

Contract Unobservability and Downstream Competition

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Abstract

Problem definition: In this paper, we consider a supply chain with a manufacturer and two retailers who are contracted through wholesale prices or two-part tariffs. We depart from the existing literature by assuming that contract terms between the manufacturer and a retailer are not observed by the rival retailer. *Academic/practical relevance:* While the existing literature typically assumes that they are common knowledge in the market, contract terms may not be observed by rival retailers under certain circumstances. This paper contributes to the literature by studying the effect of contract unobservability on supply chain performance. *Methodology:* We use game theoretical methods to find the equilibrium. When there are multiple equilibria, we adopt passive beliefs as an equilibrium refinement criterion. *Results:* We find that certain established results regarding observable supply chain contracts do not always apply when those contracts become unobservable to competing retailers. In particular, compared to when using two-part tariff contracts, the manufacturer may benefit from using wholesale price contracts when contract terms are unobservable. Moreover, the total industry profit may increase under wholesale price contracts. *Managerial implications:* Our results offer an alternative explanation for the popularity of the wholesale price contracts and suggest that members of the supply chain must take unobservability into account when selecting the right contracts. We also offer new insights into buyback contracts and downstream mergers under unobservable contracts.

Keywords: contract unobservability; downstream competition; wholesale price contract; two-part tariff contract.

1 Introduction

It is typical practice in a supply chain for a manufacturer to sell its products through competing retailers. Examples of this are abundant and commonplace: Home electronic appliances are sold at both Best Buy and Fry's Electronics while household supplies are provided by Walmart, Carrefour, and Target. Previous studies of supply chain competition have typically assumed that supply chain contracts are observable to all the competing retailers. In other words, if a manufacturer sells its products through different retailers, the contract terms between the manufacturer and an individual retailer are known to every member of the channel. Thus, the manufacturer makes a public commitment to the contracts offered to all the competing retailers.

This modelling assumption, however, does not necessarily hold up in all realistic situations. When selling to Best Buy and Fry's or Walmart and Target, does a manufacturer always publicly announce and credibly commit to the contracts it offers to all retailers? This answer, in practice, is rarely affirmative. McAfee and Schwartz (1994) show that, even when contracts are announced, the manufacturer has the incentive to deviate from the outset of the contracts and draft private contracts with each retailer, thus making those particular contract terms unobservable to competing partners.

One may argue that offering competing retailers different contracts may be prohibited by antitrust laws, most notably the United States' Robinson-Patman (RP) Act, which bans price differences of "commodities of like grade and quality." Under such circumstances, unobservability is not an issue because all retailers are required to receive the same contract. Nonetheless, we believe that unobservability remains a realistic assumption for the following reasons. First, evidence indicates that the enforcement of RP is on the decline. The U.S. Department of Justice (DoJ) and the Federal Trade Commission (FTC) have legal jurisdiction to pursue violations of RP; and yet, the DoJ has not enforced the act since the 1960s and the FTC has substantially decreased its enforcement activity since the late 1970s (Luchs et al., 2010). As for private party suits, Luchs et al. (2010) empirically study the courts' views of RP, collecting over 28 years of data from cases tried in the U.S. federal courts. Their analysis indicates that the likelihood of a plaintiff winning an RP Act-related case has considerably lessened over the past a few years: From 1982 to 1993, cases brought by private party plaintiffs were successful, on average, 35 percent of the time. This likelihood then dropped to less than 5 percent from 2006 to 2010. The authors conclude that "the legal risk that managers attribute to RP may be outdated." Second, RP does not apply to the sale of services. The U.S. courts have consistently held that grants of trademark and franchise licenses

do not constitute sales of commodities (Zeidman, 1991; McAfee and Schwartz, 1994); in fact, only eight states have price-discrimination laws that do cover services (ABA, 1991). In this sense, our work can apply to the franchising relationship so long as they do not violate state regulations. Third, it is impractical for a retailer to sue a manufacturer for violating RP given that manufacturers often offer secret discounts to retailers so that a single retailer does not always know the true input prices charged to its rivals even ex post. Even if a retailer were to still sue, similar regulations are not enforced in many other jurisdictions including Australia, Canada, China, EU, India, Japan, and Russia. In summary, the declining enforcement of RP and the challenge of winning a lawsuit brought under price protection laws indicate that observability is not at all assured in practice. Then, unobservable contract terms become less conjecture and more of a reality under certain circumstances.

In this paper, we study a situation in which a manufacturer sells products through two competing retailers with private contracts whose contract type is public information. It is common practice for a particular contract type to be used in certain industries. For example, wholesale price contracts prevail between book publishers and retailers (Gilbert, 2015), between manufacturers of medical devices and hospitals (Grennan, 2013), and between channels and cable TV providers (Crawford and Yurukoglu, 2012). Although the contract type is public information, each retailer has specific contract terms with the manufacturer, which are only known to that retailer and not to the rival retailer. This setting is reasonable in the sense that the choice of contract type is a long-term strategic decision: once it is determined, the contract type remains constant for a protracted period. But in the short run, a manufacturer may frequently renegotiate contract terms with its downstream retailers, e.g., offer short-term trade-deal promotions. Most existing studies on supply chain contracting assume that contracts are observed by all members; however, the distinguishing feature of our work is the assumption that each retailer's contract terms remain known only to that retailer, which we call "contract unobservability." In our model, two retailers compete on price, and each retailer's demand depends on the retail prices charged by both retailers. We study wholesale price and two-part tariff contracts, which are commonly used in both theory and practice. Then, we compare the performances of the manufacturer, the retailers, and the entire supply chain under these two contract types. When the manufacturer makes private contract offers to the retailers, the competition between the retailers is the one with imperfect information. Therefore, we solve a game of imperfect information. Furthermore, even when one retailer observes deviations from the equilibrium contract, the retailer still believes that the contract offered to the rival retailer remains the same; that is, our model assumes passive beliefs off

the equilibrium path.

Based on the model characteristics, we make a number of observations. Our main finding is that, under contract unobservability, the manufacturer may prefer wholesale price contracts over two-part tariff contracts — a result that starkly contrasts with established knowledge that claims, when contracts are observable, the manufacturer always prefers two-part tariff contracts that can help it achieve the first-best outcome and coordinate the supply chain. However, we find that, under contract unobservability, the manufacturer always has an incentive to offer one retailer a better deal to increase bilateral profits at the expense of the other retailer. In particular, when the supply chain is contracted through two-part tariffs, the manufacturer sets the unit price equal to the marginal cost, leading to extremely fierce price competition between the retailers. Because the retail competition is so intense at this wholesale price, even though the manufacturer extracts the entire channel profit via the fixed fee, there is little profit to extract. But when the supply chain is contracted through wholesale prices, the manufacturer sets prices higher than the marginal cost because the wholesale price is the manufacturer's sole source of profit. Then, downstream competition is less severe than what it would be under two-part tariff contracts, and the manufacturer benefits accordingly. In other words, when the same contract type is used with unobservable contract terms, wholesale price contracts can be preferable to two-part tariff contracts. In this way, contract unobservability can change the manufacturer's contract preference, which suggests that channel members should take (un)observability into account when making this decision. The above results hold under both passive beliefs and wary beliefs, which are commonly used in games of imperfect information.

The remainder of this paper is organized as follows. Section 2 reviews the related literature. Section 3 presents our basic model. Section 4 provides benchmark results of two-part tariff and wholesale price contracts when contracts terms are observable. Section 5 characterizes the equilibrium results under these two contract types when the contract terms are not observable. Section 6 extends the basic model to situations of buyback contracts, asymmetric retailers, and downstream mergers. Section 7 offers a discussion of our work and concludes the paper.

2 Literature Review

Our work contributes to the literature on unobservable and private contracts among suppliers and retailers. While most existing studies simply (and often implicitly) assume that retailers' contract terms are always known in the market, several exceptions in economics exist.

For instance, O'Brien and Shaffer (1992) study a case in which a supplier makes secret non-linear contract offers to multiple retailers, i.e., each retailer does not observe the contract terms made to its rivals. They find that the equilibrium retail prices fall well below vertically integrated levels because the supplier has an incentive to increase bilateral profits with one retailer at the expense of another. Examining a similar setting in which a supplier offers two-part tariff contracts to multiple downstream firms, McAfee and Schwartz (1994) analyze a supplier's incentive to cut prices caused by its inability to commit to its contract's terms, and show that the problem cannot be completely eliminated even when nondiscrimination clauses are implemented. Hart and Tirole (1990) consider a model with two upstream Bertrand manufacturers and two downstream Cournot retailers under general contract arrangements. They focus on vertical integration caused by different motives and, in particular, examine how vertical integration changes the competition in upstream and downstream markets. Segal (1999) examines a more general contracting problem between one principal and multiple agents in the presence of multilateral externalities, showing that, when the principal's offers are privately observed, inefficiencies arise due to the externalities of efficient outcomes. Montez (2015) investigates how to control the supplier's problem in vertical contracting when each retailer's capacity is constrained by its stock. He finds that, under certain conditions, an appropriately designed buyback contract can restore the supplier's monopoly power.

These papers all conclude that, if manufacturers/suppliers cannot commit to a set of public contracts or that individual contract terms are not observable to competing retailers, the supply chain cannot be coordinated because non-committed/private contracts can alter the manufacturer/supplier's behavior. In contrast, Ingene and Parry (1995) show that supply chain coordination is typically achievable under observable contracts unless discriminatory price contracts are banned. With these studies as our backdrop, we explore how contract unobservability affects the performance of different contracts. Particularly, we study a setting in which a manufacturer sells products through two competing retailers via private contracts and focus on two common and well-adopted contracts: wholesale price contracts and two-part tariff contracts. We investigate how, under these two contracts, unobservability changes the performances of the manufacturer, retailers and the whole supply chain. Furthermore, we delineate the preference of the manufacturer over the two different contract types.

Our work is closely related to one recent paper in the operations management literature by Feng and Lu (2013). They consider a setting in which two competing manufacturers sell products to two competing retailers under both wholesale price and two-part tariff contracts with unobserv-

able contract terms. Their focus is to show how different game structures — Stackelberg game and bargaining game — affect the performance of each partner and the whole supply chain. In contrast to this work, ours considers a supply chain consisting of a single manufacturer and two competing retailers in only a Stackelberg game and emphasize on how contract unobservability changes the performance of different contract types. Our model yields different results from theirs: they show that, in a Stackelberg game, the manufacturer's profit is higher while the retailers' profit is lower when under two-part tariff contracts and when product substitutability is absent; the total system profit is also higher under these conditions. On the other hand, we show that both the manufacturer and retailers can gain higher profits under wholesale price contracts, leading also to a higher total system profit.

Contract unobservability also arises under chain-to-chain competition in which the contract terms of a supply chain are often unobserved by the rival chain. Coughlan and Wernerfelt (1989) show that cross-chain unobservability may cause manufacturers to prefer vertical integration over decentralization, thereby defying the results of McGuire and Staelin (1983). Recently, several studies on chain-to-chain competition also model unobservable contracts, but their focus is not necessarily on the role and effects of contract unobservability but on information sharing between manufacturers and retailers regarding the state of market demand: Ha and Tong (2008) investigate how quantity-based contracts and wholesale price contracts affect the value of information sharing and the profits of each supply chain. Ha, Tong and Zhang (2011) explore how, when two retailers engage in quantity or price competition, production diseconomy affects information sharing differently between two competing supply chains. Ha, Tian and Tong (2017) examine the effect of cost reduction on information sharing between competing supply chains. Li, Li and Chen (2018) reveal that strategic inventories in supply chain competition alleviate double marginalization and intensify competition.

The issue of (un)observability has also been discussed in other contexts as well. Shin and Tunca (2010) discuss the observability of forecast investments in supply chains and find that forecast observability amplifies over-investments in forecasting and leaves firms worse off. Meanwhile, a recent paper by Roy, Gilbert and Lai (2018) examines the impacts of unobservable strategic inventory in a supply chain. Instead of assuming that strategic inventory is always observable by manufacturers, they consider an equally plausible setting in which the manufacturer cannot observe the retailer's sales or inventory. They find that, under wholesale price contracts, the manufacturer may prefer not to observe the retailer's inventory while the retailer may be willing to reveal its inventory under certain conditions.

Our work is akin to those that study contract preference under various factors. One closely related paper by Cachon and Kök (2010) investigates competition as a driver for contract preference. Their work explores a setting in which two competing manufacturers sell products through a common retailer under different contract types and studies how upstream competition changes the preference of different types of contracts. They find that, under two-part tariff or quantity-discount contracts, upstream competition may benefit retailers while leaving manufacturers worse off than it would be under wholesale price contracts. We reach the similar conclusions, however, from a different driving force. In our model, a retailer’s contract terms are unobservable to its rival — an issue that is not present in Cachon and Kök’s model. Such contract unobservability incentivizes the manufacturer to cut wholesale prices, leaving both the manufacturer and retailers better off under wholesale price contracts than under two-part tariff contracts.

3 The Model

Our model consists of a monopolist manufacturer and two downstream retailers. The manufacturer produces a single product and sells it to consumers through these downstream retailers. The unit production cost is constant and normalized to zero without loss of generality. The retailers compete on price. The demand for retailer i is specified below:

$$D_i = 1 - p_i + \theta(p_j - p_i), \quad i \in \{1, 2\}, \quad j = 3 - i,$$

where p_i is the retail price charged by retailer i . $\theta \geq 0$ captures the extent of competition between the two retailers. When $\theta \rightarrow 0$, a retailer’s demand depends only on that retailer’s price and there is virtually no competition between the retailers. When $\theta \rightarrow \infty$, the retailers engage in Bertrand competition. This demand structure has been used in past studies (e.g., Tsay and Agrawal 2000 and Desai, Koenigsberg and Purohit 2010).

In the model, the manufacturer first makes contract offers to the two retailers using the same contract type. We make the critical assumption that the contract terms between the manufacturer and an individual retailer are not observed by the rival retailer, although the contract type is known to both retailers. In other words, retailer i does not observe the detailed contract terms that the manufacturer offers to retailer j . As mentioned before, contract terms may be unobservable, but the contract type is common knowledge in the market. As noted by Ha and Tong (2008), “it is common to have a prevailing contract type in an industry because of trade practice or other factors such as transaction cost or technology.” We consider two types of contracts: wholesale

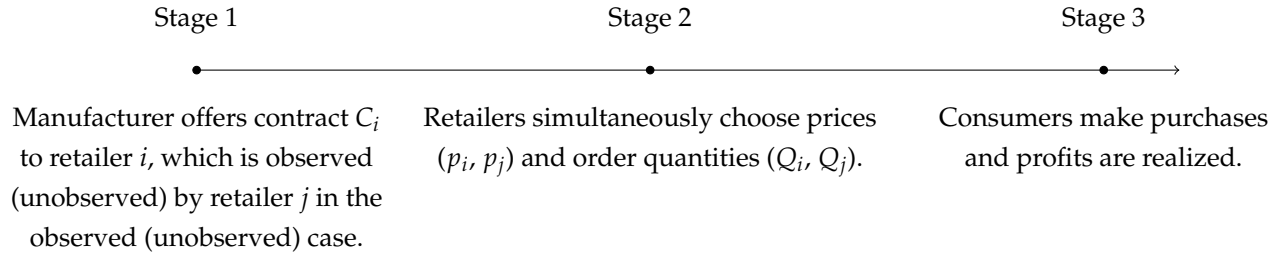


Figure 1: The sequence of events in the basic model

price contracts and two-part tariff contracts. Under wholesale price contracts, the manufacturer sets a wholesale price w_i ; under two-part tariff contracts, the manufacturer sets both a fixed fee, K_i , and a marginal wholesale price, w_i . We use Π and π_i to denote the manufacturer's and retailer i 's profit, respectively.

Upon observing the contract offers, the retailers simultaneously decide Q_i , the purchase quantities from the manufacturer, and p_i , their retail prices ($i = 1, 2$). Then, retail demands materialize. The timing of the game is illustrated in Figure 1, and the notations are summarized in Table 1.

Since a retailer does not observe the contract terms between the manufacturer and the rival retailer, the model falls into a game of imperfect information. When solving the game, the out-of-equilibrium beliefs must be treated with caution. Let C_i^* and C_j^* be the equilibrium contracts offered to the retailers: upon receiving an unexpected offer $C_i \neq C_i^*$, retailer i is free to change its belief about C_j and thus, the model features multiple equilibria. To pin down the equilibrium, we assume *passive beliefs* in the basic model. A commonly used equilibrium refinement criterion, passive beliefs dictate that a retailer's beliefs are not updated when an out-of-equilibrium offer is observed (De Fontenay and Gans 2005; Gavazza and Lizzeri 2009; Hart and Tirole 1990; McAfee and Schwartz 1994; O'Brien and Shaffer 1992; Segal 1999; Rey and Tirole 2007). In short, retailer i 's belief about C_j does not change upon observing an out-of-equilibrium contract offer $C_i \neq C_i^*$ and, therefore, its belief about p_j is also unaffected. One justification for passive beliefs is that a retailer interprets the deviation by the manufacturer as a tremble and that trembles are uncorrelated.

Other alternative equilibrium selection criteria outside of passive beliefs, include *wary beliefs* and *symmetric beliefs*. Under wary beliefs, another equilibrium refinement criterion proposed by McAfee and Schwartz (1994), a downstream retailer believes that the other retailer received an offer that is the manufacturer's optimal choices given the offer made to that retailer. In the Online Appendix, we show that our results do not change under wary beliefs and that the firms'

Table 1: Table of Notation

C_i	Contract offered to retailer i
\tilde{C}_j	Retailer i 's belief of C_j
w_i	Retailer i 's marginal wholesale price
\tilde{w}_j	Retailer i 's belief of w_j
K_i	Retailer i 's fixed fee
p_i	Retailer i 's retail price
\tilde{p}_j	Retailer i 's belief of p_j
θ	Intensity of market competition
D_i	Retailer i 's demand
Q_i	Retailer i 's order quantity
$\tilde{\pi}_i$	Retailer i 's anticipated profit
π_i	Retailer i 's actual profit
Π	Manufacturer's profit
CS	Consumer surplus
SW	Social welfare

actions are identical under both passive and wary beliefs. Meanwhile, under symmetric beliefs, a downstream retailer who receives an out-of-equilibrium offer believes that all other retailers must have received the same out-of-equilibrium offer. However, as McAfee and Schwartz (1994) commented, "symmetric beliefs are not very compelling" and have been rarely followed in the literature. Hence, we focus on passive beliefs in this paper.

4 Benchmark: Observed Contracts

To illustrate how unobservability affects the supply chain equilibrium, it is useful to study a benchmark case in which all members observe the supply chain contracts, a common assumption in the literature. In other words, retailer i observes the contract terms between the manufacturer and retailer j . We use superscript o to represent the observed case.

4.1 The Centralized Outcome

Before characterizing the equilibrium outcome in a decentralized channel, we consider a centralized system in which both retailers are owned by the manufacturer, which renders observability a non-issue. The following lemma summarizes the equilibrium outcome:

Lemma 1. *In a centralized channel, the retail prices are $p_i^C = p_j^C = \frac{1}{2}$, and the manufacturer's profit is $\Pi^C = \frac{1}{2}$.*

4.2 Two-Part Tariffs

Consider the case in which the supply chain is contracted through two-part tariffs. A two-part tariff is a nonlinear pricing schedule of the form $P_i^o(Q_i^o) = K_i^o + w_i^o \cdot Q_i^o$ if $Q_i^o > 0$, where K_i^o is the fixed fee and w_i^o is the marginal wholesale price. Two-part tariffs revert to a linear pricing contract by setting $K_i^o = 0$. Such contracts are widely used in the business-to-business environment and known to help a monopoly manufacturer coordinate the supply chain and achieve the first-best solution, and their popularity is second only to wholesale price contracts.

We use backward induction to find the subgame perfect equilibrium. Given the contracts between the manufacturer and the two retailers $(K_i^o, w_i^o), (K_j^o, w_j^o)$, suppose that the retailers accept the manufacturer's offers and then choose retail prices that maximize their individual profits, i.e.,

$$\pi_i^o = (p_i^o - w_i^o)(1 - p_i^o + \theta(p_j^o - p_i^o)) - K_i^o.$$

When demand uncertainty is absent, retailer i 's procurement is always equal to its demand. (For the sake of simplicity, we implicitly assume that the price induces nonnegative demand; we verify later this is indeed the case in equilibrium.) Then, the equilibrium outcome for the pricing subgame is

$$p_i^o = \frac{2(1 + w_i^o) + \theta(3 + 2(2 + \theta)w_i^o + w_j^o + \theta w_j^o)}{(2 + \theta)(2 + 3\theta)}. \quad (1)$$

Given these retail prices, the problem facing the manufacturer is to maximize its total profit Π^o by choosing contracts $(K_i^o, w_i^o), (K_j^o, w_j^o)$, where

$$\Pi^o = w_i^o(1 - p_i^o + \theta(p_j^o - p_i^o)) + w_j^o(1 - p_j^o + \theta(p_i^o - p_j^o)) + K_i^o + K_j^o,$$

subject to the retailers' participation constraints $\pi_i^o \geq 0, \pi_j^o \geq 0$. We solve the problem and summarize the results in the following lemma:

Lemma 2. *Under contract observability, suppose that the supply chain is contracted through two-part tariffs. In equilibrium, the pricing schemes are $(K_i^o, w_i^o) = (K_j^o, w_j^o) = (\frac{1}{4+4\theta}, \frac{\theta}{2+2\theta})$, the retail prices are $p_i^o = p_j^o = \frac{1}{2}$. The manufacturer's profit is $\Pi^o = \frac{1}{2}$ and the retailers' profits are $\pi_i^o = \pi_j^o = 0$.*

Lemma 2 replicates conventional wisdom, which states that, under observable two-part tariff contracts, the manufacturer can always achieve the first-best outcome and coordinate the supply chain. Note that, in equilibrium, the marginal wholesale price is positive whenever $\theta > 0$. The manufacturer uses the marginal wholesale price as a means to achieve the preferred level of downstream competition.

4.3 Wholesale Prices

Next, consider the case in which the supply chain is contracted through wholesale price contracts. Again, we work backward to solve the game. Given wholesale prices w_i^o and w_j^o , the retailers choose p_i^o and p_j^o that maximize their individual profits:

$$\pi_i^o = (p_i^o - w_i^o)(1 - p_i^o + \theta(p_j^o - p_i^o)).$$

The retailers' best response is characterized by

$$p_i^o = \frac{2(1 + w_i^o) + \theta(3 + 2(2 + \theta)w_i^o + w_j^o + \theta w_j^o)}{(2 + \theta)(2 + 3\theta)}.$$

Given the retailers' best response functions, the manufacturer's profit Π^o is maximized by choosing appropriate values of w_i^o and w_j^o , where

$$\Pi^o = w_i^o(1 - p_i^o + \theta(p_j^o - p_i^o)) + w_j^o(1 - p_j^o + \theta(p_i^o - p_j^o)).$$

We then solve the manufacturer's pricing problem and summarize the results in the following lemma.

Lemma 3. *Under contract observability, suppose that the supply chain is contracted through wholesale prices. In equilibrium, the wholesale prices are $w_i^o = w_j^o = \frac{1}{2}$, the retail prices are $p_i^o = p_j^o = \frac{3+\theta}{4+2\theta}$. The manufacturer's profit is $\Pi^o = \frac{1+\theta}{4+2\theta}$ and the retailers' profits are $\pi_i^o = \pi_j^o = \frac{1+\theta}{4(2+\theta)^2}$.*

Immediately following Lemma 3, the manufacturer always benefits from fiercer downstream competition whereas the retailers would prefer milder competition, i.e., $\frac{d\Pi}{d\theta} > 0$, $\frac{d\pi_i}{d\theta} < 0$. This result is intuitive: holding the wholesale prices constant, as competition becomes fiercer, retailers must squeeze their retail margins to compete for consumers. As a result, market demand increases and more consumers are served. While the manufacturer benefits from this market expansion, the intensified competition and thinner retail margins leave retailers worse off. Meanwhile, total channel profits increase in θ , since competition tightens retail margins, alleviates double marginalization, and improves supply chain efficiency.

4.4 Two-Part Tariffs Versus Wholesale Prices

A simple comparison of the two cases suggests that the manufacturer will always prefer two-part tariffs to wholesale prices while the retailers would prefer just the opposite. These findings are in line with the established wisdom that more complex transfer pricing schemes, such as two-part tariffs, can increase channel profitability by inducing channel members to maximize total channel profits, rather than just their own profits. However, as we will show in the following section, the above findings do not hold when supply chain contracts are unobservable to rival retailers.

5 Unobserved Contracts

After exploring the benchmark cases, we study a basic model in which the contract terms between the manufacturer and one retailer are unobservable to the rival retailer. More specifically, we consider regimes in which the supply chain is contracted through two-part tariff and wholesale price contracts, and compare the equilibrium results.

5.1 Two-Part Tariffs

To demonstrate how unobservability affects the supply chain equilibrium, we show that the equilibrium characterized in Lemma 2 is *not* sustained when a retailer cannot observe its rival's con-

tract terms.

Assume for contradiction that the same contracts $(K_i^*, w_i^*) = (K_j^*, w_j^*) = (\frac{1}{4+4\theta}, \frac{\theta}{2+2\theta})$ are offered to retailers in equilibrium. Consider the following deviance by the manufacturer: it still offers retailer i the equilibrium contract $(K_i, w_i) = (K_i^*, w_i^*) = (\frac{1}{4+4\theta}, \frac{\theta}{2+2\theta})$ but offers retailer j a different contract $(K_j, w_j) = (\frac{(2+\theta)^2}{16(1+\theta)}, 0)$. Subsequently, retailer i does not observe any deviation and, thus, follows the equilibrium strategy. As such, the manufacturer's profit earned from retailer i is not affected. In contrast, retailer j receives an unexpected offer. Under passive beliefs, retailer j 's belief of p_i does not change ($p_i^* = \frac{1}{2}$). If it accepts this offer, retailer j can optimize the price at $p_j = \frac{2+\theta}{4(1+\theta)}$ and make a profit of $\pi_j = \frac{(2+\theta)^2}{16(1+\theta)} - K_j = 0$. Hence, retailer j will accept the manufacturer's offer. In equilibrium, the manufacturer makes a total profit of $\frac{1}{4} + \frac{(2+\theta)^2}{16(1+\theta)} \geq \frac{1}{2}$. Therefore, the manufacturer finds it profitable to deviate (the above inequality is strict when $\theta > 0$). To gain intuitions into the results, note that, because retailer i does not observe the contract terms between the manufacturer and retailer j , the manufacturer is incentivized to offer retailer j a better deal and make a higher profit at the expense of retailer i . Straightforward calculation shows that retailer i , who holds the incorrect belief, will make a profit of $-\frac{\theta^2}{8(1+\theta)^2} \leq 0$. Therefore, in anticipation of the manufacturer's incentive to cut wholesale prices, retailer i will turn down the original offer $(\frac{1}{4+4\theta}, \frac{\theta}{2+2\theta})$. As such, the first-best solution in the observed case is not achieved.

Next, we solve the equilibrium formally under contract unobservability. Since contract terms are unobservable, the model does not have any proper subgames aside from the whole game and, hence, we cannot use subgame perfection to pin down the equilibrium.

Let \tilde{p}_j be retailer i 's belief of retailer j 's retail price, p_j . Let \tilde{C}_j be retailer i 's belief of the contract between the manufacturer and retailer j , we have $\tilde{p}_j = p_j(\tilde{C}_j)$, where $p_j(\cdot)$ is retailer j 's strategy profile. Under passive beliefs, \tilde{p}_j can be viewed as a constant because retailer i never changes its belief of C_j , even when it receives an unexpected offer, $C_i \neq C_i^*$ (see Ha and Tong 2008). Thus, if it accepts the offer, retailer i chooses values for p_i and Q_i that maximize its conjectured profit, denoted by $\tilde{\pi}_i$, in the following:

$$\tilde{\pi}_i = p_i \min(Q_i, 1 - p_i + \theta(\tilde{p}_j - p_i)) - Q_i \cdot w_i - K_i,$$

where $1 - p_i + \theta(\tilde{p}_j - p_i)$ is retailer i 's conjecture of demand. We then solve the retailer's profit maximization problem as follows:

$$Q_i = 1 - p_i + \theta(\tilde{p}_j - p_i),$$

and

$$p_i = \frac{1 + \theta\tilde{p}_j}{2 + 2\theta} + \frac{w_i}{2}, \quad (2)$$

if $w_i \leq \bar{p}_j$ (otherwise, retailer i does not procure from the manufacturer, which is clearly suboptimal for the manufacturer). Note that in Equation (2), retail price p_i is not a function of w_j whereas, in the observed case, p_i^o increases in w_j^o (see Equation (1)); that is, retailer i is no longer responsive to the marginal wholesale price that the manufacturer offers to retailer j . This distinction leads to notably different results between cases using observed and unobserved contracts.

We then solve for the manufacturer's problem and summarize the results in the following proposition:

Proposition 1. *Under contract unobservability, suppose that the supply chain is contracted through two-part tariffs. In equilibrium, the contracts are*

$$(K_i, w_i) = (K_j, w_j) = \left(\frac{1 + \theta}{(2 + \theta)^2}, 0 \right),$$

the retail prices are $p_i = p_j = \frac{1}{2 + \theta}$. The manufacturer's profit is $\Pi = \frac{2(1 + \theta)}{(2 + \theta)^2}$ and the retailers' profits are $\pi_i = \pi_j = 0$.

In Proposition 1, the manufacturer always charges the marginal wholesale prices at $w_i = w_j = 0$, below what is charged under contract observability ($w_i^o = w_j^o = \frac{\theta}{2 + 2\theta}$). But why does the manufacturer offer such low marginal wholesale prices under contract unobservability? The intuition is as follows. The manufacturer always has an incentive to reduce the wholesale price, thereby expanding the market size and increasing retailer profit, which can then be extracted via the fixed fee of the manufacturer's two-part tariff contracts. As we know, in the absence of downstream competition (i.e., $\theta = 0$), a wholesale price of zero is indeed optimal. When θ increases, the manufacturer must increase the wholesale price above zero because there is now a counteracting, competitive force: as the manufacturer reduces w_i , retailer j orders less from the manufacturer and, naturally, the manufacturer's gain from retailer j decreases. However, when contracts terms are unobservable, retailer j does not observe w_i and the above effect vanishes. As a result, the manufacturer cannot help but lower wholesale prices to zero, at which downstream competition becomes too fierce from the manufacturer's perspective.

Table 2 summarizes the equilibrium results under both contract observability and unobservability. Under contract observability, for any level of competition between the retailers, θ , the manufacturer can always achieve the first-best outcome by setting the marginal wholesale prices at $\frac{\theta}{2 + 2\theta}$. However, under contract unobservability, the manufacturer always charges zero wholesale prices ($w_i = w_j = 0$), regardless of the intensity of the downstream competition, θ . Given the low wholesale prices, the downstream competition becomes veritably too fierce. Mathematically, this is delineated as $p_i \leq p_i^o, p_j \leq p_j^o$ and the inequalities are strict whenever $\theta > 0$.

Table 2: Equilibrium strategies under two-part tariff contracts

	Observed case		Unobserved case
K_i	$\frac{1}{4+4\theta}$	\leq	$\frac{1+\theta}{(2+\theta)^2}$
w_i	$\frac{\theta}{2+2\theta}$	\geq	0
p_i	$\frac{1}{2}$	\geq	$\frac{1}{2+\theta}$
Q_i	$\frac{1}{2}$	\leq	$\frac{1+\theta}{2+\theta}$
Π	$\frac{1}{2}$	\geq	$\frac{2(1+\theta)}{(2+\theta)^2}$
π_i	0	$=$	0
CS	$\frac{1}{4}$	\leq	$\frac{(1+\theta)^2}{(2+\theta)^2}$
SW	$\frac{3}{4}$	\leq	$1 - \frac{1}{(2+\theta)^2}$

Regarding the manufacturer's profit, the following corollary follows immediately.

Corollary 1. *When the supply chain is contracted through unobservable two-part tariffs, the manufacturer's profit always decreases in θ .*

As discussed above, the manufacturer charges zero wholesale prices when contract terms are not observable. As θ increases, the retailers, faced with zero marginal cost, compete head-to-head for consumers, which drives down the industry profit that is fully extracted by the manufacturer via the fixed fees. As such, the fierce competition backfires on the manufacturer's profit. In particular, when $\theta \rightarrow \infty$, $p_i, p_j \rightarrow 0$ and the manufacturer's profit completely vanishes. Meanwhile, consumers benefit unanimously because prices are lower and demands become higher.

Given these circumstances, the manufacturer will always prefer observable contracts over unobservable contracts. Under observable contracts, the manufacturer secures the ability to manage the downstream competition and achieve the first-best outcome through marginal wholesale prices. Under unobservable contracts, the manufacturer is incentivized to set its wholesale prices to zero marginal cost, which ultimately hurts its profit as well as total industry profit.

5.2 Wholesale Prices

In this section, we consider the case in which the supply chain is contracted through wholesale prices and the manufacturer makes private contract offers to the retailers. As with before, we assume passive beliefs in this analysis. We solve for the equilibrium outcome and present the

results in the following proposition:

Proposition 2. *Consider the unobserved case. Suppose that the supply chain is contracted through wholesale prices. In equilibrium, the wholesale prices are $w_i = w_j = \frac{2}{4+\theta}$, the retail prices are $p_i = p_j = \frac{3}{4+\theta}$. The manufacturer's profit is $\Pi = \frac{4(1+\theta)}{(4+\theta)^2}$ and the retailers' profits are $\pi_i = \pi_j = \frac{1+\theta}{(4+\theta)^2}$.*

Immediately following Proposition 2, both the manufacturer's and the retailers' profits increase in θ when $\theta < 2$ and, otherwise, decrease in θ . This contrasts with the observed case in which the manufacturer's profit always increases in θ (see Lemma 3 and Table 3). Figure 2 illustrates this result.

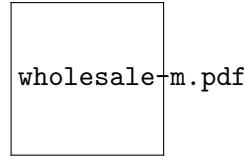


Figure 2: The manufacturer's profit under wholesale price contracts

To understand this situation, consider unobservability's effect on the supply chain equilibrium. Note that, in the observed case, the retailers' orders from the manufacturer, Q_i^o, Q_j^o , satisfy the following:

$$\frac{\partial Q_i^o}{\partial w_i^o} = -\frac{(1+\theta)(2+4\theta+\theta^2)}{(2+\theta)(2+3\theta)} < 0, \quad \frac{\partial Q_j^o}{\partial w_i^o} = \frac{\theta(1+\theta)^2}{(2+\theta)(2+3\theta)} > 0.$$

We can see that a decrease in w_i^o has two effects on the supply chain equilibrium that play against each other: (1) a direct demand expansion effect from increasing Q_i^o , and (2) a strategic competition effect from lowering Q_j^o . Note that the strategic competition effect arises because, as w_i^o decreases, retailer j expects a competitive disadvantage and responds by undercutting procurement. The direct demand expansion effect clearly benefits the manufacturer whereas the strategic competition effect hurts the manufacturer. Hence, the manufacturer has to take both effects into account when choosing the wholesale prices.

However, under unobservability, retailer j does not observe w_i when making its procurement decisions, which means that retailer j 's ordering decision must be independent of w_i ; hence the strategic competition effect disappears. As such, the manufacturer will cut w_i to boost retailer i 's order with no effect on retailer j 's order. The manufacturer's behavior leads, again, to lower wholesale prices, which induces intensified competition between the retailers. As the downstream competition becomes too fierce, the manufacturer suffers. Our analysis shows that, when the

Table 3: Equilibrium strategies under wholesale price contracts

	Observed case		Unobserved case
w_i	$\frac{1}{2}$	\geq	$\frac{2}{4+\theta}$
p_i	$\frac{3+\theta}{4+2\theta}$	\geq	$\frac{3}{4+\theta}$
Q_i	$\frac{1+\theta}{4+2\theta}$	\leq	$\frac{1+\theta}{4+\theta}$
Π	$\frac{1+\theta}{4+2\theta}$	\geq	$\frac{4(1+\theta)}{(4+\theta)^2}$
π_i	$\frac{1+\theta}{4(2+\theta)^2}$	\leq	$\frac{1+\theta}{(4+\theta)^2}$
CS	$\frac{(1+\theta)^2}{4(2+\theta)^2}$	\leq	$\frac{(1+\theta)^2}{(4+\theta)^2}$
SW	$\frac{(1+\theta)(7+3\theta)}{4(2+\theta)^2}$	\leq	$1 - \frac{9}{(4+\theta)^2}$

competition is already fierce (i.e., $\theta > 2$), an increase in θ makes it even tauter and hurts both the manufacturer and retailers alike.

Comparing equilibrium profits under unobservability versus observability, we offer the following corollary.

Corollary 2. *Suppose that the supply chain is contracted through wholesale prices. The manufacturer's (retailers') profit is lower (higher) under unobservability than under observability.*

When rivaling contract terms are not observed, the manufacturer always has an incentive to cut wholesale prices. As a result, the manufacturer is worse off, whereas the retailers are better off thanks to the lowered procurement costs.

5.3 Two-Part Tariff Versus Wholesale Price Contracts

The literature on supply chain management commonly shows that, under observable contracts, retailers make higher profits when contracted through wholesale prices whereas the manufacturer's profit, the channel profit, and social welfare are all higher when contracted through two-part tariffs. But do these insights hold when supply chain contracts are unobservable?

To investigate the above question, we compare the manufacturer's and the retailers' profits under alternative supply chain contracts, assuming that contract terms are unobservable. Proposition 3 summarizes the results.

Proposition 3. *Consider the case of unobserved contracts.*

1. *The manufacturer's profit is higher under wholesale prices when $\theta \geq 2\sqrt{2} \approx 2.828$.*
2. *The retailer's profits are always higher under wholesale prices.*
3. *The total industry profit is higher under wholesale prices when $\theta \geq \sqrt{3} - 1 \approx 0.732$.*

Surprisingly, Proposition 3 shows that, when $\theta \geq 2\sqrt{2}$, wholesale price contracts improve both manufacturer's and retailers' profits, thereby leading to a "win-win" outcome. To explain this, we supplement Proposition 3 by plotting the manufacturer's profits in Figure 3, the retailer's profits in 4, and the total industry profit in Figure 5, all under two-part tariff and wholesale price contracts. When $\theta \rightarrow \infty$, wholesale prices lead to a 100 percent and 200 percent improvement in the manufacturer's profit and total industry profit, respectively. Why does the manufacturer prefer wholesale price contracts over two-part tariff contracts especially when competition becomes intense under contract unobservability?

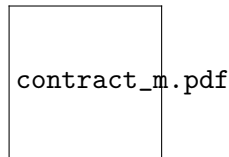


Figure 3: The manufacturer's profit under alternative supply chain contracts

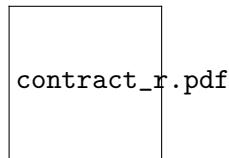


Figure 4: The retailer's profit under alternative supply chain contracts (the retailer's profit is always zero under two-part tariffs)

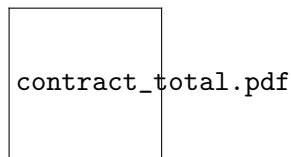


Figure 5: The industry profit under alternative supply chain contracts

When both types of contracts are unobservable, the manufacturer suffers from the following problem: a low marginal wholesale price must be offered to one individual retailer to improve bilateral profits at the expense of the other retailer. As marginal wholesale prices go down, so do the retailers' unit costs, and the two retailers must compete head-to-head on price. When θ is large, fierce competition between the retailers significantly drives down the total industry profit, which also hurts the manufacturer under both types of contracts.

Under two-part tariff contracts, the manufacturer's entire profit is obtained from fixed fees: marginal wholesale prices are always zero and the downstream competition becomes extremely fierce. However, under wholesale price contracts, the manufacturer does not collect fixed fees and, instead, relies on wholesale prices as its sole source of profit. As such, the manufacturer must keep its wholesale prices positive to maintain reasonable margins. In other words, wholesale price contracts help the manufacturer commit to positive wholesale prices, which then raises the retailers' marginal cost and alleviates downstream competition to come back and benefit the manufacturer.

In a decentralized supply chain, simple wholesale price contracts are known to generate a sub-optimal double-marginalization outcome (Tirole, 1988), because prices are too high and demand is too low. One remedy for this problem is to use nonlinear price contracts such as two-part tariffs; with that being said, channel transactions, in practice, are "governed by simple contracts defined only by a per unit wholesale price" (Lariviere and Porteus, 2001). Several explanations have been proposed to reconcile this discrepancy. For example, firms often prefer contracts that are simple to implement (Raju and Srinivasan, 1996). Carroll (2015) argues that a linear contract can maximize the worst-case performance under reasonably general circumstances. Cui, Raju and Zhang (2007) show that simple wholesale price contracts may be preferred when firms have fairness concerns. Meanwhile, Ho and Zhang (2008) experimentally investigate two-part tariff contracts, as well as a quantity discount contract, and find that neither improves channel efficiency more than wholesale price contracts. They also report that loss aversion and bounded rationality can explain the difference in performance between two-part tariff and quantity discount contracts. Yet, the wide adoption of simple wholesale prices suggests that more may be behind this phenomenon.

Our analysis offers an alternative explanation for the prevalence of wholesale price contracts. In reality, supply chain contracts are not always observable. When this is the case, a wholesale price contract can curb the manufacturer's incentive to lower wholesale prices too much, thus alleviating downstream competition and improving the manufacturer's profit. Therefore, channel members must take (un)observability into consideration when choosing the contract form.

As final notes on our exploration of contract unobservability, we first remark that wary beliefs,

another equilibrium refinement criterion proposed by McAfee and Schwartz (1994), generate the same equilibrium outcome as passive beliefs (the Online Appendix offers a definition of wary beliefs and the analysis for this case). The key for the equivalence of the results is the following: under both beliefs, changing the unobserved contract offer of one retailer does not affect the order quantity from the other retailer. Therefore, a retailer always views the contract terms between the manufacturer and the rival retailer as constant.

We also find that our analysis rests on the assumption that the manufacturer can offer discriminatory wholesale prices to competing retailers; as mentioned before, in equilibrium, two retailers always receive the same contract offers, but the manufacturer can offer discriminatory wholesale prices off the equilibrium path. Assume now that discriminatory wholesale prices are forbidden (e.g., by RP): no matter what a retailer receives, it believes that its rival has received the same wholesale price, $w_j = w_i$. Such a belief is exactly the “symmetric belief” defined by McAfee and Schwartz (1994). Straightforward analyses show that, under symmetric beliefs, the manufacturer would raise wholesale prices, and the resulting equilibrium mimics that of the perfect information benchmark discussed in Section 4.

It follows that banning discriminatory wholesale prices has both positives and negatives. On the one hand, it reduces downstream competition, thereby improving channel efficiency and the channel members’ profits. On the other hand, consumers suffer (consumer surplus is lowered), and social welfare is lowered as prices become higher. As such, our results suggest that regulations banning discriminatory wholesale prices can lead to unintended consequences on welfare distribution and market efficiency — key considerations for public policy makers who seek to restrict discriminatory wholesale prices.

6 Extensions

Although our basic model focuses on wholesale price and two-part tariff contracts, various types of contracts are used in actual practice. Under unobservable contract terms, can any other type of contract perform better than these two types of contracts? Furthermore, the basic model’s results are affected by intense downstream competition caused by contract unobservability; however, the degree of the downstream competition can be influenced by retailers’ asymmetric demands, or even eliminated by downstream mergers. When these events happen, how will the results for the basic model be altered? We answer our first question regarding other contract types in Section 6.1, and attempt to answer the latter two questions in Section 6.2 (asymmetric retailers) and Section

6.3 (downstream merger).

6.1 Buyback Contracts

In the basic model, both the manufacturer and retailers prefer wholesale price contracts when the competition is fierce enough. However, even under wholesale price contracts, these firms' profits decline quickly in θ , and completely vanish when $\theta \rightarrow \infty$. It is reasonable to wonder if the channel members can do better under alternative channel contracts.

We find that, when competition is escalated, the manufacturer benefits from a buyback contract, i.e., the manufacturer offers wholesale price contracts to the retailers with the promise to buy back any unsold quantities at the original prices. Figure 6 shows the decision timeline for a buyback contract. On the surface, it seems that buyback contracts are redundant because the current model does not have any demand uncertainty. However, as will be shown later, allowing the retailers to return their unsold products to the manufacturer has substantial effects on the equilibrium outcome.

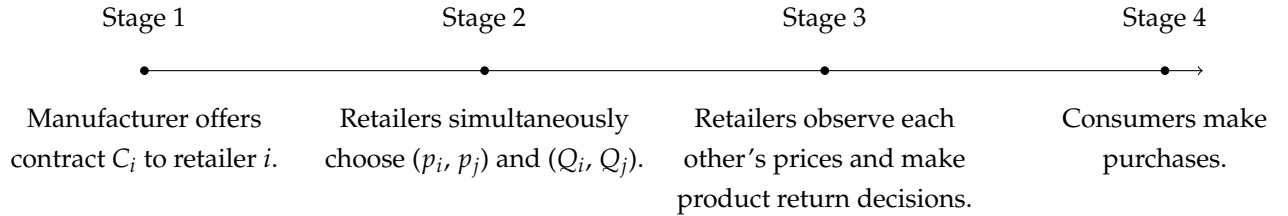


Figure 6: The sequence of events under a buyback contract

Lemma 4. *Consider the unobserved case. Suppose that the supply chain is contracted through buyback contracts. In equilibrium, the wholesale prices are $w_i = w_j = \frac{2(1+\theta)}{4+3\theta}$, the retail prices are $p_i = p_j = \frac{3+2\theta}{4+3\theta}$. The manufacturer's profit is $\Pi = \frac{4(1+\theta)^2}{(4+3\theta)^2}$ and the retailers' profits are $\pi_i = \pi_j = \frac{1+\theta}{(4+3\theta)^2}$.*

Comparing buyback contracts with the wholesale price and two-part tariff contracts, we find that:

Proposition 4. *Consider the unobserved case. We have the following findings.*

- *Compared to wholesale price contracts, buyback contracts always improve the manufacturer's profit, and improve the total channel profit when $\theta \geq 5.4641$.*

- Compared to two-part tariff contracts, buyback contracts improve the manufacturer's profit when $\theta \geq 2.1787$, and improve the total channel profit when $\theta \geq 1.4142$.

Surprisingly, even in the absence of demand uncertainty, buyback contracts help improve the manufacturer's profit. For example, when $\theta \rightarrow \infty$, the manufacturer's profit is zero under both wholesale price and two-part tariff contracts; but, under buyback contracts, the manufacturer still enjoys a profit of $\Pi = \frac{4}{9}$. The rationale for this result is as follows. While the option to return unsold products to the manufacturer does not affect the retailers' profits along the equilibrium path, it does off the equilibrium path. Under wholesale price contracts (without buyback), retailer i orders $Q_i = 1 - p_i + \theta(\tilde{p}_j - p_i)$ units from the manufacturer, and the manufacturer's profit from the retailer, $\Pi_i = w_i Q_i$, is independent of the realization of p_j . In this case, the manufacturer has an incentive to undercut w_j to boost retailer j 's order, which has no effect on Π_i . Now examine the buyback contract: when the manufacturer undercuts w_j , p_j also goes down, and the realized demand is $D_i = 1 - p_i + \theta(p_j - p_i) < Q_i$. And when retailer i returns the unsold units, the manufacturer's profit from retailer i is reduced. In other words, buyback contracts reduce the manufacturer's incentive to cut wholesale prices and, hence, improves its profit. Interestingly, in equilibrium, the return policy is never evoked; nevertheless, the manufacturer benefits from committing to buy back returns from the retailers.

Although the manufacturer's incentive to lower wholesale prices is reduced, it cannot be completely eliminated. Hence, the manufacturer's profit is still lower under contract unobservability with buybacks than under contract observability, which is illustrated in Figure 7.

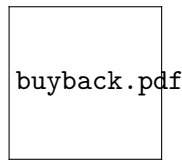


Figure 7: The manufacturer's profit under buyback contracts

6.2 Asymmetric Retailers

Our basic model assumes that the two retailers are symmetric in terms of their demand, a restrictive assumption given that retail demands are often asymmetric among retailers. In fact, Ingene and Parry (1995) show that asymmetry between retailers may affect channel coordination negatively.

To model asymmetric retail demands, we suppose that the two retailers' demands are given by $D_i = 1 - p_i + \theta(p_j - p_i)$, and $D_j = 1 + \Delta - p_j + \theta(p_i - p_j)$. Our basic model is, therefore, a special case in which $\Delta = 0$. In practice, retailers' demands may not be symmetric for multiple reasons, e.g., different service capabilities or geographic locations. Again, we solve the supply chain model under wholesale price and two-part tariff contracts respectively and arrive at the following lemma:

Lemma 5. *Consider the case of asymmetric retail demands. When the supply chain is contracted through wholesale prices or two-part tariffs, in equilibrium, the contracts can be explicitly characterized. Results are included in the Online Appendix.*

We then compare the manufacturer's profits under alternative contracts and summarize the results in the following proposition:

Proposition 5. *Consider a manufacturer selling through two asymmetric retailers with unobservable contract terms. When the competition between the two retailers is fierce enough, the manufacturer's profit is higher under wholesale prices.*

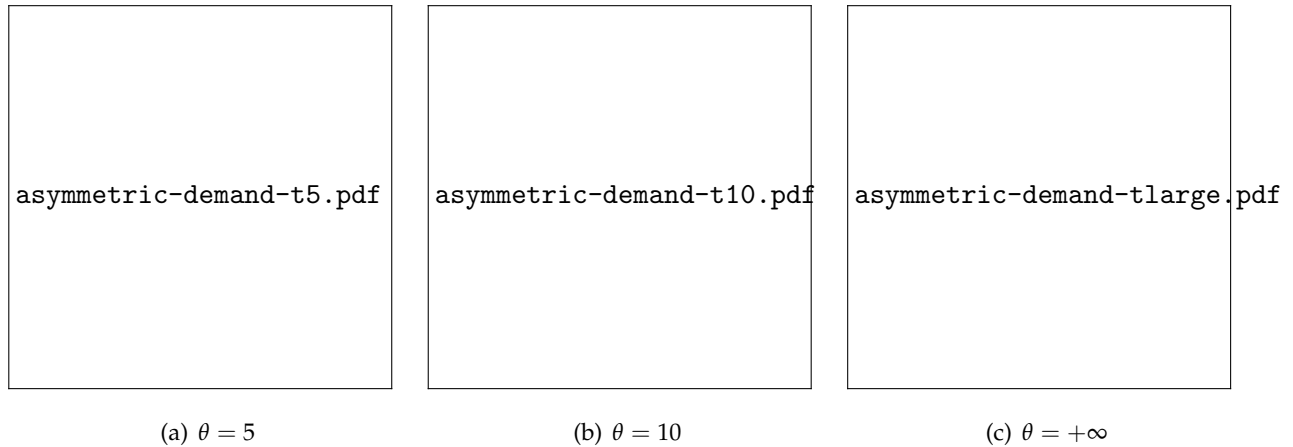


Figure 8: The profitability of wholesale price contract under asymmetric demands (r denotes the relative profit improvement of wholesale price over two-part tariff contracts)

To further illustrate demand asymmetry's effect on the profitability of wholesale prices, in Figure 8 we plot the manufacturer's profit improvements at different levels of competition, where r is the ratio of how much profits improved under wholesale-price contracts versus two-part tariff contracts. Consistent with the basic model, the manufacturer prefers wholesale price contracts over two-part tariff contracts when θ is large.

Figure 8 illustrates another interesting result: the (relative) profitability of wholesale price is highest when the two retailers have symmetric demand (i.e., $\Delta = 0$) and, reversely, lower when $|\Delta|$ becomes larger. This is because, when $|\Delta|$ becomes larger, the retailers become more differentiated, which reduces the downstream competition. As competition becomes less fierce, the role of wholesale price contracts in alleviating downstream competition becomes less valuable.

6.3 Downstream Merger

In the basic model, we show that unobservability often hurts the manufacturer because it intensifies downstream competition beyond which the manufacturer would prefer. However, retailer mergers are commonly known to reduce competition. How, then, do retailer mergers affect channel equilibrium under unobservable contract terms?

In recent years, downstream mergers have drawn considerable attention from policymakers, antitrust authorities and economists (Symeonidis, 2010). While antitrust authorities are unlikely to approve mergers that lead to price increases, merging firms often argue that they can achieve cost savings through a merger, which, in turn, will be passed on to consumers (Cho and Wang, 2016). Antitrust agencies seem to view such cost savings positively (U.S. Department of Justice/Federal Trade Commission, 2010). This goes to uphold common wisdom, which states that downstream mergers are anticompetitive, and empower retailers but reduce the power of the upstream firm. As a result, a downstream merger will hurt the manufacturer's profit. This intuition indeed holds under contract observability — the manufacturer never benefits from its two downstream retailers merging. But would these results continue to hold when supply chain contracts are unobservable?

After a merger, one monopoly retailer manages both retail outlets and sets both retail prices, p_i , and p_j for two outlets (note that our results are not qualitatively altered when the merged retailer charges a uniform price for both retail outlets). Under two-part tariff contracts, the manufacturer offers the merged retailer a single price schedule (K, w) , where K is the fixed fee and w is the marginal wholesale price. If the merged retailer accepts the contract, the retailer pays the fixed fee and then chooses p_i and p_j to maximize the total retail profit from both retail outlets. We solve the game, which resulted in the following lemma:

Lemma 6. *Suppose that the supply chain is contracted through two-part tariffs. After the downstream merger, in equilibrium, the manufacturer offers a contract $(\frac{1}{2}, 0)$ to the retailer. The retailer charges at $p_i = p_j = \frac{1}{2}$. The manufacturer's profit is $\Pi = \frac{1}{2}$ whereas the retailer's profit is $\pi = 0$.*

Comparing these equilibrium results to those of the basic model, we find that the manufacturer

again charges the marginal wholesale price at the marginal cost. However, because the retailers are merged, the manufacturer now makes a higher profit through a higher fixed fee. In the basic model, the downstream retailers (under unobservability) compete for consumers too fiercely, which reduces the manufacturer's profit. In this sense, the manufacturer prefers less intense competition. But when the downstream merger completely eliminates competition in the consumer market, industry profit rises. The manufacturer, extracting the entire industry profit through the fixed fee, also benefits from the elimination of downstream competition and makes a higher profit.

Now, as for wholesale price contracts, we offer the following lemma:

Lemma 7. *Suppose that the supply chain is contracted through wholesale prices. After the downstream merger, in equilibrium, the manufacturer charges the retailer $w = \frac{1}{2}$. The retailer charges at $p_i = p_j = \frac{3}{4}$. The manufacturer's profit is $\Pi = \frac{1}{4}$ whereas the retailer's profit is $\pi = \frac{1}{8}$.*

A direct comparison between Lemma 7 and the basic model reveals an important finding: compared to the basic model in which the retail outlets are independently run, the manufacturer now charges a higher wholesale price ($\frac{1}{2} > \frac{2}{4+\theta}$), starkly challenging the conventional belief that "a downstream merger will reduce the price charged by the manufacturer" (Symeonidis, 2010). This is because a downstream merger removes the issue of unobservability, allowing the manufacturer to charge a higher wholesale price.

Next, we have the following proposition regarding equilibrium profits:

Proposition 6. *Under wholesale prices, the manufacturer and retailers benefit from a downstream merger when $\theta > 8$.*

Proposition 6 suggests that the effect of a downstream merger is ambiguous when the supply chain is contracted through wholesale prices: the manufacturer can benefit from a downstream merger when the competition is fierce enough, i.e., $\theta > 8$. Note that the role of a downstream merger under contract unobservability is two-fold: First, the downstream merger can have competitive consequences such as empowering the downstream retailer, increasing retail margins, and worsening double marginalization. Second, the downstream merger can have informational consequences: eliminating unobservability and raising the wholesale price by preventing the manufacturer from setting prices too low. While the former role hurts the manufacturer, the latter works to its benefit. When $\theta < 8$, the former role dominates, leaving the manufacturer worse off. When $\theta > 8$, the latter role prevails, benefiting the manufacturer from the merger.

Given these analyses, a downstream merger is not necessarily detrimental to the manufacturer when supply chain contracts are unobservable. In fact, under two-part tariff contracts, a

downstream merger always benefits the manufacturer more than the basic model would. Under wholesale price contracts, for intense downstream competition, the manufacturer may still benefit from a merger which helps alleviate downstream competition.

Our analysis suggests that the anti-competitive consequences of a downstream merger may be more pronounced than previously known. For example, suppose that $\theta = 1$ and that the supply chain is contracted through wholesale prices. Ignoring cost savings, when contract terms are observable, a downstream merger leads to a 12.5 percent increase in retail prices. When contract terms are unobservable, a downstream merger leads to a 25 percent increase in retail prices. In short, a downstream merger not only reduces downstream competition at the retail level but also strengthens the manufacturer's market power and increases wholesale prices, which ultimately affects consumers. As such, antitrust authorities must evaluate the downsides of downstream mergers more carefully, even when they can generate appealing cost savings.

7 Conclusions

Most of the existing literature on supply chain contract assumes that contract terms are public information in the market. However, under certain circumstances, contract terms may only be observed by the firms signing their respective contracts and remain unobserved by other parties. To resolve this discrepancy, we study the unobservability of contracts. We consider how contract unobservability affects the manufacturer's preference between wholesale price and two-part tariff contracts. We find that certain accepted thoughts about the comparison between wholesale price and two-part tariff contracts do not necessarily hold. When contract terms are observable, the manufacturer always makes a higher profit under two-part tariff contracts than under wholesale price contracts. However, when contract terms are unobservable, both the manufacturer and retailers may prefer wholesale price contracts to two-part tariff contracts. Under two-part tariff contracts, the manufacturer always has an incentive to offer one retailer a lower unit selling price to increase bilateral profits at the expense of the other retailer. This drives the unit price of two-part tariff contracts down to the marginal cost and induces extremely fierce price competition among the retailers. As we show, this fierce competition backfires on the manufacturer's profit. Under wholesale price contracts, the marginal wholesale price is the manufacturer's sole source of profit. Therefore, the manufacturer has to charge a higher price to guarantee a positive margin. This passes down to retail prices, resulting in milder downstream competition. Hence, when contract terms are unobservable, both the manufacturer and retailers can benefit from alleviated compe-

tition and earn higher profits under wholesale price contracts than they would under two-part tariff contracts.

We also extend the basic model to various situations such as buyback contracts, asymmetric retailers, and downstream mergers. Our main result remains robust but we also arrive at several more intriguing results. For example, we find that an appropriately designed buyback contract can reduce the manufacturer's incentive to cut wholesale prices and, hence, improve its profit. Compared with wholesale price and two-part tariff contracts, buyback contracts can also improve the total channel profit when the downstream competition is fierce enough. We also find that contract unobservability can fundamentally change the manufacturer's attitude towards a downstream merger. When the contract terms are observable, the manufacturer is harmed by downstream mergers due to reduced competition between the retailers. However, when contract terms are unobservable, the manufacturer can benefit from the alleviated downstream competition; in such a case, both the manufacturer and retailers may come to favor a downstream merger. It is also noteworthy that the downstream merger can raise the wholesale price, defying the conventional belief that a downstream merger reduces the wholesale price under contract observability.

Our analysis can benefit firms and public policy makers in a multitude of ways. Our results suggest that, in situations where contract terms are unobservable to competing retailers, channel members should choose wholesale price contracts when the downstream competition is fierce. When contracted through wholesale prices, manufacturers can offer buyback options to retailers and alleviate the negative consequences of contract unobservability. Our results also show that banning discriminatory wholesale pricing and downstream mergers can benefit manufacturers but hurt consumers. Public policy makers must take these effects into consideration when implementing related regulations.

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