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by

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Imperfect Legal Unbundling of Monopolistic Bottlenecks

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Abstract

We study an industry with a monopolistic bottleneck (e.g. a transmission network) supplying an essential input to several downstream firms. Under legal unbundling the bottleneck must be operated by a legally independent upstream firm, which may be partly or fully owned by an incumbent active in downstream markets. Access prices are regulated but the upstream firm can perform non-tariff discrimination. Under perfect legal unbundling the upstream firm maximizes only own profits; with imperfections it considers to some extend also the profits of its downstream mother. We find that reducing imperfections in legal unbundling (keeping ownership fixed) generally increases total output. Increasing the incumbent's ownership share increases total output if imperfections are sufficiently small, otherwise the effects are ambiguous. Surprisingly, higher ownership shares of the downstream incumbent may sometimes lead to lower degrees of imperfections. Our analysis suggests that consumers may benefit most from legal unbundling with strong regulation and parts of ownership given to a minority outside shareholder.

Keywords: Network industries, regulation, vertical relations, ownership, corruption, sabotage

JEL-Classification: L11, L42, L43, L51

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1 Introduction

In many network industries like energy, rail, or telecommunications the network is a naturally monopoly and network access is an essential input for firms competing in downstream markets. Monopolistic bottlenecks are also an issue in other industries, like the software industry where undiscriminating access to the functionality of an operation system is an essential input for firms competing in the application markets.

An important question for regulatory policy is whether a firm active in the downstream market is allowed to operate the monopolistic bottleneck or to have ownership shares in the upstream firm that controls this bottleneck. While most academic research focuses only on the comparison between vertical integration and full ownership separation, there is an important alternative: legal unbundling.

Legal unbundling means that the monopolistic bottleneck must be operated by a legally independent upstream firm, but the upstream firm may be fully or partially owned by a firm active in the downstream market. The downstream mother is not allowed to interfere in the upstream operations, but its ownership share gives entitlement to the corresponding proportion of upstream profits.

In Europe, legal unbundling is the standard requirement for the energy industry[3], and similar forms of "partial separation" are common in the telecommunications industry in Europe and the US.[4].

We know so far of only two papers — Höffler and Kranz (2007) and Cremer et. al. (2006) — that perform a theoretical analysis of legal unbundling (Cremer et. al. consider, however, the reverse case where the downstream firm is legally unbundled and owned by the upstream firm). Both papers assume that legal unbundling is perfect in the sense that the unbundled firm maximizes only its own profits, while only the mother company maximizes joint profits.

Höffler and Kranz show that under this assumption and regulated access prices legal unbundling leads to highest output quantities in a model where the upstream firm can hamper the operations of downstream firms. They also show that the attractive features of legal unbundling persist when upstream investments into capacity, marginal cost reduction or network reliability are considered.

[3]For the electricity market see Directive 2003/54/EC, Articles 10 (1) and 15 (1), for the gas market see Directive 2003/55/EC, Articles 9 (1) and 13 (1).

[4]For the US see Section 272 of the Telecommunications Act of 1996; for the European Union see Directive 2002/21/EC, Article 13 (1b).

In this paper we extend their basic model to analyze cases of imperfect legal unbundling and partial ownership. There is one upstream monopolist (F_0), a downstream incumbent (F_1) that can have a positive ownership share σ in F_0 and possible has some influence on F_0's management, and $n-1$ potential downstream competitors. The upstream firm produces an essential input at constant marginal cost c_0 which the downstream firms need in a fixed proportion (1:1) to produce the final output. Downstream competition is modeled quite generally. Downstream decisions could, for example, be made about quantities, (non-linear) prices, investments or market entry. Access prices are set by the regulator. Our results hold for all price regulation schemes where profits from upstream operations are strictly increasing in total output. One example is a linear access price above the marginal costs of the upstream firm. F_0 can perform non-tariff discrimination by sabotaging downstream firms or allocating investments in areas that benefit only specific downstream firms. Imperfect unbundling is modeled by a non-negative weight ω that F_0's management attaches in its decisions on the downstream profits of the incumbent F_1.

In Section 3, we analyze how total output depends on this weight and on the incumbent's ownership share in F_0. We find that total output weakly increases when the upstream firm F_0 attaches lower weight on incumbent's downstream profit. This result holds for every ownership share that F_1 can have in F_0. Thus, regulations that increase independence of the upstream firm (but do not change ownership shares) seem in general beneficial to consumers. When the weight that F_0 attaches on downstream profits is sufficiently low then total output also weakly increases in F_1's ownership share. When this weight is higher, i.e. legal unbundling is less perfect, an increase in F_1's ownership share has ambiguous effects: total output may increase or decrease. Hence, although legislation that forces F_1 to give up ownership in F_0 may increase output under weak regulation (high ω), under more effective regulation (lower ω) higher output can be achieved when the downstream incumbent F_1 keeps ownership shares in the upstream firm F_0.

In Section 4, we examine a micro-foundation for the weight ω that the upstream firm attaches on downstream profits of the incumbent. We especially want to gain insight about plausible relations between this weight and F_1's ownership share in F_0. We derive an endogenous formula for ω from a model where F_0 can either make a decision that maximizes upstream profits, or is be manipulated by F_1 and then makes a decision that leads to higher downstream profits of the incumbent. For F_1

manipulation is costly. Manipulation costs can decrease in F_0's ownership share whenever it becomes so large that no outside investors has any substantial stakes in F_0 that would give incentives to control F_0's management. Still, the model shows that higher ownership shares of F_1's in the upstream firm F_0 can cause F_0 to put lesser weight on F_1's downstream profits. The intuition for this — at first sight surprising — result is that under larger ownership shares the incumbent F_1 receives a higher share of upstream profits and therefore has smaller incentives for manipulations that reduce upstream profits.

The remaining paper is structured as follows. In Section 2 we present the model. Section 3 derives the general results and illustrates why total output may fall in F_1's ownership share when ω is high. In Section 4 we give a micro-foundation for the weight ω and examine its relation with F_1's ownership share. Section 5 summarizes the results and concludes.

2 The model

Active firms There is a monopolistic upstream firm F_0 that produces a good at constant marginal costs c_0, which is used as input good for n competing downstream firms, $F_1, ..., F_n$. Each downstream firm needs a constant and identical amount of the input good to create an output good. For simplicity, we normalize input quantities such that each firm needs exactly one unit of the input good to create one unit of an output good.

Non-tariff discrimination We assume F_0 is a regulated natural monopoly, e.g. the owner of an essential transmission network in electricity or telecommunication markets. Access prices are regulated such that upstream profits π_0 are strictly increasing in total output (details are given below). We assume that F_0 can perform the operation of the network in ways that may discriminate distinct downstream firms. Formally, F_0 chooses a discrimination (or sabotage) strategy $h \in H$ that influences output, costs and consumer prices of downstream firms. The strategy h can describe measures like disclosure of confidential information to competitors, delay or excessive formalities when dealing with requests, or network repairs at times that are especially inconvenient for some downstream firms. We make the simplifying assumption that the choice of h has no direct impact on the profits of F_0, although perhaps indirectly if it changes the total quantity sold. The variable h can also be interpreted as the allocation of a fixed budget of

capacity investments that influences the maximal output of different downstream firms. For example, F_0 can increase interconnection capacity between countries or alternatively extend the domestic network. We do not consider decisions about the total size of the investment budget. Those issues are analyzed, however, in the related model of Höffler and Kranz (2007).

Downstream market The decision of downstream firm i is denoted by $x_i \in X_i$ and $x = (x_1, ..., x_n) \in X_1 \times ... \times X_n$ denotes the vector of chosen downstream actions. These downstream actions describe very general decisions, e.g. about quantities, prices, investments, entry or sabotage against competitors. Downstream actions x together with upstream discrimination h determine downstream firms' output $q_i(x, h)$, their market prices $p_i(x, h)$ and their total costs $C_i(x, h|a)$. Total output quantity is given by $Q(h, x) = \sum_{i=1}^{n} q_i(x, h)$.[5] Profits of downstream firm i are given by

$$\pi_i(x, h|\alpha) = p_i(x, h)q_i(x, h) - C_i(x, h|\alpha) \text{ for } i = 1, ..., n \tag{1}$$

We assume that no downstream firm can make infinite high profits or losses, i.e. the set of possible downstream profits is bounded. Furthermore the regularity condition C1 (see below) will require existence of subgame perfect equilibria. Otherwise, there are no further restrictions on functional forms.

Access price regulation and upstream profits

The parameter α in downstream costs functions denotes an access price regulation scheme. We assume that the access price regulation schemes α fulfills two conditions. First, the profits of F_0 shall depend only on total output Q, i.e. it does not matter which downstream firm contributed how much to the total output Q. This is a sensible requirement, since otherwise the regulator would give the upstream firm explicit incentives to prefer output from specific downstream firms, which may cause sabotage of competitors of those firms. Second, we require that F_0's profits are strictly increasing in total output. This also seems sensible, since there is typically a problem of underprovision of output, because of downstream market power.

Thus upstream profits are given by a function

$$\pi_0(x, h|\alpha) = \pi_0(Q(x, h)|\alpha) \tag{2}$$

[5] If firms play mixed strategies these variables denote expected values. In that case, we assume that all firms are risk-neutral.

that is strictly increasing in total output Q. A simple example for such a price scheme is a common linear access price a above marginal costs c_0. Another example is that the regulator pays a linear access price above marginal costs to F_0 but charges downstream firms a two-part tariff with marginal access price of c_0 plus a fixed fee. It is not necessary that downstream payments have to equal the payments the upstream firm receives; part of the payments may also be subsidies.

Timing The price regulation scheme is exogenously given in our model. Then F_0 chooses its discrimination strategy h. Afterwards the downstream incumbent F_1 chooses its action x_1. These decisions are observed by the downstream entrants $F_2, ..., F_n$ who then make their downstream decisions. Whether downstream entrants move simultaneously or sequentially does not matter for our model.

Ownership by downstream incumbent The downstream incumbent F_1 can own some or the complete share of the upstream firm F_0. We denote F_1's ownership share by σ and assume that F_1 maximizes its totally received profits, given by

$$u_1 = \pi_1 + \sigma\pi_0 \text{ with } 0 \leq \sigma \leq 1. \tag{3}$$

Imperfect legal unbundling Under perfect legal unbundling the upstream firm F_0 has an independent management, which maximizes only upstream profits π_0, even if F_0 is wholly or partially owned by the downstream incumbent. Existing legislation, for example, explicitly forbids direct interference by the mother company (Directive 2003/54/EC, Article 10 and 15) or prescribes arm's length relations (US Telecommunications Act 1996, Section 272 (b) [5]). Still field evidence suggests that legal unbundling is not always perfect. We model imperfect legal unbundling by assuming that F_0 attaches a positive weight ω on the downstream profits of the incumbent. Thus F_0 maximizes

$$u_0 = \pi_0 + \omega\pi_1 \text{ with } 0 \leq \omega. \tag{4}$$

Our model encompasses the 4 vertical structures studied in Höffler and Kranz (2007) as special cases, which are vertical separation: $\sigma = 0, \omega = 0$, (perfect) legal unbundling (with full ownership): $\sigma = 0, \omega = 1$, (perfect) reverse legal unbundling: $\sigma = 0, \omega = 1$ and vertical integration: $\sigma = 1, \omega = 1$.

Regularity conditions For every pair (σ, ω) our model formally consists of a multi-stage game. The timing and strategy-space of these games is the same for all (σ, ω) and only the payoff functions for F_0 and F_1 differ. We call a *situation* a pair of (σ,ω) and some history of the corresponding multi-stage game, where

at least one player still has to move. To avoid technical complications that could arise if some continuation games have no subgame-perfect equilibrium, we require:

C1 *In every situation there is a subgame-perfect continuation equilibrium.*

Note that a given situation may have multiple subgame-perfect continuation equilibria. We also make a regularity condition on equilibrium selection for those cases:

C2 *Assume two situations have an identical set of subgame-perfect continuation equilibria. Then in both situations the same subgame-perfect continuation equilibrium shall be selected from this identical set.*

This regularity condition avoids tedious comparision of sets of equilibria. Note that C2 is obviously not needed when in every situation there is a unique continuation equilibrium.

We want to remark the following direct implications of our model under these regularity conditions.

Remark *Under the condition above entrants equilibrium decisions only depend on h and the decision of the incumbent x_1. This means given h firm 1 can choose between different decision profiles $x = (x_1, x_2(x_1, h), ..., x_n(x_1, h))$. Furthermore the incumbent's decision x_1 only depends on h and on his ownership share σ. Thus the equilibrium choices in the downstream markets x can be described as a function of h and σ.*

3 Results

3.1 General output results

In this Section we analyze the comparative statics of total output with respect to changes in the degree of imperfection in legal unbundling ω and F_1's ownership share σ. The results are formalized in Propositions 1 and 2 and illustrated in Figure 1.

The arrows in Figure 1 indicate the direction of weakly increasing total output. The downward oriented vertical arrows indicate that making F_0 more independent, i.e. reducing ω weakly increases output for any given ownership share of F_1. This is formally stated in Proposition 1:

Proposition 1 *For every given ownership share σ the total output is weakly decreasing in ω.*

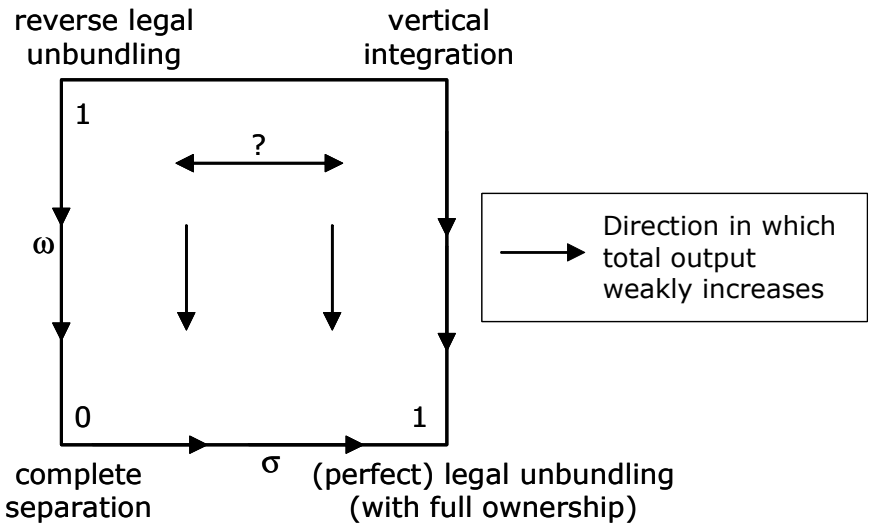

Figure 1: Effects of ω and σ on total output Q.

Proof. Consider two different ownership shares ω^a and ω^b with $\omega^a < \omega^b$. Since σ is the same in both cases, the action profile x selected by downstream firms only depends on the F_0's choice of h (see remark above). Let $\pi_i(h) = \pi_i(x(h,\sigma),h)$ denote the resulting profits of firm i as a function of h only. Let h^a and h^b denote those disctimination strategies that maximize F_0's objective function u_0 under ω^a and ω^b, respectively. Optimal choice by F_0 implies:

$$\pi_0(h^a) + \omega^a \pi_1(h^a) \geq \pi_0(h^b) + \omega^a \pi_1(h^b)$$
$$\pi_0(h^b) + \omega^b \pi_1(h^b) \geq \pi_0(h^a) + \omega^b \pi_1(h^a).$$

If $\omega^a = 0$, we find directly from the first inequality $\pi_0(h^a) \geq \pi_0(h^b)$. If $\omega^a > 0$ we divide the first inequality by ω^a and the second inequality by ω^b. Adding the two resulting inequalities yields $(\frac{1}{\omega^a} - \frac{1}{\omega^b})\pi_0(h^a) \geq (\frac{1}{\omega^a} - \frac{1}{\omega^b})\pi_0(h^b)$. Dividing by $(\frac{1}{\omega^a} - \frac{1}{\omega^b})$ yields again $\pi_0(h^a) \geq \pi_0(h^b)$. Since total output is strictly increasing in upstream profits π_0 this inequality implies that total output must be weakly higher under ω^a than under ω^b. ■

The horizontal arrows in figure 1 have the following meaning: When F_0 acts completely independent, i.e. $\omega = 0$, we find that total output is weakly increasing in F_1's ownership share σ. This result also holds approximately for small ω, but for high levels of ω the effects of σ can be ambiguous, as we illustrate in the example of Section 3.2. Formally, we find:

Proposition 2 *If $\omega = 0$ then total output is weakly increasing in the incumbent's ownership share σ. Furthermore, the following limit result holds: Consider two ownership shares σ^a and σ^b with $\sigma^a < \sigma^b$ and let Q^a and Q^b be the corresponding resulting total outputs. Then $Q^b - Q^a$ has a lower bound that converges to zero as $\omega \to 0$.*

Proof. Let h^a and h^b denote the optimal choice of F_0 under σ^a and σ^b, respectively. Let x^a denote the resulting downstream equilibrium after optimal choice of F_1 given σ^a and h^a. We define x^b correspondingly. Furthermore, let x^{ba} denote the resulting downstream equilibrium after optimal choice of F_1 given σ^b and h^a. Optimal choice by the incumbent F_1 implies

$$\pi_1(x^a, h^a) + \sigma^a \pi_0(x^a, h^a) \geq \pi_1(x^{ba}, h^a) + \sigma^a \pi_0(x^{ba}, h^a)$$
$$\pi_1(x^{ba}, h^a) + \sigma^b \pi_0(x^{ba}, h^a) \geq \pi_1(x^a, h^a) + \sigma^b \pi_0(x^a, h^a)$$

Adding these two inequalities and dividing by $(\sigma^b - \sigma^a)$ yields:

$$\pi_0(x^{ba}, h^a) \geq \pi_0(x^a, h^a)$$

Optimal choice by the upstream firm F_0 implies

$$\pi_0(x^b, h^b) + \omega \pi_1(x^b, h^b) \geq \pi_0(x^{ba}, h^a) + \omega \pi_1(x^{ba}, h^a)$$

Combining with the previous inequality and rearranging yields

$$\pi_0(x^b, h^b) - \pi_0(x^a, h^a) \geq \omega \left(\pi_1(x^{ba}, h^a) - \pi_1(x^b, h^b) \right)$$

The term on the RHS equals 0 for $\omega = 0$. Also its limit for $\omega \to 0$ is 0, because we assumed that minimal and maximal downstream profits are bounded. Since π_0 only depends on total output Q and is strictly increasing in Q, this implies the proposition. ■

The two results imply that perfect legal unbundling with full ownership ($\sigma = 1, \omega = 0$) leads to a weakly higher output than every other combination of σ and ω. Thus whenever higher total output is linked to higher welfare it would indeed be desirable to achieve such perfect legal unbundling with full ownership.

The main results are quite intuitive. Output increases when F_0 becomes more independent, since for lower ω the upstream firm attaches a smaller weight on F_1's downstream profits and therefore a relatively bigger weight on output maximization. Similarly, when F_1's ownership share σ increases, F_1 attaches greater weight on upstream profits, which increase in total output. Intuitively, this should lead to an increase in total output.

3.2 Example of ambiguous effects of σ when ω is large

Given this intuition it is somewhat surprising that there can be cases where for a given high level of ω an increase in ownership share σ may decrease total output. We illustrate such a case with the following example. Assume there are two downstream firms with constant marginal costs $c_1 = 0.4$ and $c_2 = 0.3$ who compete by setting simultaneously quantities (Cournot).[6] The inverse demand is given by $p = 1 - q_1 - q_2$. There is a linear access price of 0.25 per input unit and F_0 produces at zero marginal costs $c_0 = 0$. F_0 can hamper downstream firm i by increasing marginal costs to an arbitrary level $c_i + h_i$. Figure 2 illustrates the resulting total output for all combinations of ω and σ.

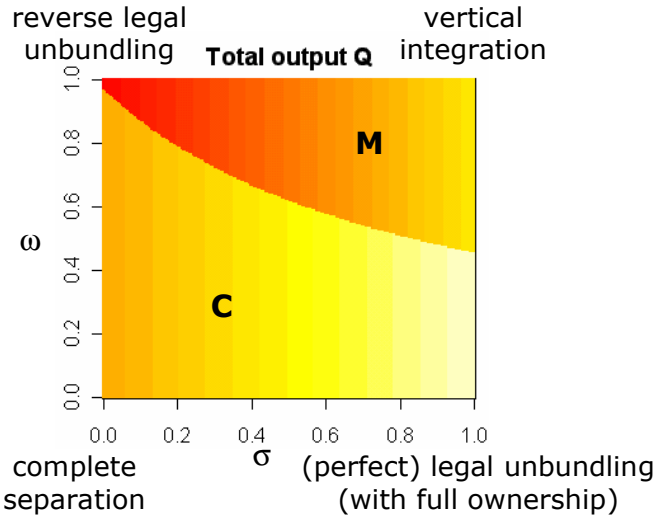

Figure 2: Total output Q in Cournot example. Brighter colors indicate higher levels of total output.

There are two classes of equilibria corresponding to the areas C and M in figure 2. Either there is no sabotage and both downstream firms compete (area C) or we have a downstream monopoly of F_1 where the downstream competitor F_2 will be strongly sabotaged and therefore produces 0 (area M). As is intuitively clear, the monopoly outcome arises only for sufficiently high levels of ω. Within the sets of monopoly outcomes and competitive outcomes total output is always increasing in F_1's ownership share σ, which is in line with the intuition that higher

[6] Although simultaneous quantity setting violates our assumption that F_1 moves first, Cournot competition nicely illustrates the intuition. Similar examples can be found where F_1 moves first.

σ give F_1 stronger incentives to increase total output. But for high levels of ω an increase in σ may lead from a competitive outcome to a monopoly outcome with lower total output. The intuition is that achieving the monopoly outcome by sabotaging F_2 is more attractive for F_0 when F_1's ownership share σ is high, since for higher σ output losses due to double marginalization are less severe. If ω is low this effect does not arise because then F_0 mainly cares about high output and therefore always prefers the competitive solution.

4 A micro-foundation for imperfections in legal unbundling and the relation with downstream ownership

In this section we give an example for a simple a micro-foundation for the weight ω that F_0 attaches on downstream profits of the incumbent F_1. The example also provides insights how this weight may depend on F_1's ownership share σ in the upstream firm F_0.

Assume F_0 can make a binary decision $d \in \{d_0, d_1\}$. Decision d_0 will lead to a higher total output Q and higher upstream profits π_0 than d_1, whereas d_1 leads to higher downstream profits π_1 for the incumbent. Let $\Delta_0 < 0$ and $\Delta_1 > 0$ denote the change in profits π_0 and π_1, respectively, when the decision changes from d_0 to d_1. Under perfect legal unbundling F_0 will always select decision d_0. Assume that under imperfect legal unbundling F_1 has the opportunity to manipulate decision makers of F_0 such that they will change the decision to d_1. For successful manipulation F_1 has to spend an amount $-\Delta_0 c$ (with $c > 0$) of money, which is proportional to the loss $-\Delta_0$ that F_0 makes when the decision changes from d_0 to d_1.

These proportional costs capture the idea that detection risk and possible punishment by the regulator are higher for manipulations that are very costly for the upstream firm F_0. Proportional costs are also plausible when the management of F_0 directly participates in the upstream profits of via incentive contracts and therefore needs higher bribes to change decision from d_0 to d_1 whenever this reduces upstream profits to a large extend.

In addition to the costs of manipulation, the downstream incumbent F_1 will also take into account that changing the decision from d_0 to d_1 reduces its share

$\sigma\pi_0$ of received upstream profits. Considering these two kinds of costs, we find that manipulating the decision from d_0 to d_1 is profitable for F_1 if and only if

$$(\sigma + c)\,\Delta_0 + \Delta_1 > 0 \tag{5}$$

Thus whenever this inequality is fulfilled, d_1 is selected instead of d_0. It is straightforward to see that resulting behavior corresponds to the optimal decision rule for maximizing the following weighted sum of profits $\pi_0 + \frac{1}{\sigma+c}\pi_1$. Hence, the actual decisions of F_0 look like F_0 maximizes $u_0 = \pi_0 + \omega\pi_1$ with ω now being endogenously given by

$$\omega = \frac{1}{\sigma + c}. \tag{6}$$

If manipulation costs c are independent of F_1's ownership share σ, we therefore find that ω is strictly decreasing (!) in F_1's ownership share σ. Thus higher ownership shares of the downstream incumbent cause the upstream firm to attach less weight on the incumbent's downstream profits. The intuition for this result is that with a higher ownership share the downstream incumbent takes upstream profits more strongly into account and has therefore less incentives to manipulate the upstream firm in a way that decreases total output.

It is plausible, however, that F_1's manipulation costs c are decreasing in its ownership share σ. One reason is the following: Assume F_1 has not complete ownership of F_0, but there is also an independent outside investor that holds shares in F_0 and has no stakes in firms that operate downstream. Since such an outside investor participates only in the upstream profits π_0, he has incentives to effectively control that the management of F_0 does indeed maximize π_0 and is not manipulated by the downstream incumbent. If σ is lower, then outside investors have higher ownership shares, control should be tougher and therefore manipulation costs for F_1 should be higher than for higher levels of σ. In result, if c is decreasing in σ, the total effect of a change in σ on the weight ω becomes ambiguous.

It is perceivable that outside investors already have sufficient interests to control F_0's management for a substantial minority share, like 20% ownership in F_0 and that higher shares of outside ownership do not increase control effort much. Assuming that control costs are continuously decreasing in σ and strictly concave i.e. $c'(\sigma) < 0$ and $c''(\sigma) < 0$ may therefore not be a bad approximation. Under this assumption we find $\frac{d\omega}{d\sigma} = -\frac{1}{(\sigma+c)^2}\,(1 + c')$ for $0 < \sigma < 1$ and ω is minimized either by the corner solutions $\sigma^* = 0$ or $\sigma^* = 1$ or we have an interior solution σ^*

given by the simple condition

$$c'(\sigma^*) = -1.$$

Considering the results from Section 3, we should note that the ownership fraction σ^* that minimizes the weight ω that F_0 attaches on downstream profits π_1 is in general not that ownership fraction that maximizes total output. If the minimal level of ω is sufficiently small, increasing σ will weakly increase total output and therefore the level of σ that maximizes total output is likely above σ^*. If the minimal level of ω is quite high, it may, however, be the case that total output is maximized for ownership shares below σ^*.

5 Summary

We analyzed imperfect legal unbundling of a monopolistic provider of a bottleneck input. The upstream monopoly is price regulated and fully or partially owned by an incumbent active in the downstream markets. While under perfect legal unbundling the upstream monopolist maximizes only its own profits, under imperfect legal unbundling the upstream firm can be manipulated by the incumbent and then attaches a positive weight to the incumbent's downstream profits. For every given ownership share of the downstream incumbent we find that total output weakly increases when manipulation is made more difficult by stronger regulatory requirements. If regulation is sufficiently strong, such that the upstream firm attaches only a small weight to the incumbent's downstream profits, total output also weakly increases in the incumbent's ownership share. If regulation is weak the effect of incumbent's ownership share on total output can be ambiguous, however. Furthermore, we show that the incumbent's ownership share also has ambiguous effects on the weight that the upstream firm attaches to the incumbent's downstream profits.

We show that total output can be maximized under legal unbundling with partial ownership by the incumbent and an additional independent outside investor in the upstream firm. Since typically consumer surplus increases in total output, our analysis suggest that these arrangements may be optimal for consumers.

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