F}_D]$ and: for $F_D < F_D^W$ refusal to supply is detrimental, whereas for $F_D > F_D^W$ it is beneficial.

Next, we should compare the critical values γ_I^w and γ_I^W with the conditions under which the incumbent refusal to supply is profitable. As an illustration, consider the case where $\gamma_E = 0$ and $c = 1/4$. From the study of the profitability conditions, we know that refusal to supply will always occur at equilibrium within the feasible interval of values of γ_I. But the welfare effects will depend on γ_I. For $\gamma_I < \gamma_I^w = .0484$ refusal to supply will be beneficial; for $\gamma_I > \gamma_I^W = .0871$, refusal to supply will be detrimental; whereas for intermediate values the welfare effects will depend on the values of F_D.

Case (ii): Refusal to supply discourages entry in both markets

The difference in welfare between trade and refusal to supply is given by:

$$W^T - W^{RR} = \frac{3(1-\gamma_E)^2}{8} + \frac{3(1-c-\gamma_E)^2}{8} - F_D - F_U - [\frac{3(1-c-\gamma_I)^2}{4}]$$

implying that refusal would be detrimental iff:

$$F_D + F_U \leq \frac{3[2\gamma_I(2-\gamma_I) + 2c(1+\gamma_E - 2\gamma_I) - c^2 - 4\gamma_E + 2\gamma_E^2]}{8} \equiv F_{DU}^{WW},$$

and beneficial to total surplus otherwise.

Combining the assumptions on fixed costs, it must be $F_D + F_U > \Pi_D(D,U)$ and $F_D + F_U \leq \overline{F}_D + \overline{F}_U$. Hence, we could have three cases, according as to whether F_{DU}^{WW} lies (a) to the left of $\Pi_D(D,U)$, (b) between $\Pi_D(D,U)$ and $\overline{F}_D + \overline{F}_U$, or (c) to the right of $\overline{F}_D + \overline{F}_U$.

(a) The analysis of the inequality $\Pi_D(D,U) - F_{DU}^{WW} > 0$ reveals that it is never satisfied for any feasible value of the parameter set.[40]

(c) if $\gamma_I > -c + \gamma_E + \frac{\sqrt{c(2-c-2\gamma_E)}}{2} \equiv \gamma_I^{WW}$ then $F_{DU}^{WW} > \overline{F}_D + \overline{F}_U$ and —whenever it occurs — refusal to supply is always detrimental;

(b) if $\gamma_I \in [\gamma_E, \gamma_I^{WW}]$, then $F_{DU}^{WW} \in [\Pi_D(D,U), \overline{F}_D + \overline{F}_U]$ and: for $F_D + F_U < F_{DU}^{WW}$ refusal to supply is detrimental, whereas for $F_D + F_U > F_{DU}^{WW}$ it is beneficial.

To check the profitability condition, consider again the example where $\gamma_E = 0$ and $c = 1/4$. From the study of the profitability conditions, we know that refusal to supply occurs at equilibrium whenever $\gamma_I \leq \gamma_I^{PP} = .307$. For $\gamma_I < \gamma_I^{WW} = .0807$ the effects of refusal to supply will depend on the values of $F_D + F_U$; for $\gamma_I > \gamma_I^{WW} = .0807$, refusal to supply will always be detrimental.

[40] $\Pi_D(D,U) > F_{DU}^{WW}$ is solved for $\gamma_I < 3 - 2c - 2\gamma_E - \sqrt{4c^2 - 8c(1-\gamma_E) + 9(1-\gamma_E)^2} \equiv \gamma_I^-$ and $\gamma_I > 3 - 2c - 2\gamma_E + \sqrt{4c^2 - 8c(1-\gamma_E) + 9(1-\gamma_E)^2} \equiv \gamma_I^+$, but $\gamma_I^- < \gamma_E$ and $\gamma_I^+ > (1+\gamma_E)/2 - c$, and therefore there are no values of γ_I within the feasible set that satisfy the inequality.

A.2 Proofs of the Extensions

A.2.1 Proof of Lemma 6: Ability to exclude under vertical integration.

In order to understand whether I is able to foreclose entry, we have to study the entry decision of the vertically integrated entrant E in period 2 when it did not enter the downstream market in period 1, and understand whether second period profits alone suffice to make entry (in both markets) profitable. If they are, refusal to supply does not lead to exclusion.

The vertically integrated entrant E will decide to enter both markets in period 2 if the following conditions are satisfied:

(i) $\Pi_E^{vie}(D,U) \geq F_D + F_U$, i.e. by entering both markets firm E makes enough profits to cover the total entry costs.

(ii) $\Pi_E^{vie}(D,U) - F_D - F_U \geq \Pi_E^{vie}(\emptyset,U) - F_U$, i.e. entering both markets is more profitable for firm E than entering only upstream.

(iii) $\Pi_E^{vie}(D,U) - F_D - F_U \geq \Pi_E^{vie}(D,\emptyset) - F_D$, i.e. entering both markets is more profitable for firm E than entering only downstream.

Note first that all the three conditions are satisfied if $F_D \leq \Pi_D(D,U)$. From property P4 we know that $\Pi_E^{vie}(D,U) \geq \Pi_D(D,U) + \Pi_U(D,U) \geq F_D + F_U$ where the last inequality comes from $F_D \leq \Pi_D(D,U)$ and from assumption $(A1)$. Consider now condition (ii). From property P4 (and from $\Pi_E^{vie}(\emptyset,U) = \Pi_U(\emptyset,U)$) we can write $\Pi_E^{vie}(D,U) - \Pi_E^{vie}(\emptyset,U) \geq \Pi_D(D,U) + \Pi_U(D,U) - \Pi_U(\emptyset,U) > F_D$ where the last inequality comes from $F_D \leq \Pi_D(D,U)$ and from property P3 (which leads to $\Pi_U(D,U) - \Pi_U(\emptyset,U) > 0$). Finally consider condition (iii). From property P4 (and from $\Pi_E^{vie}(D,\emptyset) = \Pi_D(D,\emptyset)$) we can write $\Pi_E^{vie}(D,U) - \Pi_E^{vie}(D,\emptyset) \geq \Pi_D(D,U) + \Pi_U(D,U) - \Pi_D(D,\emptyset) > F_D$ where the last inequality comes from assumption $(A1)$ and from property $P2$ (which leads to $\Pi_D(D,U) - \Pi_D(D,\emptyset) > 0$).

Then, if $F_D \leq \Pi_D(D,U)$, the vertically integrated entrant decides to enter both markets in period 2. In this case refusal to supply does not lead to exclusion both when the entrants are vertically integrated and when they are independent (as shown by Lemma 1).

Let us consider now the case in which $F_D > \Pi_D(D,U)$. Condition (iii) is satisfied for the same argument developed above. However, condition (i) and (ii) are satisfied if (and only if) $F_D < \Pi_E^{vie}(D,U) - F_U$ and $F_D < \Pi_E^{vie}(D,U) - \Pi_U(\emptyset,U)$, respectively.

Note that both $\Pi_E^{vie}(D,U) - F_U$ and $\Pi_E^{vie}(D,U) - \Pi_U(\emptyset,U)$ are greater than $\Pi_D(D,U)$.[41] This implies that there exist values of F_D such that downstream entry would be discouraged when the entrants are independent whereas downstream entry occurs under vertical integration. To see this it is convenient to analyse two separate cases according to the value of F_U.

If $F_U \leq \Pi_U(\emptyset,U)$ condition (ii) is more stringent than condition (i). Then, if $F_U \leq \Pi_U(\emptyset,U)$ and $F_D \in (\Pi_D(D,U), \Pi_E^{vie}(D,U) - \Pi_U(\emptyset,U)]$, conditions (i), (ii) and (iii) are all satisfied and the vertically integrated entrant decides to enter both the upstream and downstream market. If the entrants are independent, only upstream entry would occur in this case (as shown by Lemma 1). If, instead $F_U \leq \Pi_U(\emptyset,U)$ but $F_D > \Pi_E^{vie}(D,U) - \Pi_U(\emptyset,U)$, then condition (ii) is not satisfied and the

[41] Indeed property P4 implies that $\Pi_E^{vie}(D,U) - F_U \geq \Pi_D(D,U) + \Pi_U(D,U) - F_U$; moreover $\Pi_D(D,U) + \Pi_U(D,U) - F_U > \Pi_D(D,U)$ because of assumption $(A1)$. Similarly, $\Pi_E^{vie}(D,U) - \Pi_U(\emptyset,U) \geq \Pi_D(D,U) + \Pi_U(D,U) - \Pi_U(\emptyset,U) > \Pi_D(D,U)$ because of property P3.

vertically integrated entrant decides to enter only the upstream market (taking the same decision as in the case of independent entrants).[42]

Let us consider now the case in which $F_U > \Pi_U(\emptyset, U)$ so that condition (i) is more stringent than condition (ii). Then, if $F_U > \Pi_U(\emptyset, U)$ and $F_D \in (\Pi_D(D, U), \Pi_E^{vie}(D, U) - F_U]$, conditions (i), (ii) and (iii) are all satisfied and the vertically integrated entrant decides to enter both the upstream and downstream market. If the entrants are independent, no entry would occur in this case (as shown by Lemma 1). If, instead $F_U > \Pi_U(\emptyset, U)$ but $F_D > \Pi_E^{vie}(D, U) - F_U$, then condition (i) is not satisfied and the vertically integrated entrant decides to enter neither markets in period 2 (taking the same decision as in the case of independent entrants).[43]

A.2.2 Proof of Proposition 3: Incentive to exclude. (Refusal to supply at equilibrium with vertically integrated entrants)

Proposition 3 focuses on the values of F_D that are large enough so that refusal to supply discourages entry both when the entrants are vertically integrated and when they are vertically separated. The payoff that the incumbent earns when it engages in refusal to supply is the same in the two cases, and amounts to $\pi_I(\emptyset, \emptyset) + \pi_I(\emptyset, U)$ when $F_U \leq \Pi_U(\emptyset, U)$ (and refusal to supply excludes only D) and to $\pi_I(\emptyset, \emptyset) + \pi_I(\emptyset, \emptyset)$ when $F_U > \Pi_U(\emptyset, U)$ (and refusal to supply excludes both D and U). However, the payoff that the incumbent earns when it does not engage in refusal to supply is (weakly) lower when the entrants are vertically integrated: under vertical separation it is $\pi_I(D, \emptyset) + \pi_I^{vie}(D, U)$, while under vertical separation it is $\pi_I(D, \emptyset) + \pi_I(D, U)$; the former is lower because $\pi_I^{vie}(D, U) \leq \pi_I(D, U)$ by property ($P5$). Then the incumbent is more likely to benefit from refusal to supply when the entrants are vertically integrated.

A.2.3 Proof of Lemma 7: Exclusivity decision with menu offers.

(i) Within the setting of Section 3, condition (3) becomes (see Lemma 3.2):

$$\Pi_{I+D}^{ED} = \pi^m(c + \gamma_E) \geq \pi^m(\gamma_E) - \frac{\pi^d(\gamma_E, c + \gamma_I)}{2} - \frac{\pi^m(\gamma_I)}{2} + \frac{\pi^m(c + \gamma_E)}{2} = \Pi_{I+D}^{NoED}.$$

Rearranging, the condition for exclusivity to be agreed upon becomes:

$$\pi^m(c + \gamma_E) + \pi^d(\gamma_E, c + \gamma_I) + \pi^m(\gamma_I) - 2\pi^m(\gamma_E) \geq 0 \tag{10}$$

Note that condition (10) is always satisfied either when $c \to 0$ or when $\gamma_E \to \gamma_I$. This is intuitive because the lower c the lower the cost of excluding the upstream entrant. Moreover the more similar are the incumbent's downstream affiliate and the independent firm, the more intense competition for the input, the more likely that U obtains more than its marginal contribution.

(ii) Let us study now the case in which market demand is $Q = 1 - p$. Condition (10) becomes:

$$\frac{(1 - c - \gamma_E)^2}{4} + (c + \gamma_I - \gamma_E)(1 - c - \gamma_I) + \frac{(1 - \gamma_I)^2}{4} - \frac{(1 - \gamma_E)^2}{2} \geq 0,$$

[42] Without imposing additional structure it is not possible to establish whether $\Pi_E^{vie}(D, U) - \Pi_U(\emptyset, U)$ is smaller than $\overline{F}_D$. If not, the vertically integrated entrant would always enter both markets in period 2.

[43] Without imposing additional structure it is not possible to establish whether $\Pi_E^{vie}(D, U) - F_U$ is smaller than $\overline{F}_D$. If not, the vertically integrated entrant would always enter both markets in period 2.

with $\gamma_E \leq \gamma_I \leq \frac{1+\gamma_E}{2} - c$. (Recall that for effective competition to take place, it must be $p^m(\gamma_E) > c + \gamma_I$, which becomes $\gamma_I \leq \frac{1+\gamma_E}{2} - c$.)

Note that the LHS of this inequality increases in γ_I until it reaches a maximum in $\gamma_I = \frac{1-4c+2\gamma_E}{3} < \frac{1+\gamma_E}{2} - c$. One can check that the inequality holds at both extremes of the interval of the admissible values of γ_I (i.e. at $\gamma_I = \gamma_E$ and at $\gamma_I = \frac{1+\gamma_E}{2} - c$). Hence, it holds for any admissible value of γ_I. Then, I and D will always agree on exclusivity.

A.2.4 Proof of Proposition 4: Refusal to supply vs. exclusive dealing in equilibrium, with menu offers and linear demand.

Case I: In this case refusal to supply does not discourage downstream entry and the incumbent has no reason to engage in it. When market demand is $Q = 1 - p$, lemma 7 establishes that exclusivity is always agreed upon in period 1 in the admissible parameters' space $\gamma_E < \gamma_I < \frac{1+\gamma_E}{2} - c$.

Case II: As mentioned above exclusivity is always agreed upon in period 1. In that case upstream entry is discouraged. The incumbent's payoff is $\pi_I(D, \emptyset) + \Pi_I(D, U) + \frac{1}{2}[\pi_{I+D}^{ED} - \pi_{I+D}^{NoED}]$. If the incumbent engages in refusal to supply, downstream entry is discouraged and its payoff is $\pi_I(\emptyset, \emptyset) + \pi_I(\emptyset, U)$. In the specific case with menu offers the condition such that refusal to supply is more profitable for the incumbent than exclusive dealing can be expressed as:

$$\pi^m(c + \gamma_I) + \frac{\pi^m(\gamma_I)}{4} - \frac{3\pi^m(c + \gamma_E)}{4} - \frac{\pi^m(\gamma_E)}{2} + \frac{3}{4}\pi^d(\gamma_E, c + \gamma_I) > 0 \tag{11}$$

In the case of *linear demand* $Q = 1 - p$, condition (11) is satisfied iff:

$$\gamma_I < \frac{1 + 6\gamma_E - 8c + \sqrt{-13c^2 + 54c(1 - \gamma_E) + (1 - \gamma_E)^2}}{7} \equiv \gamma_I^R. \tag{12}$$

When $c = 0$, it turns out that $\gamma_I^R(0) = \frac{2+5\gamma_E}{7} \in (\gamma_E, \frac{1+\gamma_E}{2} - c)$. As long as $c \leq \frac{(7-\sqrt{43})}{4}(1 - \gamma_E) \equiv c^R$, the function $\gamma_I^R(c)$ is increasing in c and lies below the upper bound of the admissible values of γ_I (i.e. $\frac{1+\gamma_E}{2} - c$). When $c > c^R$, the function $\gamma_I^R(c)$ is first increasing and then decreasing in c. Notice that c cannot exceed $\frac{1-\gamma_E}{2}$: above that threshold $\gamma_E > \frac{1+\gamma_E}{2} - c$ and the set of admissible values of γ_I would be empty. Since at $c = \frac{1-\gamma_E}{2}$ it holds that $\gamma_I^R(c) > \frac{1+\gamma_E}{2} - c$, the same inequality holds for any $c \in (c^R, \frac{1-\gamma_E}{2}]$. Within this range of values of c, the incumbent finds refusal to supply more profitable than exclusive dealing for any admissible value of γ_I.

Case III: When exclusivity is agreed upon in period 1 the incumbent's payoff is $\pi_I(D, \emptyset) + \Pi_I(D, U) + \frac{1}{2}[\pi_{I+D}^{ED} - \pi_{I+D}^{NoED}]$. If the incumbent engages in refusal to supply, both downstream and upstream entry are discouraged and the incumbent's payoff is $\pi_I(\emptyset, \emptyset) + \pi_I(\emptyset, \emptyset)$. In the specific case with menu offers the condition such that refusal to supply is more profitable for the incumbent than exclusive dealing can be expressed as:

$$\frac{3}{4}\pi^m(c + \gamma_I) - \frac{\pi^m(\gamma_I)}{4} - \frac{3\pi^m(c + \gamma_E)}{4} - \frac{\pi^m(\gamma_E)}{2} + \frac{3}{4}\pi^d(\gamma_E, c + \gamma_I) > 0 \tag{13}$$

In the case of *linear demand* $Q = 1 - p$, condition (11) is satisfied iff:

$$\gamma_I < \frac{1 + 6\gamma_E - 6c + \sqrt{-27c^2 + 30c(1 - \gamma_E) + (1 - \gamma_E)^2}}{7} \equiv \gamma_I^{RR}. \tag{14}$$

It can be easily shown that $\gamma_I^{RR} < \gamma_I^R$. When $c = 0$, it turns out that $\gamma_I^{RR}(0) = \frac{2+5\gamma_E}{7} \in (\gamma_E, \frac{1+\gamma_E}{2} - c)$. As long as $c \leq \frac{(5-\sqrt{13})}{8}(1-\gamma_E) \equiv c^{RR}$, the function $\gamma_I^{RR}(c)$ lies below the upper bound of the admissible values of γ_I (i.e. $\frac{1+\gamma_E}{2} - c$). When $c > c^{RR}$, the function $\gamma_I^{RR}(c)$ is decreasing in c. Since at $c = \frac{1-\gamma_E}{2}$ it holds that $\gamma_I^{RR}(c) > \frac{1+\gamma_E}{2} - c$, the same inequality holds for any $c \in \left(c^{RR}, \frac{1-\gamma_E}{2}\right]$. Within this range of values of c, the incumbent finds refusal to supply more profitable than exclusive dealing for any admissible value of γ_I.