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# Less is more in bilateral channel coordination? Linear wholesale pricing may outperform more complex contracts

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**Abstract:** In many markets we observe that suppliers and retailers use simple, linear wholesale tariffs instead of non-linear tariffs. Does this mean that they leave money on the table? Not necessarily. On the contrary, in a bilateral bargaining framework with a dominant supplier and two competing retailers, we find that firms may leave money on the table if they use non-linear tariffs. Fewer instruments could generate more profit (less is more).We show that whether industry profit is higher with linear tariffs or non-linear tariffs depends on the degree of retail competition and the distribution of bargaining power. In some cases, the retailers and the supplier have conflicting preferences with respect to the contract structure (linear or non-linear tariffs). In other cases, however, both the supplier and the retailers are better off with linear tariffs.

# 1 Introduction

Non-linear wholesale contracts (e.g. two-part tariffs) are common in many markets. However, we also observe markets in which suppliers and retailers negotiate over surprisingly uncomplex contracts, such as simple linear wholesale prices. This raises some crucial questions: When do suppliers and retailers prefer linear wholesale contracts, and when do they prefer non-linear wholesale contracts? And do the market players have conflicting interests? Could it be that suppliers prefer non-linear contracts and retailers prefer linear contracts? Or vice versa? In a bilateral bargaining framework with one supplier and two competing retailers, we show how the answers to these questions depend on the degree of retail competition, the distribution of bargaining power, and whether contracts are observable.

Since the seminal paper by Spengler (1950), it has been known that firms may leave "money on the table" with linear wholesale prices. As Spengler showed, in the absence of retail competition, double marginalization causes consumer prices to be above the ones that maximize industry profit.[1] Others have shown, however, that this problem can be solved by using somewhat more complex contracts, e.g. two-part tariffs. Setting the wholesale unit price equal to the supplier's marginal cost of production ensures that the retailer will choose the consumer price that maximizes industry profit (given that the retail price is the only target of control and there is no uncertainty).[2] The fixed fee is then used to distribute profit between the retailer and the supplier according to their respective bargaining powers.

Why then would we ever observe firms negotiating over linear wholesale prices? We suggest that the answer may lie in the fact that Spengler's insight (about double marginalization necessarily causing consumer prices to be too high from an industry perspective) is limited to bilateral monopoly settings, whereas in practice suppliers often sell their products through multiple, competing retailers. This difference between theory and practice matters, because when the supplier's retailers compete with each other, the supplier's unit wholesale prices *must* be set above cost if the retailers are to be induced to charge the consumer prices that maximize industry profit (the more fiercely the retailers compete, the

[1] The extent of the double marginalization will depend on the pass-through rate (curvature of demand) and distribution of bargaining power between the supplier and retailer, as shown by Gaudin (2016).

[2] This presumes that the supplier has only one product. If instead the supplier sells a product line of substitutes, then even a two-part tariff may not be enough to eliminate double marginalization in the absence of some form of bundling (see e.g., Shaffer, 1991; Vergé, 2000; and Dertwinkel-Kalt and Wey, 2016).

higher the unit wholesale prices must be, see, e.g., Miklós-Thal and Shaffer, 2019). Double marginalization in these settings is thus required if industry profits are to be maximized.

The problem that arises with non-linear wholesale contracts is that the requisite double marginalization that is needed to induce industry profits to be maximized when there are competing retailers will not generally be obtainable in equilibrium when contracts are unobservable and/or the retailers have some bargaining power vis a vis the supplier. To see why, suppose that unit wholesale prices are set above marginal costs and contracts are unobservable. Then, as shown in Hart and Tirole (1990), O'Brien and Shaffer (1992), McAfee and Schwartz (1994), Rey and Vergé (2004), and others, the supplier and any of the retailers can increase their bilateral channel profit by (secretly) agreeing on a reduction in the unit wholesale price; this will induce the retailer to charge a lower consumer price and increase its sales at the expense of its rivals (business-stealing effect).[3] This opportunism problem is rationally understood by all of the market participants, and under plausible restrictions on beliefs, the best the supplier and each retailer can do is to negotiate a wholesale price that is equal to the supplier's marginal cost of supplying that retailer.[4] The situation is even worse when the contracts are observable and the firms compete a la Cournot downstream, because then maximizing bilateral channel profits when there is bargaining leads to unit wholesale prices that are *below* the supplier's marginal costs. The driving mechanism in both of these cases is closely related to the Coase conjecture, where a monopoly provider of a durable good competes with itself (see, e.g., the discussion in Rey and Tirole, 2007).

The solution suggested in the literature to reduce the opportunism is to add even more complexity to the wholesale contracts, through, e.g., resale price maintenance (O'Brien

[3] More recent contributions on supplier opportunism include Avenel (2012), Bedre-Defolie (2012), Reisinger and Tarantino (2015), Montez (2015), Rey and Vergé (2017), and Pagnozzi et al (2018).

[4] See Collard-Wexler et al. (2019) on the robustness of the result that the wholesale price equals the supplier's marginal cost. Hart and Tirole (1990) assume "passive beliefs;" if a retailer receives an out-of-equilibrium offer, s(he) believes that the rival is given the equilibrium offer (wholesale price equal to the supplier's marginal cost). O'Brien and Shaffer (1992) restrict attention to "contract equilibria." McAfee and Schwartz (1994) consider "wary beliefs." If a retailer receives an out-of-equilibrium offer, s(he) assumes that the rival is given an offer that maximizes the supplier's profit given the deviation instead of just a wholesale price that equals the supplier's marginal cost at the margin, as under passive beliefs. In such a case, Rey and Vérge (2004) show that the wholesale price is higher than the supplier's marginal cost when there is price competition. However, if retailers compete a la Cournot, then we still have a wholesale price equal to the supplier's marginal cost at the margin. Interestingly, under wary beliefs, the (unit) wholesale prices are so much lower under Cournot than under Bertrand competition that even the consumer prices are lower under Cournot competition compared to Bertrand Competition (Rey and Vergé, 2004, p. 738).

and Shaffer, 1992), exclusive dealing/foreclosure (Rey and Tirole, 2007) or (wholesale) most-favoured-nation clauses (McAfee and Schwartz, 1994). But it should be recognized that such measures have their own associated costs, and do not really target the root of the problem, which is that the non-linear contracts fail to achieve double marginalization. In the presence of retail competition, some double marginalization is needed to increase channel profit. This holds as long as the consumer prices are below the monopoly prices.

In contrast, double marginalization always arises with linear wholesale contracts (except in the polar case where the retailers have all the bargaining power). This may help to solve the channel-coordination problem. More precisely, we show that there exist combinations of bargaining weights (distribution of bargaining power) and degrees of retail competition such that industry profit is maximized under linear contracts. Since such an outcome cannot arise under bargaining when contracts are non-linear and there is retail competition, it follows immediately that linear wholesale contracts can outperform non-linear contracts.

This is not to say that we would always expect to observe linear wholesale contracts in settings in which a supplier sells its product through multiple, competing retailers. To the contrary, the double marginalization that arises in equilibrium may go too far (which was the case in Spengler's setting), or the supplier and its retailers may have conflicting preferences with respect to the contract structure (linear or non-linear tariffs), and the side that favors non-linear tariffs may win out. In particular, we can show that if the retailers' bargaining power vis a vis the supplier is relatively low, their profit is approximately equal to zero with non-linear wholesale contracts, but non-negligible under linear wholesale pricing, whereas if their bargaining power vis a vis the supplier is sufficiently high, on the other hand, they are better off under non-linear wholesale pricing. Interestingly, however, we find that there exist combinations of retail competition and distribution of bargaining power where both the retailers and the supplier make higher profit under linear wholesale pricing.

As mentioned previously, we also investigate how the results may change if contracts are observable. We know from Gaudin (2019) that if the supplier offers take-it-or-leave-it linear wholesale contracts to the retailers, the wholesale prices will be lower under unobservable than under observable (and credible) linear wholesale contracts when the firms compete as Cournot competitors. We find that this result may change when we allow for bargaining. Specifically, we find that wholesale prices will be higher under unobservable than observable linear wholesale prices if the retailers' bargaining power is sufficiently high. It will therefore be ambiguous whether a change from unobservable to observable linear contracts will lead wholesale prices to increase or decrease. With non-linear tariffs, however, we find that the effect of changing to observability is more clear-cut: the unit wholesale prices unambiguously fall. Our qualitative result that linear wholesale tariffs may outperform non-linear tariffs thus holds both with observable and unobservable wholesale contracts.

This paper contributes to the literature on multi-lateral bargaining with vertical contracts. Much of this literature looks at the effects of bargaining on downstream competition with linear input prices (e.g., Horn and Wolinsky, 1988; O'Brien, 2014, and Aghadadashli et al., 2016; and Gaudin, 2018) with respect to incentives for merger, price discrimination, and countervailing power. Some more recent literature (e.g., Rey and Vergé, 2017; and Collard-Wexler et al., 2019) has also considered, as we do, the effects of non-linear tariffs.

The rest of the paper is organized as follows. We lay out the model in Section 2, and consider first the case of unobservable wholesale contracts (2.1), and then the case of observable wholesale contracts (2.2). We also consider the possibility of wholesale price discrimination when the retailers differ in size (2.3). Section 3 concludes the paper. Some of the derivations, including the proof of Proposition 3, can be found in the Appendices.

# 2 The model

We consider a model where a single supplier offers an essential input to two retailers, $i = 1, 2$. The wholesale contract between retailer $i$ and the supplier specifies the unit price $w_i \geq 0$ and the fixed fee $F_i$ that the retailer shall pay (where $F_i = 0$ with linear wholesale contracts). We normalize all other retailing costs to zero. Retailer $i$'s profit level is thus

$$\pi_i = (p_i - w_i)\, q_i - F_i, \tag{1}$$

where $p_i$ is the consumer price set by retailer $i$ and $q_i$ is its output.

The profit level of the supplier (the upstream firm) is equal to

$$U = (w_1 - c)\, q_1 + (w_2 - c)\, q_2 + F_1 + F_2, \tag{2}$$

where $c \geq 0$ denotes the supplier's (constant) marginal cost of producing the input.

The supplier and each retailer engage in simultaneous Nash bargaining over their contract terms. That is, retailer $i$ and the supplier choose $w_i$, $F_i$ to maximize $\phi_i(\circ)$, where

$$\phi_i(\circ) = [U(\circ) - T_i(\circ)]^{1-\gamma_i} [\pi_i(\circ) - t_i(\circ)]^{\gamma_i}\,. \tag{3}$$

The Nash bargaining solution to (3) is derived under the assumption that retailer $j$, $j = 1, 2$, $j \neq i$, and the supplier have agreed, or are expected to agree, in their negotiations (see e.g., O'Brien, 2014, for a discussion). In (3), $U(\circ)$ is the supplier's profit if agreements are reached with both retailers. If there is no agreement with retailer $i$, the supplier still expects to sell through retailer $j$ and make $T_i(\circ) \geq 0$ in profit. The term $U(\circ) - T_i(\circ)$ thus measures the supplier's gain from trade with retailer $i$, and we can interpret $T_i(\circ)$ as the supplier's disagreement payoff or threat point against retailer $i$. Similarly, $\pi_i(\circ)$ is retailer $i$'s profit if agreements are reached with both retailers, and $t_i(\circ) \geq 0$ is its threat point, implying that the difference $\pi_i(\circ) - t_i(\circ)$ is retailer $i$'s gain from trade with the supplier. We assume there are no substitutes to the supplier's good, and we therefore set $t_i(\circ) = 0$.

The parameter $\gamma_i \in (0, 1)$ is retailer $i$'s bargaining weight (we abstract from the extreme cases where the supplier either has no bargaining power or can offer take-it-or-leave-it contracts). Below, we first assume that the retailer and the supplier use a simple linear wholesale tariff ($F_i = 0$). In this case the supplier and retailer $i$ maximize (3) with respect to $w_i$. Thereafter, we assume that they use a two-part tariff, such that (3) is maximized with respect to $w_i$ and $F_i$. Since we want to consider the pros and cons of linear tariffs compared to two-part tariffs *per se*, we abstract from any differences in the bargaining weights between the retailers, and set $\gamma_1 = \gamma_2 = \gamma$.

On the consumer side, we use the following Shubik-Levitan (1980) utility function:[5]

$$\Omega = \sum_{i=1}^{2} q_i - \frac{1}{2}\left[2(1-s)\left(\sum_{i=1}^{2} q_i^2\right) + s\left(\sum_{i=1}^{2} q_i\right)^2\right]. \tag{4}$$

From this it follows that the inverse demand curve for good $i = 1, 2$ is given by

$$p_i = 1 - 2(1-s)\,q_i - s(q_1 + q_2). \tag{5}$$

The parameter $s \in [0, 1]$ in (5) is a measure of how substitutable the goods are for consumers. The goods are perceived as unrelated if $s = 0$ and as perfect substitutes if $s = 1$.

In the event that only retailer $j$, $j \neq i$, reaches an agreement with the supplier, retailer $j$ will have monopoly power in the retail market. For the subsequent analysis, it is useful

[5] The Shubik-Levitan demand system has the appealing property that we may vary the degree of substitution among retailers, s, without affecting the size of the market (see Inderst and Shaffer, 2018, for an discussion). Hence, the parameter s is a pure measure of the degree of retail competition.

to note that in this case the profit maximizing output from retailer $j$ is then equal to

$$q_j^m = \frac{1 - w_j}{2(2-s)}. \tag{6}$$

If retailer $i$ as well as retailer $j$ reach an agreement with the supplier, the two retailers engage in Cournot competition. We consider both the case where the wholesale prices are observable and the case where the wholesale prices are unobservable. In the latter case, retailer $i$'s output is based on a rational expectation of the wholesale price that retailer $j$ is charged, given by $w_j^e$.[6] Solving $\partial \pi_i / \partial q_i = 0$ for $i = 1, 2$, we find that retailer $i$'s output is

$$q_i = \frac{4 - 3s - (4-s) w_i + s \left( w_i + w_j^e \right)}{(4-3s)(4-s)}, \tag{7}$$

where $w_j^e = w_j$ if retailer $i$ is able to observe retailer $j$'s wholesale price.

As a benchmark, it is useful to note that if the supplier and the retailers were able to cooperate and maximize industry profit (i.e., the sum of $\pi_1$, $\pi_2$, and $U$), we would have

$$p_i = p^{opt} = \frac{1+c}{2}, \; q_i = q^{opt} = \frac{1-c}{4} \text{ and } \Pi^{opt} = \frac{(1-c)^2}{4}, \tag{8}$$

where $\Pi^{opt}$ denotes the maximized industry profit.

As noted in the Introduction, there exists a large literature that analyzes how additional vertical constraints may be added to increase industry profitability when the potential for opportunistic behavior from the supplier implies that two-part tariffs are insufficient. In a sense, we go in the opposite direction in this paper; we will show that if two-part tariffs are insufficient, industry profit might increase if wholesale contracts are reduced from two-part tariffs to simple linear tariffs. Fewer instruments could generate more profit (less is more).

To highlight the forces at work, we shall assume in what follows that the supplier (for exogenous reasons) either uses a linear tariff with both retailers or a two-part wholesale tariff with both retailers. Allowing for endogenous asymmetric tariffs structures (such that the supplier in principle could use a two-part tariff with one retailer and a linear tariff with the other) would make the analysis significantly more complex and blur our main message — which is that industry profit might be higher with linear wholesale tariffs than with two-part tariffs. As we will show, it might even be the case that both the retailers and the supplier are all individually better off with linear wholesale tariffs. If so, then it follows as

[6] Throughout, we assume passive beliefs.

a consequence that when one observes linear tariffs (as is alleged to be the case in many industries (see e.g. Gaudin, 2018, 2019), it does not necessarily mean that money is being left on the table. On the contrary, it might be the case that both the retailers and the supplier would be worse off if they change from linear wholesale tariffs to two-part tariffs.

## 2.1 Unobservable wholesale contracts

For each of the settings below, we consider a two-stage game. At stage one, the supplier bargains over the unit wholesale prices with each retailer (and a fixed fee if they use a two-part tariff), and at stage two, the retailers compete in quantities (Cournot competition).

### 2.1.1 Linear wholesale pricing

We start out by assuming that the wholesale contracts are linear (i.e., $F_i = 0$). We also assume that the unit wholesale price $w_i$ that retailer $i$ and the supplier agree on is unobservable for retailer $j$. From equation (6), we know that if the supplier and retailer $i$ do not reach an agreement, retailer $j$ will sell its monopoly quantity, $q_j = \frac{1-w_j}{2(2-s)}$ units. This means that the threat point for the supplier when it bargains with retailer $i$ equals

$$T_i = (w_j - c)\frac{1 - w_j}{2(2 - s)}. \tag{9}$$

When the supplier and retailer $i$ negotiate, they maximize the Nash bargaining product in equation (3) with respect to $w_i$. This yields the first order condition

$$\frac{d\phi_i}{dw_i} = (1 - \gamma)\pi_i\frac{dU}{dw_i} + \gamma (U - T_i)\frac{d\pi_i}{dw_i} = 0. \tag{10}$$

Note that with unobservable wholesale contracts, the supplier and retailer $i$ cannot affect the output from retailer $j$ through changing their unit wholesale price $w_i$. This implies that $dq_j/dw_i = 0$. Taking this into account, and using equation (2), it follows that

$$\frac{dU}{dw_i} = (w_i - c)\frac{dq_i}{dw_i} + q_i. \tag{11}$$

The supplier thus faces the traditional trade-of in (11): by increasing the unit wholesale price $w_i$, the supplier sells less to retailer $i$ ($dq_i/dw_i < 0$) but makes a higher profit margin.

The retailer, of course, clearly loses from paying a higher unit wholesale price:

$$\frac{d\pi_i}{dw_i} = (p_i - w_i)\frac{dq_i}{dw_i} + q_i\left(\frac{dp_i}{dw_i} - 1\right) < 0, \tag{12}$$

where

$$\frac{dp_i}{dw_i} \;=\; -\left(2-s\right)\frac{dq_i}{dw_i} \;>\; 0. \tag{13}$$

Inserting equations (9), (11), (12), and (13) into equation (10), we find that in the equilibrium, the wholesale prices are symmetric and satisfy $w_1 = w_2 = w_{LP}^{unobs}$, where

$$w_{LP}^{unobs} \equiv \frac{\left(4-2s\right)c+\left(4-3s\right)}{8-5s} - \frac{\gamma\left(4-s\right)\left(4-3s\right)^3\left(1-c\right)}{\left(8-5s\right)\left(2\left(8-5s\right)\left(2-s\right)^2 - s\gamma\left(8-4s-s^2\right)\right)}. \tag{14}$$

It is straightforward to show from equation (14) that

$$\frac{dw_{LP}^{unobs}}{d\gamma} = -\frac{2\left(4-3s\right)^3\left(2-s\right)^2\left(4-s\right)\left(1-c\right)}{\left(s\gamma\left(8-4s-s^2\right)-2\left(8-5s\right)\left(2-s\right)^2\right)^2} < 0,$$

which means that $w_{LP}^{unobs}$ will be lower the greater is the bargaining power of the retailers. In the limit when all bargaining power belongs to the retailers ($\gamma \to 1$), we have $w_{LP}^{unobs} = c$. For all other $\gamma$, $w_{LP}^{unobs} > c$, implying that there will be double marginalization. Whether this double marginalization will lead to a problem in the Spengler (1950) sense of leading to equilibrium retail prices that exceed $p^{opt}$ (i.e., to prices that exceed the industry-profit maximizing level), however, depends on the degree of competition $s$ in the retail market.

In the polar case in which the retailers have all the bargaining power, industry profits are maximized at $s = 0$ (i.e., when the retailers' goods are unrelated). But, for all $s > 0$, competition between the retailers implies that $p_{LP}^{unobs}(s) < p^{opt}$ when $\gamma \to 1$. More generally, it can be deduced from (14) that there exists a continuum of combinations of $\gamma$ and $s$ where linear wholesale pricing generates consumer prices (quantities) that coincide with the industry optimum. This is illustrated by the curve $\gamma_{LP}^{uobs}(s)$ in Figure 1. Consumer prices are higher than the ones that maximize industry profit below the curve $\gamma_{LP}^{unobs}(s)$ and lower than industry optimum above the curve. Clearly, in the neighborhood of the curve $\gamma_{LP}^{unobs}(s)$ the differences between the industry optimum and the market outcome are small.

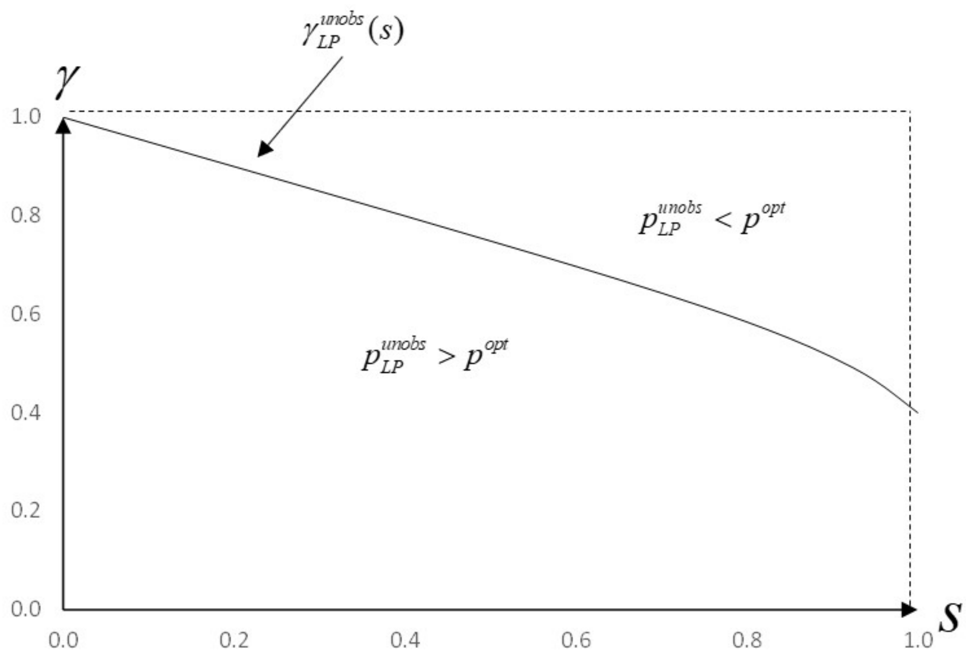


**Figure 1:** *Unobservability. Linear wholesale contracts. Equilibrium consumer prices compared to industry optimum.*

We can state (see Appendix A for proof):

**Proposition 1.** *Linear unobservable wholesale contracts may generate industry optimum: The Nash bargaining solution coincides with the industry optimum for all combinations of* $\gamma$ *and* $s$ *which satisfy* $\gamma_{LP}^{unobs}(s) \equiv \frac{2\left(16-20s+5s^2\right)(2-s)^2}{(8(1-s)+s^2)(16-12s+s^2)}$. *From the industry's point of view, market prices are inefficiently high for all* $\gamma$ *below the curve* $\gamma_{LP}^{unobs}(s)$ *and inefficiently low for all* $\gamma$ *above it.*

Figure 2 shows the equilibrium profits as a function of the retailers' bargaining power for $s = 1/2$ (the profit expressions are given in Appendix A).[7] As expected, the greater is $\gamma$ (the retailers' bargaining power), the higher will be the profit of the retailers and the lower will be the profit of the supplier. The curve for joint profit ($\Pi_{LP}^{Unobs}$) is hump-shaped. The intuition for this follows from Figure 1 and Proposition 1: at $s = 1/2$, consumer prices are too high from the industry's point of view for relatively low values of $\gamma$ (harmful double marginalization; $p_{LP}^{unobs} > p^{opt}$) and too low for relatively high values of $\gamma$ (*i.e.*, $p_{LP}^{unobs} < p^{opt}$).

[7] In all figures, we have set $c = 1/2$.

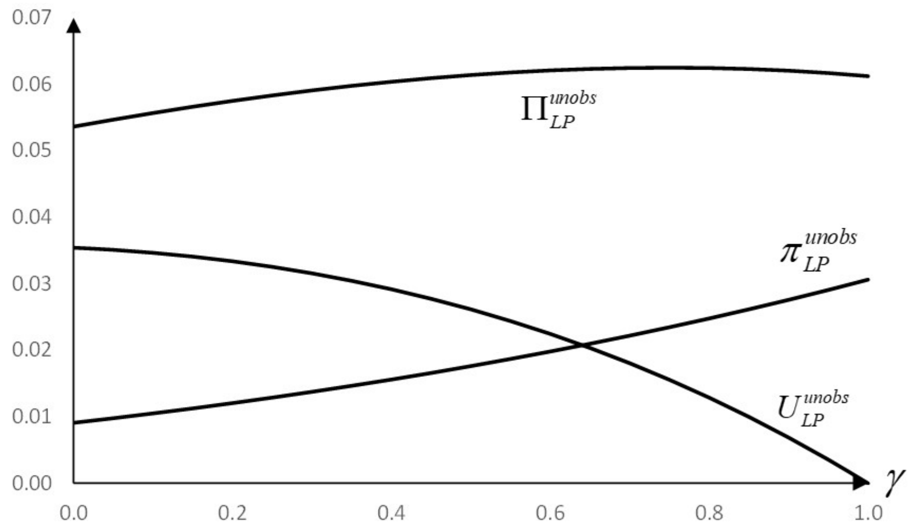


**Figure 2:** *Unobservable linear tariff. Profit as function of retailer bargaining power.*

### 2.1.2 Non-linear wholesale pricing

When a two-part tariff is used, retailer $i$ and the supplier maximize the Nash bargaining product in (3) with respect to $w_i$ and $F_i$. We proceed to do this in two steps. Solving first for $F$, from $\partial\phi_i/\partial F_i = 0$, we find that the fixed fee from the retailer to the supplier equals

$$F_i = (1-\gamma)(p_i - w_i)\, q_i - \gamma (w_i - c)\, q_i - \gamma \left(F_j^e + \left(w_j^e - c\right) q_j^e - T_i\right). \tag{15}$$

Inserting this into the profit functions allows us to write

$$\pi_i = \gamma \left((p_i - c)\, q_i + F_j^e + \left(w_j^e - c\right) q_j^e - T_i\right) \tag{16}$$

and

$$U = (1-\gamma)\left((p_i - c)\, q_i + F_j^e + \left(w_j^e - c\right) q_j^e - T_i\right) + T_i. \tag{17}$$

Using (5), (7) and (15), the Nash bargaining product can now be expressed as

$$\phi_i = \gamma^\gamma (1-\gamma)^{1-\gamma} \left[F_j^e - T_i + (p_i - c)\, q_i + \left(w_j^e - c\right) q_j^e\right]. \tag{18}$$

Differentiating (18) with respect to $w_i$, and noting that $q_j^e$ is unaffected by $w_i$, yields

$$\frac{d\phi_i}{dw_i} = \gamma^\gamma (1-\gamma)^{1-\gamma} \frac{\partial (p_i - c)\, q_i}{\partial w_i},$$

where

$$\frac{\partial (p_i - c)\, q_i}{\partial w_i} = q_1 \frac{\partial p_1}{\partial q_1} \frac{dq_1}{dw_1} + (p_1 - c) \frac{dq_1}{dw_1}. \tag{19}$$

Using (5) and (7), we can rewrite the first-order condition as

$$\frac{d\phi_i}{dw_i} = -\gamma^{\gamma}(1-\gamma)^{1-\gamma}\frac{2(2-s)}{(4-3s)(4-s)}(w_i - c) = 0. \tag{20}$$

It follows from this that $w_i$ is independent of $w_j^e$ and equal to $c$. In equilibrium, we have

$$w_1 = w_2 = w_{TP}^{unobs} \equiv c. \tag{21}$$

This finding, that each retailer will negotiate a wholesale price equal to the supplier's marginal cost independent of how much bargaining power it possesses, generalizes a well known result from the literature. It accords with, among others, Hart and Tirole (1990), O'Brien and Shaffer (1992), and Rey and Vergé (2004), who show that marginal cost pricing will prevail when the supplier can make take-it-or-leave-it offers and beliefs are passive.

Combining (5), (7) and (21) it follows that the equilibrium consumer price equals

$$p_{TP}^{unobs} = \frac{2(1+c)-s}{4-s}. \tag{22}$$

To find $F_i$, $F_j$, we note that if there is no trade between the supplier and retailer $i$, the supplier will earn $T_i = F_j^e + (w_i - c)\, q_j^e\big|_{q_i=0}$ from retailer $j$. Since $w_j^e = w_j = c$ in equilibrium with unobservable contracts, we have $T_i = F_j$. From (15), we can then deduce that

$$F_1 = F_2 = F_{TP}^{unobs} = (1-\gamma)\frac{(2-s)(1-c)^2}{(4-s)^2}. \tag{23}$$

Comparing the equilibrium consumer price (22) with the consumer price in the industry optimum, given by equation (8), we find that $p_{TP}^{unobs} < p^{opt}$ for all $s > 0$. We can thus state:

**Proposition 2.** *Two-part unobservable wholesale contracts cannot generate industry optimum: The Nash bargaining solution yields consumer prices that are below the industry optimum for all $s > 0$, and increasingly so the greater is the degree of competition between retailers (i.e., $dp_{TP}^{unobs}/ds < 0$).*

It follow that the industry optimum is never obtained with unobservable two-part tariffs if there is any substitution between retailers. From Propositions 1 and 2, we can conclude:

**Corollary 1.** *Fewer instruments could generate more profit (less is more): With unobservable wholesale contracts, there exist combinations of $\gamma$ and $s$ for which industry profit is strictly higher with linear tariffs than with two-part tariffs.*

### 2.1.3 Comparing profit under linear and non-linear wholesale contracts

Let us now compare profit under linear and non-linear contracts (two-part tariffs) in more detail. In particular, we want to shed light on the range of parameter values where industry profit is higher with linear tariffs than with two-part tariffs, and to investigate whether the supplier and the retailers have conflicting interests with respect to the tariff structure.

Inserting equations (14) and (21) into equation (7), we find that industry profit under linear contracts is equal to industry profit under two-part tariff contracts along the curve

$$\gamma^{unobs}(s) \equiv \begin{cases} \frac{2(4-5s)(2-s)^3}{64-112s+56s^2-8s^3+s^4} & \text{if } s < 4/5 \\ 0 & \text{if } s \geq 4/5 \end{cases}$$

This is illustrated in Figure 3 below. For all $\gamma$ above $\gamma^{unobs}(s)$, industry profit is higher with linear tariffs than with two-part tariffs. For all $\gamma$ below $\gamma^{unobs}(s)$, the opposite is true.

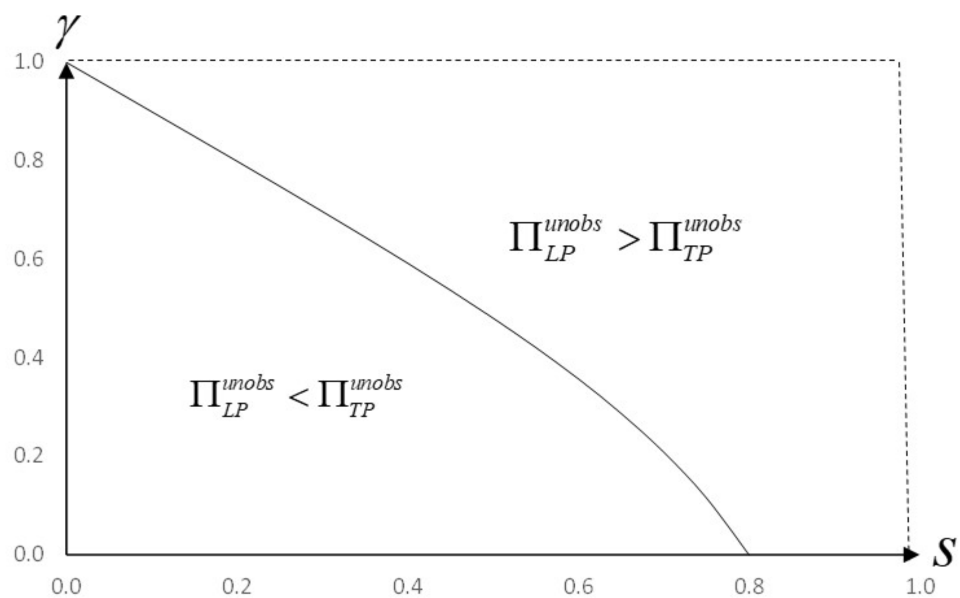


**Figure 3:** *Unobservable. Comparision of profits.*

If $s > 0.8$, it is always true that industry profit under linear tariffs is greater than industry profit under two-part tariffs, $\Pi_{LP}^{unobs} > \Pi_{TP}^{unobs}$. Thus, we can clearly see that linear tariffs are preferable to two-part tariffs for the industry over a large set of parameter values.

Turning to the question of whether the retailers and the supplier may have conflicting preferences with respect to the contract structure, note that if the retailers' bargaining power is very low, they will make approximately zero profit with a two-part tariff (since

$F_i \approx (p_i - c)q_i)$ but a non-negligible profit with a linear tariff ($\pi_i = (p_i - w_i)q_i$), whereas the supplier will extract nearly all of the profit under the former, but have to share some of it under the latter. This suggests that there may indeed be a conflict between channel members. Figure 4, however, shows that there will not always be a conflict. Whether the firms have conflicting or non-conflicting preferences regarding the contract structure depend on the bargaining weights and competitive pressure between retailers. In the area between the solid curves in Figure 4, both the retailers and the supplier prefer linear tariffs to two-part tariffs. However, the retailers prefer a two-part tariff and the supplier prefers a linear tariff if the retailers' bargaining power is larger than the ones corresponding to the upper curve.[8] Likewise, if the retailers bargaining power is below the ones corresponding to the lower curve, the supplier prefers a two-part tariff and the retailers prefer a linear tariff. The dotted curve plots $\gamma^{unobs}(s)$ (i.e., the combinations of $s$ and $\gamma$ for which linear tariffs can achieve the industry optimum, c.f. Proposition 1).

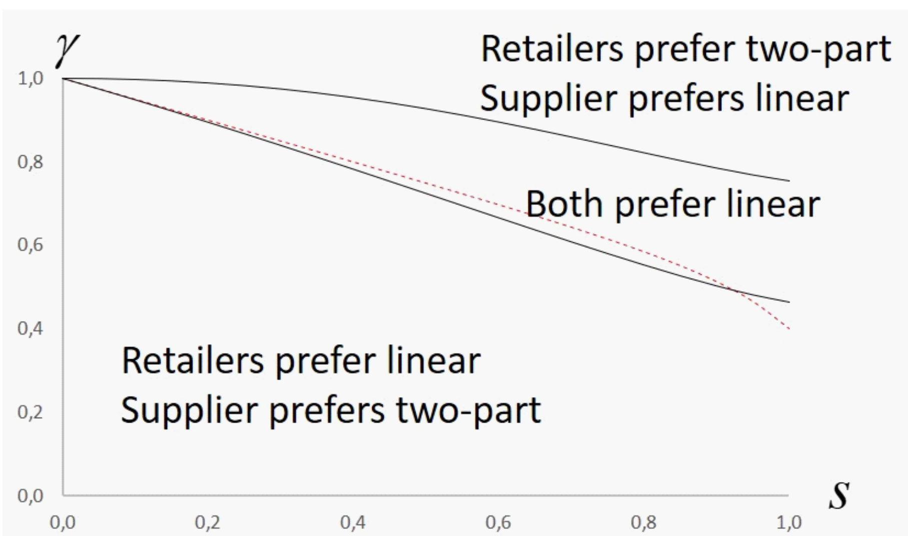


**Figure 4:** *Tariff structure preferences*

### 2.1.4 Competition law and the supplier's preferred tariff structure

Let $\gamma \in (0, 1)$ continue to measure the bargaining power of the retailers, but suppose for the purposes of this subsection that it is the supplier who *de facto* decides whether to use two-part tariffs or linear tariffs (we maintain the assumption that the supplier either uses linear tariffs with both retailers or two-part tariffs with both retailers). Then, assuming it

[8] At $\gamma = 1$, both the retailers and the supplier are indifferent between linear and two-part tariffs.

is optimal for the supplier to serve both retailers (an implicit assumption until now), the supplier's preferred choice is as depicted in Figure 4. It will use two-part tariffs as long as $\gamma$ is below ($s$ is to the 'left' of) the lower of the two solid curves, and linear tariffs otherwise.

However, for some combinations of $\gamma$ and $s$, it may be optimal for the supplier to serve only one retailer. In this case, the supplier's choice of tariff structure will depend on (i) whether it can commit to doing so, and (ii) whether it is allowed to do so. Among other things, this implies that the supplier's optimal choice of tariff structure may depend not only on $\gamma$ and $s$, but also on competition law. The reason for this is that in some countries, competition law may require suppliers (e.g., suppliers of essential inputs) to serve all firms.

To illustrate how this might affect things, let $\gamma = 1/2$ and suppose the supplier is able to commit to serving only one retailer if feasible. In Appendix B, we prove the following:

**Proposition 3.** *Exclusion: Let $\gamma = 1/2$ and suppose the supplier decides the tariff structure.*

*a) If competition law requires the supplier to offer the same contracts to both retailers, then the supplier will use a two-part tariff if $s \in [0, 0.908]$ and a linear tariff if $s > 0.908$.*

*b) If competition law does not require the supplier to offer the same contracts to both retailers, then the supplier will use a two-part tariff and serve both retailers if $s \in [0, 0.906]$. Otherwise, the supplier will use a two-part tariff and serve only one of the two retailers.*

Proposition 3 implies that small suppliers (and other suppliers who are not required to treat all retailers the same) will always prefer to use two-part tariffs when $\gamma = 1/2$ and they can de facto choose the tariff structure. However, this is not the case for suppliers who are constrained to treat all retailers equally (typically large, so called dominant suppliers). For these suppliers, whether linear or non-linear (two-part) tariffs will be preferred depends on the degree of competition downstream. The more intense the competition, the more likely it is that linear tariffs will be preferred. An observation that dominant suppliers are more likely than non-dominant suppliers to serve all retailers, but use linear wholesale tariffs when there is fierce downstream competition, is consistent with Proposition 3.

## 2.2 Observable wholesale contracts

Let us now assume that the wholesale contracts that the supplier signs with each retailer are observable to both retailers. As we did above, we consider first the case of linear wholesale pricing (linear tariffs) and then the case of non-linear pricing (two-part tariffs).

### 2.2.1 Linear wholesale pricing

When wholesale contracts are linear and observable, the first-order condition that arises when the firms maximize the Nash bargaining product in equation (3) with respect to $w_i$,

$$\frac{d\phi_i}{dw_i} = (1-\gamma)\pi_i \frac{dU}{dw_i} + \gamma\,(U - T_i)\,\frac{d\pi_i}{dw_i} = 0, \tag{24}$$

is qualitatively the same as before. However, the individual expressions differ. The change in the supplier's profit when $w_i$ increases under observability, for example, is now given by

$$\frac{dU}{dw_i} = (w_i - c)\,\frac{dq_i}{dw_i} + q_i + (w_j - c)\,\frac{dq_j}{dw_i}. \tag{25}$$

As we can see from this, in addition to retailer $i$ selling less as $w_i$ increases, there is now an additional effect, which is that retailer $j$ will respond by selling more (since quantities are strategic substitutes). More precisely, we can see from equation (7) that the increase in retailer $j$'s quantity when $w_i$ increases is given by $\frac{dq_j}{dw_i} = \frac{s}{(4-3s)(4-s)} > 0$ for all $s > 0$. This expected response by retailer $j$ (as a result of being able to observe retailer $i$'s contract terms) in turn has the effect of increasing the supplier's profit at the margin (given that $w_j$ will be greater than $c$ for all $\gamma < 1$), and thus indicates that the supplier's profit will be maximized at a *higher* unit wholesale price than is the case under unobservable contracts.

All else equal, therefore, we might expect the wholesale price the supplier negotiates in equilibrium to be higher with observable contracts than with unobservable contracts (where $\frac{dq_j}{dw_i} = 0$). However, all else is not equal. For retailer $i$, the change in profit is now

$$\frac{d\pi_i}{dw_i} = (p_i - w_i)\frac{dq_i}{dw_i} + q_i\left(\frac{dp_i}{dw_i} - 1\right), \tag{26}$$

where

$$\frac{dp_i}{dw_i} = -\,(2-s)\,\frac{dq_i}{dw_i} - s\frac{dq_j}{dw_i}. \tag{27}$$

The equivalent of the last term in (27) is equal to zero under unobservable contracts ($dq_j^e/dw_i = 0$), while it is positive under observable contracts. With observable contracts, the retailer is thus more harmed if the unit wholesale price increases than it is under unobservable contracts. This indicates that if retailer $i$ had its way, it would want to have a *lower* unit wholesale price when contracts are observable than when they are unobservable.

Taken together, equations (25) and (26) therefore paint an ambiguous picture as to whether one would expect unit wholesale prices to increase or decrease when contracts become observable. It will in general depend on the relative bargaining power of each side.

Solving (24) for a symmetric equilibrium, we find that under observability,

$$w_1 = w_2 = w_{LP}^{obs} = \frac{1-\gamma}{2} + \frac{1+\gamma}{2}c. \tag{28}$$

Compared to its counterpart, $w_{LP}^{unobs}$, given in equation (14), the unit wholesale price when contracts are observable only depends on the bargaining power of the retailers (and marginal costs $c$) and not on the intensity of competition between the retailers. In the neighborhood of $\gamma = 0$, the unit wholesale price equals $(1+c)/2$, while it is equal to $c$ in the neighborhood of $\gamma = 1$. More generally, we have

$$\frac{dw_{LP}^{obs}}{d\gamma} = -\frac{1-c}{2} < 0.$$

Inserting (28) into (5) and (7), we find that the equilibrium price to consumers when contracts are observable is given by $p_{LP}^{obs} = \frac{2(1-\gamma)-s}{2(4-s)}(1-c)$, whereas at the industry optimum, we know that $p^{opt} = \frac{1+c}{2}$. From this it is straightforward to deduce the following:

**Proposition 4.** *Linear observable wholesale contracts may generate industry optimum: The Nash bargaining solution coincides with the industry optimum for all combinations of* $\gamma$ *and* $s$ *which satisfy* $\gamma_{LP}^{obs}(s) \equiv 1 - \frac{s}{2}$*. From the industry's point of view, market prices are inefficiently high for all* $\gamma$ *that lie below the curve* $\gamma_{LP}^{obs}(s)$ *and inefficiently low for all* $\gamma$ *that lie above this curve.*

Proposition 4 is thus qualitatively similar to Proposition 1; whether the supplier's wholesale contracts are observable or unobservable between retailers, there exist combinations of $\gamma$ and $s$ for which the industry optimum is obtained with simple, linear wholesale tariffs.

In a setting where the supplier offers take-it-or-leave-it contracts to retailers, Gaudin (2019) finds that wholesale prices are higher with observable contracts than with unobservable contracts when, as in our case, there is Cournot competition among retailers. However, this result turns out not to be robust when there is a more even distribution of bargaining power. As noted above, there are forces pulling towards higher as well as lower wholesale prices with observable compared to unobservable contracts. In particular, equation (25), which measures the supplier's benefit of a higher $w_i$, suggests that wholesale prices will be higher when contracts are observable, while equation (26), which measures the cost for the retailer of a higher $w_i$, suggests the opposite. Consistent with this, we find that wholesale prices will be lower with observability than with non-observability if the retailers' bargaining power is sufficiently high. Specifically, from equations (28) and (33) it can be deduced that if $\gamma < \tilde{\gamma}(s) = \frac{2(2-s)^2}{4(2-s)-s^2}$, then wholesale prices are highest if the contracts are observable. This is illustrated in Figure 5, where the downward-sloping curve depicts $\tilde{\gamma}(s)$.

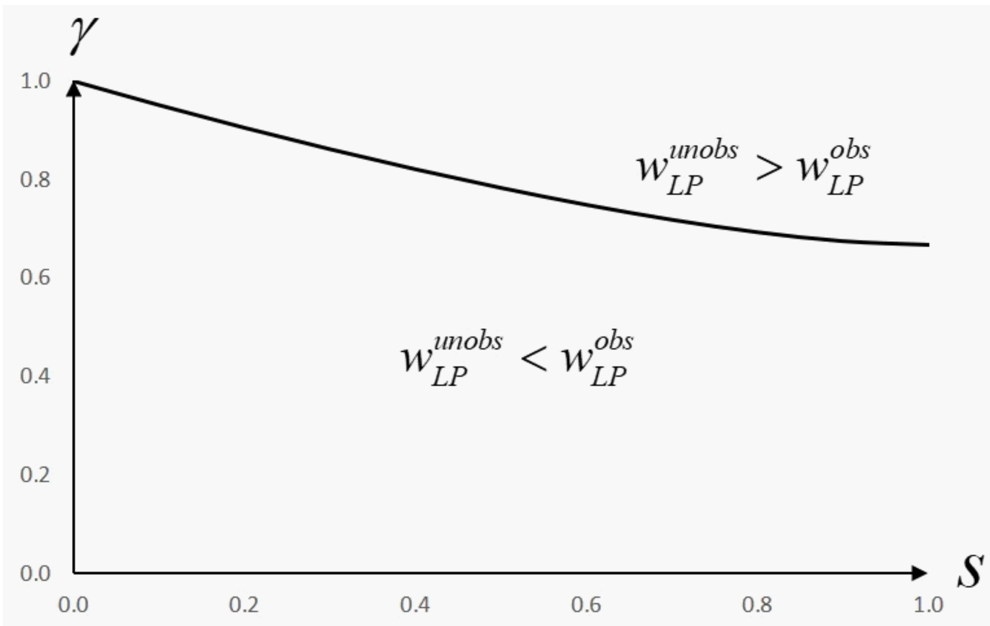


**Figure 5:** *Unit prices, observable and unobservable linear tariffs*

Since consumer price changes mimic wholesale price changes, we have the following:

**Proposition 5:** *The equilibrium wholesale and consumer prices are (weakly) lower when contracts are linear and unobservable than when they are linear and observable if and only if* $\gamma \leq \tilde{\gamma}(s) = \frac{2(2-s)^2}{4(2-s)-s^2}$ *(i.e., when the retailers' bargaining power is sufficiently low).*

Since Gaudin (2019) only considers the case of $\gamma = 0$, where wholesale prices - and thus consumer prices - are lower with unobservable than with observable contracts, he puts forward the policy recommendation that retailers should not be allowed to exchange information about purchasing prices.[9]

[9] More specifically, Gaudin (2019) shows that under take-it-or-leave-it contracts from the supplier, the outcome depends on whether retailers' instruments are strategic substitutes or strategic complements. Under strategic substitutes, the outcome is the same as in Proposition 5. In contrast, under strategic complements, wholesale and retail prices are higher under unobservable contracts. His policy recommendation in the latter case is that the retailers should be allowed to exchange information about purchasing prices.

#### 2.2.2 Non-linear wholesale pricing

When contracts are observable and a two-part tariff is used, equations (15) - (18) from section 2.1.2 still apply (but without the superscript $e$). It follows directly from equation (18), then, that the Nash bargaining product after optimizing over $F_i$ can be written as:

$$\phi_i = \gamma^\gamma (1-\gamma)^{1-\gamma} ((p_i - c) q_i + F_j + (w_j - c) q_j - T_i) \tag{29}$$

Differentiating this with respect to $w_i$, and noting that now $q_j$ is affected by $w_i$, we obtain:

$$\frac{\partial \phi_i}{\partial w_i} = \gamma^\gamma (1-\gamma)^{1-\gamma} \left[ \frac{\partial (p_i - c) q_i}{\partial w_i} + \frac{\partial (w_j - c) q_j}{\partial w_i} \right] = 0. \tag{30}$$

From (30), it is straightforward to find the wholesale price 'reaction function':

$$w_i(w_j) = \frac{(4-3s)\left(16c(1-s) + (3c-1)s^2\right)}{4(2-s)(8(1-s)+s^2)} + \frac{s}{2(2-s)} w_j, \tag{31}$$

which shows that the retailers' wholesale prices - as expected - are strategic complements.

Looking at the first-order condition in (30) in more detail, we can see that the second term in the square brackets is new. When contracts are observable, an increase in $w_i$ will necessarily induce retailer $j$ to sell more ($dq_j/dw_i > 0$ for $s > 0$). It therefore follows that if $w_j$ were greater than $c$, we would expect the wholesale price to be higher with observable than with unobservable contracts ($\partial\phi_i/\partial w_i$ increases). However, the profit margin need not be positive. To see why, note that the first term in the square brackets in (30) equals

$$\frac{d (p_1 - c) q_1}{dw_1} = q_1 \left[ \frac{\partial p_1}{\partial q_1} \frac{dq_1}{dw_1} + \frac{\partial p_1}{\partial q_2} \frac{dq_2}{dw_1} \right] + (p_1 - c) \frac{dq_1}{dw_1}. \tag{32}$$

From here, note that the second term in the square brackets of (32) is zero with unobservable contracts (c.f. also equation (19)). This is why it is optimal there to set $w_i = c$, independent of the size of $w_j$. But with observable contracts, the term is negative if the retailers compete, i.e., if $s > 0$ (a higher $w_i$ increases $q_j$, which in turn reduces $p_i$). This indicates that it is optimal to set $w_i < 0$ for $s > 0$ (in which case the the internalization term $\frac{\partial (w_j - c) q_j}{\partial w_i}$ in (30) actually strengthens the incentive to set a "low" value of $w_i$). This conjecture is confirmed by setting $w_1 = w_2 = w_{TP}^{unobs}$ in (31) - the retailers are symmetric - from which we find:

$$w_{TP}^{obs} \equiv c - \frac{s^2}{2(8(1-s)+s^2)} (1-c) \quad < \quad c, \tag{33}$$

and

$$\frac{dw_{TP}^{obs}}{ds} = -\frac{4s(2-s)}{(8(1-s)+s^2)^2} (1-c) \quad < \quad 0.$$

The above analysis suggests that the equilibrium unit wholesale prices will be below the supplier's marginal production costs when the wholesale contracts are non-linear and observable, and the retailers compete, and that they will be increasingly so the greater is the degree of competition. Relative to unobservability, this implies lower industry profits.

Since $w_{TP}^{unobs}$ is already too low from the industry's point of view when the retailers compete, it follows that industry profit will be even further away from the industry optimum when the contracts are nonlinear and observable. On the basis of Proposition 5 and equation (33) we can - similar to Corollary 1 in the case of unobservable contracts - conclude:

**Corollary 2.** *Fewer instruments could generate more profit: With observable wholesale contracts, there exist combinations of $\gamma$ and $s$ for which industry profit is strictly higher with linear tariffs than with two-part tariffs.*

Figure 6 compares industry profit with linear tariffs and two-part tariffs when the contracts are observable. From it, we can conclude that with observable contracts (as was the case with unobservable contracts, c.f. Figure 3), one needs information both about the competitive pressure between retailers and the distribution of bargaining power across the value chain before one can ascertain whether the use of linear or two-part tariffs will generate higher industry profit. Linear tariffs do not necessarily leave money on the table.

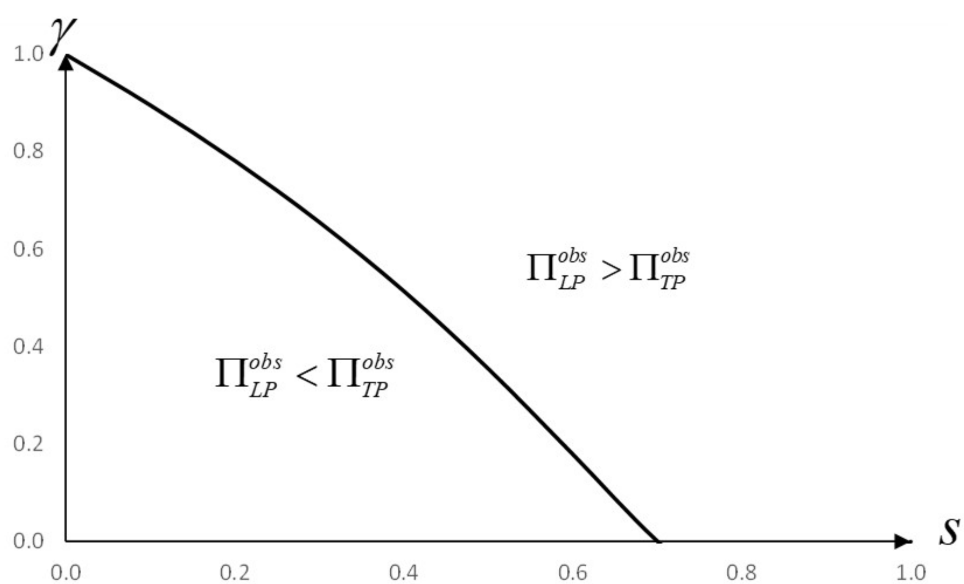


**Figure 6.** *Observable. Comparison of profits.*

## 2.3 Price discrimination if the retailers differ in size?

In the analysis thus far, we have assumed that the retailers are symmetric, and found - not surprisingly - that they face the same unit wholesale prices. An interesting question to ask is whether the same will be true if the retailers were to differ in size. Let us therefore assume that retailer 1 has twice as many outlets as retailer 2. Other things equal, retailer 1 will then sell twice as much as retailer 2. Not least in popular debates, it has been argued that with such an asymmetry, we may expect retailer 1 to be able to negotiate lower unit wholesale prices than retailer 2 ($w_1 < w_2$). The reasoning behind this claim is that retailer 1 will have a greater bargaining power than retailer 2, presumably because it is more costly for the supplier to lose a large customer than it is to lose a small customer. If it turns out that $w_1 < w_2$, we shall say that the supplier price discriminates in favor of retailer 1.

To test the price discrimination hypothesis, assume that retailer 1 has two outlets (labelled 0 and 1) and that retailer 2 has only one (labelled 2). Since we want to focus on implications of differences in size *per se*, we assume that consumers perceive the three outlets as symmetric. More precisely, we let the consumers' utility function be given by

$$\Omega = \sum_{i=1}^{3} q_i - \frac{1}{2}\left[3(1-s)\sum_{i=1}^{2}(q_i)^2 + s\left(\sum_{i=1}^{3} q_i\right)^2\right].$$

This is basically the same utility function as in (4), except that we now have three goods (or outlets) instead of two. The inverse demand curves are in this case given by

$$p_i = 1 - 3(1-s)\,q_i - s\,(q_i + q_j + q_k)\,.$$

Retailer profits thus equal

$$\pi_1 = (p_0 - w_1)\,q_0 + (p_1 - w_1)q_1 - F_1 \tag{34}$$

and

$$\pi_2 = (p_2 - w_2)\,q_2 - F_2. \tag{35}$$

Retailer 1 maximizes joint profit for its two outlets, and with Cournot competition between the two retailers, we have the following equilibrium quantities:

$$q_0 = q_1 = \frac{6 - 5s - 2(3-2s)\,w_1 + sw_2}{6\,(6\,(1-s) + s^2)}$$

and

$$q_2 = \frac{3 - 2s - (3 - s) w_2 + s w_1}{3 (6 (1 - s) + s^2)}.$$

We are now ready to consider whether there will be price discrimination in the contracts between the supplier and retailer 1 on the one hand and the supplier and retailer 2 on the other. Let us first assume that we have observable linear tariffs ($F_1 = F_2 = 0$). Maximizing the Nash bargaining product in each case, we find that the wholesale prices are the same:

$$w_{LP}^{obs} = \frac{1-\gamma}{2} + \frac{1+\gamma}{2} c.$$

Thus, there will be no price discrimination. Similar calculations show that the same is true if instead the contracts are linear and unobservable. With two-part unobservable contracts, we obviously have $w_{TP}^{unobs} = c$, as the opportunism problem is the same whether the retailers are symmetric or not. If the supplier and each retailer were to engage in Nash bargaining over observable two-part tariffs, on the other hand, we find that $w_1 = w_2 = w_{TP}^{obs}$, where

$$w_{TP}^{obs} = c - \frac{s^2}{18(1-s) + 2s^2} (1 - c).$$

Similar to what we showed in the case with symmetric retailers, we thus see that the equilibrium unit wholesale prices are lower than the supplier's marginal production costs if $s > 0$. More to the point, however, we also see that the supplier will not price discriminate.

In Foros et al. (2018), we analyzed a case were the retailers compete a-la Bertrand. We found that there will be price discrimination in favor of the small retailer with observable linear tariffs and in favor of the large retailer if the supplier offers observable take-it-or-leave-it contracts to the retailers. In neither case, however, does the discrimination hinge on size differences per se (rather, it is related to the fact that the large retailer internalizes competition between its outlets if $s > 0$; see Foros et al., 2018, for a detailed discussion). We shall therefore not go further into that discussion. However, it can be shown that if the firms *bargain* over observable two-part tariffs under Bertrand competition, we have

$$w_1 = w_2 = c + \frac{s^2}{18(1-s) + 4s^2}.$$

The result that there might be unit wholesale price discrimination with two-part tariffs thus holds only in the polar case with observable take-it-or-leave it contracts. There will be no price discrimination if the retailers have at least some bargaining power. Roughly speaking, the intuition is simply that even though it is twice as valuable for the supplier to trade with retailer 1 as with retailer 2, it is also twice as valuable for retailer 1 as for retailer 2 to reach an agreement with the supplier. Size per se therefore does not affect individual bargaining power, and will consequently not generate differences in unit wholesale prices.

## 3 Conclusion

Due to the potential for a supplier to act opportunistically, or simply because it is engaged in bargaining and cannot resist incentives to cut unit prices, non-linear tariffs alone fail to generate wholesale prices that induce competing retailers to set consumer prices that maximize industry profit. The solution suggested in the literature to reduce the opportunism problem is to add more complexity to the wholesale contracts, for instance, in form of resale price maintenance, exclusive dealing, foreclosure or most-favored nation clauses.

We have taken the opposite approach in this paper and shown that both the supplier and the retailers might be better off if they commit to use simple linear tariffs instead of more complex contracts. The decisive factors that determine whether linear or non-linear wholesale contracts are preferable include (i) the competitive pressure between the retailers and (ii) their bargaining power over the supplier. We have further shown that the possible inferiority of two-part tariffs compared to simple linear tariffs might be greater if the supplier's wholesale contracts are observable than if they are unobservable. Finally, we have shown that a supplier's preferred tariff structure might depend on competition law. In particular, we found that it may prefer linear tariffs if price discrimination is illegal.

In our analysis, we derived explicit solutions for equilibrium wholesale prices by applying a linear demand system. This allowed us to show that both the retailers and the supplier prefer linear tariffs to non-linear tariffs for a large set of parameter values, but we also showed that they may have conflicting interests. Our main result is that whether linear or non-linear wholesale tariffs generate the higher industry profit, depend on the distribution of the bargaining weights and the degree of downstream competition. We believe that this result holds quite generally and does not depend on demand linearity. Specifically, it is well known that wholesale prices are equal to the supplier's marginal costs with unobservable non-linear wholesale contracts (and we should expect them to be lower than marginal costs when contracts are observable and there is Cournot competition between the retailers).[10]

[10] More precisely, when the supplier and retailer i bargain, they would like to limit sales from retailer j.

This is far from optimal from the industry's point of view if there is fierce downstream competition; consumer prices will then be too low. With linear contracts, on the other hand, wholesale prices will be strictly above marginal costs if the supplier has some bargaining power. Consumer prices will therefore be higher than under non-linear contracts. In principle, the extent of double marginalization could become too high if the supplier's bargaining weight is sufficiently high (though that did not happen in the analysis above). However, some double marginalization is better than no double marginalization if the retailers compete fiercely. The result that linear wholesale contracts may yield higher industry profit than non-linear wholesale contracts therefore seems robust. The opposite result, that non-linear contracts could yield strictly higher profit than linear contracts, is also robust: using linear contracts between a supplier and a retailer leaves money on the table if there is no downstream competition (Spengler, 1950), given that the supplier has some bargaining power. By continuity, the same must be true if there is sufficiently weak competition between the retailers.

# 4 Appendix

## 4.1 Equilibrium with unobservable contracts

### 4.1.1 Appendix A. Unobservable contracts and linear tariffs

From equations (1), (2), (7) and (9), we find that in a symmetric equilibrium with unobservable linear contracts,

$$\pi_{LP}^{unobs} = \frac{(2-s)\left(1-w_{LP}^{unobs}\right)^2}{(4-s)^2}, \tag{36}$$

$$U_{LP}^{unobs} = \frac{2\left(1-w_{LP}^{unobs}\right)\left(w_{LP}^{unobs}-c\right)}{4-s}$$

and

$$T_{LP}^{unobs} = \frac{\left(1-w_{LP}^{unobs}\right)\left(w_{LP}^{unobs}-c\right)}{2\left(2-s\right)}.$$

If the retailers' actions are strategic substitutes (which is typically the case under Cournot competition), this can be achieved by reducing the wholesale price that retailer i is charged. Other things equal, this implies that when there is bargaining, wholesale prices will be set at a lower level if the contracts become observable to rivals than if they remain unobservable to rivals when the retailers compete in quantities.

Inserting $w_{LP}^{unobs}$ from equation (14) into equation (36), we find that the difference between the equilibrium industry profit and the industry optimum (c.f. equation (8)) equals

$$\Pi_{LP}^{unobs} - \Pi^{opt} = -\frac{(\gamma - \gamma_{LP}(s))^2 (16 - 12s + s^2)^2 (8(1-s) + s^2)^2 (1-c)^2}{4(s-4)^2 \left((8 - 4s - s^2) s\gamma - 2(8-5s)(s-2)^2\right)^2},$$

where

$$\gamma_{LP}(s) \equiv \frac{2(16 - 20s + 5s^2)(2-s)^2}{(8(1-s) + s^2)(16 - 12s + s^2)}.$$

In Figure 2, we have set $s = 1/2$. Inserting $s = 1/2$ into the expressions in (36), we find

$$\pi_{LP}^{unobs} = \frac{6(67\gamma + 108)^2 (1-c)^2}{49(198 - 23\gamma)^2} \tag{37}$$

and

$$U_{LP}^{unobs} = \frac{360(1-\gamma)(67\gamma + 108)(1-c)^2}{7(198 - 23\gamma)^2}. \tag{38}$$

### 4.1.2 Appendix B. Proof of Proposition 3

To prove part (a) of Proposition 3, suppose the supplier serves both retailers and uses two-part tariffs. Setting $\gamma = 1/2$, and using $U_{TP}^{unobs} = 2F_{TP}^{unobs}$, equation (23) implies that

$$U_{TP}^{unobs} = \frac{2-s}{(4-s)^2}(1-c)^2.$$

With linear tariffs, we find from equation (36) that

$$U_{LP}^{unobs} = \frac{4(4-3s)(2-s)^2(96 - 160s + 84s^2 - 13s^3)}{(4-s)(128 - 216s + 116s^2 - 19s^3)^2}(1-c)^2.$$

We now find that $U_{LP}^{unobs} > U_{TP}^{unobs}$ if $s > 0.908$. Otherwise, we find that $U_{LP}^{unobs} < U_{TP}^{unobs}$.

To prove part (b) of Proposition 3, suppose without loss of generality that the supplier serves only retailer 1, say. It is then clearly optimal to use a two-part tariff. Setting $w = c$, we have that profit maximizing behavior yields $q_1 = (1-c)/(2(2-s))$. This implies that

$$U_{R1} = \frac{1}{8(2-s)}(1-c)^2,$$

where our use of the superscript $R1$ indicates that the supplier only serves retailer 1.

It can be shown from this that $U_{R1} > U_{TP}^{unobs}$ if $s > 0.906$. It can also be shown from this that $U_{R1} > U_{LP}^{unobs}$ if $s > 0.905$. However, it is never optimal to serve both retailers and use a linear tariff if $s < 0.908$ (since we then have $U_{TP}^{unobs} > U_{LP}^{unobs}$). The relevant threshold for when it is optimal to serve only retailer 1 is consequently that $U_{R1} > U_{TP}^{unobs}$. It follows from this that the supplier will choose to serve both retailers (and use a two-part tariff) if $s < 0.906$, but choose to serve only retailer 1 (and use a two-part tariff) if $s > 0.906$.

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