Dynamic Vertical Foreclosure*

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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, monopolising the downstream market may prevent the incumbent from losing most of its future profits because: (a) it allows the incumbent to extract 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, Monopolisation.

JEL Classification: K21, L41

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1 Introduction

Vertical foreclosure refers to situations in which a vertically integrated firm which 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]

However, 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 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 are not always satisfactory, and either require strong assumptions or apply only to very particular (e.g., regulated) sectors. They also 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 future period. (However, the same mechanism would apply if the scope for current entry is 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, if downstream entry occurs in the current period, also upstream entry will occur in the future, and with entry in both markets the incumbent will make little profits. Instead, if the incumbent engages in refusal to supply, it will affect the future market structure and will earn higher future profits. Lack of suitable access to the input may deprive the rival of the critical profits (or, more generally, of the critical scale, customer base, or reputation) it needs in order to be successful in the downstream market. Then refusal to supply excludes (or marginalises) 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 relative to the profits the entrant could make even in the worst case scenario), the

[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.

incentives to engage in vertical foreclosure turn out to be very strong. The incumbent knows that it will lose the upstream monopoly in any event, but it finds it optimal to foreclose the downstream competitor in the current period so as to obtain 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 the upstream entrant.) In this case foreclosure is motivated by the incumbent's intent to build monopoly power downstream so as to gain a better position when contracting with the upstream rival.

If upstream entry costs are not that small, then foreclosure of the downstream rival will weaken competition for input procurement, and reduce the post-entry profits of the prospective upstream competitor, thereby discouraging also *future* upstream entry. In this case foreclosure *protects* the incumbent's monopoly position in *both* the vertically related market. Note that the incumbent's incentive to engage in vertical foreclosure is weaker in this latter case: once the incumbent dominates the downstream market, its future profits are higher when the independent upstream firm – rather than the own less efficient affiliate – operates in the upstream market, because some rents can be extracted from it. However, monopolising both markets is more profitable than facing competition in both of them, and the incumbent benefits from vertical foreclosure also in this latter case, although to a lower extent.

The reader familiar with the literature on exclusionary practices[2] 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. We will discuss in Section 2.4 the additional insights that our analysis of vertical foreclosure brings as compared to Carlton and Waldman (2002).

We study the dynamic rationale for anti-competitive vertical foreclosure in a baseline model in which the rival in the downstream market is a potential entrant (Section 2). In this environment the decision to engage in refusal to supply needs to have commitment value to lead to foreclosure. We extend the baseline model considering the case in which the decision to engage in refusal to supply is reversible (Section 4). We show that refusal to supply can nonetheless lead to foreclosure because it allows a weak (or inefficient) incumbent to build a reputation of being tough (or very efficient), thereby discouraging entry in other downstream markets. We also modify the baseline model considering a downstream market characterized by learning effects and we study whether the incumbent can engage in refusal to supply to exclude a rival that is already in the market (Section 5 IN PROGRESS). Finally, we will discuss in the Conclusions (6) the crucial ingredients for our theory of harm to be applied as well as some recent cases in which our theory might rationalize the conduct of the dominant firm.

We close the Introduction with a brief discussion of the related literature on vertical foreclosure. As we mentioned earlier, in this literature it is the inability of the upstream monopolist to extract sufficient rents from the more efficient downstream competitor that may generate an incentive to foreclose its activity. This inability to extract rents may be due 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

[2]See Fumagalli et al (2018) for an extensive discussion.

[3]See Jullien, Rey and Saavedra (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.

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] The vertically integrated incumbent would like to extract the entire rents produced by the more efficient downstream competitor, through a suitable choice of contracts. For instance, it may want the more efficient downstream rival to set all or most of the production; to set (industry) profit maximizing prices and to earn high profits. Such profits would then be extracted by the upstream monopolist by requiring a large (fixed) payment for the input in exchange. However, if the downstream rival feared that the incumbent might use its downstream affiliate to compete for consumers (i.e. that it would behave opportunistically, rather than being inactive in the downstream market) its willingness to pay for the input would decrease, since expected competition from the incumbent's downstream affiliate would decrease the rival's expected profits. In turn, this would limit the ability of the incumbent to extract profits from the independent downstream rival and may make a foreclosure strategy potentially more profitable.[5]

Finally, if the incumbent faces some competition in the provision of the input, then the incentive to deny the input to 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 once the integrated incumbent commits not to serve the input to it. 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.[6] The credibility of the commitment is also a delicate issue in this theory, since after the upstream independent rival raises its input price, the vertically integrated affiliate would be tempted to serve the independent downstream rival.

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 sacrifices 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*.

2 The Baseline Model

An indispensable input is sold by a monopolist seller, U_I, which is the upstream affiliate of the vertically integrated firm I. Firm I also operates in a downstream market through its downstream

[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]Interestingly, Reisinger and Tarantino (2014) shows that the inability not to operate the downstream affiliate does not necessarily lead to complete foreclosure of the independent rival. If the efficiency gap between the incumbent's affiliate and the independent rival is not too large, the incumbent engages in partial foreclosure: it does supply the independent rival, but at less favourable terms (i.e. at a higher wholesale price than the own affiliate. Instead, if the efficiency gap is large enough, the incumbent finds it optimal to offer to the independent rival a wholesale price which is even lower than the one paid by the own affiliate.

[6]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 - from refusal to supply.

affiliate D_I which uses one unit of the input to produce one unit of a final product. Upstream and downstream production is 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_E can enter at a subsequent period, i.e. in period 2. The two entrants are not vertically integrated.

Upstream firms and (respectively) downstream firms sell perfectly homogeneous inputs and (respectively) outputs. We also assume that potential entrants are more efficient than the incumbent both upstream - $c_U = 0 < c = c_{U_I}$ - and downstream - $c_D = \gamma_E < c_{D_I} = \gamma_I$. However, we assume that the efficiency gap between the incumbent and the independent entrants is not too large, so that $c + \gamma_I < p^m(\gamma_E)$. Upstream and downstream entry entails fixed costs F_U and F_D respectively, which satisfy the following restrictions:

$$0 \leq F_U \leq \frac{1}{2}[\pi^d(\gamma_E, c+\gamma_I) + (\pi^m(\gamma_I) - \pi^m(c+\gamma_E))] \equiv \overline{F}_U \tag{A1}$$

$$0 \leq F_D \leq \frac{1}{2}[\pi^m(c+\gamma_E) - \pi^m(c+\gamma_I)] + \frac{1}{2}[\pi^d(\gamma_E, c+\gamma_I) - (\pi^m(\gamma_I) - \pi^m(c+\gamma_E))] \equiv \overline{F}_D \tag{A2}$$

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.[7] These upper bounds on the fixed costs ensure that, absent refusal to supply, entry (in the downstream and upstream market respectively) is profitable. This makes 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.

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

3. Period 1, stage 2: If D is active, 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.

4. Period 1, stage 3: If D is active, the contract offer is accepted/rejected. Then 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: With probability $1/2$ active upstream firms make take-it-or-leave-it offers; with probability $1/2$ active downstream firms do.

[7] Throughout the paper, 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 $c_j > c_i$ and $p^m(c_i) > c_j$.

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

All offers and acceptance/rejection decisions are publicly observed. We also assume that all firms discount future profits at a factor $\delta = 1$. The timing of the game is summarised by Figure 1.

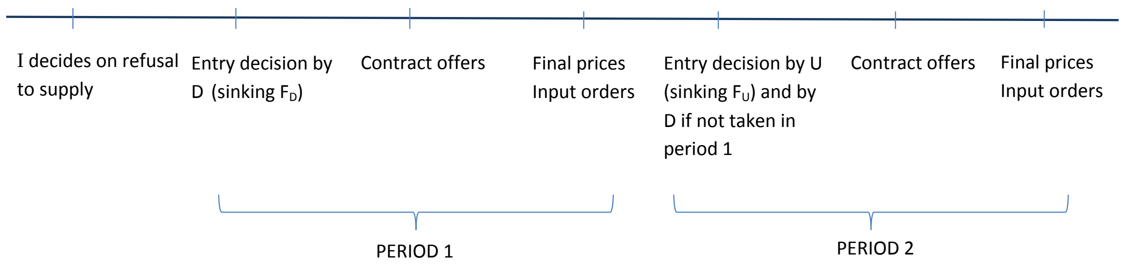

Figure 1. Timeline

Discussion of the assumptions. Before solving the model by backward induction, let us discuss some assumptions more extensively.

Feasible contracts. We allow firms to offer "rich" contracts. We allow upstream firms to make offers that commit to exclusive distribution, i.e. not to sell the input to downstream firms other than the one involved in the contract. Similarly, we allow downstream firms to 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 exclusivity. Consider the case in which upstream firms make the offer. Each upstream firm, say U_I, can offer a contract that specifies different terms of trade (i.e. marginal price w and fixed fee F) when the downstream firm D accepts only U_I's offer (thereby purchasing in exclusivity from U_I) or when D accepts the offers of both upstream suppliers. Similarly, when downstream firms make the offer: each downstream firm, say D_I, can offer a contract that specifies different terms of trade when the upstream firm U accepts only D_I's offer (thereby selling in exclusivity to D_I) or when U accepts the offers of both downstream firms.

Such contracts allow firms to sustain the maximal industry profits in period 2, when both D and U are active. (See Section 2.1 and Appendix A.1.1.) Among the equilibria that sustain maximal industry profits, we will focus on the one that attributes the highest payoff to the incumbent. This 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.[8]

Furthermore, the assumptions that upstream firms can make offers that commit to exclusive distribution rules out the possibility for the incumbent to engage in opportunistic behaviour in period

[8]In Section 3.4 we will analyse a setting in which neither exclusivity clauses nor menus of contracts are allowed. In a previous version of the paper (CEPR DP No 12498) we did not allow to remunerate a firm, U_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 now.

1 when only firm D has entered the market.[9] We do so because we want to highlight a new rational for vertical foreclosure, other than *static* imperfect rents extraction.

Commitment value of refusal to supply In the baseline model we assume that the incumbent is able to (publicly and irreversibly) commit not to serve the independent downstream firm at the beginning of the game. The commitment value of the decision to engage in refusal to supply is assumed to last for one period. To simplify the exposition we do not allow the incumbent to engage again in refusal to supply at the beginning of period 2, once the period-0 decision has expired and before period-2 entry decision are taken. As we explain more in detail in Section 3.1, allowing for this possibility does not add new insights.

An alternative assumption is that the commitment value of refusal to supply lasts forever. In that case refusal to supply would be more likely to discourage downstream entry – it would reduce the post-entry profits of firm D also in period 2 (see the discussion in Section 3.1) – and vertical foreclosure would be more likely to emerge at the equilibrium. 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.

Note that the commitment value of refusal to supply is crucial for foreclosure to arise in the baseline model. If that decision was reversible, then the downstream entrant would always enter in period 1, even it observes 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 the benefits that the more efficient downstream firm brings into the market. 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). Another possibility is to allow for refusal to supply to be reversible, but to consider a setting in which the incumbent plays a repeated game with incomplete information. In that setting the incumbent may want to refuse to supply an early downstream entrant in order to build up a reputation to be very efficient and discourage future entrants. In Section 4 we will analyse this case.

Probability to make take-it-or-leave-it offers In the baseline model we assume that upstream and downstream firms have equal probability to make take-it-or-leave-it offers when contracting the terms of trade. For our analysis to be meaningful we have to exclude the extreme case is which upstream firms always make the offers. Once that extreme case is exclude, 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 3.2).

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

2.1 Post-entry payoffs in period 2

The following Lemma summarises the post-entry payoffs of the incumbent and of the independent firms in period 2 depending on the configurations of active firms. Since the commitment to refusal to supply lasts one period, these period-2 payoffs are relevant both for the subgame following the incumbent's initial decision not to engage in refusal to supply and the subgame following the incumbent's

[9] See Hart and Tirole (1990) and Reisinger and Tarantino (2015).

decision to engage in refusal to supply.

Lemma 1. ***Post-entry payoffs in period 2***
The post-entry payoffs of the incumbent and of the independent firms (gross of the entry costs), in the different configurations of active firms are as follows:

Table 1. Post-entry payoffs in period 2.

$D\backslash U$	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.1.1. □

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 profits of the incumbent, firm D and firm E in each configuration are indicated according to this notation, as displayed by Table 1. The equilibria producing those payoffs are discussed in detail in Appendix A.1.1. Here, we highlight some features of those equilibria.

First the incumbent is better off when *one* independent firm is active than when none is active. If no independent firm is active, 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, 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 U_I 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 $\gamma_I > \gamma_E$. (Recall that the upstream affiliate can commit to exclusive distribution when making the offer, which removes the scope for opportunistic behavior through the downstream affiliate and allows the incumbent to sustain and extract the maximal profits $\pi^m(c + \gamma_E)$). The logic is similar when only the upstream firm is active. Then, when one independent firm is active – either in the upstream or downstream market – the incumbent appropriates part of its efficiency rents and earns higher profits than in the case in which no independent firm is active.

Instead for the incumbent it is more profitable that *no* independent firm is active rather than that they are *both* active. Note that, when both independent firms are active, 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 D_I 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, D_I 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 D_I'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. 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. Nonetheless, as Table 1 shows, the incumbent is worse off when both independent firms are active than when none of them is active: $\pi^m(\gamma_E) - \pi^d(\gamma_E, c + \gamma_I) < \pi^m(c + \gamma_I)$ by the Arrow replacement effect.

Finally, each independent firm makes higher profits when the other independent firm is also active in the vertically related market and competition in the latter market intensifies. Consider for instance the downstream independent firm. It earns $\frac{1}{2}[\pi^d(\gamma_E, c + \gamma_I) - (\pi^m(\gamma_I) - \pi^m(c + \gamma_E))]$ when U is also active, and $\frac{1}{2}[\pi^m(c + \gamma_E) - \pi^m(c + \gamma_I)]$ when U is not. The Arrow replacement effect implies that $\pi^d(\gamma_E, c + \gamma_I) > \pi^m(\gamma_E) - \pi^m(c + \gamma_I)$, while $\gamma_I > \gamma_E$ implies that $\pi^m(\gamma_E) - \pi^m(c + \gamma_I) > \pi^m(\gamma_I) - \pi^m(c + \gamma_I)$.

2.2 Entry decisions in period 2

Since the commitment to engage in refusal to supply lasts one period, also the entry decisions at time 2 do not depend on the initial decision taken by the incumbent. From the comparison of profits displayed in Table 1 the following Lemma can be trivially derived:

Lemma 2. ***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 (by assumption A1).

(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 decisions follow trivially from the comparison of profits displayed in Table 1. □

2.3 Entry decision in period 1.

The entry decision taken by D in the first period is illustrated by Lemma 3. 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 firm 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 3. ***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) its second period post-entry profits are insufficient to cover the entry cost (i.e. iff $F_D \in (\Pi_D(D,U), \overline{F}_D])$. In that case, refusal to supply discourages also upstream entry in period* 2 *if (and only if) upstream entry costs are sufficiently large: $F_U > \Pi_U(\emptyset, U)$.*

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 cover the fixed entry cost: D earns $\frac{1}{2}[\pi^m(c+\gamma_E)-\pi^m(c+\gamma_I)]$ in period 1 and $\frac{1}{2}[\pi^d(\gamma_E, c+\gamma_I) - (\pi^m(\gamma_I) - \pi^m(c+\gamma_E))]$ in period 2 (by Lemma 2 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 $F_U \in (\Pi_U(\emptyset,U), \overline{F}_U]$, firm 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. □

2.4 Refusal to supply in equilibrium

In discussing Lemma 2.1 above, we highlighted that the incumbent obtains a higher payoff when one independent firm is active than when neither is. An obvious corollary of that result is that refusal to supply D sacrifices the incumbent's profits in period 1 - which is exactly what the usual Chicago School argument tells us. 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 short-run, refusing to supply is costly, but in the long-run it is beneficial.

Refusal to supply increases the incumbent's 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 *build 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. $F_U > (\emptyset, U)$), lack of downstream entry, by reducing the post-entry profits of the upstream independent firm, discourages also future upstream entry. In this case in which the dowsntream rival's success is a pre-condition for upstream entry, refusal to supply allows the incumbent to increase future 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.

Then refusal to supply can have a *dynamic rationale* and will emerge at the equilibrium when the sacrifice of profits in the first period is dominated by the second period beneficial effect. The following Proposition illustrates under which conditions this is the case.

Proposition 1. ***Profitability of Refusal to Supply***

(i) ***Refusal to Supply discourages only downstream entry***

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. $Q(p) = 1 - p$) one can show that 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.

In the linear demand case one can show that 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.*
- *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 can be written as:

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

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 $\gamma_I < c + \gamma_E$ then $\frac{1}{2}[\pi^m(c+\gamma_E) - \pi^m(\gamma_I)] < 0$ and $\Delta\pi_I > 0$.

See Appendix A.1.2 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 can be written as:

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

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.1.2 for the analysis of the linear case.

□

Discussion Finally, the underlying mechanism in the case 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.[10] 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.

An important difference between our model and theirs, though, is that in the setting proposed by Carlton and Waldman (2002) vertical foreclosure motivated by the intent to 'transfer' or 'create' a downstream monopoly in the future cannot arise. In their setting entry in complementary market is necessary for entry in the primary market, whereas in ours, upstream entry may take place independently of downstream entry.

Then our model 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, as focusing on the latter case would suggest. Indeed we show that a crucial ingredient for a theory of harm is that future entry in the upstream market is conceivable, 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*. Indeed, so far U and D are stand-alone entrants. We consider the case of vertically integrated entrants in Section 3.3.

[10] 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.

2.5 Welfare effects of refusal to supply

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)). $\square$

Refusal to supply is detrimental also for total welfare as long as it discourages efficient entry, i.e. when entry costs are sufficiently low.

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

Case (i): Refusal to supply discourages efficient downstream entry iff $F_D \leq F_D^W$.

Case (ii): Refusal to supply discourages efficient entry in both markets iff $F_D + F_U \leq F_{D+U}^W$.

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, 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 discourages efficient downstream entry iff

$$F_D \leq F_D^W \equiv W(p^m(c+\gamma_E)) + W(p^m(\gamma_E)) - W(p^m(c+\gamma_I)) - W(p^m(\gamma_I))$$

Case (ii).
When the incumbent engages in refusal to supply, 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 discourages efficient entry is both markets iff

$$F_D + F_U \leq F_{D+U}^W \equiv W(p^m(c+\gamma_E)) + W(p^m(\gamma_E)) - 2W(p^m(c+\gamma_I))$$

With generic demand functions it is not possible to establish whether the threshold levels of fixed costs F_D^W and F_{D+U}^W fall within or outside the feasible interval of the fixed cost F_D identified by assumptions A1 and A2. However, we show in the Appendix that for the specific case of linear demand $Q(p) = 1 - p$, different values of the parameter space can give rise to situations where F_D^W is (a) below the lower bound, (b) falls within the interval, or (c) is above the upper bound, implying that refusal to supply would respectively be (a) always beneficial, (b) either detrimental or beneficial, or (c) always detrimental to welfare.

□

3 Extensions to the baseline model

3.1 Commitment to refusal to supply

In the baseline model 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. Imagine, instead, that at the beginning of period 2 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 the incumbent has no incentive to engage again in refusal to supply. Since D has entered, also firm U will enter: if the incumbent engages in refusal to supply and cannot deal with D, firm D will be more dependent on U for the provision of the input and post-entry profits of firm 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, anticipating this, 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 2.4. If, instead, $F > \Pi_D(D, U)$, firm 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.

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 firm D in period 2. As mentioned above, if the incumbent commits not to deal with D, firm 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. 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.

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

The baseline model assumes 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 are 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 firm 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 firm D $\Pi_D(D, U)$. As a consequence, as we discussed in Section 2.4, 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 firm D in period 1 when it does not engage in refusal to supply. Then the lower β the lower the profit sacrifice of in 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 that upstream firms make the offers the stronger the incumbent's incentive to engage in refusal to supply.

3.3 Vertically Integrated Entrants

IN PROGRESS

3.4 Exclusivity clauses and menus of contracts are not allowed

IN PROGRESS

4 Reputation can explain foreclosure when the incumbent is unable to credibly commit

In the base model the commitment to refuse to supply the downstream entrant is crucial for the exclusionary effect. Indeed, if the decision to engage in refusal to supply were reversible, then the independent firm D would decide to enter the downstream market in period 1 despite the incumbent's threat not to supply it. D would correctly anticipate that, once entry has taken place, the incumbent would renege on its previous decision and would supply D instead, because not trading with the more efficient downstream firm reduces the profits that the incumbent can extract from the negotiation for the input.

In this section we relax the assumption that refusal to supply has commitment value and we show that, in a modified version of the game, the incumbent may find it optimal to engage in it once entry has occurred to build a reputation of being "tough" and discourage subsequent entry. The logic is very similar to the predation model of Kreps and Wilson (1982).

Description of the game We consider a situation where in period 1 (i) the incumbent faces successive downstream entry in two separate geographic markets, market A and B, and (ii) there is incomplete information: the downstream entrants do not know whether the incumbent's affiliates are inefficient like in the base model (having marginal costs $c_{U_I} = c$ and $c_{D_I} = \gamma_I$), or they are very efficient, and hence have both marginal costs 0. We call the inefficient incumbent "weak", and the efficient incumbent "tough". At the beginning of the game, the probability that the incumbent is tough is $x > 0$. Downstream entrants have marginal cost γ_E. In period 2, like in the baseline model, entry can occur in the upstream market, both in geographical market A and B. Upstream entrants have marginal cost 0. The timing of the game is the following:

1. Period 1, stage 1: Firm D_A decides whether to enter (and pay fixed sunk cost F_D) or not in market A;
2. Period 1, stage 2: The incumbent decides whether to 'refuse (R) to supply' or, alternatively, to supply (S) the downstream rival D_A;
3. Period 1, stage 3: Firm D_B decides whether to enter (and pay fixed sunk cost F_D) or not in market B;
4. Period 1, stage 4: The incumbent decides whether to 'refuse to supply' or, alternatively, to supply the downstream rival D_B;
5. Period 1, stage 5: Contracts are offered in each market where entry has occurred. In each market, with probability 1/2 the incumbent's upstream affiliate makes a take-it-or-leave-it offer, with probability 1/2 the downstream firm (if active) makes a take-it-or-leave-it offer. We maintain the same assumptions as in the baseline concerning the set of feasible contracts.
6. Period 1, stage 6: If D_i (for $i = A, B$) is active, the contract offer is accepted/rejected. Then active downstream firms choose final prices p_i and p_I, firm D_i orders the input to satisfy demand, paying accordingly, and transforms one unit of the input into one unit of the final product.
7. Period 2, stage 1: Firm U_i enters the upstream market i (and pays $F_U = 0$), with $i = A, B$.
8. Period 2, stage 2: In each market separately, with probability 1/2 active upstream firms make take-it-or-leave-it offers; with probability 1/2 active downstream firms do. The decision taken in period 1 concerning refusal to supply is reversible.
9. Period 2, stage 3: Contract offers are accepted/rejected. The active downstream firms set final prices p_i and p_I, orders are made, payments take place and payoffs are realized.

Note that consistently with the assumption that refusal to supply has no commitment value, we allow the incumbent to modify its supply strategy even in period 2.

Moreover, we make a number of simplifying assumptions to avoid a proliferation of cases. Notably we assume that $F_{U_i} = 0$, so that entry occurs for sure in the upstream market is period 2. This allows us to disregard the upstream entrant's entry decision and hence simplifies the analysis. We also assume that, absent refusal to supply, second period profits alone are insufficient for a downstream entrant facing a weak incumbent to cover the entry cost, whereas entry in period 1 is profitable for a downstream entrant facing a weak incumbent (like in the baseline model). As a consequence, F_D is subject to the following restrictions:

$$\Pi_D(D,U) < F_D < \overline{F}_D \tag{A}$$

where $\overline{F}_D$ and $\Pi_D(D,U)$ are defined in Section 2.

As the timing of the game indicates, in period 1 contracts in market A are offered and final prices are established after entry decisions and refusal to supply decisions are taken in both downstream markets. Results would not change if contracts were offered and acceptance decision were made at stage 2. Instead, the assumption that final prices are chosen after entry decisions and refusal to supply decisions are taken in both downstream markets simplifies the analysis: otherwise also final prices should be chosen by the incumbent in order to affect the beliefs of the entrant in market B concerning the incumbent's marginal costs.

4.1 Market profits for the incumbent and downstream entrants

We solve the game using the concept of Perfect Bayesian Nash Equilibrium. As a preliminary step let us find the equilibrium payoffs in period 2, when both independent firms are active and the incumbent is tough : $c_{U_I} = c_{D_I} = 0 = c_U < c_D = \gamma_E$.

Lemma 6. *Both with upstream and downstream offers, at an equilibrium with an efficient vertically integrated incumbent, D will never produce and the incumbent appropriates the entire maximal industry profits. There exist equilibria where the (equally efficient) upstream entrant produces the input but even in this case U will not be able to make profits. Payoffs will be:*

$$\pi_I = \pi^m(0);\ \pi_U = 0;\ \pi_D = 0 \tag{3}$$

Proof. See Appendix A.2. □

Armed with the equilibrium payoffs for the weak incumbent found in section 2.1, and those for the tough incumbent just found, let us proceed with deriving the *total* profits obtained by the incumbent and by the independent downstream firm D_i in market i, with $i = A, B$ when one considers market i in isolation, thereby abstracting from possible reputation building effects. Those profits depend on whether entry occurred in period 1, on the incumbent's type and on whether the incumbent engages or not in refusal to supply.

Firm D_i did not enter and the incumbent is tough. In this case the incumbent monopolises the final market through its own affiliate in period 1 and is indifferent between doing the same also in period 2 and trading with U_i (since the upstream affiliate is equally efficient). Then, total profits across the two periods are given by:

$$\pi_{I,t}^{NoEntry} = \pi^m(0) + \pi^m(0); \quad \Pi_{D_i,t}^{NoEntry} = 0.$$

Firm D_i did not enter and the incumbent is weak. In this case the incumbent monopolises the final market through its own affiliate in period 1, while in period 2 it trades with the upstream independent firm, partially appropriating the increase in monopoly profits that the latter's more efficient technology produces. Then total profits over the two periods are given by:

$$\pi_{I,w}^{NoEntry} = \pi^m(c+\gamma_I) + \frac{\pi^m(\gamma_I) + \pi^m(c+\gamma_I)}{2}; \quad \Pi_{D_i,w}^{NoEntry} = 0$$

Firm D_E entered and the incumbent is tough. In period 1 the efficient incumbent finds it more profitable not to trade with the less efficient downstream entrant and to monopolise the market through to own affiliate make profits $\pi^m(0)$. We know from lemma 6 that the incumbent obtains the entire industry profits $\pi^m(0)$ also in period 2. Total profits over the two periods are given by:

$$\pi_{I,t}^{Entry} = \pi^m(0) + \pi^m(0); \quad \Pi_{D_i,t}^{Entry} = 0$$

Note that D_i's profits are gross of the entry cost.

Firm D_i entered and the incumbent is weak. In period 2, when both independent firms are active, the incumbent has never an incentive to refrain from making offers to the independent firms. By doing so it would lose the possibility to be remunerated not to compete downstream and its profits would decrease. In period 1, when only firm D_i is active, if the incumbent supplies the independent firm total profits over the two periods are given by:

$$\begin{aligned}\pi_{I,w}^{Entry,S} &= \tfrac{\pi^m(c+\gamma_I)+\pi^m(c+\gamma_E)}{2} + \pi^m(\gamma_E) - \pi^d(\gamma_E, c+\gamma_I);\\ \Pi_{D_i,w}^{Entry,S} &= \tfrac{1}{2}[\pi^m(c+\gamma_E) - \pi^m(c+\gamma_I)] + \tfrac{1}{2}[\pi^d(\gamma_E, c+\gamma_I) + \pi^m(c+\gamma_E) - \pi^m(\gamma_I)]\end{aligned}$$

If the incumbent decides not to trade with firm D_i in period 1, then total (gross) profits over the two periods are given by:

$$\pi_{I,w}^{Entry,R} = \pi^m(c+\gamma_I) + \pi^m(\gamma_E) - \pi^d(\gamma_E, c+\gamma_I); \quad \Pi_{D_i,w}^{Entry,R} = \frac{\pi^d(\gamma_E, c+\gamma_I) + \pi^m(c+\gamma_E) - \pi^m(\gamma_I)}{2}$$

Note that if there was only one market and reputation-building did not play any role, then the weak incumbent would find it more profitable to trade with the independent downstream firm because it would partially appropriate the increase in monopoly profits produced by D_{Ei}'s more efficient technology (as we discussed in section 2.1). Note also that by assumption A, downstream entry is profitable if the incumbent does not engage in refusal to supply in the first period, but not if it does refuse to supply.

From the discussion above we can conclude the following:

Lemma 7.

(i) A tough incumbent never supplies the input if a downstream entrant enters market i in period 1.

(ii) Absent a reputation building effect, a weak incumbent never engages in refusal to supply in period 1.

(iii) An independent firm that assigns probability 1 to the incumbent being tough does not enter the downstream market i in period 1.

4.2 The equilibria of the game

The equilibria of the game are described by the following Proposition.

Proposition 2. ***(Perfect Bayesian equilibria of the game)***

(i) The game admits a separating equilibrium in pure strategies in which a tough incumbent refuses to supply the input and a weak incumbent supplies it if (and only if):

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

(ii) There exists a pooling equilibrium in which both the weak and the tough incumbent refuse the input to the downstream entrant in market A if (and only if) $F_D \geq (1-x)\Pi_{D_w}^{Entry,S}$.

(iii) If $x < \widehat{x}$ *and* $F_D < \widehat{F}_D^{Rep}$ $\left(\textit{with } \widehat{F}_D^{Rep} < (1-x)\Pi_{D_w}^{Entry,S}\right)$, *there exist semi-separating equilibria in which:*

> *(1.i) Firm* D_A *enters the downstream market A.*
>
> *(1.ii) The tough incumbent engages in refusal to supply in market A. The weak incumbent engages in refusal to supply with probability* $\frac{xF_D}{(1-x)(\Pi_{D_w}^{Entry,S}-F_D)}$.
>
> *(1.iii) Firm* D_B *enters the downstream market B with probability* $(1-\frac{\pi_{I,w}^{Entry,S}-\pi_{I,w}^{Entry,R}}{\pi_{I,w}^{NoEntry}-\pi_{I,w}^{Entry,S}})$ *if* D_A *was refused the input. Firm* D_B *enters the downstream market B with probability* 1 *if* D_A *was supplied the input.*
>
> *(1.iv) If firm* D_B *enters the downstream market, the tough incumbent engages in refusal to supply, while the weak incumbent supplies it.*
>
> *(2.i) In period* 2*, if entry occurred in downstream market* i*, for the weak incumbent it is never profitable to refrain from making offers to the independent firms. The tough incumbent will never serve the input to the independent firms.*

Proof. Recall that for a candidate equilibrium to be a PBE each player's strategy must be optimal given the other player's strategies, given the player's beliefs, and with beliefs satisfying Bayes' rule.

Separating equilibrium.

At a separating equilibrium, if entry has occurred in market A, firm D_B observes the behaviour of the incumbent towards the entrant in market A and infers that the incumbent is weak if it observes supply of the input, while it infers that the incumbent is tough if it observes refusal to supply. In market B no reputation effect can arise. Then, by Lemma 7, firm D_B expects the weak incumbent not to engage in refusal to supply and enters the downstream market only if it observes supply in market A. A necessary condition for a separating equilibrium to exist is that, after observing entry in market A, the weak incumbent finds it more profitable to supply rather than mimic the tough one and refusing the input to D_A in order to induce D_B not to enter:

$$\pi_{I,w}^{Entry,S}+\pi_{I,w}^{Entry,S}\geq\pi_{I,w}^{Entry,R}+\pi_{I,w}^{NoEntry}. \tag{4}$$

By replacing the payoff values in this expression, one obtains:

$$\pi^m(c+\gamma_E) + [\pi^m(\gamma_E) - \pi^m(c+\gamma_I) - \pi^d(\gamma_E, c+\gamma_I)] - \frac{\pi^m(\gamma_I) + \pi^m(c+\gamma_I)}{2} \geq 0$$

Note that the term in square bracket is negative because of the Arrow replacement effect. Therefore, a sufficient condition for this condition not to hold (and hence the separating equilibrium not to exist) is that γ_I is close enough to γ_E. Indeed, in the extreme case where $\gamma_I = \gamma_E + \varepsilon$, $\pi^m(c+\gamma_E) - \frac{\pi^m(\gamma_I)+\pi^m(c+\gamma_I)}{2}$ amount to $\frac{1}{2}[\pi^m(c+\gamma_I) - \pi^m(\gamma_I)]$, which is negative for any $c > 0$.

In Appendix A.2.2 we will refer to the specific case with linear demand and we will identify the conditions for condition 4 to be satisfied.

Pooling equilibrium.

At a pooling equilibrium, if entry has occurred in market A, firm D_B does not revise its beliefs when observing a refusal to supply decision. The posterior belief (i.e. the probability that the incumbent is tough conditional on the observation of refusal to supply) coincides with the prior: $\Pr(t \mid R) = x$. For this to be an equilibrium, D_B must prefer not to enter after observing a refusal to supply. By Lemma 7, the downstream entrant in market B expects the incumbent not to engage in refusal to supply when weak, and expects to earn zero profits when facing a tough incumbent. Then, the no entry condition is:

$$x\Pi_{D,t}^{Entry,R} + (1-x)\Pi_{D,w}^{Entry,S} - F_D \leq 0,$$

which, after noting that $\Pi_{D,t}^{Entry,R} = 0$, becomes:

$$F_D \geq (1-x)\Pi_{D,w}^{Entry,S}, \tag{5}$$

a condition which is compatible with assumption A. Note that as x tends to zero, this equilibrium tends to disappear: if it is unlikely that the incumbent is efficient (= tough), then after observing a refusal to supply the downstream entrant in market B would still hold a high ex-post probability it faces a weak incumbent, and hence will enter (which in turn would discourage a weak incumbent from engaging in refusal to supply with the downstream entrant in market A).

Suppose that condition (4) does not hold (a separating equilibrium does not exist) and condition (5) does. Then, a weak incumbent finds it profitable to engage in refusal to supply when facing entry in market A so as to mimic a tough incumbent and discourage future downstream entry in market B. Since the first entrant anticipates that any incumbent would refuse to supply, it will not enter. By condition 5 the second downstream entrant will not enter either. Hence, refusal to supply will never be observed at equilibrium.

Semi-separating equilibrium.

Let us consider the case in which neither condition (4) nor condition (5) are satisfied. In particular:

$$F_D < (1-x)\Pi_{D,w}^{Entry,S}. \tag{6}$$

Note that as $x \to 0$, condition (6) would amount to $F_D < \Pi_{D,w}^{Entry,S}$ which is always satisfied by assumption A. Instead, if $x \to 1$, condition (6) would amount to $F_D < 0$, which contradicts assumption A. Then there exists a threshold level of the prior, $\overline{x} \in (0,1)$, such that a necessary condition for a semi-separating equilibrium to exist is that $x < \overline{x}$ and $F_D < (1-x)\Pi_{D,w}^{Entry,S}$, where $\overline{x}$ is such that:

$$(1-\overline{x})\Pi_{D,w}^{Entry,S} = \Pi_{D,w}^{Entry,R}. \tag{7}$$

Period 2 does not involve any reputation building. As shown by Lemma 6, following entry in the downstream and upstream market, the weak incumbent will always want to make offers to the independent firms; instead, the tough incumbent will never serve the input to the downstream entrant.[11] (This proves 2.i.)

No reputation can be built in market B in period 1. Hence, by Lemma 7, following entry in downstream market B, the tough incumbent engages in refusal to supply and the weak incumbent does not. (This proves 1.iv.)

The entrant in market B infers that the incumbent is weak if it observes that firm D_A was supplied the input. Since it anticipates that the weak incumbent will not engage in refusal to supply in market B, it is profitable for D_B to enter the downstream market if it observes that firm D_A was supplied the input. If D_B observes that firm D_A was refused the input, then it updates its belief about the incumbent being weak:

$$\Pr(w \mid R) = \frac{(1-x)\Pr(R \mid w)}{(1-x)\Pr(R \mid w) + x\Pr(R \mid t)} = \frac{(1-x)\Pr(R \mid w)}{(1-x)\Pr(R \mid w) + x} \tag{8}$$

since $\Pr(R \mid t) = 1$. It is optimal for D_B to randomize between entry and no entry if the two alternatives are equally profitable. Then, given its revised beliefs, the profits that it expects to make by entering market B must be equal to zero:

$$0 = \Pr(w \mid R)\Pi_{D,w}^{Entry,S} - F_D.$$

Substituting the revised beliefs from equation 8, one obtains that the probability that a weak incumbent engages in refusal to supply after downstream entry in market 1 must be:

$$\Pr(R \mid w) = \frac{xF_D}{(1-x)(\Pi_{D,w}^{Entry,S} - F_D)}. \tag{9}$$

Note that $\Pr(R \mid w) > 0$ by assumption A. Moreover, $F_D < (1-x)\Pi_{D,w}^{Entry,S}$ ensures that $\Pr(R \mid w) < 1$. (This proves 1.ii)

It is optimal for the weak incumbent to randomize between refusal to supply and supply following downstream entry in market A if the two alternatives are equally profitable. If the weak incumbent supplies the input to D_A, then firm D_E will infer that it is weak and will enter market B. The incumbent's profits (across both periods and both markets) are $2\pi_{I,w}^{Entry,S}$. If the weak incumbent refuses to supply D_A, then firm D_B will enter with probability $\Pr(Entry \mid R)$. In this case the weak incumbent's expected profits (across the two markets and the two periods) are given by:

$$\pi_{I,w}^{Entry,R} + \Pr(Entry \mid R)\pi_{I,w}^{Entry,S} + [1-\Pr(Entry \mid R)]\pi_{I,w}^{NoEntry}$$

Then, the indifference condition is:

$$2\pi_{I,w}^{Entry,S} = \pi_{I,w}^{Entry,R} + \Pr(Entry \mid R)\pi_{I,w}^{Entry,S} + [1-\Pr(Entry \mid R)]\pi_{I,w}^{NoEntry}$$

[11] To be precise, there exist equilibria where the incumbent pays an arbitrarily small or zero compensation to a downstream entrant just to make sure that it does not accept an offer from the upstream entrant.

from which one obtains:

$$\Pr(Entry \mid R) = 1 - \frac{\pi_{I,w}^{Entry,S} - \pi_{I,w}^{Entry,R}}{\pi_{I,w}^{NoEntry} - \pi_{I,w}^{Entry,S}}.$$

Recall that a necessary condition for a semi-separating equilibrium to exists is that condition 4 is not satisfied, that is:

$$\pi_{I,w}^{Entry,S} + \pi_{I,w}^{Entry,S} < \pi_{I,w}^{Entry,R} + \pi_{I,w}^{NoEntry}. \tag{10}$$

Since $\pi_{I,w}^{Entry,R} < \pi_{I,w}^{Entry,S}$ by Lemma 7, it must be that $\pi_{I,w}^{NoEntry} > \pi_{I,w}^{Entry,S}$, i.e. refusal to supply must be profitable for a weak incumbent when it discourages downstream entry. Proposition 1 (i) identifies when this is the case. Then $\Pr(Entry \mid R) < 1$. Moreover (10) also implies that $\Pr(Entry \mid R) > 0$. (This proves 1.iii.)

For firm D_A it is optimal to enter downstream market A if its expected payoff is higher than staying out:

$$-F_D + x\Pi_{D,t}^{Entry} + (1-x)\left[\Pr(R \mid w)\Pi_{D,w}^{Entry,R} + (1 - \Pr(R \mid w))\,\Pi_{D,w}^{Entry,S}\right] > 0.$$

Substituting the payoffs obtained above, the condition becomes:

$$F_D < (1-x)\left[\Pi_{D,w}^{Entry,S} - \Pr(R \mid w)\left(\Pi_{D,w}^{Entry,S} - \Pi_{D,w}^{Entry,R}\right)\right] \equiv \widehat{F}_D^{Rep}. \tag{11}$$

Note that as $x \to 0$ $\Pr(R \mid w) \to 0$. In that case $\widehat{F}_D^{Rep} \to \Pi_{D_E,w}^{Entry,S}$ and condition 11 is always satisfied. Moreover, as shown above, $F_D < (1-x)\Pi_{D_E,w}^{Entry,S}$ ensures that $\Pr(R \mid w) < 1$. This implies that when $x = \overline{x}$, $\widehat{F}_D^{Rep} < \Pi_{D_E,w}^{Entry,R}$. By assumption A condition (11) cannot be satisfied. Since $\Pr(R \mid w)$ is increasing in x, there exists a threshold level $\widehat{x} < \overline{x}$ such that:

$$(1-\widehat{x})\left[\Pi_{D_E,w}^{Entry,S} - \Pr(R \mid w)|_{x=\widehat{x}}\left(\Pi_{D_E,w}^{Entry,S} - \Pi_{D_E,w}^{Entry,R}\right)\right] = \Pi_{D_E,w}^{Entry,R} \tag{12}$$

The semi-separating equilibrium exists iff $x < \widehat{x}$ and $F_D < \widehat{F}_D^{Rep}$. $\square$

Comment Given the similarity with the Kreps and Wilson (1982)'s predation game, it is reasonable to conjecture that if there were $T > 2$ downstream entrants a similar equilibrium would arise: in the earlier periods of the game even a weak incumbent engages in refusal to supply with certainty, and anticipating this, early downstream entrants stay out. As the game proceeds, the optimal strategies are mixed ones, like in the $T = 2$ case.

The main insight of this model is that even a small departure from the perfect information setting gives rise to refusal to supply even if an incumbent were unable to credibly commit to such a strategy before downstream rivals enter.

5 A model with learning effects

In the baseline model the downstream rival is a *potential entrant.* In that setting *committing* to refusal to supply prevents the downstream rival from earning the key *profits* necessary to cover the entry cost and deters entry. Lack of downstream entry benefits the incumbent in the following period, either by also deterring upstream entry, or – when upstream entry will occur anyway – because a downstream monopoly will allow the incumbent to extract more rents when contracting for the input with the upstream independent firm. Note, however, that the mechanism of the baseline model relies on the ability of the incumbent to commit for at least one period to refusal to supply. If the incumbent could revise its refusal to supply decision before period-1 price decisions take place, the downstream entrant would enter and at that point the incumbent would prefer to supply it (the only reason to engage in refusal to supply is to deter entry).

In this Section we study whether refusal to supply could be an optimal strategy for the incumbent also in a situation where the downstream rival is already active (hence, refusal to supply is not done to deter entry), upstream entry will always occur, and the downstream market is characterised by learning effects: sales in the early period increase efficiency in the later period.

IN PROGRESS

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 (or actual) 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 with its input.

In a situation where 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 'transfer' or 'create' a downstream monopoly in the future, 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, in a situation where a downstream rival's success is a pre-condition for an upstream rival's entry, a vertically integrated dominant firm may deny the input to the downstream rival today with the objective of maintaining its monopoly power in both vertically related markets tomorrow. (If a more efficient downstream rival was in the 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.)

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. However, 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 *potential* competition both upstream and downstream (in one of the segments, competition might also be already there - like in the variant of the model where downstream competition is characterised by either learning effects or network externalities).

As for the situation where foreclosure takes place in order to "create" 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.[12]

Another vertical market where our theory of harm may conceivably be invoked to rationalise anti-competitive refusal to supply consists of services and spare parts of some primary equipment. For instance, suppose that there is an Original Equipment Manufacturer (OEM) which sells not only the primary product (say, a piece of hardware, or a machine) but also - and these are the vertically related markets we refer to in the model - spare parts (the upstream market) and Maintenance and Repair (MR) services (the downstream market). From a static perspective, the OEM would have an incentive to offer spare parts to independent providers of MR services, but if it felt that over time other manufacturers will be able to supply substitute spare parts in an efficient way, it may find it convenient to deny spare parts to MR competitors, so as to use its downstream service monopoly to appropriate rents from future competing providers of spare parts.[13]

The other situation covered in this paper deals with vertical foreclosure which maintains (or protect) overall monopoly power. 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.[14]

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 buying wholesale services from Telefónica. According to the EC, "[...]alternative operators [i.e.

[12]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.

[13]This hypothetical example shares some similarity with the complaint by IATA (the association of the airline industry) that some engine OEMs are withholding repair information from qualified third-party maintenance shops. See Financial Times, "Airlines complain to Brussels over parts and maintenance contracts", March 23, 2016.

[14]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.

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)

The dynamic theory proposed here 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. By engaging in vertical foreclosure (here taking the form of margin squeeze)[15], 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 upstream market.

Arguably, our dynamic model also fits the facts of *Genzyme*,[16] 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).[17] 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).[18]

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

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

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

[17]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.

[18]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.

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)[19]

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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A Appendix

A.1 Proofs of the baseline model

A.1.1 Proof of Lemma 1

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 à la Bertrand in the final market (with demand $Q(p)$) with a firm with marginal cost $c_j > c_i$ 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 U_I can offer to D the contract: $\{w, Exclusive\ Distribution, \widehat{F}_I, F_I\}$. Note that, in this environment in which upstream firms sell homogeneous products, exclusive distribution means that, if D accepts the offer, then D_I will not sell in the final market.[20] $\widehat{F}_I$ is the fee that D will pay in case of "exclusive purchase", namely when it accepts only U_I's offer and F_I is the franchise fee requested when D accepts both U_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: $\{w, \widehat{F}_E, F_E\}$.

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, which implies we are selecting the Pareto dominant equilibrium from the point of view of the players which make the offers (here, the upstream firms).[21]

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:* $\{w = c, Exclusive\ Distribution, \widehat{F}_I = \pi^m(\gamma_E) - \pi^d(\gamma_E, c + \gamma_I), F_I = \widehat{F}_I\}$.
- *The upstream entrant offers D:* $\{w = 0, \widehat{F}_E = \pi^m(\gamma_E) - \pi^m(c + \gamma_E), F_E = \widehat{F}_E\}$.
- *D accepts both offers*

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

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:

$$\pi^m(\gamma_E) - F_I - F_E = \pi^m(c + \gamma_E) - \widehat{F}_I = \pi^d(\gamma_E, c + \gamma_I) - \widehat{F}_E > 0 \tag{13}$$

Let us consider whether upstream suppliers have an incentive to offer alternative contracts. Can U_i deviate to a more profitable exclusive purchase arrangement with D? Since D obtains the same

[20]If upstream firms sold differentiated products, exclusive distribution would ensure that D_I does not distribute U_I's product (or, more generally, that D_I cannot obtain the input from U_I), but it would not prevent D_I from distributing U's product.

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

payoff accepting both contracts and either one, U_i should increase the joint profits with D in order to benefit from such a deviation. But at the candidate equilibrium $\pi_{D+U_I} = \pi^m(c+\gamma_E)$, which are the highest joint profits that U_I and D can produce by trading in exclusivity. Hence, U_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 U_i deviate to a more profitable common representation (CR) contract? Consider U_I. If U_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 U_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 U_I and D already jointly achieve in the candidate CR equilibrium. Hence, U_I cannot deviate to a more profitable CR contract. Likewise, consider U. If U makes a deviation offer and D accepts both contracts then U_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, U_I cannot deviate to a more profitable CR contract.

U_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 making an exclusive purchase offer to D_I. Following U's deviation offer and the standing offer of U_I to D, it is a dominant strategy for D to accept U_I's offer. Since such an offer involves a commitment not to serve the downstream market through D_I, there is no point for D_I to accept U's offer, and the deviation is not profitable.[22]

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:

$$\pi^m(\gamma_E) - F_I - F_E = \pi^m(c+\gamma_E) - \widehat{F}_I = \pi^d(\gamma_E, c+\gamma_I) - \widehat{F}_E \tag{14}$$

Let us reason a contrario and let us suppose that $\pi^m(\gamma_E) - F_I - F_E < Max[\pi^m(c+\gamma_E) - \widehat{F}_I, \pi^d(\gamma_E, c+\gamma_I) - \widehat{F}_E]$. Then a common representation equilibrium would not exist because D would prefer to buy from the firm which offers the highest exclusive representation payoff.

[22]One may also think of the following, somehow convoluted, possible deviation: U offers the input to D_I at $\{w' = 0\ F'\}$. D_I cannot use the input to serve the final market but it can transfer it to U_I that then supplies D at the conditions established by the standing offer, i.e. $w = c$ e $\widehat{F}_I$. Then, the highest payoff that U can possibly extract from the deviation offer is $cq^m(c+\gamma_E)$. However, this payoff is lower than the candidate equilibrium payoff ($cq^m(c+\gamma_E) < pi^m(\gamma_E) - \pi^m(c+\gamma_E)$, because $cq^m(c+\gamma_E) + \pi^m(c+\gamma_E) = (p^m(c+\gamma_E) - \gamma_E)q^m(c+\gamma_E) < \pi^m(\gamma_E)$) and the deviation is not profitable.

Let us suppose now that $\pi^m(\gamma_E) - F_I - F_E > Max[\pi^m(c+\gamma_E) - \widehat{F}_I, \pi^d(\gamma_E, c+\gamma_I) - \widehat{F}_E]$. Then - given the fees $\widehat{F}_{-i}$ and F_{-i} of the rival - upstream supplier U_i could slightly increase the fee F_i: firm D would still prefer common representation to exclusivity and supplier U_i would earn higher profits.

Finally, let us suppose that $\pi^m(\gamma_E) - F_I - F_E = \pi^m(c+\gamma_E) - \widehat{F}_I > \pi^d(\gamma_E, c+\gamma_I) - \widehat{F}_E$. Then firm I would have an incentive to slightly increase both F_I and $\widehat{F}_I$ so that $\pi^m(\gamma_E) - F_I' - F_E = \pi^m(c+\gamma_E) - \widehat{F}_I'$ is still larger than $\pi^d(\gamma_E, c+\gamma_I) - \widehat{F}_E$. Firm D would still prefer common representation (or exclusivity with I) to exclusivity with E and firm I would earn higher profits. (Likewise, if it was $\pi^m(\gamma_E) - F_I - F_E = \pi^d(\gamma_E, c+\gamma_I) - \widehat{F}_E > \pi^m(c+\gamma_E) - \widehat{F}_I$.)

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

$$\widehat{F}_I \leq F_I; \quad \widehat{F}_E \leq F_E. \tag{15}$$

Otherwise upstream firm i would have an incentive to slightly decrease $\widehat{F}_i$ and sell in exclusivity to D. For instance, if at the candidate equilibrium (that is, in a situation where (14) holds) upstream firm U_j's fees were $\widehat{F}_j > F_j$, then U_j could slightly reduce its exclusivity fee so that $\widehat{F}_j - \varepsilon > F_j$. D would then choose exclusive representation by U_j and the deviation would be profitable.

There exist different combinations of fees that satisfy conditions (14) and (15) and that allow to identify candidate equilibria that implement different distributions of the maximal industry profits.[23] 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 U_I could profitably deviate offering an exclusive purchase contract to D. □

Downstream firms make the offers.
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 $F_i = \widehat{F}_i$ – 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:*

- D_I *offers* U*:* $\{w = 0, \widehat{F}_I = \pi^m(\gamma_I) - \pi^m(\gamma_E) + \pi^d(\gamma_E, c+\gamma_I)\}$ *if* U *accepts only* D_I*'s offer and supplies only* D_I*;* $\{w = p^m(\gamma_E), excl.purchase, F_I = -[\pi^m(\gamma_E) - \pi^d(\gamma_E, c+\gamma_I)]\}$ *if* U *accepts both contracts.*

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

- *D offers U: $\{w = 0, \widehat{F}_E = \pi^m(\gamma_I) - \pi^m(\gamma_E) + \pi^d(\gamma_E, c + \gamma_I), F_E = \pi^m(\gamma_I)\}$, where $\widehat{F}_E$ is the fee that D commits to pay to U if U accepts only D's offer and supplies only D, and F_E is the one when U accepts both 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 D_I, so we need to check that it makes a net positive profit. Indeed, $F_E + F_I = \pi^m(\gamma_I) - \pi^m(\gamma_E) + \pi^d(\gamma_E, c + \gamma_I) > 0$, 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 D_I's, it obtains the same payoff.

Let us consider whether downstream firms have an incentive to offer alternative contracts. Can D_i deviate to a more profitable exclusivity arrangement with U? Since U obtains the same payoff accepting both contracts and either one, D_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 D_I can produce by trading in exclusivity. Hence, D_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 D_i deviate to a more profitable CR contract? Consider D. Given the standing offer of D_I (that U must accept in a CR scenario), D_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 D_I. In a CR scenario U accepts the standing offer of D and earns $\pi^m(\gamma_I)$. Then, if D_I deviates and makes an offer to U, the highest bilateral profits that D_I and U can rely upon is $\pi^m(\gamma_I)$: if the deviation offer involves D_I competing in the downstream market, then D_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 D_I not competing in the final market, then D_I does not make downstream profits. But in the candidate equilibrium the joint profit of D_I and U is already $\pi^m(\gamma_I)$. Hence D_I cannot profitably deviate to a different CR contract.

Can D deviate and make an offer to U_I? It cannot be profitable to make an offer that both U and U_I accept. Imagine instead that D makes an offer to U_I which involves exclusive distribution at $w = 0, F'$. Irrespective of whether U_I accepts or rejects the deviation offer, given the standing offer of D_I to U, the incumbent has to pay the fee $\widehat{F}_I$ 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 $\widehat{F}_I$ to U). Then, if I rejects the deviation offer, D will be unable to sell downstream, D_I will monopolise the market and get $\pi^m(\gamma_I) - \widehat{F}_I$. If U_I accepts D's deviation offer, the incumbent can obtain the input at $w = 0$ through the contract between D_I and U and sell it to D. The incumbent's payoff is the fee F' minus the exclusivity fee $\widehat{F}_I$ that it has to pay to U. Therefore, the lowest deviation fee that D can offer and that induces U_I to accept is $F' = \pi^m(\gamma_I)$. 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:

$$F_I + F_E = \widehat{F}_I = \widehat{F}_E. \tag{16}$$

Like in the proof of Lemma 14 we can reason a contrario. Let us suppose that $F_I + F_E < Max[\widehat{F}_I, \widehat{F}_E]$. 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 $F_I + F_E > Max[\widehat{F}_I, \widehat{F}_E]$. Then - given the fees $\widehat{F}_{-i}$ and F_{-i} of the rival - D_i could slightly decrease F_i: U would still prefer common representation and D_i would make higher profits.

Finally, let us suppose that $F_I + F_E = \widehat{F}_I > \widehat{F}_E$. Then firm I could deviate and slightly decrease F_I and $\widehat{F_I}$ so that $F'_I + F_E = \widehat{F'}_I > \widehat{F}_E$: U still prefers to deal with both, but I raises its profit because it pays a lower fee. (Likewise, if it was $F_I + F_E = \widehat{F}_E > \widehat{F}_I$, then D would have an incentive to deviate.)

Note also that at a common representation equilibrium (in which therefore condition 16 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 $\widehat{F}_i$. Firm U would choose to sell in exclusivity to D_i and D_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:

$$\pi^m(\gamma_E) - F_E \geq \pi^d(\gamma_E, c + \gamma_I) - \widehat{F}_E \quad \Rightarrow F_E - \widehat{F}_E \leq \pi^m(\gamma_E) - \pi^d(\gamma_E, c + \gamma_I) \tag{17}$$

and

$$F_I \geq \pi^m(\gamma_I) - \widehat{F}_I \quad \Rightarrow \widehat{F}_I - F_I \geq \pi^m(\gamma_I). \tag{18}$$

There might exists different combinations of fees that satisfy conditions (16), (17) and (18), 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 D_I could profitably deviate offering an exclusive purchase contract to U.

Considering the probabilities that offers are made upstream and downstream, the expected profits of the incumbent and the upstream rival are the following:

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

(2) Only downstream independent firm is active.

Upstream firm makes the offer.
The incumbent offers firm D the contract $\{w = c, Exclusive\ distribution,\ F_I = \pi^m(c+\gamma_E)\}$. Since the commitment not to sell the input to anyone else (including the own affiliate D_I) removes the scope for opportunistic behavior, firm D accepts the contract and the incumbent extracts all the rents from the more efficient downstream competitor.

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 $F_I = \pi^m(c+\gamma_I)$ under the commitment of the incumbent to exclusive distribution. The incumbent accepts the offer. Firm D extracts the increase in monopoly profits due to its more efficient production process.

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

$\pi_I(D,\emptyset) = \frac{1}{2}[\pi^m(c+\gamma_E)] + \frac{1}{2}[\pi^m(c+\gamma_I)]; \Pi_D(D,\emptyset) = \frac{1}{2}[\pi^m(c+\gamma_E) - \pi^m(c+\gamma_I)]; \Pi_U(D,\emptyset) = 0$

(3) Only the independent upstream firm is active.

Upstream firms make the offer.
Firm U offers the incumbent the contract involving $w = 0$ and $F = \pi^m(\gamma_I) - \pi^m(c+\gamma_I)$. 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 profits of the incumbent and the upstream rival are the following:

$\pi_I(\emptyset,U) = \frac{1}{2}[\pi^m(c+\gamma_I)] + \frac{1}{2}[\pi^m(\gamma_I)]; \Pi_U(\emptyset,U) = \frac{1}{2}[\pi^m(\gamma_I) - \pi^m(c+\gamma_I)]; \Pi_D(\emptyset,U) = 0$

(4) No independent firm is active.

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

$\square$

A.1.2 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 restriction $c + \gamma_I < p^m(\gamma_E)$ translates into $c + \gamma_I < \frac{1+\gamma_E}{2}$.

A.1.2.1 Profitability of refusal to supply

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

The incumbent's gain from refusal to supply can be expressed as follows:

$$\Delta\pi_I = (c + \gamma_I - \gamma_E)(1 - c - \gamma_I) - [\frac{(1-\gamma_E)^2}{4} - \frac{(1-c-\gamma_I)^2}{4}] - \frac{1}{2}[\frac{(1-c-\gamma_E)^2}{4} - \frac{(1-\gamma_I)^2}{4}] \quad (19)$$

Note that the feasible values of the feasible values of γ_I are such that $\gamma_I \in (\gamma_E, \frac{1+\gamma_E}{2} - c]$ the upper bound corresponding to the condition $p^m(\gamma_E) > c + \gamma_I$. We also know that if $\gamma_I \leq c + \gamma_E$, then $\Delta\pi_I > 0$. Hence if $c + \gamma_E \geq \frac{1+\gamma_E}{2} - c$, i.e. if $c \geq \frac{1-\gamma_E}{4} \equiv c^*$, $\Delta\pi_I > 0$ for any feasible value of γ_I.

Let us consider now $c < c^*$. One can the check that the inequality $\Delta\pi_I > 0$ is solved for $\gamma_I < \frac{1}{5}\left(1 - 6c + 4\gamma_E + \sqrt{c^2 + 18c(1-\gamma_E) + (1-\gamma_E)^2}\right) \equiv \gamma_I^P$.[24] 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 $\gamma_I^P > \frac{1+\gamma_E}{2} - c$ if and only if $\gamma_E > 1 - 12c$. Hence, if $c > (1-\gamma_E)/12$ then refusal is always profitable. If $c < (1-\gamma_E)/12$ then refusal is profitable if and only if $\gamma_I < \gamma_I^P$.

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

The incumbent's gain from refusal to supply can be expressed as follows:

$$\Delta\pi_I = (c + \gamma_I - \gamma_E)(1 - c - \gamma_I) - [\frac{(1-\gamma_E)^2}{4} - \frac{(1-c-\gamma_I)^2}{4}] - \frac{1}{2}[\frac{(1-c-\gamma_E)^2}{4} - \frac{(1-c-\gamma_I)^2}{4}] \quad (20)$$

When $\gamma_I = \gamma_E$ then $\Delta\pi_I > 0$. By solving the inequality $\Delta\pi_I > 0$ one can see it holds for: $\gamma_I < \frac{1}{5}\left(1 - 5c + 4\gamma_E + \sqrt{-5c^2 + 10c(1-\gamma_E) + (1-\gamma_E)^2}\right) \equiv \gamma_I^{PP}$.[25] 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 $c > (1 - \frac{\sqrt{3}}{2})(1-\gamma_E) \equiv c^{PP}$. 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:

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

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

implying that refusal is 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 surplus otherwise.

Now, 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 $F_D \leq \overline{F}_D$, 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 will raise 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 — whenever it occurs — refusal will always be 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 will be detrimental, whereas for $F_D > F_D^W$ it will be beneficial.

Next, we should compare the critical values γ_I^w and γ_I^W with the conditions under which the 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 will be beneficial; for $\gamma_I > \gamma_I^W = .0871$, refusal 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:

$$W^T - W^{RR} = \frac{3(1-\gamma_E)^2}{8} + \frac{3(1-c-\gamma_E)^2}{8} - F_D - F_U - [\frac{3(1-c-\gamma_I)^2}{4}] \tag{21}$$

implying that refusal would be detrimental iff:

$$F_D + F_U \leq \frac{3(2\gamma_I(2-\gamma_I)+2c(1+\gamma_E-2\gamma_I)-c^2-4\gamma_E+2\gamma_E^2}{8} \equiv F_{DU}^{WW}, \tag{22}$$

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 $\Pi_D(D,U) - F_{DU}^{WW}$ reveals that it is never satisfied for any feasible value of the parameter set.[26]

[26] $\Pi_D(D,U) > F_{DU}^{WW}$ 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.

- (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 will always be 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 will be detrimental, whereas for $F_D + F_U > F_{DU}^{WW}$ it will be 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 will always be detrimental.

A.2 Proofs of the reputation model

A.2.1 Proof of Lemma 6

Proof. Let us first look at *upstream offers*. An is given by:

- U_I offers D $\{w = p^m(0), ExclusivePurchase, F_I = 0\}$
- U offers D $\{w = 0, F = 0\}$
- D accepts U_I's exclusivity offer but the market is served by D_I.
- Equilibrium payoffs are: $\pi_I = \pi^m(0)$; $\pi_U = 0$; $\pi_D = 0$.

Given the offers D_E is indifferent between accepting U_I and U's offer. Can upstream firms deviate profitably? The incumbent is already extracting the first best profits so it cannot improve them in any way. As for U, any offer that it could make to D_I only will result in a joint payoff $\pi^m(0)$, which equals the incumbent's equilibrium profits. Hence, in order for any deviation of this type to be accepted, it would have to leave $\pi^m(0)$ to D_I, implying that U cannot get more than zero. Hence, the deviation would not be profitable.

Let us consider now whether U can deviate and make offers to both D_I and D. Imagine U offers D the contract $\{w = 0, F = \pi^m(\gamma_E)\}$ and D_I the contract $\{w = p^m(\gamma_E) - \varepsilon, F = -\pi^d(0, \gamma_E) + \varepsilon\}$. In the continuation game either both D and D_I accept U's offer, or they both reject. The deviation is profitable in the former case and it is not in the latter. Hence, the proposed equilibrium is sustained by continuation equilibria in which both downstream firms reject.

We do not see any other possible profitable deviation for U.

There is also another equilibrium which results in a similar outcome (the only difference being that U - rather than the equally efficient U_I - is serving D):

- U offers D_I $\{w = 0, F_I = 0\}$
- D_I accepts U's offer.
- Equilibrium payoffs would be: $\pi_I = \pi^m(0); \pi_U = 0; \pi_D = 0$.

D_I is indifferent between accepting and rejecting the contract. Firm U cannot profitably deviate making an offer to D only, as there would be no rents that it could extract from the less efficient D. If sustained by the appropriate equilibria in the continuation game, U has no incentive to make an offer to both D_I and D either (see argument above).

Consider now *downstream offers*. The equilibrium is given by:

- D_I offers U $\{w = 0, exclusive\ distribution, F_I = 0\}$

- D offers U $\{w = 0, F = 0\}$

- U accepts D_I's exclusivity offer.

- Equilibrium payoffs are: $\pi_I = \pi^m(0); \pi_U = 0; \pi_D = 0$.

U is indifferent between D_I and D's offer. D_I is already getting the maximal industry profits, so no profitable deviations are possible. D cannot make any better offer to U. If it tried to make an offer to U_I instead, the joint payoffs of the incumbent and D would be at most $\pi^m(\gamma_E)$ which are lower than the equilibrium payoff of the incumbent, so the latter would not accept. □

A.2.2 Condition for separating equilibrium to exist in the case of linear demand

In the case of linear demand condition 4 becomes:

$$\frac{7}{8}c^2 + \frac{5}{4}c\gamma_I - \frac{1}{2}c\gamma - E - \frac{3}{4}c + \frac{1}{2}\gamma_I^2 - \gamma_I\gamma_E + \frac{1}{2}\gamma_E^2 \geq 0 \tag{23}$$

Recall that we are assuming that $p^m(\gamma_E) > c + \gamma_I$.

One can check that condition 23 is satisfied iff $c < c_1$, with

$$c_1 = \frac{3}{7} + \frac{2}{7}\gamma_E - \frac{5}{7}\gamma_I - \frac{\sqrt{3}}{7}\sqrt{-\gamma_I^2 + 12\gamma_I\gamma_E - 10\gamma_I - 8\gamma_E^2 + 4\gamma_E + 3}$$

when either $\gamma_I < \frac{2+\sqrt{21}-3}{2+\sqrt{21}+12} = \widehat{\gamma}_I$ or $\gamma_I \geq \widehat{\gamma}_I$ and $\gamma_E \geq \frac{1}{5} + \frac{4}{5}\gamma_I - \frac{2\sqrt{21}}{15}(1 - \gamma_I) \equiv \widehat{\gamma}_E$. Note the as $\gamma_E \to \gamma_I$, $c_1 \to 0$. When $\gamma_I \geq \widehat{\gamma}_I$ and $\gamma_E < \widehat{\gamma}_E$, condition 23 is satisfied for any feasible value of c.