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# Foreclosure and Tunneling with Partial Vertical Ownership

Matthias Hunold* and Vasilisa Petrishcheva†

September 2022

**Abstract**

We study the incentives of firms that hold partial vertical ownership to foreclose rivals. Compared to a full vertical merger, with partial ownership, a firm may obtain only part of the target's profit but may nevertheless be able to influence the target's strategy significantly. The target may be either a supplier or a customer, which opens the scope for either input foreclosure or customer foreclosure. We show that the incentives to foreclose can be higher, equal, or even lower with partial ownership than with a vertical merger, depending on how the protection of minority shareholders and transfer price regulations are specified.

**JEL classification:** G34, L22, L40

**Keywords:** Backward ownership; Entry deterrence; Foreclosure; Minority shareholdings; Partial ownership; Uniform pricing; Vertical integration

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# 1 Introduction

Foreclosure is a major policy concern related to vertical mergers. A vertically integrated entity may not be willing to supply rivals of its downstream unit (input foreclosure) or on-sell the products of a competing upstream firm (customer foreclosure). The Chicago School has argued that an integrated entity that can write efficient contracts does not foreclose other vertically related firms if there are gains from trade. Meanwhile, economists have formally shown that this argument may not apply in certain situations, and foreclosure can occur as a result of vertical mergers.

There are crucial differences between a vertical merger and partial controlling backward ownership of the downstream incumbents. Typically, the direction of acquisition does not matter for the competitive effects if the result is a new entity. In particular, a merged entity cannot commit to an internal transfer price above costs (at least the literature on vertical mergers typically assumes this, such as Chen, 2001). This tends to reduce double marginalization within the integrated vertical chain – a pro-competitive effect. The literature has also pointed out the possible anti-competitive effects of vertical mergers.[1]

Baumol and Ordover (1994), Spiegel (2013), and Levy, Spiegel and Gilo (2018) mainly consider the effects of controlling an upstream or downstream firm via partial ownership and argue that the foreclosure incentives may be even stronger with partial vertical ownership that involves control. For example, if there are voting and non-voting shares of an upstream firm, a downstream firm may own all voting shares and have full control. These articles emphasize that by controlling partial acquisitions, a firm only internalizes parts of another firm's profits and losses, although it can fully distort its strategy to increase its own profit. Consequently, dedicated foreclosure strategies (such as a refusal to supply) can be more attractive when compared to full integration. A crucial assumption for these results on controlling partial ownership is how the controlling owner can extract profits from the partially owned target firm (*tunneling*). Our main contribution is to show that the effects of foreclosure depend on the type of tunneling in surprising and policy-relevant ways.[2]

In this article, we add to this literature by studying contracting and corporate governance of partially integrated firms. When a partial owner has control over a target firm but only obtains part of its profits,[3] the questions arise whether, how, and to what extent the control-

[1]See Rey and Tirole (2007) for a detailed overview.

[2]Other articles on partial vertical ownership focus more on the case of no or limited control, such that tunneling is less of an issue (Flath, 1989; Fiocco, 2016; Greenlee and Raskovich, 2006; Hunold and Stahl, 2016; Hunold, 2020).

[3]A partial owner may obtain the target firm's profits through a variety of channels, including dividends, stock repurchases, options, etc.

ling owner can extract profits from the target firm. Whereas minority shareholder protection aims to limit such tunneling, it does take place in practice as our literature review indicates.

We show that different restrictions on profit shifting lead to distinctively different incentives to foreclose rivals. Certain restrictions indeed strengthen the incentives to foreclose with partial ownership than in the case of a full vertical merger, in line with the literature mentioned above. However, with other restrictions on tunneling, there are the same or weaker incentives to foreclose in case of partial vertical ownership. We discuss the tools used by minority shareholders to limit tunneling in Section 2. Overall, institutional insights indicate that the restrictions we consider are plausible in practice. For competition policy, it is important to understand under what conditions partial ownership tends to create high foreclosure incentives. We complement the existing literature in this respect.

We focus on studying the restriction on the amount that can be taken out of the target firm (Restriction 1) and the restriction on the amount that must be left in the target firm (Restriction 2). Both types of restrictions can naturally result from rules that aim to protect minority shareholders of the upstream firm. This protection might require profits to reach at least the minimum threshold to be satisfied or restrict the amount of money to be transferred downstream. Restriction 1 reflects situations where the minority shareholders might be able to successfully sue the controlling shareholders or fire the top manager if the amount of money or resources moving between the target firm and the partial owner is "suspiciously" large. Restriction 2 describes situations where the minority shareholders' primary concern is the firm's profit. Essentially, if the firm is significantly underperforming compared to certain benchmarks, the minority shareholders would initiate an investigation against the controlling shareholders and/or the top management.

At first sight, it might seem that the restrictions are equivalent. For instance, if the target's profit is 100, one can either specify that at most 40 can be taken out ($t \leq 40$) or that 60 need to be left ($\underline{\pi}^U \geq 60$). However, we will show below that the foreclosure incentives differ substantially. We demonstrate that, for different tunneling restrictions, a partial owner's optimal strategy may vary between higher incentives to foreclose than under vertical integration (as discussed in Levy, Spiegel and Gilo (2018), henceforth LSG), the same incentives (because of fully taking into account the target firm's residual profit) and no incentives at all (if the transfer of money into the target firm is sufficiently restricted). We analyze the partial owner's foreclosure incentives for different market environments. In particular, we distinguish between the case where an upstream firm holds shares of a customer (partial forward ownership) and the case where a customer holds shares of its supplier (partial backward ownership).

When a downstream firm partially owns a supplier, we find, in line with LSG, that the restriction on the maximal tunneling amount indeed increases partial owner's incentives to foreclose its downstream rivals (input foreclosure). As a numerical example, suppose that the target's profit is 100 without foreclosure and 70 with foreclosure. The upstream profit loss due to foreclosure is thus 30. Suppose that the the partial owner can extract at most 40 through tunneling and internalizes 50 of the target's remaining profits, so that it will get in total $40 + 50\%$ of the upstream profits absent foreclosure. Suppose further that the target, when foreclosing the downstream rival, makes a profit of 70 instead of 100. The partial owner will thus get $40 + 50\%$ so that it internalizes only 15 of the upstream loss due to foreclosure. The partial owner consequently has less to lose from upstream foreclosure than under full integration, which improves the cost-benefit trade-off of foreclosure for given downstream gains.

Interestingly, the alternative restriction on the minimal profit that needs to be left in the target firm yields the same customer and input foreclosure incentives as full integration. Intuitively, this happens because the minimal profit restriction can be seen as a fixed fee the partial owner has to pay to the target firm. Hence, all the target firm's incentives are taken over by the partial owner. Building on the previous numerical example, suppose that the partial owner needs to leave profits of 60 in the target. Absent foreclosure, the upstream profit before tunneling is 100, so that the partial owner can extract 40 and earns $50\% \cdot 60$ through its profit participation. With foreclosure, the profit decreases to 70, so that the partial owner can only extract 10 to ensure a minimal upstream profit of 60, of which it again internalizes 50. The partial owner thus internalizes the full difference of upstream losses from foreclosure of 30 as it obtains the residual upstream profit in any case.

Additionally, the restriction on the minimal profit might necessitate shifting profit into the target firm (*propping*) to foreclose. For the case that propping is not feasible at all, or not to a required extent, we find lower incentives for input foreclosure compared to a full integration benchmark. Building once more on the numerical example, suppose that the minimal upstream profit is now 80 instead of 60. As inducing the upstream target to foreclose the downstream rival reduces the target's profit from 100 to 70. The partial owner would need to shift an amount of 10 into the target firm to make foreclosure feasible. Propping can be profitable. Note that the partial owner can extract 20 absent foreclosure. Foreclosure in combination with propping is thus profitable if the downstream gains from foreclosure exceed 30.

We also review the case where an upstream firm partially owns a downstream firm where the incentives of the upstream partial owner to force the target to not trade with its own upstream rivals (customer foreclosure) are of particular interest. The restriction on the tunneling amount decreases the incentives of the partial upstream owner to induce customer foreclosure by downstream target. Again, this restriction follows LSG and the results are in line with their findings as well. The minimal profit restriction, however, yields the same foreclosure incentives as full integration, provided that the partial owner can prop its target firm when the required minimal profit level is relatively high. Additionally, if propping is not feasible at all, or not to a required extent, there are lower customer foreclosure incentives in comparison to a fully integrated firm. The results are thus largely analogous to the case of backward ownership and input foreclosure.

The structure of the remaining text is as follows. Section 2 discusses evidence on tunneling and propping, and minority shareholder protection. Based on this, it demonstrates under which circumstances different restrictions on tunneling are plausible. We discuss the foundation of the tunneling restrictions in Section 3. Section 4 studies the input foreclosure incentives under partial backward ownership under different types of restrictions on profit shifting. Section 5 contains the analysis for customer foreclosure. We compare the different results in Section 6 and also relate them specifically to LSG. Section 7 concludes with a discussion of implications for regulation and competition policy.

# 2 Evidence on tunneling, propping, and minority shareholder protection

In this section, we first present empirical evidence demonstrating that tunneling and propping are relevant and prominent phenomena and theoretical work analyzing their underlying mechanisms. We then discuss real-life applications of tools used for minority shareholder protection to prevent tunneling or reduce its harmful impact.

**Empirical evidence on tunneling.** Tunneling can take a variety of different forms.[4] The simplest form is shifting profits to the benefit of the controlling shareholder through self-

[4] See Atanasov et al. (2014) for a detailed discussion of three main types of tunneling: cash flow tunneling, asset tunneling, and equity tunneling. Cash flow tunneling is shifting a part of the target firm's current profits (e.g. through transfer pricing, excessive salaries, etc). Asset tunneling is buying the firm's major assets for a price above the market value or selling them for a price below the market value, thereby influencing the firm's long-term profitability. Equity tunneling is increasing the controller's share at the expense of minority shareholders.

dealing transactions. These may include the sale of over-priced output to the target firm, the purchase of under-priced input from the target firm, excessive salaries, and bonuses for top managers and executives, and even using a corporate jet for private reasons. According to Johnson et al. (2000), this form of tunneling is illegal everywhere if it includes theft or fraudulent behavior. However, the controlling shareholders may legally shift profits through asset sales or excessive pricing agreements, exploit corporate monetary and non-monetary opportunities, or use more complex instruments for profit-shifting.

The key obstacle in the empirical literature on tunneling is how to quantify profit shifting as it is often concealed and hardly directly observable. For example, Bertrand et al. (2002) analyze Indian business groups and compare the firm's actual reported performance and its predicted performance as well as the predicted performance of other firms in the same business group. They find evidence that tunneling occurs mainly through the firm's non-operating profits and is partly incorporated into the stock market prices. Similarly, Baek et al. (2006) analyze private placements of listed South Korean firms and focus on business groups. They compare deals within one business group with other deals and provide evidence for tunneling activities within business groups: the firms with favorable past performance sell their securities at a discount to other group members. In China, controlling shareholders widely use corporate loans to shift profits from listed Chinese companies. The tunneling problem is the most severe if the control right is significantly larger than the profit right (Jiang et al., 2010). Cheung et al. (2006) analyze transactions between partial owners and target firms of Hong Kong listed companies and document that excess returns from those transactions are significantly negative, and negatively related to the percentage ownership of a controlling shareholder. Additionally, they find that the connected party transactions are more likely to be undertaken if the controlling shareholder can be traced to the mainland of China. They explain that those firms find it easier to expropriate their minority shareholders because rulings by courts in Hong Kong are not enforceable in China and thus Hong Kong investors have little chance to recover shifted assets. Atanasov (2005) finds that the absence of regulation in Bulgaria allows majority shareholders to extract up to 85% of the target's firm value to its private benefit and provides several examples supporting his evidence: in the year 2000, the national oil refinery Neftochim's stock was only valued at 24% of the price paid by Lukoil for the majority block; Balkanfarma, a holding of three pharmaceutical companies, had a ratio of 21%; and Sodi, the second-largest producer of soda ash in the world, had a ratio of 10.8%. Atanasov argues that controlling shareholders have a strong preference for expropriating minority shareholders rather than adding value through monitoring.

Although a lot of empirical literature focuses on evidence of tunneling from developing countries, Backus et al. (2021) point out the United States might be subject to it as well. Typically the US is not considered an environment particularly prone to tunneling practices. Most of their publicly-traded firms have diluted control (i.e., "widely-held" firms, Berle and Means, 1932), and investor protection in the US is quite strong which facilitates healthy financial markets (La Porta et al., 1999). However, Backus et al. (2021) find that there is a non-negligible share of firms that have incentives to tunnel and this share rapidly increases over time, especially in the period from 1993 to 2002 and again after 2015.

Tunneling also occurs in the context of profit shifting across countries due to tax differences. In their seminal study, Grubert et al. (1991) focus on the ability of firms to shift profits from high-tax to low-tax countries through their foreign affiliates. They use data from 1982 from 33 countries and find that the US-based multinational enterprises shift disproportionally large amount of income to the countries with low statutory tax rates. Moreover, they export more to their foreign affiliates in low-tax countries. More recent examples include Microsoft allegedly shifting profits to its foreign affiliates in Ireland, Puerto Rico, and Singapore to reduce its tax burden in Europe and avoid the US corporate income tax.[5] Moreover, Apple allegedly uses offshore structures to shift billions of dollars out of the United States.[6]

**Propping.** Opposite to shifting profits from the target firm to the partial owner (tunneling), firms might also shift profits from the owner to the target firm (propping). The literature documents that propping takes place in practice. For instance, partial owners use propping to avoid a potential bankruptcy of the target firm.[7] Friedman et al. (2003) show theoretically that, in case of a moderate negative shock in the market, a partial owner may find it optimal to prop the target firm to prevent its bankruptcy. They focus on firms hit by the Asian crisis 1997-1998 and provide empirical evidence of propping. The Asian crisis 1997-1998 is a quasi-natural experiment that triggered a large and unexpected enough shock to induce propping. Friedman et al. (2003) analyze the effect of debt and corporate governance on firm-level performance by applying difference-in-difference analysis and find evidence for propping, especially pronounced in specific ownership structures, such as pyramids.[8] In gen-

[5] See United States Congress Senate Committee on Homeland Security and Government Affairs. 2012. Offshore Profit Shifting and the U.S. Tax Code - Part 1 (Microsoft and Hewlett Packard), Hearings, September 20, 2012. 112th Cong. 2nd sess. Washington: GPO.

[6] See United States Congress Senate Committee on Homeland Security and Government Affairs. 2013. Offshore Profit Shifting and the U.S. Tax Code - Part 2 (Apple). Hearings, May 21, 2013. 113th Cong. 1st sess. Washington: GPO.

[7] Similarly, the partial owner might engage in tunneling to protect itself from bankruptcy.

[8] In a pyramidal ownership structure, several firms form a business group. This business group is a top-down chain of companies usually controlled by the ultimate shareholder who may only own a small part of

eral, certain ownership structures are more prone to tunneling than others. Solarino and Boyd (2020) empirically show that business groups and family-owned businesses are more likely to engage in tunneling/propping practices. They also document that state ownership is negatively associated with tunneling.

We add to the literature by showing that, in addition to preventing the target's bankruptcy, partial owners might use propping to induce customer foreclosure in the case of partial backward ownership.

**Minority shareholder protection.** There are several real-life tools that minority shareholders can use to limit their expropriation by controlling shareholders.[9] First of all, many tunneling practices are illegal. Strong institutions help enforce controlling shareholders' lawfulness. According to Johnson et al. (2000), strong legal institutions are key and common-law countries tend to be more protective of minority shareholders than civil-law countries. Additionally, extralegal institutions play a crucial role. Holmen and Knopf (2004) focus on Sweden, where the share of pyramids and other company structures prone to tunneling is particularly high, however, the actual shareholder expropriation is relatively low. They show that the presence of strong extralegal institutions in Sweden may significantly offset firms' tunneling incentives.

Arguably, the most common minority shareholder protection tool is preemptive rights (Holderness, 2018). Preemptive rights give all shareholders access to buying new stock pro rata and hence do not allow controlling shareholders to tunnel cheap stock.

Another effective corporate governance tool to limit minority shareholder expropriation is veto rights. Fried et al. (2020) study the 2011 reform in Israel that extended the rights of minority shareholders. In particular, it gave minority shareholders the right to veto the financial bonuses of controllers and controller executives. Their empirical analysis shows that this reform led to lower and no pay to certain executives as well as some resignations of top management. Overall, the authors conclude that the veto rights of minority shareholders might be an effective tool to limit their expropriation. Fried and Spamann (2020) show that preemptive rights help prevent tunneling if the minority shareholders are well-informed, meaning they understand when the newly issued stock is priced below or above its market

firms located in the lower levels of the pyramidal structure but can control it fully (Riyanto and Toolsema (2008)).

[9]In our model, we reduce minority shareholder protection to two different tunneling restrictions. Our modeling approach is general, yet it allows for flexible execution of the practices discussed in this section, i.e., minority shareholders might enforce the tunneling restrictions through veto rights, preemptive rights, etc. We discuss the restrictions in detail in Section 3.

value. If the information asymmetry is strong, although minority shareholders may still exercise their preemptive rights, it would not protect them from the expropriation from the controlling shareholders as well.

# 3 Tunneling restrictions: Foundation

We focus on studying the restriction on the amount that can be taken out of the target firm (Restriction 1) and the restriction on the amount that must be left in the target firm (Restriction 2). Both types of restrictions can naturally result from rules that aim at protecting minority shareholders of the upstream firm. We explain in this section how the institutional setting, in particular shareholder protection and transfer price regulations, can give rise to these different restrictions.

Veto rights can protect minority shareholders. If the minority shareholders are fully informed, they might be able to directly observe the amount of tunneling that has materialized, at least if it surpasses a certain threshold. They might then be able to use their veto rights to prevent tunneling. This could lead to a restriction on the maximum amount that can be tunneled by the controlling shareholders (Restriction 1).

Moreover, to the extent that tunneling takes place through the input prices between the firm at stake and the firm of the controlling shareholders, transfer price regulations may also restrict the maximum amount that can be tunneled. In particular, the arm's length principle prescribes that the price agreed in a transaction between two related parties must be the same as the price agreed in a comparable transaction between two unrelated parties.[10] If effectively enforced, this could again give rise to Restriction 1. It should be noted, however, that, besides input prices, other channels for tunneling profits out of a firm may exist, as discussed in Section 2.

One general problem with minority shareholder expropriation is asymmetric information. First of all, there is the well-known and extensively studied information asymmetry between the owner of a firm, the principal, and the manager, the agent (Ross, 1973). In the context of partial ownership, there is scope for additional asymmetry. Minority shareholders are structurally at an informational disadvantage. They tend to have fewer or no board seats and potentially fewer informal channels of communication with the managers than controlling shareholders.

Under asymmetric information, minority shareholders might find it impossible to identify

[10] See, e.g., Wittendorff (2010) for a comprehensive overview of the arm's length principle and transfer pricing.

and limit tunneling directly. Although they observe a low profit, attributing this unambiguously to tunneling may be impossible. Analyzing the company's performance compared to benchmarks like other firms in related markets, business cycles and key performance indicators may allow the minority shareholders to identify that the low profit is firm-specific and presumably caused by wrong decisions of its management. Although minority shareholders may not be able to identify the exact cause for the low performance, they may be able to discipline the firm's management in the case of low profits. It could take place, for instance, at the general assembly through veto rights regarding the discharge of the management, or a lawsuit against the firm or the top managers, possibly even against majority shareholders. In the case of asymmetric information, the trigger for an action of minority shareholders against the management is the firm's low profit that cannot be explained by general market trends or idiosyncratic events, such as a fire in a factory. In the context of tunneling, this naturally shapes a restriction on the profit that controlling owners need to leave in the target firm (Restriction 2).

In summary, the plausibility of tunneling restrictions 1 and 2 presumably depends on how informed minority shareholders are about tunneling actions, the relevance of transfer prices as the channel through which tunneling takes place and, correspondingly, the effectiveness of transfer price regulations. It thus depends on the institutional context which tunneling restriction an analyst should assume to be most relevant. Both restrictions may also co-exist, for instance, in the case of poorly informed minority shareholders and strict transfer price regulations. One then would need to assess which restriction is likely to bind first. In what follows, we study the incentives of input and customer foreclosure under both restrictions and show that the modeling choice of the tunneling restriction can decisively influence the results.

# 4 Input foreclosure incentives with partial ownership

## 4.1 Model framework

In this section, we consider a setting with one upstream firm $U$ which potentially supplies two symmetric downstream firms, $D_1$ and $D_2$, as shown in Figure 1. The upstream firm can sell each downstream firm $i$ one unit of the input at a price of $f_i$. To keep the model simple and focus on the main mechanism, we abstract from upstream production costs. One can interpret upstream product either being indeed one unit, such as an engine of which a downstream firm only needs one, or as multiple units, such as merchandise, for which the price is a fixed transfer of $f_i$. For instance, fixed transfers and unit prices equal to costs can result from secret contracting, see Hart and Tirole (1990).

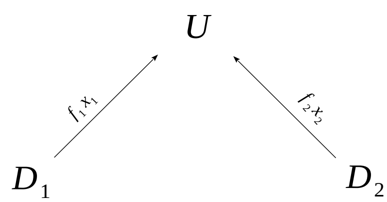


Figure 1: Market structure: input foreclosure setup.

profit of $U$ is

$$\pi^U = f_1 x_1 + f_2 x_2, \tag{1}$$

where $x_i \in \{0, 1\}$ denotes the input sales to firm $i$.We follow LSG and denote the profit of the downstream firm $i$ as

$$\pi_i = \pi(x_i, x_{-i}) - f_i x_i,$$

where $\pi(x_i, x_{-i})$ is the downstream flow profit before input costs. A firm can produce the output in a more competitive way with the input from $U$ (cheaper or at a higher quality):

**Assumption 1.** $\pi(1, x_{-i}) > \pi(0, x_{-i})$.

A firm's profit decreases if its rival has obtained a unit of input because this intensifies competition:

**Assumption 2.** $\pi(x_i, 1) \leq \pi(x_i, 0)$, *with the latter holding strictly at least for* $x_i = 1$.

These assumptions on the downstream profits allow for the case that a firm cannot make a positive profit without the input, which is consistent with a downstream monopoly if only one firm has the input. The assumptions also allow for a situation where a firm without the input from upstream firm $U$ can still get the input from another source, such as a fringe supply. The reduced form downstream profits also allow for markets where there are other downstream competitors besides $D_1$ and $D_2$, which are supplied by other upstream firms than $U$.

We study the cases of vertical separation, a full merger between $U$ and $D_1$, and partial vertical ownership where $D_1$ owns a share $\alpha \in (0; 1)$ of $U$ and can influence the strategy of $U$ to some degree (we explain the restrictions below). For a given ownership structure:

1. Upstream firm $U$ sets input prices $f_1$ and $f_2$.

2. Each downstream firm $D_i, i \in \{1;2\}$, chooses whether to purchase the input ($x_i \in \{0;1\}$) and then sells its output.

For the analysis of tunneling, we use the *"market price"* $f^*$. We let the market price have any level in the interval $[\underline{f}, \overline{f}]$. The lower bound $\underline{f}$ is the reservation value of $U$, which equals its marginal costs of 0, and the upper bound equals the willingness-to-pay of each $D_i$ under vertical separation.[11] It is defined as the maximal price that $U$ can charge each firm, which is equal to the incremental profit from the input, given the other downstream firm also uses the input:

$$\overline{f} = \pi(1,1) - \pi(0,1). \quad \textit{(take-it-or-leave-it price)} \tag{2}$$

One can thus think of $f^*$ as a price that results for a certain level of bargaining power in the price negotiations under vertical separation. We first treat $f^*$ as exogenous. By this we mean that the upstream firm can either sell the input to an independent downstream firm at a price of $f^*$ or refuse to sell the input.[12] We discuss an endogenous formation of $f^*$ in Section 4.3.

In the present setting, under vertical separation serving both downstream firms clearly maximizes the profit (1) of the upstream firm. Vertical ownership can change these incentives and lead to input foreclosure.

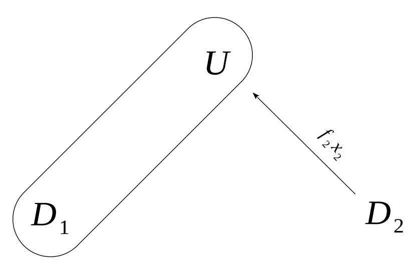


Figure 2: Full integration: input foreclosure setup.

**Definition 1.** Input foreclosure refers to a situation where $U$ is (partially) integrated with $D_1$ and does not sell input to $D_2$. This implies $x_2 = 0$.

[11] One can interpret the price $f^*$ as the result of Nash bargaining in the case of vertical separation. The lower bound price $f^* = \underline{f}$ results if all the bargaining power is downstream whereas $f^* = \overline{f}$ results if upstream firm $U$ has all the bargaining power. Similarly, Levy et al. (2018) focus on take-it-or-leave-it prices and show in an appendix that their results generalize to a bargaining approach.

[12] By this we abstract from partial foreclosure in the sense of charging an independent firm a higher input price at which trade still takes place.

**Benchmark: full vertical integration.** Full integration between $U$ and $D_1$ is our benchmark in the subsequent sections where we show that the input foreclosure incentives of partial ownership depend crucially on how we model the restrictions on tunneling and transfer prices (see Figure 2). The joint profit of $U$ and $D_1$ is

$$\pi^U_{D1} = \pi(x_1, x_2) + f_2 x_2. \tag{3}$$

To start, let us establish

**Lemma 1.** *It is always optimal for the fully integrated unit of $U$ and $D_1$ to supply its downstream business with the input.*

*Proof.* This and most other proofs are in the appendix. Certain proofs, which we consider to be particularly instructive, are below the respective lemma or proposition. □

It is optimal for the integrated entity to supply both downstream firms if the joint profit, when doing so, exceeds the joint profits under foreclosure:

$$\pi(1,1) + f^* \geq \pi(1,0) \tag{4}$$

$$\implies f^* \geq \pi(1,0) - \pi(1,1). \tag{5}$$

We refer to (5) as *"non-foreclosure condition under vertical integration"* in this section.

The non-foreclosure condition together with the definition of $f$ implies $2 \cdot \pi(1,1) \geq \pi(1,0) + \pi(0,1)$. We illustrate in the appendix for which types of competition models this condition holds. For instance, it can hold if getting the upstream firm's input corresponds to a non-drastic marginal cost reduction. If the input is essential and there is a downstream duopoly of firms $D_1$ and $D_2$, such that one downstream firm not getting the input from $U$ transforms the downstream market from duopoly to monopoly, the condition does not hold. However, the condition may well hold for downstream oligopolies with more than two firms. This is fully consistent with our model. Some downstream firms may not get the input from upstream firm $U$, so that the downstream interaction is fully captured by the reduced form downstream profits $\pi(x_i, x_{-i})$.

## 4.2 Partial backward ownership

This section focuses on the case that $D_1$ has partial ownership of $U$, as shown in Figure 3. This partial ownership entitles $D_1$ to a share $\alpha \in (0,1)$ of $U$'s profits, which yields for $D_1$ a total profit of

$$\pi_{D1} = \pi(x_1, x_2) - f_1 x_1 + \alpha(\underbrace{f_1 x_1 + f_2 x_2}_{\pi^U}). \tag{6}$$

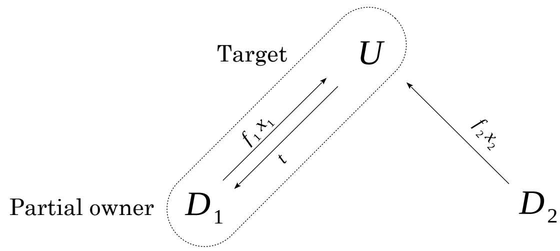


Figure 3: Partial backward ownership: $D_1$ owns stake of $U$.

In line with LSG, we assume that the ownership arrangement allows $D_1$ to exert control over the strategy of $U$, subject to different restrictions. The strategy of $U$ essentially consists of setting the input prices $f_1$ and $f_2$ for the two downstream firms.

Firm $D_1$ can, if the restrictions allow so, use its control to require such a high input price from $D_2$ that $D_2$ does not buy the input (input foreclosure). Any price above $\overline{f}$ achieves this, for instance, $f_2 = \infty$.[13]

As regards the own input price $f_1$, the partial owner $D_1$ can generally demand a price that differs from the market price $f^*$. We speak of *tunneling* in the case of a lower input price ($f_1 < f^*$), whereas we speak of *propping* in the case of a higher input price ($f_1 > f^*$). We denote by $t$ the amount that $D_1$ tunnels out of $U$:

$$t = f^* - f_1. \tag{7}$$

The profit of supplier $U$ is

$$\pi^U = f_1 x_1 + f_2 x_2 = (f^* - t)\, x_1 + f_2 x_2.$$

In what follows, we focus on the natural case that $D_1$ never forecloses itself, which means

[13] We abstract from partial foreclosure in the sense of $U$ charging the independent firm $D_2$ a higher input price at which $D_2$ still buys the input. This is not essential for our analysis of the foreclosure incentives under different tunneling restrictions. What matters is that we keep the input price for $D_2$ the same under different tunneling restrictions.

$x_1 = 1$.[14] We can write the profit of $D_1$ as

$$\pi_{D1} = \pi(1, x_2) - f^* + t + \alpha(\underbrace{f^* - t + f_2 x_2}_{\pi^U}). \tag{8}$$

We now present alternative restrictions on tunneling and compare how these restrictions affect the foreclosure incentives. We focus on restrictions on the amount to tunnel and on the minimal upstream profit. Both types of restrictions can naturally result from rules that aim at protecting minority shareholders of the upstream firm as discussed in Section 3. This protection might require profits to reach at least the minimum threshold to be satisfied or restrict the amount of money to be transferred downstream. In some cases, however, it might be optimal for the partial owner $D_1$ to prop $U$, i.e., to transfer profits upstream. In this case, the minority shareholder protection of the downstream firm can play a role. They can also either restrict the minimal amount of $D_1$'s profits to be left in the firm or the amount of money that can be transferred upstream.

*Remark* (Potential channels for tunneling in practice.). Although we model tunneling as an adjustment of the input price of $D_1$, our results also extend to the case that tunneling does not take place through the input price but through other channels. See the discussion in Section 3.

**Tunneling Restriction 1: exogenous limit on the tunneling amount: $t \leq \bar{t}$.** Following LSG, we assume that tunneling from $U$ to $D_1$ is limited to an exogenous amount of $\bar{t}$, which yields the restriction $t \leq \bar{t}$. For the following analysis we focus on the instance where this tunneling restriction binds in both cases of foreclosure and supplying the independent downstream firm. If there are other restrictions, such as a zero profit restriction, this means that $\bar{t}$ must not be too large because otherwise another restriction would bind first. [15]

Intuitively, we expect the limit $\bar{t}$ to be higher if the protection of minority shareholders is weaker: the less the minority shareholders are protected, the easier it should get for the controlling shareholder to shift the profits out of the firm. Similarly, $\bar{t}$ should be higher if the transfer price regulation is weaker.

[14] Supplying the own downstream unit is profitable under full integration (Lemma 1). If a downstream firm partially owns the upstream firm and obtains its full downstream profits but only part of the upstream profits, it is even less profitable to not supply itself as it would bear the full downstream loss and only obtain part of the upstream gain.

[15] Their assumption A5 reads $t \leq min\{G, L\}$. The assumption implies that the amount to tunnel should not exceed the minimum of downstream gains and upstream losses from foreclosure: the authors define the difference between downstream profits with and without foreclosure as $G$ (gains) and the respective difference between upstream profits as $L$ (losses).

**Lemma 2.** *Under the restriction on the absolute tunneling amount, the partial owner $D_1$ has strictly stronger incentives to foreclose its rival than in the case of full integration.*

*Proof.* The partial owner $D_1$ is not able to tunnel all profits, neither with nor without foreclosure. This means that $D_1$ can shift up to $\bar{t}$ out of the upstream firm independent of whether it supplies $D_2$ or not. Substituting $t = \bar{t}$ in the profit of $D_1$ yields

$$\pi_{D1}^{F} = \pi(1,0) - f^* + \bar{t} + \alpha\left(f^* - \bar{t}\right) \tag{9}$$

in the case of foreclosure, and

$$\pi_{D1}^{S} = \pi(1,1) - f^* + \bar{t} + \alpha\left(2f^* - \bar{t}\right) \tag{10}$$

when supplying $D_2$. Supplying is weakly more profitable than foreclosure if $\pi_{D1}^{S} \geq \pi_{D1}^{F}$, which implies

$$f^* \geq {}^1\!/\!{}_\alpha \left[\pi(1,0) - \pi(1,1)\right]. \tag{11}$$

As $\alpha < 1$, Condition (11) implies that foreclosure is more profitable for $D_1$ than in the case of a vertical merger (Condition (5)). □

For a given tunneling restriction, foreclosure is more profitable when the profit share $\alpha$ from partial ownership is smaller. This condition is similar to the foreclosure incentive condition in Levy et al. (2018)[16] as they assume an exogenous limit on tunneling and restrict the amount of tunneling to be smaller than the downstream gains and upstream losses from not supplying to $D_2$.

**Tunneling Restriction 2: minimal upstream profit ($\pi^U \geq \underline{\pi}^U$).** Instead of restricting the amount that the downstream firm can tunnel ($t \leq \bar{t}$), in certain settings minority shareholders might require a lower limit $\underline{\pi}^U$ on the profits that need to be left in the upstream firm. This restriction is arguably more relevant in certain settings, in particular if the minority shareholders cannot directly observe tunneling and this is not sufficiently restricted by regulation (see Section 3). For example, one interpretation is that the supplier must have at least a certain profit level ($\underline{\pi}^U$), such that the other shareholders (or stakeholders) of the upstream firms do not become suspicious or too unsatisfied. For instance, one can imagine that, in case of a profit level below $\underline{\pi}^U$, these other parties would be able to sue $D_1$ successfully. So, $D_1$

[16] See the foreclosure condition on page 143.

needs to leave at least this amount of profit with $U$. The amount $\underline{\pi}^U$ could be an industry benchmark that provides an indication of what profit to expect under normal circumstances.

We restrict $\underline{\pi}^U$ to the natural upper bound of $2f^*$ because $\underline{\pi}^U > 2f^*$ would mean that $U's$ profits need to be higher than the highest profit achievable at market prices absent vertical ownership.

**Assumption 3.** $\underline{\pi}^U \leq 2f^*$.

At first sight, it might seem that the restriction on the amount that can be taken out of the target firm (Restriction 1) and the restriction on the amount that must be left in the target firm (Restriction 2) are equivalent. For instance, if the target's profit is 100, one can either specify that at most 20 can be taken out ($t \leq 20$) or that 80 need to be left ($\pi^U \geq 80$). However, we will show below that the foreclosure incentives differ substantially.

In the present case, the tunneling restriction

$$\pi^U \geq \underline{\pi}^U$$

can be written as

$$f^* - t + f_2 x_2 \geq \underline{\pi}^U. \tag{12}$$

The restriction implies a maximal tunneling amount of

$$t = f^* + f^* x_2 - \underline{\pi}^U.$$

Assumption 3 implies that the tunneling amount is non-negative if $U$ supplies both downstream firms with input.

**Lemma 3.** *Under the tunneling restriction of a minimal profit that needs to be left in the upstream firm, the partial owner $D_1$ has the same incentive to foreclose its downstream rival as under full vertical integration.*

*Proof.* Substituting for $t$ in the profit of $D_1$ in Equation (6) yields

$$\begin{aligned} \pi_{D1} &= \pi(1, x_2) - f^* + \underbrace{\left(f^* + f^* x_2 - \underline{\pi}^U\right)}_{t} + \alpha \underline{\pi}^U \quad (13) \\ &= \pi(1, x_2) + f^* x_2 - (1-\alpha)\underline{\pi}^U. \quad (14) \end{aligned}$$

$D_1$ prefers to supply $D_2$ if the resulting profits are higher than the profits in the case of foreclosure:

$$\pi(1,1) + f^* - (1-\alpha)\underline{\pi}^U \geq \pi(1,0) - (1-\alpha)\underline{\pi}^U,$$

which reduces to

$$f^* \geq \pi(1,0) - \pi(1,1). \tag{15}$$

This is the same condition as under full vertical integration (Equation (5)). Firm $D_1$ has the same foreclosure incentives as when $U$ and $D_1$ are fully integrated. □

The foreclosure condition does not depend on the degree of minority shareholder protection and the share $\alpha$. The reason is that the partial owner internalizes the full difference of upstream losses from foreclosure as it obtains the residual upstream profit in any case. This is different from the foreclosure condition (11) that we obtained when restricting the amount that $D_1$ can tunnel with the condition $t \leq \bar{t}$. In this case, the partial owner can extract a certain amount through tunneling, leaving the residual profits in the upstream firm. Of these profits, the partial owner only obtains a share of $\alpha < 1$,which implies higher foreclosure incentives. The latter condition is also the relevant foreclosure condition of LSG for their partial (backward) ownership case.

**Propping and foreclosure.** Without profit shifting ($t = 0$), the minimum profit condition (12) in the case of foreclosure ($x_2 = 0$) becomes $\underline{\pi}^U > f^*$. To ensure the minimum profit of $U$, $D_1$ would need to engage in negative tunneling ($t < 0$, "*propping*") in the case of foreclosure. Therefore, we specifically analyze the case when $\underline{\pi}^U$ is in the interval $(f^*; 2f^*]$.[17] This is a subset of the cases considered under Lemma 3.

**Lemma 4.** *If foreclosure is more profitable than supplying $D_2$ (Condition 15 does not hold) and the minimal profit that needs to be left in the upstream firm is relatively large ($\underline{\pi}^U > f^*$), the partial owner $D_1$ optimally props $U$ to foreclose $D_2$ by shifting an amount of $\underline{\pi}^U - f^*$ to the target firm.*

*Proof.* We have shown in the proof of Lemma 3 that foreclosure is profitable in case of the minimal profit restriction under the same condition as under vertical integration (see Equation (5)), that is:

$$\pi(1,0) > \pi(1,1) + f^*.$$

[17] The upper bound of the interval is determined by Assumption 3.

Propping is equivalent to $t < 0$ and occurs as part of the foreclosure strategy when the above condition holds and, in addition, $\underline{\pi}^U > f^*$.

To see this, note that in the absence of profit shifting and thus propping ($t = 0$), $U$ supplying both downstream firms at market prices fulfills the restriction $\pi^U \geq \underline{\pi}^U$ as $\underline{\pi}^U \in (f^*; 2f^*]$ and the profit $\pi^U$ then equals $2f^*$.

Instead, foreclosure of $D_2$ does not satisfy $\pi^U \geq \underline{\pi}^U$ as the profit $\pi^U$ then equals $f^*$ and $\underline{\pi}^U > f^*$ by construction of this case. In order so satisfy the minimal profit restriction of $U$, $D_1$ must shift profits to $U$, such that $\pi^U = f^* + t \geq \underline{\pi}^U$. The lowest transfer which satisfies this is given by $\underline{\pi}^U - f^*$, which implies

$$t = f^* - \underline{\pi}^U < 0.$$

which is negative by construction as $\underline{\pi}^U > f^*$.

Therefore, if foreclosure is profitable for $D_1$, the partial owner will prop $U$ to ensure that its profit level is not below $\underline{\pi}^U$. □

If propping is restricted or not possible, foreclosure may not be feasible with partial ownership, although it would be profitable. For example, suppose that $f^* = 50$, $\underline{\pi}^U = 60$, $\pi(1,1) = 100$, $\pi(1,0) = 200$. Absent foreclosure, $U's$ profit equals

$$2f^* - t = 100 - t \geq \underline{\pi}^U = 60,$$

which implies that $D_1$ optimally tunnels an amount of $t = 40$ in this case and obtains a profit of

$$\pi(1,1) - f^* + t = 100 - 50 + 40 = 90.$$

With foreclosure, the profit of $U$ becomes

$$f^* - t = 50 - t \geq \underline{\pi}^U = 60,$$

which implies an optimal amount of profit shifting of $t = -10$ and yields a profit for $D_1$ of

$$\pi(1,0) - f^* + t = 200 - 50 - 10 = 140.$$

Foreclosure is only feasible with propping ($t \leq -10$) and turns out to be profitable for $D_1$ at $t = -10$ because its foreclosure profit is 140 and thus larger than the profit of 90 absent foreclosure. See Table 1 for a summary.

| | Profit of target firm $U$ | Profit of partial owner $D_1$ |
|---|---|---|
| No foreclosure | $\pi^U = 2f^* - t = 100 - t = 60$ $\implies t = 40$ | $\pi_{D1} = 100 - f^* + t = 90$ |
| Foreclosure with propping | $\pi^U = f^* - t = 50 - t \geq \underline{\pi}^U = 60$ $\implies t = -10$ | $\pi_{D1} = 200 - f^* + t = 140$ |

Table 1: Example with propping in the case of foreclosure where $f^* = 50$, $\underline{\pi}^U = 60$, $\pi(1,1) = 100$, $\pi(1,0) = 200$.

Note that if propping were not possible (which corresponds to $t \geq 0$), then there would not be foreclosure, and $D_1$ would earn the profit of 90. We generalize these insights in

**Lemma 5.** *Foreclosure of the downstream rival does not occur with partial backward ownership in situations where it would occur with a full vertical merger if the target firm's minimum profit level is above the profit obtainable with foreclosure ($\underline{\pi}^U > f^*$) and profit shifting into the target firm (propping) is not feasible at all, or not to the required extent (this corresponds to the restriction $t > \underline{\pi}^U - f^*$).*

This lemma sheds new light on the foreclosure effects of partial vertical ownership: Restrictions on the money a partial owner can prop into the target firm as part of a foreclosure strategy may render foreclosure impossible. Even if the vertically related partial owner has full control over the target firm and seemingly more incentives to foreclose than in the case of a full vertical merger (as argued by LSG). Foreclosure may nevertheless not occur, although it would have occurred with a merger. As propping is a form of expropriation, strong enough minority shareholder protection might assure it is not unlimited. Additionally, transfer price regulations may also limit the scope for propping.

The next proposition summarizes the results on the input foreclosure incentives with partial backward ownership of the lemmas 2, 3, and 4.

**Proposition 1.** *Relative to full vertical integration, partial backward ownership (PBO) affects the incentives for input foreclosure in the following ways:*

1. *PBO strengthens the foreclosure incentives if the absolute amount of tunneling is effectively restricted (Lemma 2);*

2. *PBO has the same effect as full vertical integration if tunneling is restricted by a minimum profit that needs to be left in the target firm, provided that propping is unrestricted (Lemma 3);*

3. *The foreclosure incentives are lower with PBO if tunneling is restricted by a minimum profit that needs to be left in the target firm and if propping is restricted as well (Lemma 4).*

**Comment on the role of propping when the foreclosure strategy is continuous.** We have derived the result that propping can be optimal to enable foreclosure only holds in cases where the supply choice of $U$ is binary: either supply the independent downstream firm with the input or do not. Such binary cases can occur, for instance, if the question is whether to supply an essential piece of equipment or not. In other cases, the supply choice can be continuous, e.g., how many units to supply to the independent downstream firm. Even in this case, full foreclosure might be optimal.

In the case of a continuous supply choice, partial foreclosure, in the sense of supplying less units than otherwise optimal, may be feasible without propping. Even in this case, the optimal foreclosure strategy might involve propping. For instance, it might be optimal to fully foreclose the independent downstream firm and compensate the upstream firm through propping if supplying even one unit of input to the independent downstream could yield a discrete drop in the profits of the vertically related downstream rival. For example, the independent downstream firm may be able to advertise that is has products of $U$ once it has one unit of them and this could induce many consumers to start visiting stores of this downstream firm.

More generally, suppose there is a fixed unit input price $w^*$. At the margin, supplying one less unit of input reduces the upstream profit by $w^*$ but may increase the profit of the integrated downstream rival by more than $w^*$. In this case propping would be preferable over marginally reducing the supply of the independent downstream firm.

## 4.3 Endogenous transfer prices

We now consider a setup where $f^*$ may change depending on the market structure. Let us assume that the upstream firm has bargaining power of degree $b \in [0, 1]$. We compare cases of endogenous price formation under vertical separation, full integration and partial vertical ownership with Restrictions 1 and 2 on profit shifting. For each case, the market price is as follows:

$$f^* = b\overline{f} + (1-b)\underline{f}.$$

First, let us determine the upper and lower bounds for each case. The minimal price at which $U$ is willing to sell input to an independent downstream firm is $\underline{f}$. This price changes depending on the ownership structure. The maximal price the downstream firms would accept is $\overline{f}$. This price is unaffected by the ownership structure and is determined by the intensity of competition downstream. It is a take-it-or-leave-it price the downstream firms would face:

$$\overline{f} = \pi(1,1) - \pi(0,1).$$

For vertical separation, $\underline{f_S} = 0$ because $\underline{U}$ only makes profit by selling units of input and has no additional incentives to withhold it. Under full vertical integration and partial backward ownership structures, $U$ never forecloses $D_1$. The minimal price at which the fully integrated firm is willing to sell to $D_2$ is the difference in profits it makes from selling only through $D_1$ compared to selling through both downstream suppliers: $\underline{f_I} = \pi(1,0) - \pi(1,1)$. For partial backward ownership ($\alpha < 1$), the minimal prices the partial owner is willing to accept are $\underline{f_{BR1}} = {}^1/_\alpha[\pi(1,0) - \pi(1,1)]$ and $\underline{f_{BR2}} = \pi(1,0) - \pi(1,1)$ under the tunneling Restrictions 1 and 2, respectively. Otherwise, it becomes more profitable to not supply $D_2$. It holds that $\underline{f_S} < \underline{f_I} = \underline{f_{BR2}} < \underline{f_{BR1}}$. However, for $j \in \{I, BR1, BR2\}$, $\underline{f_j}$ is not necessarily below $\overline{f}$. The relation $\underline{f_j} > \overline{f}$ implies that foreclosure is more profitable than supplying the downstream rival.

If the bargaining power parameter $b$ is fixed across different ownership structures and tunneling restrictions, the above implies the following order of the *market prices* under vertical separation, vertical integration, and partial ownership with Restrictions 1 and 2:

$$f_S^* < f_I^* = f_{BR2}^* < f_{BR1}^*.$$

We summarize the price ranges and market prices in Figure 4. In the left column, we illustrate cases where the operational profits $\pi(1,0)$, $\pi(0,1)$ and $\pi(1,1)$ are such that $\underline{f_j} < \overline{f}$. Then, it is profitable to supply the downstream rival under all ownership structures because $f_j^* < \overline{f}$. In the right column of Figure 4 we depict the cases where $\underline{f_j}$ is higher: Keeping $\alpha$ constant, it can be due to a higher value of $\pi(1,0)$ or a lower value of $\pi(1,1)$.[18] While $\underline{f_I}$ and $\underline{f_{BR2}}$

[18] In principle, $\underline{f_{BR1}}$ also decreases in $\alpha$. In Figure 4, the change from the left to the right column affects

are higher compared to the respective cases in the left column, they are still below $\overline{f}$, so supplying the downstream rival is still profitable. However, $\underline{f_{BR1}} > \underline{f_{BR2}}$ as $\alpha < 1$. We show the case where $\underline{f_{BR1}} > \overline{f}$, so $f^*_{BR1} > \overline{f}$ and foreclosure is more profitable than supplying the downstream rival.

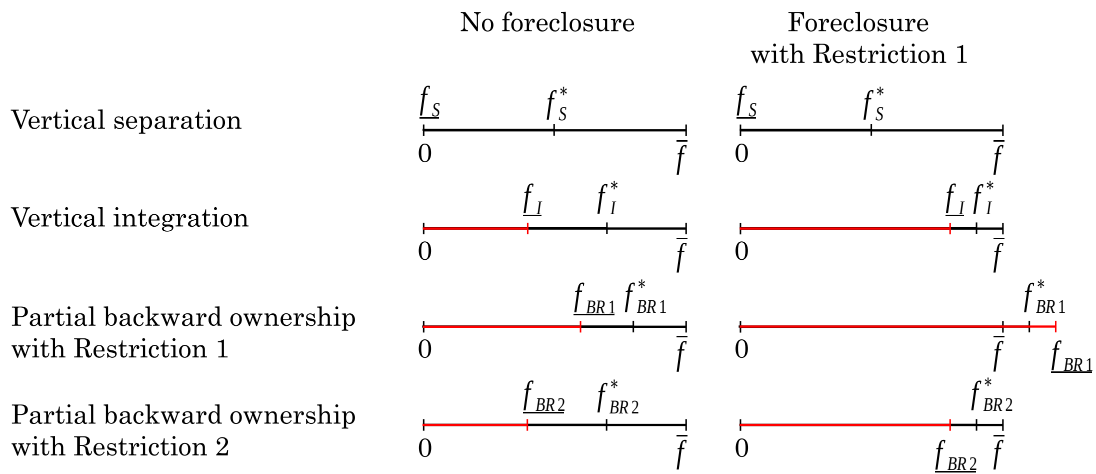


Figure 4: Endogenous market prices under different ownership structures for a given bargaining power parameter $b$: cases without and with downstream foreclosure as the result of different values of the lower bound price $\underline{f_j}$.

Foreclosure does not arise under any ownership structure if

$$f^*_S < f^*_I = f^*_{BR2} < f^*_{BR1} < \overline{f}. \tag{16}$$

Rearranging Condition (16) yields $\underline{f_S} < \underline{f_I} = \underline{f_{BR2}} < \underline{f_{BR1}} < \overline{f}$. This case is depicted on the left side of Figure 4. Instead, foreclosure arises under partial backward integration and tunneling Restriction 1 but does not arise under full integration and partial backward integration with tunneling Restriction 2 if

$$f^*_S < f^*_I = f^*_{BR2} < \overline{f} < f^*_{BR1},$$

or, equivalently, $\underline{f_S} < \underline{f_I} = \underline{f_{BR2}} < \overline{f} < \underline{f_{BR1}}$. This is the case on the right side of Figure 4

Foreclosure arises under full integration and partial backward integration with any tunneling restrictions if

$$f^*_S < \overline{f} < f^*_I = f^*_{BR2} < f^*_{BR1},$$

or, equivalently, $\underline{f_S} < \overline{f} < \underline{f_I} = \underline{f_{BR2}} < \underline{f_{BR1}}$. Importantly, for each ownership structure, the

all $\underline{f_j}$ for $j \in \{I, BR1, BR2\}$. Hence, it cannot be triggered (exclusively) by the change in $\alpha$.

comparison of $\underline{f}$ and $\overline{f}$ corresponds to the non-foreclosure conditions considered in Section 4 (Conditions (5), (11) and (15)).

To summarize, in the present formalization of endogenous input prices, foreclosure arises under the same conditions as with the pre-determined market price $f^*$. Namely, the scope for foreclosure under partial backward ownership and tunneling Restriction 1 is higher than under full integration. Also, the scope for foreclosure under partial backward ownership and tunneling Restriction 2 is the same as under full integration. Our results thus hold when allowing the input prices to arise endogenously in a reasonable way in each scenario in dependence on the different ownership structures and tunneling restrictions.

## 4.4 Partial forward ownership

For the industry structure with one upstream and two downstream firms, we now consider the case where $U$ owns a share $\alpha \in (0, 1)$ of $D_1's$ profits. The market structure is shown in Figure 5. The partial owner $U$ can exert full control over its target's strategy, subject to tunneling restrictions.

As the derivations are similar to the case of partial backward ownership in the previous section, we present the detailed analysis in the Appendix and only summarize and discuss the result in this section.

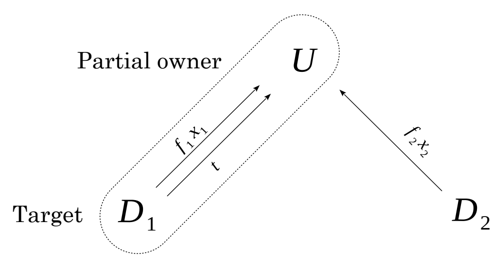


Figure 5: Partial forward ownership: $U$ owns stake of $D_1$.

**Proposition 2.** *Relative to full vertical integration, partial forward ownership (PFO) tends to affect the incentives for input foreclosure in the following ways:*

1. *PFO decreases the foreclosure incentives if the absolute amount of tunneling is effectively restricted (Lemma 9);*

2. *PFO has the same effect as full vertical integration if tunneling is restricted by a minimum profit that needs to be left in the target firm, provided that propping is unrestricted (Lemma 10).*

*Proof.* See the Appendix for the lemmas and their proofs. □

The intuition for result 1 of the proposition is that the partial owner U internalizes additional upstream profits more than additional downstream profits of $D_1$. Consequently, it has fewer incentives to foreclose than under full integration where both profits have the same value. This is in line with Levy et al. (2018). Result 2 is analogous to the result in Proposition 1.

Note that propping is not an issue here as foreclosure requires an upstream action from the partial owner but not from the downstream target and we assume that the owner maximizes its own profit without minority shareholder restrictions within its own entity.

# 5 Customer foreclosure with partial ownership

We now study the case of customer foreclosure where a downstream firm prevents an upstream firm from selling its products to consumers. We consider a setup with two upstream firms and one downstream firm now, symmetric to the one in Section 4. For customer foreclosure, the critical difference is partial forward ownership where an upstream firm has a stake of the downstream firm and thereby potentially the means and incentives to induce the downstream firm not to trade with the independent upstream firm. Our findings are analogous to the case of input foreclosure. Again, Restriction 1 on tunneling facilitates foreclosure whereas Restriction 2 has the same effects as full integration, provided that propping is feasible. We discuss and compare the results of input and customer foreclosure in Section 6 where Table 2summarizes the different results.

## 5.1 Model framework

We consider a setting with two symmetric upstream firms, $U_1$ and $U_2$, and a downstream monopolist $D$, as shown in Figure 6. We assume that the upstream firms produce differentiated input goods. Downstream firm $D$ can use at most two units of input. Those two units can be purchased from a single upstream firm or each input unit from each firm.

**Definition 2.** In the present setting, customer foreclosure refers to a situation where $D$ buys no input from $U_2$ and two units of input from $U_1$.

We further assume that the downstream firm's flow profits before input costs are higher

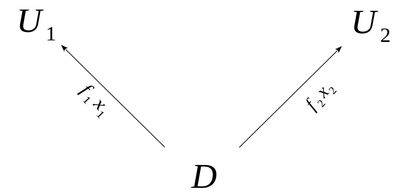


Figure 6: Market structure: customer foreclosure setup.

when the input units are differentiated. In particular, we assume

$$\Pi(1,1) > \Pi(2,0) > \Pi(1,0) > \Pi(0,0) = 0, \tag{17}$$

where $\Pi(x_1, x_2)$ is the downstream flow profit as a function of the input quantities $x_1$ and $x_2$ from $U_1$ and $U_2$, respectively.[19] We assume that both upstream firms produce at zero costs.[20] These assumption lead to the natural benchmark where, under vertical separation, $D$ finds it optimal to buy the input from both upstream firms.

Upstream firm $j \in \{1, 2\}$ sells at a unit price of $f_j$. The profit of upstream firm $j$ when selling one unit is thus

$$\pi^{Uj} = x_j \cdot f_j = 1 \cdot f_j. \tag{18}$$

The minimal price at which an upstream firm could sell without making a loss is equal to the cost of producing the input:

$$\underline{f} = 0. \tag{19}$$

Such a price might arise if the downstream firm has all the bargaining power.

**Lemma 6.** *The maximal price at which the downstream firm is best off buying one unit from each upstream firm is*

$$\overline{f} = \min\left[\Pi(1,1) - \Pi(1,0), \Pi(1,1)/2\right]. \tag{20}$$

*Proof.* The downstream firm buys one unit from each upstream firm if the following three

[19] For homogeneous products (and no non-linear transaction costs, etc.), the first inequality would hold with equality.

[20] We consider zero production costs for the sake of simplicity and comparability to the setup of Section 4.1. Our model yields conceptually identical predictions if a firm's production costs are non-decreasing in the number of units produced.

requirements hold:

$$\begin{aligned}\Pi(1,1) - 2\overline{f} &\geq \Pi(2,0) - 2\overline{f} \ (i),\\ \Pi(1,1) - 2\overline{f} &\geq \Pi(1,0) - \overline{f} \ \ (ii),\\ \Pi(1,1) - 2\overline{f} &\geq 0 \qquad\qquad (iii).\end{aligned}$$

The first requirement holds by the assumption that $\Pi(1,1) > \Pi(2,0)$.

The second requirement implies

$$\begin{aligned}\Pi(1,1) - \overline{f} &\geq \Pi(1,0)\\ \implies \overline{f} &\leq \Pi(1,1) - \Pi(1,0).\end{aligned}$$

Suppose that $\overline{f} = \Pi(1,1) - \Pi(1,0)$. Does this satisfy the third requirement? Substituting in (iii) yields

$$\begin{aligned}\Pi(1,1) - 2\left(\Pi(1,1) - \Pi(1,0)\right) &\geq 0\\ 2\Pi(1,0) &\geq \Pi(1,1).\end{aligned}$$

The latter inequality should hold for substitutes on the demand side and no costs. It might not hold in the case of economies of scale (e.g. fixed costs that arise once selling products).

In general, the largest price that satisfies all three requirements is

$$\overline{f} = \min\left[\Pi(1,1) - \Pi(1,0), \Pi(1,1)/2\right].$$

□

In the following we use a general *"market price"* $f^*$, which we restrict to be in the interval $[\underline{f}, \overline{f}]$. For reference, let us describe prices which may arise when the upstream firms non-cooperatively and simultaneously set their prices.

**Lemma 7.** *When the upstream firms non-cooperatively and simultaneously set their prices, a symmetric price of* $\overline{f}$ *is an equilibrium if product differentiation, measured as the difference* $\Pi(1,1) - \Pi(2,0)$*, is large enough.*

*Proof.* See Appendix. □

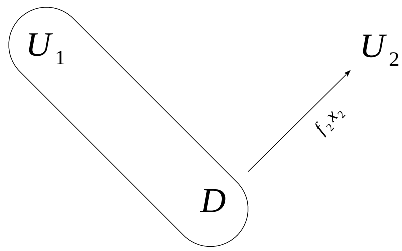


Figure 7: Full integration: customer foreclosure setup.

**Benchmark: full vertical integration.** Full integration between $U_1$ and $D$ is our benchmark in the subsequent sections where we show that the customer foreclosure incentives of partial ownership depend crucially on how we model the restrictions on tunneling and transfer prices (see Figure 7).

The joint profit of $U$ and $D$ is

$$\pi_I^S = \Pi(1,1) - f^*$$

when the inputs of both upstream firms are used, and

$$\pi_I^F = \Pi(2,0)$$

in the case where upstream firm 2 is foreclosed. The integrated entity decides to source from $U_2$ if $\pi_I^S \geq \pi_I^F$, which is equivalent to

$$\Pi(1,1) - f^* \geq \Pi(2,0)$$

$$\implies f^* \leq \Pi(1,1) - \Pi(2,0). \tag{21}$$

We refer to Equation (21) as *the "non-foreclosure condition under vertical integration"*. As $f^* \in [\underline{f}, \overline{f}]$, a necessary condition for foreclosure to arise is that $\overline{f} > \Pi(1,1) - \Pi(2,0)$.

**Lemma 8.** *The highest feasible input price $\overline{f}$ is larger than the incremental profit of dual sourcing,* $\Pi(1,1) - \Pi(2,0)$, *if* $2 \cdot \Pi(2,0) > \Pi(1,1)$.

*Proof.* See Appendix. □

Note that the requirement $2\Pi(2,0) > \Pi(1,1)$ in Lemma 8 is fulfilled in many plausible cases. In general, it holds if the inputs of the upstream firms are similar enough. Moreover, it may also hold with strong substitutes. Exceptional cases where the condition might not hold would be when it is not profitable to sell both units of the same kind, such that essentially $\Pi(2,0) = \Pi(1,0)$ or if there are fixed costs of selling products, such that $2 \cdot \Pi(1,0)$ would be smaller than $\Pi(1,1)$.

**Corollary 1.** *Together, lemmas 6, 7 and 8 imply that the competitive input price may well be at the level $\overline{f}$ where foreclosure of $U_2$ is jointly profitable for $U_1$ and $D$ if they are vertically integrated.*

## 5.2 Partial forward ownership

As regards customer foreclosure, the partial forward ownership is the more interesting case. Suppose that $U_1$ owns a share $\alpha \in (0,1)$ of $D$'s profits. The partial owner $U_1$ can exert full control over its target's strategy, subject to tunneling restrictions. See Figure 8 for an illustration.

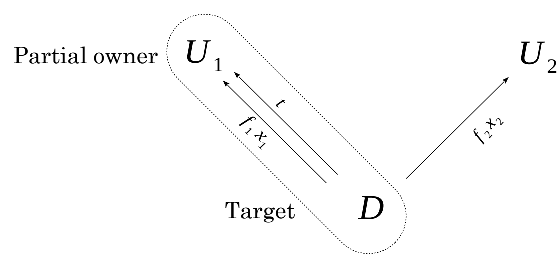


Figure 8: Partial forward ownership: $U_1$ owns a stake of $D$.

Our results under these assumptions are summarized in Proposition 3.

**Proposition 3.** *Relative to full vertical integration, partial forward ownership (PFO) tends to affect the incentives for customer foreclosure in the following ways:*

1. *PFO increases the foreclosure incentives if the absolute amount of tunneling is effectively restricted (Lemma 11);*

2. *PFO has the same effect as full vertical integration if tunneling is restricted by a minimum profit that needs to be left in the target firm ($\pi_D \geq \underline{\pi}_D$), provided that propping is unrestricted (Lemma 12);*

3. *The foreclosure incentives tend to be lower with PFO if tunneling is restricted by a minimum profit that needs to be left in the target firm and if propping is restricted as well (Lemma 13).*

*Proof.* See the Appendix for the lemmas and their proofs. □

The mechanism for result 1 of the proposition is analog to the case of input foreclosure and PBO in Proposition 1. When the partial ownership values own profits more than the target's profits, then commanding a foreclosure action that hurts the target is more profitable than under full integration where both profits have the same value.

With the minimal profit restriction, the partial owner becomes the claimant of the full incremental profits of the target and thus has the same foreclosure incentives as under full integration (result 2). However, when the partial owner has to ensure a higher profit of the target $D$ than would arise under foreclosure ($\underline{\pi}_D > \Pi(2,0) - 2f^*$) but propping is not possible, foreclosure is harder than under full integration (result 3). This result is relevant as the competitive input price may well be at the level $\overline{f}$ where foreclosure of $U_2$ is jointly profitable for $U_1$ and $D$ (Corollary 1).

## 5.3 Partial backward ownership

Downstream firm $D$ owns a share $\alpha \in (0,1)$ of $U_1's$ profits. The partial owner $D$ can exert full control over its target's strategy, subject to tunneling restrictions (see details on the market structure in Figure 9).

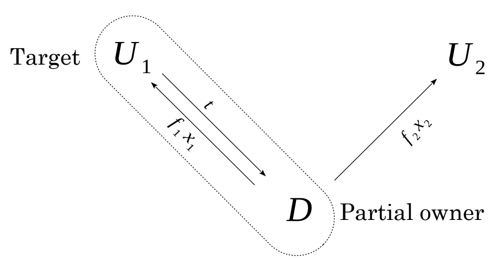


Figure 9: Partial backward ownership: D owns stake of $U_1$.

Absent foreclosure and absent tunneling ($t = 0$), the profit of each upstream firm equals $f^*$. With customer foreclosure of $U_2$ and absent tunneling ($t = 0$), the profit of $U_1$ equals $2f^*$ whereas the profit of $U_2$ equals 0.

Analog to Assumption 3, we assume that the minimal profit $\underline{\pi}_{U1}$ is not larger than the equilibrium profit of the upstream firm under vertical separation (see Equation (18)).

We summarize $D$'s incentives to foreclose $U_2$ subject to different tunneling restrictions in Proposition 4.

**Proposition 4.** *Relative to full vertical integration, partial backward ownership (PBO) tends to affect the incentives for customer foreclosure in the following ways:*

1. *PBO decreases the foreclosure incentives if the absolute amount of tunneling is effectively restricted (Lemma 14);*

2. *PBO has the same effect as full vertical integration if tunneling is restricted by a minimum profit that needs to be left in the target firm, provided that propping is unrestricted (Lemma 15).*

*Proof.* See the Appendix for the lemmas and their proofs. □

The intuition for result 1 of the proposition is that when the partial owner D internalizes additional downstream profits more than additional upstream profits of $U_1$, there is less incentive than under full integration to sacrifice downstream profits to the benefit of upstream profits.

Note that propping is not an issue here as foreclosure requires a downstream action from the partial owner but not from the upstream target and we assume that the owner maximizes its own profit without minority shareholder restrictions within its own entity.

# 6 Discussion

## 6.1 Overview of results

For Restriction 1 on the amount that a partial owner can tunnel, our results are in line with the existing literature (Baumol and Ordover, 1994; Spiegel, 2013; LSG). Compared to full integration, partial backward ownership leads to higher input foreclosure incentives than full integration but lower customer foreclosure incentives. Partial forward ownership has the opposite effects. See Table 2 for an overview of our main results.

We add to this the insight that the restriction on the minimal profit leads to the same foreclosure incentives as full integration. The reason is that the partial owner becomes a residual claimant of the joint profits – which implies the same incentives as full integration.

When the minimal profit that needs to be left in the target firm is higher than the profit obtainable in the case a foreclosure strategy is in place, the latter equivalence result relies on the assumption that propping is feasible. Propping means that the partial owner can shift funds into the target firm. The partial owner may need to prop to induce the target firm to foreclose a rival of the owner. A foreclosure action, which may be profitable for the partial owner, can reduce the target's profit below the critical level, such that propping may be necessary for foreclosure to be feasible. When propping is not feasible, the foreclosure incentives are eliminated under the minimal profit restriction and, thus, can be lower than with full integration.

A key distinction between Restriction 1 on the tunneling amount and Restriction 2 on the minimal profit of the target firm is whether or not propping might occur. Intuitively, Restriction 2 sets a target profit level that the partial owner has to assure, which means that if this target profit level is high enough, the partial owner cannot satisfy the restriction without additional transfers to the target firm. Under Restriction 1, the mechanism is different: The non-controlling shareholders of the target firm can only impose restrictions on how much value is tunneled out of the firm. Profit shifting into the target firm is thus not an issue when there is solely a restriction on the amount that can be tunneled out of the target firm. Of course, in a real-world case, several restrictions on tunneling can be in place simultaneously, including the restrictions 1 and 2 that we study. Indeed, a restriction on propping is essentially a restriction on negative tunneling. Table 2 summarizes our results.

Table 2: Overview of results

**Input foreclosure (not serving the downstream rival)**

Benchmark – non-foreclosure condition with full integration: $f^* \geq \pi(1,0) - \pi(1,1)$

| | Partial backward ownership | Partial forward ownership |
|---|---|---|
| Restriction 1: tunneling amount | $f^* \geq 1/\alpha\,[\pi(1,0) - \pi(1,1)]$<br>Higher incentives to foreclose than with full integration; | $f^* \geq \alpha\,[\pi(1,0) - \pi(1,1)]$<br>Lower incentives to foreclose than with full integration; |
| Restriction 2: minimal profit | $f^* \geq \pi(1,0) - \pi(1,1)$<br>Same incentives to foreclose as with full integration;<br>Propping needed if $\underline{\pi}^U > f^*$. | $f^* \geq \pi(1,0) - \pi(1,1)$<br>Same incentives to foreclose as with full integration;<br>No propping needed.$^+$ |

**Customer foreclosure (not buying rival's input)**

Benchmark – foreclosure condition with full integration: $f^* \leq [\Pi(1,1) - \Pi(2,0)]$

| | Partial backward ownership | Partial forward ownership |
|---|---|---|
| Restriction 1: tunneling amount | $f^* \leq 1/\alpha\,[\Pi(1,1) - \Pi(2,0)]$<br>Less incentives to foreclose than with full integration; | $f^* \leq \alpha\,[\Pi(1,1) - \Pi(2,0)]$<br>More incentives to foreclose than with full integration; |
| Restriction 2: minimal profit | $f^* \leq [\Pi(1,1) - \Pi(2,0)]$<br>Same incentives to foreclose as with full integration;<br>No propping needed.$^+$ | $f^* \leq [\Pi(1,1) - \Pi(2,0)]$<br>Same incentives to foreclose as with full integration;<br>Propping needed if $\underline{\pi}_D > \Pi(2,0) - 2f^*$. |

$^+$No propping is needed in the sense that foreclosure requires an action from the partial owner and we assume that the owner maximizes its own profit without minority shareholder restrictions within its own entity.

## 6.2 A review of the results in Levy, Spiegel and Gilo (2018)

LSG base their analysis on comparing the downstream gains ($G$ in their notation) and upstream losses ($L$) of foreclosing $D_2$. Our model is sufficient to replicate their findings and can naturally extend to their setting with $N$ upstream suppliers. We can rearrange Condition (4) to show that the fully integrated entity chooses to supply $D_2$ if the downstream gains of foreclosure ($G$) do not exceed the foregone upstream profits from supplying an additional retailer ($L$):

$$\underbrace{\pi(1,0)-\pi(1,1)}_{G} \leq \underbrace{\pi(1,1)-\pi(0,1)}_{L}.$$

What we call exogenous restriction on the tunneling amount, $t \leq \bar{t} < f^*$, corresponds to the case considered in LSG. Their Assumption 5 requires that the effect of tunneling on $D_1$'s and $U$'s payoffs is smaller than the effect of foreclosure, i.e., $t \leq \min\{G, L\}$. The partial owner has stronger incentives to foreclose its rival in comparison to the full integration case, namely, $D_1$ chooses to let $U$ supply $D_2$ with an input if

$$\underbrace{\pi(1,0)-\pi(1,1)}_{G} \leq \underbrace{\alpha\left[\pi(1,1)-\pi(0,1)\right]}_{\alpha L}.$$

We argue that the way one specifies the restriction on tunneling plays a crucial role in shaping the incentives of the partial owner to foreclose its rival. By restricting the minimal profit which has to stay in the upstream firm (what we call Restriction 2) instead of imposing an exogenous limit on tunneling (what we call Restriction 1), the foreclosure condition becomes

$$\underbrace{\pi(1,0)-\pi(1,1)}_{G} \leq \underbrace{\pi(1,1)-\pi(0,1)}_{L}.$$

This condition is the same as it would have been for the full merger with $U$ and is strictly lower than under an exogenous tunneling restriction.

LSG implicitly assume that the tunneling amount $t$ is non-negative[21] which is non-binding under Restriction 1 but could be binding under Restriction 2. We show in Lemma 5 that propping restrictions may eliminate the incentives to foreclose $D_2$ completely. If the minimal profit which has to stay in the upstream firm is large enough, i.e. $\underline{\pi}^U$ is in the interval $(\pi(1,1)-\pi(0,1); 2(\pi(1,1)-\pi(0,1))]$, and tunneling is restricted to be non-negative, it becomes impossible for the partial owner to foreclose its rival. Foreclosure is not feasible, although it could be profitable for the partial owner.

Therefore, the ability and incentives to foreclose depend crucially on the assumptions on the minority shareholder protection structure and the types of tunneling restrictions minority shareholders may impose. As Levy et al. (2018) show, restrictions on the tunneling amount in partial backward ownership may increase the input foreclosure incentives compared to the full integration case. In this article, we show that other tunneling restrictions may leave the foreclosure incentives of partial vertical owners unchanged or even eliminate them.

[21] LSG write on page 142: "$D_1$ pays for [$U$'s] input the same amount it pays under non-integration, but minus a discount $t$ if $D_1$ controls [$U$]".

# 7 Conclusion

We study the incentives of a firm that holds partial vertical ownership to foreclose rivals. The partial owner only obtains the part of its target's profits but it may substantially change its strategy and foreclosure incentives. We focus on the phenomena of tunneling and propping, that is shifting profits out of and into the target firm, and demonstrate how the different restrictions imposed on these activities alter the downstream firm's incentives to foreclose a rival. This phenomenon has, to our knowledge, so far received only limited and, arguably, insufficient attention in theoretical competition policy analyses.

We show that, depending on the type of tunneling restrictions, a partial owner's optimal strategy may vary between higher incentives to foreclose than under vertical integration (as discussed in LSG), the same incentives (because of fully taking into account the target firm's residual profit) and no incentives at all (if propping is sufficiently restricted). We analyze the partial owner's foreclosure incentives for a variety of market environments.

For partial backward ownership, we confirm that the restriction on the maximal tunneling amount increases the partial owner's incentives to foreclose its downstream rivals (input foreclosure) and decreases the incentives to foreclose the rivals of the upstream target (customer foreclosure). This is in line with LSG who exclusively use this kind of tunneling restriction. Interestingly, we find that the alternative restriction on the minimal profit that needs to remain in the target firm yields the same customer and input foreclosure incentives as full integration. Additionally, the restriction on the minimal profit might necessitate propping money into the target firm in order to foreclose. If propping is not feasible at all, or not to a required extent, the partial backward owner faces lower incentives for input foreclosure compared to a full integration benchmark.

For partial forward ownership we also confirm the results of LSG whereby the restriction on the tunneling amount decreases the incentives of the partial owner to foreclose its target's downstream rivals (input foreclosure) but increases the incentives to foreclose its own upstream rivals (customer foreclosure). Analogous to above, we find that the minimal profit restriction yields the same foreclosure incentives as full integration, provided that the partial owner can prop its target firm if the minimal profit level is relatively high. Additionally, if propping is not feasible at all, or not to a required extent, the partial forward owner has lower customer foreclosure incentives in comparison to a fully integrated firm.

In summary, the way tunneling is modeled can substantially affect the results of a foreclosure analysis in the case of partial vertical ownership. A precise understanding of the tunneling restrictions is thus crucial for a correct assessment of possible foreclosure incentives. Albeit, as our literature review reveals, tunneling is a common phenomenon, it so far appears to be less clear how one should precisely think of the restrictions on tunneling in a vertical relations framework. We have argued that the plausibility of the tunneling restrictions presumably depends on how informed minority shareholders are about tunneling actions and possibly on the relevance of transfer prices as the channel through which tunneling takes place and, correspondingly, the effectiveness of transfer price regulations. This suggest that an analyst should study the institutional context to assess which tunneling restriction should be most relevant. Both restrictions may also co-exist, for instance in the case of poorly informed minority shareholders and strict transfer price regulations. One then would need to assess which restriction is likely to bind first. It would be fruitful for future research to look more closely at different institutional contexts, possibly also from a legal perspective, to provide more precise guidance on what kind of tunneling restrictions are most relevant in practice.

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# Appendix

## Additional lemmas and proofs for input foreclosure

*Proof of Lemma 1.* Suppose that the integrated entity can commit to not supplying itself (for instance, by setting a fee of $f_1 = \infty$ if that is public). The integrated entity's profit in Equation (3) when not supplying itself equals $\pi(0,1) + f^*$ and if supplying itself equals $\pi(1,0)$. If the entity does not supply $D_2$, but only $D_1$, its joint profits are

$$\pi^U_{D1}(x_1 = 1, x_2 = 0) = \pi(1,0).$$

It is weakly more profitable for the integrated unit to supply itself than only $D_2$ because

$$\begin{aligned}
&\pi^U_{D1}(x_1 = 0, x_2 = 1) \leq \pi^U_{D1}(x_1 = 1, x_2 = 0) \\
&\iff \pi(1,0) \geq \pi(0,1) + f^* \\
&\iff f^* \leq \pi(1,0) - \pi(0,1).
\end{aligned}$$

It is weakly more profitable for the integrated unit to supply itself when not supplying $D_2$ because

$$\begin{aligned}
&\pi^U_{D1}(x_1 = 0, x_2 = 0) \leq \pi^U_{D1}(x_1 = 1, x_2 = 0) \\
&\iff \pi(0,0) \geq \pi(1,0) \\
&\iff f^* \leq \pi(1,0) - \pi(0,1).
\end{aligned}$$

It is weakly more profitable for the integrated unit to supply itself than only $D_2$ because

$$\begin{aligned}
&\pi^U_{D1}(x_1 = 0, x_2 = 1) \leq \pi^U_{D1}(x_1 = 1, x_2 = 1) \\
&\iff \pi(0,1) + f^* \leq \pi(1,1) + f^* \\
&\iff \pi(0,1) \leq \pi(1,1),
\end{aligned}$$

which holds by Assumption (1). The latter condition holds due to Assumption (2) and Condition 2.

Moreover, if $f_1$ and $f_2$ are set secretly (downstream firm 1 does not see $f_2$ when accepting the contract and vice versa), the integrated unit simply cannot commit to not supplying itself. Thus, it cannot charge $D_2$ a transfer price above $f^*$ in equilibrium as it would do better with charging a price at which the downstream firm buys the input. □

**Forward ownership: lemmas for Proposition (2) and their proofs**

**Lemma 9.** *Under the restriction on the absolute tunneling amount, the partial owner $U$ has strictly lower incentives to foreclose its target's rival $D_2$ than in the case of a full integration.*

*Proof.* The upstream profits without and with foreclosure are

$$\pi_U^S = 2f^* + \bar{t} + \alpha\left(\pi(1,1) - f^* - \bar{t}\right),$$

$$\pi_U^F = f^* + \bar{t} + \alpha\left(\pi(1,0) - f^* - \bar{t}\right).$$

The upstream owner is better off when supplying $D_2$ if

$$\pi_U^S \geq \pi_U^F$$

$$\implies f^* \geq \alpha\left[\pi(1,0) - \pi(1,1)\right].$$

The foreclosure incentives for the upstream firm are lower than in the case of full integration (Condition (4)). □

**Lemma 10.** *Under the tunneling restriction of a minimal profit that needs to be left in the upstream firm, the partial owner $U$ has the same incentive to foreclose its target's downstream rival $D_2$ as under vertical integration.*

*Proof.* If both tunneling and propping are feasible, the downstream firm $D_1$ ends up with the profit of $\underline{\pi}_{D1}$ in any case, but the amount of tunneling , $t^S$ and $t^F$, differ in general. The upstream profits are

$$\pi_U^S = 2f^* + \underbrace{\left(\pi(1,1) - f^* - \underline{\pi}_{D1}\right)}_{\mathrm{t}^S} + \alpha\underline{\pi}_{D1},$$

$$\pi_U^F = f^* + \underbrace{\left(\pi(1,0) - f^* - \underline{\pi}_{D1}\right)}_{\mathrm{t}^F} + \alpha\underline{\pi}_{D1}.$$

The upstream owner is better off when supplying $D_2$ if

$$\pi_U^S \geq \pi_U^F$$

$$\implies f^* \geq \pi(1,0) - \pi(1,1). \tag{22}$$

The foreclosure incentives are the same as in the full integration case. □

## Additional lemmas and proofs for customer foreclosure

*Proof of Lemma 7.* By construction, it is optimal at the price $\overline{f}$ for the downstream firm to source one unit from each downstream firm. Can an upstream firm deviate profitably? It could benefit from selling two units by lowering the price. What is the largest deviation price $p$ which leads to this outcome?

The price $p$ needs to satisfy the following:

$$\begin{aligned} &\Pi(2,0) - 2p \geq \Pi(1,1) - f^* - p \;\; (i) \\ &\Pi(2,0) - 2p \geq \Pi(1,0) - p \qquad (ii) \\ &\Pi(2,0) - 2p \geq 0 \qquad\qquad\quad (iii). \end{aligned}$$

Case 1: Suppose that

$f^* = \min\left[\Pi(1,1) - \Pi(1,0), \Pi(1,1)/2\right] = \Pi(1,1) - \Pi(1,0)$.

This corresponds to no economies of scale – selling substitutes in isolation is better than selling them together:

$$\Pi(1,1) - \Pi(1,0) < \Pi(1,1)/2$$
$$\implies \Pi(1,1) < 2\Pi(1,0).$$

The first condition (i) from above becomes

$$\Pi(2,0) - 2p \geq \Pi(1,1) - \Pi(1,1) + \Pi(1,0) - p$$
$$\implies \Pi(2,0) - \Pi(1,0) \geq p.$$

This is equivalent to the second condition.

At $p = \Pi(2,0) - \Pi(1,0)$, the third condition holds as

$$\Pi(2,0) - 2\Pi(2,0) + 2\Pi(1,0) = 2\Pi(1,0) - \Pi(2,0) > 2\Pi(1,0) - \Pi(1,1) > 0.$$

Is such a price cut profitable? It is not if

$$\begin{aligned} \Pi(1,1) - \Pi(1,0) &> 2[\Pi(2,0) - \Pi(1,0)] \\ \implies \Pi(1,1) - \Pi(2,0) &> \Pi(2,0) - \Pi(1,0)], \end{aligned}$$

that is if the differentiation effect is larger than the quantity expansion effect.

Case 2: Suppose that

$f^* = \min\left[\Pi(1,1) - \Pi(1,0), \Pi(1,1)/2\right] = \Pi(1,1)/2.$

This corresponds to economies of scale: Selling more units together is better than selling each substitute in isolation:

$$\begin{aligned} \Pi(1,1) - \Pi(1,0) &> \Pi(1,1)/2 \\ \implies \Pi(1,1) &> 2\Pi(1,0). \end{aligned} \tag{23}$$

The first condition (i) from above becomes

$$\begin{aligned} \Pi(2,0) - 2p &\geq \Pi(1,1) - \Pi(1,1)/2 - p \\ \implies \Pi(2,0) - \Pi(1,1)/2 &\geq p. \end{aligned}$$

Together with the second condition (ii) from above, the highest possible deviation price is

$$p = min\left[\Pi(2,0) - \Pi(1,1)/2, \Pi(2,0) - \Pi(1,0)\right].$$

The first argument of the minimum function is smaller as:

$$\begin{aligned} \Pi(2,0) - \Pi(1,1)/2 &< \Pi(2,0) - \Pi(1,0) \\ \implies \Pi(1,1) &> 2\Pi(1,0), \end{aligned}$$

which corresponds to Condition (23) which constitutes this case. Hence the price has to satisfy $p \leq \Pi(2,0) - \Pi(1,1)/2$.

At the price $p = \Pi(2,0) - \Pi(1,1)/2$, the third condition (iii) holds:

$$\begin{aligned}\Pi(2,0) - 2p &= \Pi(2,0) - 2[\Pi(2,0) - \Pi(1,1)/2] \\ &= \Pi(1,1) - \Pi(2,0)] > 0.\end{aligned}$$

Is such a price cut profitable? It is not if

$$\begin{aligned}&\Pi(1,1)/2 > 2[\Pi(2,0) - \Pi(1,1)/2] \\ &\implies \Pi(1,1) * 3/4 > \Pi(2,0),\end{aligned}$$

that is if the differentiation effect is large enough. □

*Proof of Lemma 8.* Case 1: $\overline{f} = \min\left[\Pi(1,1) - \Pi(1,0), \Pi(1,1)/2\right] = \Pi(1,1) - \Pi(1,0)$.

$$\begin{aligned}&\overline{f} = \Pi(1,1) - \Pi(1,0) < \Pi(1,1) - \Pi(2,0) \\ &\implies \Pi(2,0) < \Pi(1,0).\end{aligned}$$

The latter condition contradicts the assumption in Condition (17) whereby selling two units is more profitable than selling one.

Case 2: $\overline{f} = \min\left[\Pi(1,1) - \Pi(1,0), \Pi(1,1)/2\right] = \Pi(1,1)/2$

$$\begin{aligned}&\overline{f} = \Pi(1,1)/2 < \Pi(1,1) - \Pi(2,0) \\ &\implies \Pi(2,0) < \Pi(1,1)/2.\end{aligned}$$

The latter condition implies $\Pi(1,1) > 2\Pi(2,0) > 2\Pi(1,0)$, where the latter inequality follows from the assumption in Condition (17) again. Case 2 arises under condition $\Pi(1,1) > 2\Pi(1,0)$ from Equation (23), which is implied by the previous condition already. □

**Forward ownership: lemmas for Proposition 3 and their proofs.**

**Lemma 11.** *Under the restriction on the absolute tunneling amount ($t \leq \bar{t}$), the partial owner $U_1$ has strictly higher incentives to foreclose its rival than in the case of full integration.*

*Proof.* Partial owner $U_1$ which owns a share $\alpha$ of its target's profits, may want $D$ to source from both upstream competitors and get:

$$\pi_{U1}^S = f^* + \bar{t} + \alpha\left(\Pi(1,1) - 2f^* - \bar{t}\right),$$

or, alternatively, supply input to its downstream firm only by itself and obtain:

$$\pi_{U1}^F = 2f^* + \bar{t} + \alpha\left(\Pi(2,0) - 2f^* - \bar{t}\right).$$

$D$ gets input from both downstream firms if

$$\pi_{U1}^S \geq \pi_{U1}^F$$

$$\implies f^* \leq \alpha\left[\Pi(1,1) - \Pi(2,0)\right].$$

Foreclosure is more profitable than under full integration because the partial owner $U_1$ puts relatively less weight on the downstream losses from foreclosure. □

**Lemma 12.** *Under the tunneling restriction of a minimal profit that needs to be left in the downstream firm ($\pi_D \geq \underline{\pi}_D$), the partial owner $U_1$ has the same incentive to foreclose its rival as under vertical integration.*

*Proof.* When minimal profit, which has to remain in the downstream firms, is restricted, $U_1$ gets the following profits if $D$ sources from both upstream firms:

$$\pi_{U1}^S = f^* + \alpha\underline{\pi}_D + \underbrace{\left(\Pi(1,1) - 2f^* - \underline{\pi}_D\right)}_{t_{U1}^S},$$

or only from its partial owner:

$$\pi_{U1}^F = 2f^* + \alpha\underline{\pi}_D + \underbrace{\left(\Pi(2,0) - 2f^* - \underline{\pi}_D\right).}_{t_{U1}^F}$$

$D$ gets input from both downstream firms if

$$\pi_{U1}^S \geq \pi_{U1}^F$$

$$\implies f^* \leq \left[\Pi(1,1) - \Pi(2,0)\right]. \tag{24}$$

The condition is the same as in the full integration case. □

**Lemma 13.** *If sourcing from $U_2$ is less profitable than foreclosing it (Condition 24 does not hold) and the minimal profit that needs to be left in the downstream firm is relatively large*

*($\underline{\pi}_D > \Pi(2,0) - 2f^*$), the partial owner $U_1$ optimally props $D$ in order to foreclose $U_2$. If propping is not feasible, no foreclosure takes place in this case.*

*Proof.* Propping is needed if for foreclosure if the target firm's minimal profit restriction can only be met if input comes from both suppliers, i.e.,

$$\Pi(1,1) - 2f^* > \underline{\pi}_D > \Pi(2,0) - 2f^*.$$

As $\Pi(1,1) > \Pi(2,0)$, the above condition can be reduced to

$$\underline{\pi}_D > \Pi(2,0) - 2f^*.$$

Foreclosure of $U_2$ is profitable for the partial owner $U_1$ if

$$\Pi(2,0) > \Pi(1,1) - f^*.$$

Conversely, if propping is limited or impossible, the partial owner $U_1$ would want to foreclose $U_2$ but $D$ has to source from it if $\underline{\pi}_D > \Pi(2,0) - 2f^*$. □

**Backward ownership: lemmas for Proposition 4 and their proofs.**

**Lemma 14.** *Under the restriction on the absolute tunneling amount, the partial owner $D$ has strictly lower incentives to foreclose its target's rival than in the case of full integration.*

*Proof.* The partial owner $D$ can choose to source from both upstream firms and obtain the following profits:

$$\pi_D^S = \Pi(1,1) - 2f^* + \bar{t} + \alpha\left(f^* - \bar{t}\right).$$

Alternatively, $D$ may only obtain input from its target firm and get:

$$\pi_D^F = \Pi(2,0) - 2f^* + \bar{t} + \alpha\left(2f^* - \bar{t}\right).$$

The partial owner $D$ sources from both upstream firms if

$$\pi_D^S \geq \pi_D^F$$

$$\implies f^* \leq {}^1\!/\!\alpha\left[\Pi(1,1) - \Pi(2,0)\right]$$

The foreclosure condition is stricter than under full integration: The partial owner $D$ is more affected from a downstream loss of customer foreclosure relative to the upstream gains and thus has fewer incentives to foreclose $U_2$ than under full integration. □

**Lemma 15.** *Under the tunneling restriction of a minimal profit that needs to be left in the upstream firm, the partial owner D has the same incentive to foreclose its target's downstream rival as under vertical integration.*

*Proof.* The downstream firm's profits when sourcing from either both or only one upstream firm are given by

$$\pi_D^S = \Pi(1,1) - 2f^* + \underbrace{(f^* - \underline{\pi}_{U1})}_{t^S} + \alpha\underline{\pi}_{U1},$$

$$\pi_D^F = \Pi(2,0) - 2f^* + \underbrace{(2f^* - \underline{\pi}_{U1})}_{t^F} + \alpha\underline{\pi}_{U1}.$$

Partial owner $D$ sources from both upstream firms if

$$\pi_D^S \geq \pi_D^F$$

$$\implies f^* \leq [\Pi(1,1) - \Pi(2,0)]\,. \tag{25}$$

The foreclosure incentives are the same as in the full integration case. □

## Fundamental conditions under which foreclosure is unprofitable

In the full integration benchmark, supplying both firms is profitable if Condition (5) holds, that is

$$f^* \geq \pi(1,0) - \pi(1,1).$$

Moreover, $f^*$ needs to be below $\overline{f} = \pi(1,1) - \pi(0,1)$ as defined in Equation (2). Taken together, this implies $\overline{f} \geq f^*$ and thus

$$\begin{aligned}\pi(1,1) - \pi(0,1) &> \pi(1,0) - \pi(1,1)\\ &\implies 2\cdot\pi(1,1) \geq \pi(1,0) + \pi(0,1).\end{aligned} \tag{26}$$

Let us elaborate in which settings Condition (26) holds. Although we explicitly model only the two downstream firms $D_1$ and $D_2$, the reduced form downstream profits also allow for markets where there are other downstream competitors which are supplied by other upstream firms than $U$. Therefore, an important distinction is whether there is a downstream duopoly or an oligopoly with more firms.

1. Downstream duopoly. In models of Cournot-quantity competition without fixed costs, it holds that twice the duopoly profit is below the monopoly profit. The duopoly versus monopoly comparison is relevant if $\pi(0,1) = 0$. In this case, $\pi(1,1)$ equals the duopoly profit $\Pi(n = 2)$ and $\pi(1,0)$ the monopoly profit $\Pi(n = 1)$. Condition (26) thus becomes $2\Pi(n = 2) > \Pi(n = 1)$, which is not true. Consequently, foreclosure would always be profitable under full integration.

2. Downstream oligopoly with more than two firms. Consider a setting as in the previous point but with three downstream firms where the third firm has the same cost function as firm $D_i$ with $i = 1, 2$ if firm $D_i$ got the input from $U$. The three firms are thus symmetric if both $D_1$ and $D_2$ got the input, yielding a profit of $\Pi(n = 3)$. If firm $D_2$ did not get the input, there is a duopoly of firms $D_1$ and $D_3$ where each of them obtains $\Pi(n = 2)$ whereas firm $D_2$ gets 0. In this case, Condition (26) becomes $2 \cdot \Pi(n = 3) > \Pi(n = 2)$. This holds, for instance, with homogeneous Cournot-quantity competition and is known as the Cournot-merger paradox.[22]

3. Marginal cost reduction. Even in the case of a downstream duopoly, Condition (26) may well hold if $U's$ input yields a non-drastic marginal cost reduction for the downstream firms. Non-drastic means that even without $U's$ input a downstream firm can make a positive profit when the other downstream firm got $U's$ input: $\pi(0,1) > 0$. For instance, suppose the downstream firms compete in prices with a demand of $q_i = 1 - p_i + \gamma(p_{-i} - p_i)$ with $\gamma > 0$ and profits of $(p_i - c_i)q_i$. Without the input, $i's$ marginal costs $c_i$ equal $c$ with $0 < c < 1$ whereas with the input $c_i = 0$. Solving for the Nash equilibrium yields that Condition (26) holds if for all $c$ if $\gamma$ is smaller than approximately 0.91 and, if $\gamma$ is larger, holds if $c$ is not too large: $c < \frac{18.g^2+24.g+8.}{2.g^4+10.g^3+21.g^2+16.g+4.}$, where the right hand side decreases in $\gamma$. Economically speaking, serving both firms is profitable if the firms are not too close substitutes for any marginal cost reduction. If the firms are closer substitutes, the marginal cost reduction must not be too high – otherwise, the merger-to-monopoly-effect dominates.

[22] If there are more than two firms in the market, a merger between two of them is not profitable absent synergies, as the implied quantity reduction exerts a positive externality on non-merging firms.

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