The Bright Side of Inequity Aversion

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Abstract

Modern consumers are concerned about not only their material payoff but also the fairness of the transaction when making purchasing decisions. In this paper, we investigate how consumers' inequity aversion affects a manufacturer who sources inputs from upstream suppliers. We find that, when the manufacturer sources from a single supplier or when consumers observe the manufacturer's cost, inequity aversion hurts both the supplier's and manufacturer's profits. However, when the manufacturer sources from multiple suppliers and consumers do not observe the manufacturer's cost, inequity aversion reduces both the suppliers' and manufacturer's margins, which significantly alleviates the double marginalization problem, increases consumer demand and improves channel efficiency. As a result, inequity aversion benefits the suppliers, manufacturer, and consumers alike, leading to a "win-win-win" outcome. By comparing cases in which consumers observe and do not observe the manufacturer's cost, we also find that, when faced with inequity-averse consumers, a manufacturer may find it optimal to withhold its cost information to help secure lower procurement costs from upstream suppliers.

Keywords: Inequity aversion, pricing, cost disclosure, procurement.

1 Introduction

It has long been documented that, during social interactions, market participants value fairness, defined as the preference for balanced, equitable outcomes for all parties involved. Substantial evidence suggests that, when purchasing a product, consumers frequently compare their payoffs with the seller's profit to determine whether or not the transaction is fair (Kahneman et al., 1986; Bolton et al., 2003). As Bolton et al. (2003) state:

> *"Some people are convinced, for example, that pharmaceutical companies make obscenely high profits on patent-protected drugs, that gasoline prices are exorbitant and determined more by industry collusion than market forces, that restaurants gouge patrons by selling wine at exorbitant prices... There is a general perception that prices are unfair, and that companies — not just retailers, but firms in general — make a lot of profit"* (see also Wharton 2002).

When fairness comes into play, consumers are even willing to sacrifice their own material payoffs to penalize firms for setting inequitable prices. It is not uncommon to see, for instance, consumers responding to firms' price-gouging behavior by boycotting them and their products (Fehr and Schmidt, 1999).

For such fair-minded consumers, their utility gained corresponds directly with the inequality they perceive during their transaction, i.e., the more perceivable the inequality, the lower their willingness to purchase. This rejection, called inequity aversion, affects consumers' purchasing decisions, which firms must take into account when determining their product or service pricing and making marketing decisions. For instance, high prices not only reduce an inequity-averse consumer's material payoff but also raise their perception of price unfairness, resulting in lower purchase intentions and demand. In anticipation of this, a firm could restrict itself from setting high prices — such constraints on a firm's strategy space have typically been considered to negatively affect its profitability (Kuksov and Wang, 2014).

Extant literature has established that fairness concerns directly affect consumers' utility and demand, which encourages, if not forces, firms to set "fair" prices (Bolton and Ockenfels, 2000; Guo, 2015; Guo and Jiang, 2016). However, concerns surrounding price fairness may also affect other decisions. For instance, within many industries, manufacturers often source inputs from upstream suppliers to assemble final products that they then sell to consumers. In such cases, consumers' concerns with fairness may not only influence the final retail price that the manufacturer charges but also its procurement cost, which is endogenously determined by its upstream suppliers.

We observe in practice that upstream firms (i.e., suppliers or manufacturers) are influenced by the inequity aversion of end consumers. The Organization of the Petroleum Exporting Countries (OPEC), for example, often stresses the importance of setting fair prices for crude oil: Saudi Arabia's Foreign Minister, Prince Faisal bin Farhan, said in March 2021 that OPEC was looking for an oil price that "*is fair to consumers and to producers*" (Slav, 2021). Meanwhile, in the UK, consumer goods manufacturer Unilever increased its price by 10 percent on dozens of brands after Brexit, a move that was not only heavily criticized by shoppers as "outrageous" and "exploiting customers" but also rejected by downstream retailers (e.g., Tesco). Unilever ultimately decided to withdraw its price rise (Linning et al., 2016; Diao et al., 2019).

In this paper, we attempt to address the following research questions: How should a manufacturer adjust its prices to respond to consumers' inequity aversion? How does consumers' inequity aversion affect suppliers' prices and, hence, the manufacturer's procurement cost? How does inequity aversion affect the suppliers' and manufacturer's profits as well as consumer surplus?

A critical factor that must be considered when answering these questions is the transparency of a firm's costs. More often than not, consumers do not know a firm's actual costs and, thus, must establish beliefs about them, which, in turn, affect their perception of price fairness (Bolton et al., 2003). Firms, on the other hand, can influence consumers' beliefs by disclosing their cost information, from which consumers can determine the fairness of a price. For instance, Bearden et al. (2003) show that consumers' perceived fairness of a price offer is substantially higher when they see a high invoice amount (i.e., a high seller cost) than a low invoice amount. Without this knowledge, consumers must form beliefs about the firm's costs and estimate fairness. In that sense, how a firm's cost disclosure affects its own and its suppliers' profitability also deserves examination.

To explore how consumers' inequity aversion affects firm profitability, we develop a game-theoretic model in which a downstream firm (i.e., manufacturer) sources inputs from upstream suppliers and assembles them into a final product that is sold to end consumers who suffer a psychological disutility from a transaction that is perceived to be unfair. We then compare equilibrium outcomes when consumers observe and do not observe the manufacturer's cost, which offers insights into whether or not a manufacturer should disclose its cost information to consumers.

According to the model characteristics, we make a number of noteworthy observations. First, we find that, in line with the existing literature, intensified inequity aversion reduces consumers' transaction utility and decreases demand. In anticipation of this, the manufacturer must distort its price down to compensate for consumers' psychological loss, which, as can be expected, hurts the manufacturer.

Second, consumers' inequity aversion can significantly affect the manufacturer's procurement cost when consumers do not observe that cost. When consumers observe that cost, demand is less sensitive to the manufacturer's cost, and inequity aversion has limited impacts on the suppliers' pricing decisions. But, when consumers do not observe the manufacturer's cost, they must rely on their beliefs to justify the fairness of an offered price. We consider two types of off-equilibrium beliefs, passive beliefs and linear beliefs, as well as a mixture of the two. Under passive beliefs, consumers who observe an off-equilibrium retail price believe that the suppliers followed their equilibrium strategies while the manufacturer unilaterally deviated, and their belief of the manufacturer's cost is a constant. Under linear beliefs, however, consumers believe that the suppliers deviated while the manufacturer acted optimally against that deviation, and their belief of the manufacturer's cost is linear to the retail price. We further apply the Pareto-dominance criterion and select the equilibrium outcome under passive beliefs. We find that, under passive beliefs, demand becomes more sensitive to the manufacturer's actual cost, meaning suppliers must be the ones to reduce their prices. This, of course, lowers the manufacturer's procurement cost.

Third, we find that, when consumers observe the manufacturer's cost or when the manufacturer sources from a single supplier, inequity aversion always leaves the supplier(s) and manufacturer worse off since inequity aversion leads to a deadweight loss that reduces both consumer value and demand. Interestingly, when consumers do not observe the manufacturer's cost and the manufacturer sources from multiple suppliers, inequity aversion improves the profits of all firms involved. This is because inequity aversion forces both the suppliers and manufacturer to reduce their margins, thereby alleviating the issue of double marginalization. When multiple suppliers are involved, this effect dominates the loss incurred from consumers' reduced transaction utility, benefiting all firms and consumers alike.

Finally, we compare the equilibrium outcomes of scenarios in which consumers do and do not observe the manufacturer's cost. Our results show that the manufacturer's profit can be higher when consumers do not observe its cost. This result explains why manufacturers in practice often withhold their cost information to consumers, which will then help them secure lower procurement costs from their upstream suppliers. Interestingly, when a manufacturer sources from multiple suppliers, the suppliers can also be better off when the manufacturer withholds its cost information. Nonetheless, when the suppliers make the disclosure decision, they always choose to disclose their output prices (i.e., the manufacturer's cost), thereby leading to a form of the prisoner's dilemma.

2 Literature Review

This study contributes to the growing literature on how fairness affects firms' marketing decisions and consumers' purchasing decisions. Fehr and Schmidt (1999) first model "inequity aversion", suggesting that consumers experience a psychological disutility when receiving a payoff that is different from those of others. They argue that disadvantageous inequity affects consumers more than advantageous inequity does; in particular, concerns with fairness that depend on the payoffs of peers are categorized as "peer-induced fairness", while those that depend on the payoffs of other economic agents (e.g., firms) are categorized as "distributional fairness" (Ho and Su, 2009).

In marketing, Cui et al. (2007) consider a distribution channel in which channel members are concerned with fairness and show that firms can coordinate the channel using a simple linear wholesale price. We differ from their study by employing differing channel structures and, most importantly, considering consumers' fairness concerns as opposed to those of the firms. Chen and Cui (2013) incorporate consumers' concerns of peer-induced price fairness into a model of market competition, showing that firms may prefer uniform pricing over nonuniform pricing for their branded variants. Meanwhile, Guo (2015) investigates a setting in which a firm sells a product with an uncertain variable cost to consumers who are concerned about distributional fairness and shows that the firm's ex ante profit can increase as more buyers become inequity averse. The key differences between this study and our work are as follows. First, in Guo (2015), the firm's cost is exogenous and stochastic, while in our work, the firm's cost is endogenously set by its upstream suppliers, rendering our mechanisms completely different. Second, Guo (2015) focuses on the segment size of inequity-averse consumers, whereas we focus on consumers' degree of inequity aversion, ultimately showing that firm profits can increase with consumer inequity aversion. Guo and Jiang (2016) examine how consumers' inequity aversion affects competing firms' pricing and quality decisions, showing that, when consumers are uncertain about the firms' costs, the optimal quality may be nonmonotone with consumers' degree of inequity aversion. Moreover, stronger inequity aversion can hurt an inefficient firm and benefit an efficient firm. Li and Jain (2016) consider behavior-based pricing when consumers are concerned with peer-induced fairness and find that, when their fairness concerns are intense enough, behavior-based pricing can improve the profits of competing firms. Finally, Allender et al. (2021) discover that, when consumers are fair-minded, firms may engage in price obfuscation to mitigate fairness concerns.

Our study is also related to the literature on distribution channel management, which has long established that a decentralized distribution channel suffers from the issue of double-marginalization (Spengler, 1950; Jeuland and Shugan, 1983) and also that standard marketing decisions are often distorted in a decentralized channel. For instance, Villas-Boas (1998) suggests that a firm must distort its product line design in a decentralized channel; especially, for low-end products, product quality should be significantly distorted down. Bhargava (2012) investigates product bundling in a distribution channel and shows that the retailer is less willing to offer bundles when the manufacturer charges a sufficiently high wholesale price. Li et al. (2019) show that channel members have misaligned preferences for consumer deliberation and empowerment. Our work suggests that inequality aversion always hurts the seller in a centralized channel; however, all firms may benefit from consumers' inequity aversion in a decentralized channel since inequity aversion alleviates the issue of double marginalization and ultimately improves channel efficiency.

3 The Model

The Firms. Consider a downstream firm that sources inputs from K independent upstream firms, denoted by $j = 1, \ldots, K$.[1] We refer to the downstream firm as the manufacturer and the upstream firms as the suppliers, and the inputs can represent both physical

[1] Here, the number of suppliers, K, is exogenously given. If the manufacturer can choose the number of suppliers to contract with, it always chooses to contract with as few suppliers as possible.

and nonphysical supplies such as raw materials, components, hardware and software, patents, designs, and service (Guo, 2020). We assume that the inputs are independent of each other so that there is no direct competition among the suppliers. The manufacturer assembles the inputs into a final product (or service) and sells it to consumers.

Procuring from multiple suppliers is a common business practice (Guo, 2020). For instance, PC manufacturers procure a wide variety of inputs (e.g., microprocessors, memory chips, monitors, motherboards, and software) from various suppliers. Motorcycle manufacturers also procure a number of inputs (e.g., engines, transmissions, and suspensions) from different suppliers. Likewise, manufacturers of Wi-Fi routers procure inputs (e.g., routing processors, memories, patents, and software) from multiple suppliers.

For simplicity, we assume that producing a unit of final product requires a unit of each input j. Let c_j denote the manufacturer's unit procurement cost for material j and $c = \sum_j c_j$ denote its aggregate unit procurement cost. The suppliers' marginal production costs are normalized to zero without loss of generality. The manufacturer's marginal cost of assembling the inputs into final products is also normalized to zero.[2] This normalization is without loss of generality and does not affect our results. In line with the literature (Guo, 2015; Guo and Jiang, 2016), we assume that the manufacturer's fixed cost is sunk and does not affect consumers' inequity aversion.[3]

Following Guo (2015) and Guo and Jiang (2016), we assume that both the suppliers and the manufacturer make decisions to maximize their respective profits, which allows us to focus on the strategic effect of consumers' inequity aversion without muddying the waters through other effects that are not the focus of this paper.

The Consumers. The market consists of a unit mass of consumers, each of whom has a unit demand for the manufacturer's product. We assume that consumer valuations for

[2]It can be verified that the manufacturer's profit is maximized when its marginal cost of manufacturing is zero.

[3]The assumption that consumers do not take the firm's fixed cost into consideration is supported by the behavioral literature. Bolton et al. (2003) show that consumers' fairness concerns are affected mainly by direct costs (e.g., materials, procurement), but not indirect costs (e.g., rent, labor, promotion). Nunes et al. (2004) find that consumers' willingness to purchase is more responsive to variable costs than to fixed costs.

the product, v_i, follow the uniform distribution over the unit interval, i.e., $v_i \sim U[0,1]$. Thus, if the manufacturer sells to consumers at retail price p, consumer i obtains a material payoff of $v_i - p$ from the transaction. Note that in our model, there are no demand uncertainties. Our results will not be qualitatively changed when consumer demand is stochastic.

In addition to their material payoffs, consumers are also concerned about the equity of their transactions, meaning they take fairness into account when making their purchasing decisions. Following the literature (Fehr and Schmidt, 1999; Ho et al., 2014; Guo, 2015), we assume that a consumer with valuation v incurs a psychological disutility

$$S(v, p, c) = \lambda \cdot ((p - c) - (v - p)) \tag{1}$$

when purchasing the product at price p, where $\lambda \geq 0$ captures the degree of inequity aversion. The consumer makes a purchase if and only if her transaction utility is non-negative, i.e., if $v - p - S(v, p, c) \geq 0$. In (1), $p - c$ is the manufacturer's profit from the transaction while $v - p$ is the consumer's material payoff; in other words, a consumer perceives the transaction to be unfair when the manufacturer's profit margin is greater than her own material payoff. The outside option (i.e., no-purchase) renders a payoff zero to the consumer.

Note that, while we focus on a scenario in which a manufacturer procures from suppliers and sells to consumers, our model also accommodates other interpretations. For example, when $K = 1$, our model applies to a setting in which a manufacturer sells a product to consumers through a retailer, and consumers suffer a psychological disutility when that retailer makes an unreasonably high share of profit.

Information Structure. We consider two alternative information structures of the game, depending on whether or not consumers observe the manufacturer's cost.

Under the *transparency regime*, the manufacturer discloses its procurement cost to consumers so that they can observe c; as long as consumers observe c, it does not matter whether or not they observe c_j for each input j. Under the *non-transparency regime*, the manufacturer withholds its cost information so that consumers do not observe the cost of each input or the aggregate cost, c, for the final product. And, because consumers do not observe c, they also do not know the manufacturer's profit margin. In this case, consumers rely on $\tilde{c}$, their rational expectations of c, to infer the manufacturer's profit margin and estimate their psychological disutility arising from inequity aversion.[4] In equilibrium, consumers' belief must be fulfilled; that is, $\tilde{c} = c$ must hold in equilibrium but not necessarily so off the equilibrium path (Guo, 2015; Hajihashemi et al., 2020). We then compare the equilibrium outcomes in the two regimes to evaluate the effect of cost disclosure on the suppliers' and manufacturer's profits and consumer surplus.

Sequence of the Game. The game consists of three stages. In the first stage, taking other suppliers' prices c_{-j} as given, supplier j sets a price c_j for an output that will maximize its profit. In the second stage, after observing c_j's, the manufacturer procures inputs from upstream suppliers and assembles them into a final product and then decides the final product's price p to maximize its profit.[5] In the third stage, consumers observe the price p. They also observe the manufacturer's cost c under the transparency regime but not under the non-transparency regime. According to the information they gain, consumers make their purchase decisions.

[4]Using lab experiments, Allender et al. (2021) show that consumers can form rational beliefs and use them to calculate the disutility that arises from inequity aversion.

[5]Here, we make an implicit assumption that all the suppliers are monopolists of their respective outputs and that the manufacturer is a price taker. This assumption is not essential to our results: Our main results hold so long as *some* suppliers have monopolistic pricing power. Consider a manufacturer sourcing K_1 inputs from monopolistic suppliers and K_2 inputs from competitive markets: Under perfect competition, the K_2 inputs will be priced at marginal costs and do not affect our analysis, and the game is equivalent to one with only $K = K_1$ monopolistic suppliers.

4 Model Analysis Under Cost Transparency

We begin with the transparency regime under which the manufacturer discloses its procurement cost c_t to consumers. Here, we use subscript t to represent the transparency regime.

Because consumer i observes c_t directly, she will make a purchase if and only if her transaction utility is nonnegative, i.e., when

$$v_i - p_t - S(v_i, p_t, c_t) \geq 0.$$

Solving for the consumer's purchasing decision, we find that she buys whenever $v_i \geq \hat{v}_t$, where the indifference condition is characterized by

$$\hat{v}_t = p_t + \frac{\lambda}{1+\lambda}(p_t - c_t). \quad (2)$$

It follows that as consumers become increasingly inequity-averse, total consumer demand ($D = 1 - \hat{v}_t$) decreases.

The intuition for this result is as follows: High-valuation consumers (i.e., consumers with valuations $v \geq 2p_t - c_t$) enjoy a high material payoff from their transactions and their demand is unaffected. Low-valuation consumers (i.e., $v \leq 2p_t - c_t$), on the other hand, perceive the transaction to be unfair and are only willing to purchase when their material payoff is greater than the psychological cost that arises from their inequity aversion. As λ increases, they become more inequity-averse and perceive the transaction to be more unfair, thus becoming reluctant to buy. As a result, their demand decreases as does the total consumer demand.

Consider now the manufacturer. It chooses the retail price p_t, which maximizes its profit:

$$\pi_t = (p_t - c_t)(1 - \hat{v}_t).$$

Then, the manufacturer's optimal price is

$$p_t = \frac{1 + c_t + \lambda + 3c_t\lambda}{2 + 4\lambda}, \tag{3}$$

and the corresponding consumer demand is given by

$$D_t = 1 - \hat{v}_t = \frac{1 - c_t}{2}. \tag{4}$$

It follows immediately that consumer demand D_t does not depend on λ, i.e., $\frac{\partial D_t}{\partial \lambda} = 0$. In other words, from the suppliers' perspective, inequity aversion does not affect the demand for the product with an endogenized retail price p.

This is because, as inequity aversion grows, low-valuation consumers become reluctant to make purchases and, in anticipation of this, the manufacturer cuts down its retail price to compensate for consumers' psychological loss. In equilibrium, the manufacturer's price cut exactly offsets the increased inequity aversion, which leaves consumer demand unchanged. Put differently, the manufacturer completely absorbs the effect of inequity aversion through its lowered retail price.

Table 1: Equilibrium Outcome

	Transparency Regime	Non-transparency Regime		
		Passive Beliefs	Linear Beliefs	Mixture of Beliefs
c	$\frac{K}{1+K}$	$\frac{K(1+\lambda)}{1+K+(2+K)\lambda}$	$\frac{K}{1+K}$	$\frac{K(1+\lambda)}{1+K+\lambda+K\lambda+\lambda\psi}$
p	$\frac{1+2K+\lambda+4K\lambda}{2(1+K)(1+2\lambda)}$	$\frac{(1+\lambda)(1+2K)}{2(1+K+(2+K)\lambda)}$	$1-\frac{1}{2(1+K)}$	$\frac{(1+2K)(1+\lambda)}{2(1+K+\lambda+K\lambda+\lambda\psi)}$
D	$\frac{1}{2(1+K)}$	$\frac{1+2\lambda}{2(1+K+(2+K)\lambda)}$	$\frac{1}{2(1+K)(1+\lambda)}$	$\frac{1+2\lambda\psi}{2(1+K+\lambda+K\lambda+\lambda\psi)}$
Π_j	$\frac{1}{2(1+K)^2}$	$\frac{(1+\lambda)(1+2\lambda)}{2(1+K+(2+K)\lambda)^2}$	$\frac{1}{2(1+K)^2(1+\lambda)}$	$\frac{(1+\lambda)(1+2\lambda\psi)}{2(1+K+\lambda+K\lambda+\lambda\psi)^2}$
π	$\frac{1+\lambda}{4(1+K)^2(1+2\lambda)}$	$\frac{(1+\lambda)(1+2\lambda)}{4(1+K+(2+K)\lambda)^2}$	$\frac{1}{4(1+K)^2(1+\lambda)}$	$\frac{(1+\lambda)(1+2\lambda\psi)}{4(1+K+\lambda+K\lambda+\lambda\psi)^2}$
CS	$\frac{1+\lambda}{8(1+K)^2}$	$\frac{(1+\lambda)(1+2\lambda)^2}{8(1+K+(2+K)\lambda)^2}$	$\frac{1}{8(1+K)^2(1+\lambda)}$	$\frac{(1+\lambda)(1+2\lambda\psi)^2}{8(1+K+\lambda+K\lambda+\lambda\psi)^2}$

Lastly, we examine the suppliers' pricing decisions for their outputs. Supplier j chooses

c_{jt} to maximize its profit

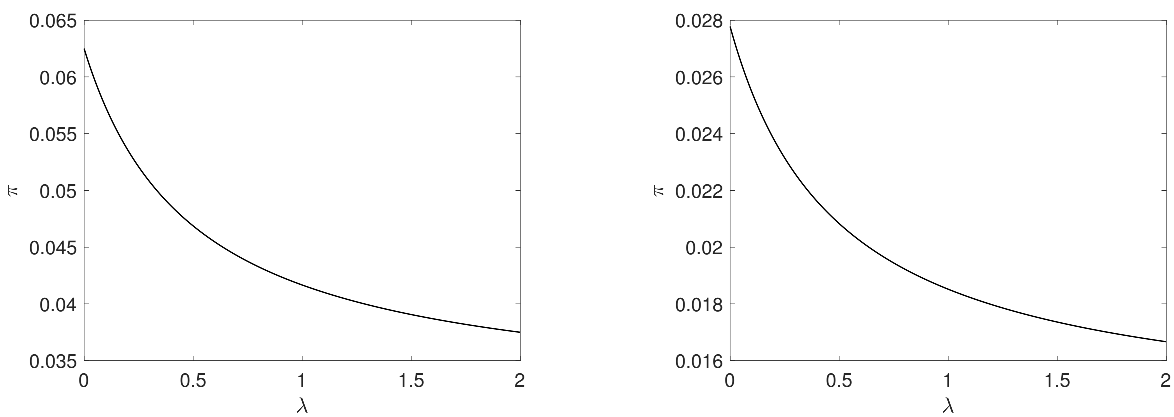
$$\Pi_{jt} = c_{jt} D_t = c_{jt} \cdot \frac{1 - (c_{jt} + c_{-jt})}{2},$$

where $c_{-jt} = \sum_{k \neq j} c_{kt}$ is the total price charged by all other suppliers. We solve for the equilibrium outcome and summarize the results in Table 1.

As for the firms' profits, we have the following proposition.

Proposition 1 *Suppose that the manufacturer discloses its cost information. In equilibrium, the suppliers' prices and their profits are constant with λ whereas the manufacturer's retail price and profit decrease with λ. Consumer surplus, by contrast, increases with λ.*

This proposition suggests that both the suppliers' prices (hence, the manufacturer's procurement cost) and their profits are constant with λ. This result arises because, as mentioned earlier, the manufacturer completely absorbs the effect of inequity aversion through its retail price p_t and, therefore, the suppliers need not to take inequity aversion into account when setting their prices.



(a) $K = 1$ (b) $K = 2$

Figure 1: The effect of inequity aversion on the manufacturer's profit in the transparency regime

The manufacturer's margin and profit, however, decrease with λ since increased inequity aversion forces the manufacturer to lower its retail price. Figure 1 illustrates this result.

Lastly, consider the effects of stronger inequity aversion on consumers. First, stronger inequity aversion reduces low-valuation consumers' transaction utility and harms them. Second, stronger inequity aversion increases high-valuation consumers' transaction utility and benefits them. Third, as the manufacturer reduces its price in response to an increase in λ, all consumers benefit. Overall, the latter two effects dominate the first effect, and consumers are collectively better off with stronger inequity aversion.

5 Model Analysis Under Cost Non-transparency

Next, we consider the non-transparency regime in which the manufacturer withholds its cost information. In this case, consumers do not observe the cost of each input c_j or the manufacturer's unit cost c and, as such, must rely on $\tilde{c}$, their belief of c, to infer the manufacturer's profit margin.

We resort to a perfect Bayesian equilibrium as our solution concept. Letting $d_i \in \{0, 1\}$ denote consumer i's purchase decision, we define our equilibrium as follows:

Definition 1 *A perfect Bayesian equilibrium of the above imperfect information game consists of a strategy profile $\sigma = \{c, p, d\}$ and a belief $\tilde{c}$ such that:*

- *Consumer i makes a purchase ($d_i = 1$) if and only if her perceived transaction utility is nonnegative, i.e., $v_i - p - S(v_i, p, \tilde{c}) \geq 0$.*[6]
- *p maximizes the manufacturer's profit given its cost c and consumers' strategy d.*[7]
- *$c_j = c_j^*$ maximizes supplier j's profit given the other suppliers' input price c_{-j}^*, the manufacturer's strategy p, and consumers' strategy d.*
- *In equilibrium, consumers' belief is correct, i.e., $\tilde{c} = c^*$ holds in equilibrium.*

[6]Here, the retail price may be off-equilibrium, i.e., we allow $p \neq p^*$.
[7]Here, the manufacturer's cost may be off-equilibrium, i.e., we allow $c \neq c^*$.

Note that a perfect Bayesian equilibrium does not place restrictions on beliefs off the equilibrium path. Within our context, a consumer is free to update her belief $\tilde{c}$ upon receiving an off-equilibrium price $p \neq p^*$, and the equilibrium outcome hinges on how we specify off-equilibrium beliefs.

Here, instead of using the refinement criteria (e.g., the intuitive criterion) for exogenous signaling games in which the sender's unobserved type is exogenously drawn by nature instead of being endogenously determined, we follow and generalize the literature on games of imperfect information and consider two refinement criteria: *Passive beliefs* and *linear beliefs* (McAfee and Schwartz, 1994; Janssen and Shelegia, 2015; Gaudin, 2019; Li and Liu, 2021).[8] Roughly speaking, under passive beliefs, a consumer, upon receiving an off-equilibrium price $p \neq p^*$, believes that the suppliers have followed their equilibrium strategies and the manufacturer has unilaterally deviated. Meanwhile, under linear beliefs, a consumer, upon receiving an off-equilibrium price $p \neq p^*$, believes that a supplier has deviated and the manufacturer has only acted optimally in response to that deviation (we show that there exists a linear equilibrium in which consumers' belief of the manufacturer's cost is linear in p). In this sense, passive beliefs capture an extreme in which consumers' cost expectation does not change instantaneously with the retail price; meanwhile, linear beliefs capture the other extreme in which consumers' cost expectation changes linearly with the retail price. We then apply the Pareto-dominance criterion and select the equilibrium outcome under passive beliefs. Beyond studying these beliefs in isolation, we also consider a scenario in which consumers adopt a mixture of passive and linear beliefs.

[8] Other common refinement criteria such as wary beliefs (or wary expectations) and symmetric beliefs (McAfee and Schwartz, 1994; Rey and Vergé, 2004; Hagiu and Halaburda, 2014) do not apply to our game. Please refer to Appendix C for a discussion on the difficulty of applying standard refinement approaches for exogenous signaling games to our game.

5.1 Passive Beliefs

Consider first the case in which consumers adopt passive beliefs. Under passive beliefs, $\tilde{c}$, consumers' belief of the manufacturer's cost, is a constant and does not depend on p. This represents an extreme case in which consumers' cost expectation does not change with the retail price. In Section 5.2, we consider the other extreme in which consumers' cost expectation changes automatically with the retail price. Given the belief, consumer i will purchase if and only if her expected transaction utility is nonnegative (Allender et al., 2021):

$$v_i - p - S(v_i, p, \tilde{c}) \geq 0,$$

or, equivalently, when $v_i \geq \hat{v}$, where the indifference condition is characterized by

$$\hat{v} = p + \frac{\lambda}{1+\lambda}(p - \tilde{c}). \tag{5}$$

Unlike under the transparency regime, now the consumer's purchasing decision no longer hinges on the manufacturer's actual cost, c. Instead, it hinges on $\tilde{c}$, the consumers' expectation of the manufacturer's cost. Note that consumer expectations must be fulfilled in equilibrium but not necessarily off the equilibrium path.

Given cost c, which can be off-equilibrium, and consumers' expectation $\tilde{c}$, the manufacturer chooses the retail price p to maximize its profit

$$\pi = (p - c)(1 - \hat{v}),$$

where $D = 1 - \hat{v}$ is the demand for the product. Solving for the manufacturer's profit maximization problem yields

$$p = \frac{1 + c + \lambda + 2c\lambda + \tilde{c}\lambda}{2(1 + 2\lambda)}. \tag{6}$$

Plugging p into the demand, we derive

$$D = 1 - \hat{v} = \frac{1 - c + \lambda - 2c\lambda + \tilde{c}\lambda}{2(1+\lambda)}. \tag{7}$$

Comparing the generated demand to that of the transparency regime, we have

$$\frac{\partial D}{\partial c} = -1 + \frac{1}{2 + 2\lambda} < \frac{\partial D_t}{\partial c_t} = -\frac{1}{2}. \tag{8}$$

Equation (8) shows that, compared to the transparency regime, consumer demand in the non-transparency regime under passive beliefs is *more* sensitive to c, the manufacturer's *actual* cost (consumer demand is also sensitive to $\tilde{c}$; but $\tilde{c}$ is constant under passive beliefs). That is, when consumers observe the manufacturer's cost, an increase in that cost has two effects on consumers: First, a higher cost forces the manufacturer to raise the retail price, which hurts consumer demand. Second, a higher cost squeezes the manufacturer's profit margin more and more, which helps consumers perceive the price to be fairer and makes them more willing to purchase. This latter effect increases consumer demand, thereby mitigating the former effect. When consumers do not observe the manufacturer's cost, they respond to $\tilde{c}$ but not c, which eliminates the second effect altogether. As a result, the cost affects consumer demand only through the first channel.

Consider, next, the suppliers' pricing decisions: Supplier j chooses c_j to maximize its profit:

$$\Pi_j = c_j(1 - \hat{v}) = c_j \cdot \frac{1 + \lambda + \tilde{c}\lambda - c_j(1+2\lambda) - c_{-j}(1+2\lambda)}{2(1+\lambda)},$$

where $c_{-j} = \sum_{k \neq j} c_k$ is, again, the total price charged by other suppliers. Solving the supplier's profit maximization problem yields

$$c_j = \frac{1 + \lambda + \tilde{c}\lambda - c_{-j}(1+2\lambda)}{2(1+2\lambda)},$$

which is immediately followed by

$$c_j = \frac{1 + \lambda + \tilde{c}\lambda}{(1+K)(1+2\lambda)}. \tag{9}$$

In equilibrium, consumers' beliefs must be fulfilled, i.e., $c = \tilde{c} = \sum_j c_j$. Using this condition, we find that

$$\tilde{c} = \frac{K(1+\lambda)}{1+K+(2+K)\lambda}. \tag{10}$$

Given this analysis, we solve for the equilibrium outcome and summarize the results, again, in Table 1. Unlike under the transparency regime, the suppliers' price and, hence, the manufacturer's variable cost, c, now depends on λ. Comparing the suppliers' price with that under the transparency regime, we arrive at the following lemma.

Lemma 1 *Suppose that consumers hold passive beliefs. For any K, the suppliers charge lower prices under the non-transparency regime, i.e., $c_j \leq c_{jt}$.*

This lemma suggests that, under passive beliefs, withholding cost information helps the manufacturer secure lower procurement costs from its upstream suppliers. For example, consider the case of $K = 2$ and $\lambda = 0.5$. Under the transparency regime, the cost is $c_{jt} = 0.333$, whereas under the non-transparency regime (passive beliefs), the cost is $c_j = 0.3$, a 10 percent decrease. But why do suppliers charge lower prices under the non-transparency regime?

As discussed above, under the transparency regime, a decrease in c_{jt} has two effects on consumer demand: First, when c_{jt} decreases, the manufacturer will at least partially pass the price cut down to consumers and charge them a lower price p, thereby encouraging more consumers to purchase. Second, as c_{jt} decreases, consumers observe that the manufacturer is enjoying a high profit margin and, thus, perceive the given price to be more unfair. While the former effect increases demand, the latter effect hurts it, and suppliers must trade-off between the two effects when setting their prices.

Now consider the non-transparency regime, under which a decrease in c_j still drives down the price p, thereby increasing consumer demand; however, because consumers do not observe c, they respond to their belief of the cost, $\tilde{c}$, instead of the actual cost, c. Because consumers' cost expectation does not change with the suppliers' pricing decisions, suppliers can now decrease the price without worrying about aggravating inequity aversion. As the suppliers charge lower output prices, the manufacturer will partially pass this price discount to consumers and charge a lower retail price, which increases consumer demand.

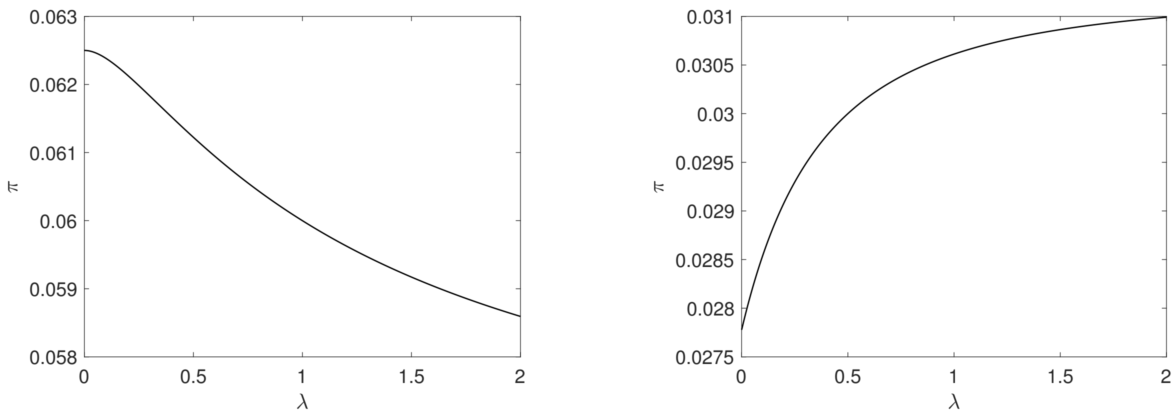
As for the firms' profits, we have the following proposition, whose results are illustrated in Figure 2:

Proposition 2 *Suppose that the manufacturer withholds its cost information and consumers hold passive beliefs:*

(1) *When the manufacturer sources from a single supplier ($K = 1$), both the supplier's and manufacturer's profits decrease with λ. Consumer surplus, by contrast, increases with λ.*

(2) *When the manufacturer sources from multiple suppliers ($K \geq 2$), the suppliers' profits, the manufacturer's profit and consumer surplus all increase with λ.*

Part (1) of Proposition 2 is intuitive: As λ increases, low-valuation consumers perceive the transaction to be more unfair and become reluctant to purchase, and overall consumer demand decreases accordingly. In anticipation of this, both the supplier and manufacturer reduce their margins to boost demand, which hurts their profits. As for consumers, inequity aversion, again, has its upsides and downsides: On the downside, stronger inequity aversion reduces the transaction utility of low-valuation consumers. On the upside, stronger inequity aversion increases the transaction utility of high-valuation consumers, and all consumers are better off when firms are forced to reduce their margins. In essence, this upside benefits all consumers and dominates the downside, leaving all consumers better off with a higher λ.



(a) $K = 1$ (b) $K = 2$

Figure 2: The effect of inequity aversion on the manufacturer's profit (non-transparency regime; passive beliefs)

Part (2) of Proposition 2 is less intuitive in that it flies in the face of common wisdom, which states that inequity aversion generates a deadweight loss that reduces consumers' transaction utility and hurts firm profits. So, why would firms benefit from inequity aversion?

The intuition is as follows: When the manufacturer sources from multiple suppliers, each supplier adds a margin to its own output. Given the presence of multiple suppliers, the manufacturer's unit cost becomes excessively high. The manufacturer further adds a margin to its cost and charges consumers a price that is much higher than that in a centralized channel. Such a high price discourages consumers from making a purchase, leading to low consumer demand and firm profits.

Now, consider the effect of inequity aversion: As in the single-supplier case, both the suppliers and manufacturer, once faced with inequity-averse consumers, are willing to undercut their margins to alleviate this aversion and boost demand. In this case, inequity aversion has three effects on a representative supplier's profit: First, inequity aversion directly reduces low-valuation consumers' purchasing incentive, which decreases demand; this effect is unambiguously detrimental. Second, faced with inequity-averse consumers, the supplier cuts its margin, hoping the manufacturer will pass the price cut down to consumers; this effect naturally hurts the supplier. Third, inequity aversion forces other suppliers and the manufacturer to squeeze their margins, which reduces the retail price, improves consumer demand, and ultimately benefits the supplier. When there are multiple suppliers involved (i.e., $K \geq 2$), they may individually lose out on their own outputs, but they also benefit from the other suppliers' similarly losing out on their outputs and thinning their margins.[9] The last effect eventually becomes so strong (i.e., the retail price is significantly pinched thanks to the thinned margins) that it outweighs the first two effects, and, overall, inequity aversion increases the suppliers' profit.

Similarly, when $K \geq 2$, the downstream manufacturer benefits from consumers' inequity aversion because it forces all suppliers to reduce their margins, thereby significantly lowering its procurement cost. As retail prices go down, consumers are also better off. In sum, inequity aversion substantially alleviates the issue of double marginalization, which dominates the cost arising from consumers' fairness concerns, leading to higher profits for the suppliers and manufacturer as well as higher consumer surplus.

5.2 Linear Beliefs

Under passive beliefs, consumers, upon observing an off-equilibrium price $p \neq p^*$, believe that suppliers have followed their equilibrium strategy whereas the manufacturer has unilaterally deviated. It is also plausible that, under certain circumstances, consumers may observe an off-equilibrium price $p \neq p^*$and believe that the suppliers are the ones to have deviated and that the manufacturer has acted optimally given the deviated input prices. In this sense, consumers should make rational inferences about c from the retail price p they observe. While Section 5.1 considers an extreme case in which consumers' cost expectation does not change with p, this section examines the opposite extreme in which consumers' cost expectation automatically changes with p.

[9] Note that, although the suppliers produce independent outputs and do not compete with each other directly, they are tied together by the common final product and enjoy the thinner margins charged by other suppliers. This increases consumer demand and benefits the focal manufacturer.

We conjecture that, under the above reasoning, a linear equilibrium exists in which consumers' beliefs are specified as follows:

$$\tilde{c} = a + bp,$$

for some constants a and b. We refer to scenarios in which consumers' beliefs are linear in p and they always attribute deviations to the suppliers as linear beliefs. The idea of linear beliefs is akin to polynomial beliefs that were used in the literature (Rey and Vergé, 2004; Llanes and Ruiz-Aliseda, 2021). Later, we show that an equilibrium does exist under linear beliefs.[10]

Given consumers' beliefs, we can derive that the indifferent consumer $\hat{v}$ is given by

$$\hat{v} = \frac{p - (a - (2-b)p)\lambda}{1+\lambda}, \tag{11}$$

and the manufacturer's profit is

$$\pi = (1 - \hat{v})(p - c).$$

Given c, the manufacturer chooses p to maximize its profit. When $b < 2 + \frac{1}{\lambda}$, solving the manufacturer's profit maximization problem yields that[11]

$$p = \frac{1 + c + \lambda + a\lambda + (2-b)c\lambda}{2 + 2(2-b)\lambda}. \tag{12}$$

[10]We are unable to find tractable solutions to other beliefs under which consumers always attribute deviations to the suppliers. It is standard in the literature to focus on a linear equilibrium that has a simple, tractable form (Kyle, 1985).

[11]It is worth mentioning that, when $b = 2 + \frac{1}{\lambda}$ and $\lambda > 0$, there exists another linear belief $\tilde{c} = (2 + \frac{1}{\lambda})p - (1 + \frac{1}{\lambda})$. Under such a belief, the indifference condition is always $\hat{v} = 1$; in equilibrium, no transactions will take place, and the manufacturer's profit is always zero regardless of c and p. As such, we omit this trivial equilibrium.

Plugging p into $\tilde{c}$, we obtain that

$$\tilde{c} = \frac{b + b\lambda + a(2 + (4-b)\lambda)}{2 + 2(2-b)\lambda} + \frac{b}{2} \cdot c. \tag{13}$$

Consumers' cost expectation must coincide with the suppliers' actual pricing decisions, i.e., $\tilde{c} = c$. That is,

$$\frac{b + b\lambda + a(2 + (4-b)\lambda)}{2 + 2(2-b)\lambda} = 0, \ \frac{b}{2} = 1. \tag{14}$$

Solving Equation (14) leads to

$$a = -1, \ b = 2, \ \tilde{c} = -1 + 2p.$$

Consider, next, the suppliers' pricing decisions: Supplier j chooses c_j to maximize its profit:

$$\Pi_j = c_j(1 - \hat{v}) = \frac{c_j(1 - c_j - c_{-j})}{2(1+\lambda)},$$

where $c_{-j} = \sum_{k \neq j} c_k$. It follows immediately that

$$c_j = \frac{1}{1+K}, \ c = \frac{K}{1+K}.$$

We solve for the equilibrium outcome and summarize the results in Table 1 and the following proposition:

Proposition 3 *Suppose that the manufacturer withholds its cost information and consumers hold linear beliefs. In equilibrium, the suppliers' profits, the manufacturer's profit, and consumer surplus all decrease with λ.*

As shown in Table 1, under linear beliefs, neither the manufacturer's cost nor its retail price changes with λ. In other words, inequity aversion does not have any effect on the issue of double marginalization. Meanwhile, inequity aversion reduces low-valuation consumers' transaction utility and decreases demand. As a result, all parties are worse off with inequity aversion.

Proposition 3 is in stark contrast to Proposition 2 which states that, under passive beliefs, all parties can be better off with stronger inequity aversion. The rationale is as follows. Under passive beliefs, consumers' estimate of the manufacturer's margin is $p - \tilde{c} = p - c^*$, which *increases* with p. As a result, a manufacturer can alleviate inequity aversion by cutting its price, which suggests a lower profit margin. Under linear beliefs, however, consumers' estimate of the manufacturer's margin is $p - \tilde{c} = p - (2p - 1) = 1 - p$, which *decreases* with p. As a result, the manufacturer does not have any incentive to cut prices when consumers become more inequity-averse. Following the logic, under linear beliefs, the manufacturer is reluctant to pass the suppliers' price cut down to consumers. In anticipation of this, suppliers are also reluctant to cut their output prices. As such, inequity aversion alleviates the issue of double marginalization under passive beliefs but not so under linear beliefs.

Equilibrium Selection. Table 1 indicates that equilibrium outcomes are different under passive and linear beliefs, i.e., the equilibrium outcome is sensitive to the specification of off-equilibrium beliefs. Moreover, different equilibrium outcomes yield different implications for firms. It is then natural to raise the question of which equilibrium outcome is more plausible.

While the literature has studied games of imperfect information under different belief specifications, the belief assumptions employed are often ad-hoc and difficult to justify. Rey and Vergé (2004) and Janssen and Shelegia (2015), by contrast, select a belief that preserves the existence of an equilibrium; nonetheless, their approach does not apply to our setting since an equilibrium always exists under either belief specification.

Nonetheless, we can apply the Pareto-dominance criterion to select the Pareto-dominant equilibrium.[12] We find that, under this criterion, we should always pick the equilibrium

[12]We thank the anonymous reviewer who suggested this selection criterion.

under passive beliefs, which maximizes the payoffs of all parties. As stated in Proposition 2, when the manufacturer sources from multiple suppliers, in equilibrium, inequity aversion benefits the manufacturer, suppliers, and consumers alike, thereby leading to a ”win-win-win” outcome.

Lastly, it is plausible that consumers do not know whether a deviation has been caused by the suppliers or the manufacturer. To investigate how consumers form their off-equilibrium beliefs upon receiving an off-equilibrium retail price, we conducted an online survey on Prolific. In the survey, we asked participants to consider a scenario in which they receive an unexpected price from a manufacturer. We then asked respondents to evaluate the likelihoods of the following two scenarios: (1) The suppliers charged the manufacturer unexpected prices for the inputs and the manufacturer responded by adjusting its retail price, and (2) the suppliers charged the manufacturer reasonable prices while the manufacturer chose the unexpected retail price.

In the survey, we ask participants to evaluate five different products including a yacht, a scooter, a lipstick, a height adjustable desk, and an ergonomic chair. Participants, on average, believe that unexpected price is caused by the manufacturer’s deviation (i.e., they adopt passive beliefs) with probability 57.1%, 70.9%, 60.9%, 58.2%, and 70.1%, respectively. This result suggests that participants do not adopt a single belief and place a heavier weight on passive beliefs.

In line with the above finding, we further consider a scenario in which consumers adopt a mixture of beliefs: upon observing an off-equilibrium price p, they believe that the deviation is caused by the manufacturer with probability ψ, and is caused by the suppliers with probability $1-\psi$.[13] Again, in the latter case, we assume that consumers’ belief is linear in p. This analysis can be viewed as a continuous case between the two extremes in which consumers’ cost expectation does not change with or changes automatically with

[13]Our analysis offers an alternative interpretation: A fraction ψ of consumers believe that the deviation is caused by the manufacturer (i.e., they adopt passive beliefs) while $1-\psi$ of them believe that the deviation is caused by the suppliers (i.e., they adopt linear beliefs). Our results continue to hold under this interpretation.

the retail price. We defer the analysis to Appendix B and summarize the results in Table 1. The following proposition follows immediately.

Proposition 4 *Suppose that the manufacturer withholds its cost information and consumers hold a mixture of beliefs. When $\psi > 0.5$, for any λ, there exists $K_0 > 0$ such that the suppliers' profits, the manufacturer's profit, and consumer surplus increase with λ when $K \geq K_0$.*

Proposition 4 illustrates that, as long as consumers place a heavy weight on passive beliefs, our key finding that firms can benefit from stronger inequity aversion continues to hold. The intuition is, as discussed in Section 5.1, when consumers adopt passive beliefs with a high probability, inequity aversion helps alleviate the issue of double marginalization, which benefits the firms and consumers alike.

It is worth mentioning that in the survey, we do find that participants place a heavy weight on passive beliefs for all five products we investigated. This result suggests that inequity aversion does benefit firms, at least in certain product categories.

5.3 Cost Disclosure

It is not uncommon for firms to disclose their cost information to consumers. For example, Everlane, a US apparel firm, builds its company on the premise of "radical transparency". On its website, Everlane publishes the cost breakdown of all its products. Asket, a Swedish apparel manufacturer, commits that "(consumers) will find the cost breakdown of every garment on each product page." Oliver Cabell, a US footwear brand, announces on its website the costs of every pair of shoes. IUIGA, a Singapore homeware manufacturer, posts on its website the production costs for each product it sells. Buffer, a software application for social media management, also provides a breakdown of its costs. Of course, many firms equally choose to remain silent regarding their cost information.

Several studies have investigated the effect of cost transparency and firms' incentives to disclose their cost information. Sinha (2000) discusses the implication of cost transparency for firms, arguing that cost transparency severely impairs a seller's ability to obtain high margins and weakens customer loyalty to brands. Simintiras et al. (2015) argue that cost transparency allows consumers to make better judgements on price fairness, and prompts firms to utilize resources efficiently. Guo (2015) considers a firm's cost disclosure decision when some consumers are inequity-averse and the firm's cost is exogenous and stochastic. He shows that the firm discloses the cost only when the cost is moderate, which increases the transaction utility of fair-minded consumers. Mohan et al. (2020) show that cost disclosure can foster trust, thereby enhancing consumers' willingness to purchase from a firm.

In this section, we investigate a manufacturer's strategic incentive to disclose its cost information to inequity-averse consumers. We focus on the case of *ex ante disclosure*: the manufacturer commits to a disclosure policy before contracting with the suppliers (i.e., before c is realized). As noted by Guo (2020), this timing captures scenarios in which the firm's disclosure decision constitutes a long-term strategic move and involves significant resources, whereas the input prices can be flexibly adjusted between the firms. Ex ante disclosure is commonly studied in the literature (Gal-Or, 1986; Guo, 2009, 2020) and is consistent with our motivating examples. For example, Everlane commits to disclosing the costs for all of its products sold online. IUIGA states that it brings "quality everyday goods to you at completely transparent prices." Nonetheless, in Appendix E we discuss the case of ex post disclosure and show that a pure strategy equilibrium may fail to exist.

We assume that the manufacturer truthfully and credibly discloses its information either because of legal constraints or reputation-related concerns. If the manufacturer can manipulate the cost information that it discloses, then cost disclosure simply becomes cheap talk and does not convey any information, and the model reverts to the nondisclosure case. We further assume that the manufacturer does not incur any cost to disclose the information, which we recognize as a mathematical assumption rather than a reflection of reality. However, this assumption allows us to capture the strategic effect of disclosure in the absence of cost considerations. Our results will only be strengthened when disclosure becomes costly to the firm.

Comparing the manufacturer's profit under the transparency versus non-transparency regimes, we observe the following proposition:[14]

Proposition 5 *Suppose that consumers adopt a mixture of beliefs. For any $\lambda > 0$, there exists $\psi_0 < 0.5$ such that the manufacturer strictly prefers to withhold its cost information to consumers when $\psi > \psi_0$.*

Proposition 5 suggests that, even in the absence of cost considerations, the manufacturer will withhold its cost information to inequity-averse consumers when consumers place a heavy weight on passive beliefs. This is because, as Table 1 suggests, information disclosure raises the manufacturer's procurement cost, and the inequality is strict whenever $\lambda > 0$ and $\psi > 0$. When consumers observe the firm's cost, an increase in the manufacturer's cost alleviates their inequity aversion, which motivates upstream suppliers to charge higher prices. As such, the manufacturer prefers to withhold its cost information to suppress its procurement cost.

While Proposition 5 suggests that a manufacturer may prefer to withhold its cost information, it would be interesting to explore the suppliers' incentive to disclose their output prices (which are the manufacturers' costs). We cannot directly compare the suppliers' profits under the transparency and non-transparency regimes because we must allow each supplier to determine whether to disclose its output price. The following proposition summarizes the results.

Proposition 6 *Suppose that consumers adopt a mixture of beliefs. For sufficiently large K, all suppliers choose to disclose their output prices.*

[14] Here, we assume that cost disclosure is a binary decision. A manufacturer may also disclose its cost to a fraction ω of consumers. While we cannot obtain tractable solutions for a general ω, numerical analysis suggests either full disclosure ($\omega = 1$) or nondisclosure ($\omega = 0$) is optimal for the manufacturer.

Proposition 6 suggests that, unlike the manufacturer who may prefer to withhold its cost information, when the number of suppliers is large enough, the suppliers always have incentives to disclose their output prices. Note that while we are unable to characterize the equilibrium outcome for a small K, numerical analysis suggests that there does exist an equilibrium in which all suppliers disclose their cost information.

Nonetheless, when $K \geq 2$, the suppliers' cost disclosure decision can lead to a prisoner's dilemma. For example, consider the case in which $K = 2$, $\lambda = 0.2$, and $\psi = 0.7$. When neither supplier discloses its output prices, each supplier makes a profit of $\Pi \approx 0.0555$. When both suppliers disclose their output prices, each supplier makes a profit of $\Pi \approx 0.0549$, lower than before. As such, suppliers are better off when they collectively withhold their output price, yet they cannot help but disclose it, which backfires on their own profits.

The intuition is as follows. When an individual supplier discloses its output price, it has a stronger incentive to charge the manufacturer a high price because a high price squeezes the manufacturer's profit margin and alleviates consumers' inequity aversion, thereby boosting up demand. The above effect, however, is less salient when the supplier withholds its output price (and it vanishes completely when consumers adopt passive beliefs). As a result, with disclosure, a supplier commits to charging a higher price, which forces the other supplier(s) to charge lower prices, thereby gaining the supplier a competitive advantage. Nonetheless, as all suppliers disclose their output prices, the manufacturer's cost becomes excessively high, worsening the double marginalization problems, which can end up hurting the suppliers themselves.

Note that the assumption that the suppliers can disclose their output prices is rather a mathematical assumption than a reflection of reality. In practice, as business-to-business companies, suppliers rarely have the channel to communicate their output prices directly to individual consumers. Theoretically, suppliers may voluntarily disclose their contract terms with downstream manufacturers through financial filings (e.g., form 10-K), but consumers are unlikely to expend the hassle to obtain such information. In addition, suppliers and consumers typically do not know the exact cost breakdown per unit of the final product, making it difficult to infer the manufacturer's cost from suppliers' disclosure.

6 Multilevel Distribution Channel

Thus far, we have shown that, when a manufacturer sources from multiple suppliers and withholds its cost information, consumers' inequality aversion can improve profits for both the suppliers and manufacturer. However, when the manufacturer sources from a single supplier, inequality aversion leaves both firms worse off. In this section, we extend the model and show that, under multi-level distribution, inequality aversion can leave all firms better off, even in the case of a single supplier.

Consider a model with a supplier, manufacturer, and retailer. The manufacturer sources an input from the supplier at a unit price s, converts each unit of input into a final product, and sells to the retailer at a unit price c. The retailer then sells the product to consumers at a retail price p. As before, we normalize the firms' production and selling costs to zero and assume that all firms make decisions to maximize their profits.

In addition to these three firms, there is a unit mass of consumers whose valuations for the product are uniformly distributed over the unit interval: $v_i \sim U[0,1]$. Consumers are inequity averse, and incur a psychological disutility $S(v,p,c) = \lambda \cdot ((p-c)-(v-p))$ when buying from the retailer at price p. Again, we consider cases in which the retailer discloses (i.e., transparency regime) and withholds its cost information (i.e., non-transparency regime).

Transparency Regime. Consider first the transparency regime under which the retailer discloses its cost c to consumers. We solve the game using backward induction and present the result in the following lemma. We use subscript t to represent the transparency regime, and Π, π_m, π_r to represent the supplier's, manufacturer's, and retailer's profits, respectively.

Lemma 2 *Consider a three-level distribution channel under the transparency regime. The equilibrium outcome is summarized in Table 2. The retailer's profit decreases with λ while the supplier and manufacturer's profits are constant with λ.*

Table 2: Equilibrium Outcome in a Three-Level Channel

	Transparency Regime	Non-transparency Regime
s	$\frac{1}{2}$	$\frac{2(1+\lambda)}{4+4\lambda+\lambda\psi}$
c	$\frac{3}{4}$	$\frac{3(1+\lambda)}{4+4\lambda+\lambda\psi}$
p	$\frac{7+13\lambda}{8+16\lambda}$	$\frac{7(1+\lambda)}{8+8\lambda+2\lambda\psi}$
Π	$\frac{1}{16}$	$\frac{(1+\lambda)(1+2\lambda\psi)}{(4+4\lambda+\lambda\psi)^2}$
π_m	$\frac{1}{32}$	$\frac{(1+\lambda)(1+2\lambda\psi)}{2(4+4\lambda+\lambda\psi)^2}$
π_r	$\frac{1+\lambda}{64+128\lambda}$	$\frac{(1+\lambda)(1+2\lambda\psi)}{4(4+4\lambda+\lambda\psi)^2}$
CS	$\frac{1+\lambda}{128}$	$\frac{(1+\lambda)(1+2\lambda\psi)^2}{8(4+4\lambda+\lambda\psi))^2}$

In line with the basic model, Lemma 2 shows that, in a three-level channel, the downstream retailer completely absorbs the downside of inequity aversion through its lowered retail price. As a result, inequity aversion does not affect the supplier or the manufacturer.

Non-transparency Regime. Consider, now, the non-transparency regime. As with before, we assume consumers adopt a mixture of beliefs, i.e.,

$$\tilde{c} = \begin{cases} c_0, & \text{with probability } \psi, \\ a + bp, & \text{with probability } 1 - \psi. \end{cases}$$

We defer the detailed analysis to the appendix and present our results in the following proposition:

Proposition 7 *Consider a three-level distribution channel. Suppose that the retailer does not disclose its cost information and that consumers adopt a mixture of beliefs. The equilibrium outcome is summarized in Table 2. When $\psi > \frac{2}{3}$, all firms' profits increase with λ when λ is not too high.*

Proposition 7 shows that, in a multilevel distribution channel, consumers' inequity aversion can benefit the supplier, manufacturer and retailer alike even when the input is supplied by a single supplier.

The rationale is as follows: A three-level distribution channel suffers significantly from the issue of triple-marginalization, given that all firms – the supplier, manufacturer, and downstream retailer – each adds a positive margin, resulting in high retail prices and low consumer demand.

Now, consider the effect of inequity aversion: As discussed before, stronger inequity aversion reduces the transaction utility of low-valuation consumers, which decreases consumer demand and forces all firms to reduce their margins. While an individual firm suffers from its thinned margin, it does benefit from the equally thinned margins of other firms in the distribution channel. When consumers place a heavy weight on passive beliefs (i.e., when ψ is large), the latter effect dominates the former, and, overall, consumers' inequity aversion significantly alleviates the issue of triple marginalization, leaving all firms better off.

Recall that, in the basic model when the manufacturer sources from a single supplier, both the supplier and manufacturer are left worse off when consumers become more inequity-averse, which contrasts with these current results. The main reason for this is that, in a two-level distribution channel, inequity aversion alleviates the issue of double marginalization, but this positive effect is not strong enough to cover the cost of aversion. In a three-level distribution channel, however, the issue of triple marginalization is so severe that inequity aversion's alleviating effect overwhelms the burden of cost; as a result, the firms' preference for inequity aversion is reversed in a three-level distribution channel.

7 Conclusion

Modern consumers value not only their material payoff but also the fairness of their transactions, penalizing firms for unfair prices even at their own expense. In this paper, we studied a manufacturer that sources inputs from upstream suppliers, assembles them into a final product, and sells it to inequity-averse consumers. We considered two scenarios depending on whether or not the manufacturer discloses its cost information to consumers.

Intuition suggests that consumers' inequity aversion generates a deadweight loss that damages consumer utility and decreases demand, which seems to hurt all firms involved. While this intuition does hold when the manufacturer sources from a single supplier or when consumers observe the manufacturer's procurement cost, it fails when the manufacturer sources from multiple suppliers and withholds its cost information. In this case, inequity aversion benefits the suppliers, manufacturer, and consumers alike, leading to a "win-win-win" outcome.

This result arises because, when faced with inequity-averse consumers, all suppliers and the manufacturer would undercut their price margins. While a firm suffers from its own thinned margin, it benefits from other firms' equally narrowed margins, which collectively decrease the retail price, thus increasing consumer demand and improving channel efficiency.

By comparing cases in which the manufacturer discloses and withholds its cost information, we further find that, when selling to inequity-averse consumers, a manufacturer can be better off withholding its procurement cost from consumers. This is because, when consumers do not observe the manufacturer's actual cost, their demand becomes more sensitive to it, which forces upstream suppliers to cut their prices significantly. In other words, by withholding its cost information, the manufacturer can secure lower procurement costs from its suppliers. Interestingly, when the manufacturer sources from multiple suppliers, the suppliers can also be better off when the manufacturer withholds its cost information. Nonetheless, when the suppliers make their disclosure decisions, they always disclose their prices, which can lead to a form of the prisoner's dilemma.

Our research can be extended in a number of directions. Our current model does not consider market competition. Future research may examine how this competition interacts with inequity aversion and affects firms and consumers. In the present model, we also only consider firms' price decisions and the manufacturer's cost-disclosure decision. Investigating how inequity aversion affects other marketing decisions, such as quality and product design, is also of interest.

Finally, from a theoretical perspective, our model's equilibrium outcome is sensitive to the specification of off-equilibrium beliefs. Future research may study the equilibrium-selection issue in games of imperfect information to pin down the most reasonable equilibrium outcome. In addition, the current game does not have any cost uncertainties. It would be interesting to generalize the model to consider a scenario in which the suppliers' or manufacturer's marginal costs are uncertain.

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A Technical Details

Proof of Proposition 1. For the retail price, we have

$$\frac{\partial p_t}{\partial \lambda} = -\frac{1}{2(1+K)(1+2\lambda)^2} < 0.$$

For the manufacturer's profit, we have

$$\frac{\partial \pi_t}{\partial \lambda} = -\frac{1}{4(1+K)^2(1+2\lambda)^2} < 0.$$

For consumer surplus, we have

$$\frac{\partial CS_t}{\partial \lambda} = \frac{1+6\lambda}{8(1+K)^2(1+2\lambda)^3} > 0.$$

This proves the proposition. Q.E.D.

Proof of Lemma 1. Comparing the costs, we have

$$c_j - c_{jt} = -\frac{K\lambda}{(1+K)(1+K+(2+K)\lambda)} < 0.$$

This completes the proof. Q.E.D.

Proof of Proposition 2. Consider first a supplier's profit:

$$\frac{\partial \Pi_j}{\partial \lambda} = \frac{-1+K+(-2+K)\lambda}{2(1+K+(2+K)\lambda)^3},$$

which is positive if and only if $K \geq 2$. Note that $\pi = \Pi_j/2$, hence the manufacturer's profit increases with λ if and only if $K \geq 2$. As for consumer surplus, we have

$$\frac{\partial CS}{\partial \lambda} = \frac{1+6\lambda+K(3+11\lambda)}{8(1+K+(2+K)\lambda)^3} > 0,$$

which completes the proof. Q.E.D.

Proof of Proposition 4. Consider first a supplier's profit:

$$\frac{\partial \Pi_j}{\partial \lambda} = \frac{(2\psi - 1)(K + K\lambda - \lambda\psi) - \lambda - 1}{2(1 + K + \lambda + K\lambda + \lambda\psi)^3}.$$

It follows that Π_j increases with λ as long as $\psi > \frac{1}{2}$ and

$$K \geq K_0 = \frac{1 + \lambda - \lambda\psi + 2\lambda\psi^2}{(1 + \lambda)(2\psi - 1)}.$$

Note that $\pi = \Pi_j/2$, hence the manufacturer's profit also increases with λ as long as $\psi > \frac{1}{2}$ and $K \geq K_0$. Lastly, consider consumer surplus:

$$\frac{\partial CS}{\partial \lambda} = \frac{A}{8(1 + K + \lambda + K\lambda + \lambda\psi)^3},$$

where $A = -(1 + K)(1 + \lambda) + (2 + 3\lambda + 4K(1 + \lambda))\psi + 4(1 + 2K)\lambda\psi^2 \geq K + \frac{3\lambda}{2} + 3K\lambda > 0$ when $\psi \geq \frac{1}{2}$. Therefore, when $\psi \geq \frac{1}{2}$, consumer surplus always increases with λ. Q.E.D.

Proof of Proposition 5. Let

$$r = \frac{\pi}{\pi_t} = \frac{(1 + K)^2(1 + 2\lambda)(1 + 2\lambda\psi)}{(1 + K + \lambda + K\lambda + \lambda\psi)^2},$$

it suffices to prove that $r > 1$ whenever $\psi \geq 0.5$. To establish the above result, we prove that (1) r increases with ψ, and (2) $r > 1$ when $\psi = 0.5$. For (1), we have

$$\frac{\partial r}{\partial \psi} = \frac{2(1 + K)^2\lambda(1 + 2\lambda)(K + \lambda + K\lambda - \lambda\psi)}{(1 + K + \lambda + K\lambda + \lambda\psi)^3} > 0.$$

For (2), straightforward calculation shows that when $\psi = 0.5$, we have $r = A/B$, where $A = (1 + K)^2(1 + \lambda)(1 + 2\lambda)$ and $B = (1 + K + (3\lambda)/2 + K\lambda)^2$. It follows that $A > 0, B > 0$ and

$$A - B = K^2\lambda(1 + \lambda) + K\lambda + (K - \frac{1}{4})\lambda^2 > 0.$$

Thus, $r > 1$ whenever $\psi > 0.5$, and we complete the proof. Q.E.D.

Proof of Proposition 6. Assume that there exists an equilibrium in which M suppliers (suppliers $1, \ldots, M$) disclose their cost information while other suppliers do not, $0 \leq M \leq K$. Let $c_d = \sum_{j=1}^{M} c_j$ and $c_{nd} = \sum_{j=M+1}^{K} c_j$, then $c = c_d + c_{nd}$. Because consumers do not observe c_{nd}, let $\tilde{c}_{nd}$ be their belief about c_{nd}. Under a mixture of beliefs, we assume that $\tilde{c}_{nd} = c_0$ with probability ψ and $\tilde{c}_{nd} = a + bp$ with probability $1 - \psi$, where c_0, a, b are constants.

Straightforward calculation shows that in equilibrium, the indifferent consumer is located at

$$\hat{v} = \frac{p + p\lambda(2 - b(1-\psi)) - \lambda(a + c_d - a\psi + c_0\psi)}{1+\lambda}.$$

Given c_d and c_{nd}, the manufacturer chooses p to maximize $\pi = (1 - \hat{v})(p - c_d - c_{nd})$, which yields that

$$p = \frac{1 + c_d + c_{nd} + c_{nd}\lambda(2 - b(1-\psi)) + c_d\lambda(3 - b(1-\psi)) + \lambda(1 + a - a\psi + c_0\psi)}{2 + 2\lambda(2 - b(1-\psi))}.$$

Using the consistency of beliefs, we obtain that

$$a = -\frac{1 + c_d + \lambda + c_d\lambda + 2c_d\lambda\psi + c_0\lambda\psi}{1 + \lambda + \lambda\psi}, \ b = 2.$$

Solving the suppliers' problem, we find that

$$c_1 = \cdots = c_M = \frac{1 + \lambda + c_0\lambda\psi}{1 + K + \lambda + K\lambda}, \ c_{M+1} = \cdots = c_K = \frac{1 + \lambda + c_0\lambda\psi}{(1+K)(1+\lambda+\lambda\psi)}.$$

Solving for c_0, we obtain that

$$c_0 = \frac{(K-M)(1+\lambda)}{1 + \lambda + K(1+\lambda) + (1+M)\lambda\psi}.$$

The suppliers' profits are

$$\Pi_1 = \cdots = \Pi_M = \frac{(1+\lambda+\lambda\psi)(1+2\lambda\psi)}{2(1+\lambda+K(1+\lambda)+(1+M)\lambda\psi)^2},$$

$$\Pi_{M+1} = \cdots = \Pi_K = \frac{(1+\lambda)(1+2\lambda\psi)}{2(1+\lambda+K(1+\lambda)+(1+M)\lambda\psi)^2}.$$

Let $\Pi_d(M, K)$ be a supplier's profit when it discloses its cost information and a total number of M firms disclose their cost information, and $\Pi_{nd}(M, K)$ be a supplier's profit when it withholds its cost information and a total number of M firms disclose their cost information. To guarantee that there exists an equilibrium in which M firms choose disclosure, we must have

$$\Pi_d(M, K) \geq \Pi_{nd}(M-1, K) \ \text{ or } \ M = 1,$$

and

$$\Pi_{nd}(M, K) \geq \Pi_d(M+1, K) \ \text{ or } \ M = K.$$

Simple algebra suggests that

$$\lim_{K \to \infty} \frac{\Pi_d(M, K)}{\Pi_{nd}(M-1, K)} = 1 + \frac{\psi\lambda}{1+\lambda} > 1,$$

and

$$\lim_{K \to \infty} \frac{\Pi_{nd}(M, K)}{\Pi_d(M+1, K)} = \frac{1+\lambda}{1+\lambda+\psi\lambda} < 1.$$

Therefore, for sufficiently large K, there exists a unique pure-strategy equilibrium in which all suppliers disclose their cost information. Q.E.D.

Proof of Proposition 7. Under the non-transparency regime, consumer i will purchase if and only if $v_i - p - S(v_i, p, \tilde{c}) \geq 0$, or when $v_i \geq \hat{v}$, where the indifference condition is characterized by

$$\hat{v} = \frac{p + p\lambda(2 - b(1-\psi)) - \lambda(a(1-\psi) + c_0\psi)}{1+\lambda}.$$

Given cost c, the retailer sets price p to maximize its profit $\pi_r = (p-c)(1-\hat{v})$, where $1 - \hat{v}$ is the consumer demand for the product. Solving the retailer's profit maximization problem yields that

$$p = \frac{1 + c + c\lambda(2 - b(1-\psi)) + \lambda(1 + a - a\psi + c_0\psi)}{2 + 2\lambda(2 - b(1-\psi))}.$$

The consistency of beliefs requires that $a + bp = c$, which yields that

$$a = -\frac{1 + \lambda + c_0 \lambda \psi}{1 + \lambda + \lambda \psi},\ b = 2.$$

Next, consider the manufacturer: Given cost s, the manufacturer chooses c to maximize its profit $\pi_m = (c - s)(1 - \hat{v})$. Then, the manufacturer's optimal price is given by

$$c = \frac{(1 + s)(1 + \lambda) + (c_0 + s)\lambda\psi}{2(1 + \lambda + \lambda\psi)}.$$

Finally, the supplier chooses its price s for its output to maximize its profit $\Pi = s(1 - \hat{v})$. Solving the supplier's profit maximization problem, we have

$$s = \frac{1 + \lambda + c_0 \lambda \psi}{2 + 2\lambda + 2\lambda\psi}.$$

In equilibrium, consumers' beliefs must be fulfilled, i.e., $c_0 = c$. Using this condition, we arrive at the equilibrium outcome.

For the equilibrium profits, we have

$$\frac{\partial \Pi}{\partial \lambda} = \frac{6\psi - 4 - (4 - 7\psi + 2\psi^2)\lambda}{(4 + 4\lambda + \lambda\psi)^2}.$$

When $\psi \geq 0.719$, $6\psi - 4 > 0$, $4 - 7\psi + 2\psi^2 < 0$, and Π increases with λ for any λ. When $\frac{2}{3} < \psi < 0.719$, $6\psi - 4 > 0$, $4 - 7\psi + 2\psi^2 > 0$, and Π increases with λ for any

$$\lambda \leq \frac{6\psi - 4}{4 - 7\psi + 2\psi^2}.$$

Similarly, we can prove the same results for π_m and π_r. This completes the proof. Q.E.D.

B Equilibrium Analysis Under A Mixture of Beliefs

As before, we conjecture that there exists a linear equilibrium under linear beliefs, under which consumers' belief is given by $\tilde{c} = a + bp$. As such, we specify the consumers' off-equilibrium beliefs as follows:

$$\tilde{c} = \begin{cases} c_0, & \text{with probability } \psi, \\ a + bp, & \text{with probability } 1 - \psi, \end{cases} \tag{15}$$

where a, b, c_0 are constants. Note that, under passive beliefs, consumers' cost expectation does not change with the suppliers' decisions on c while under linear beliefs, that cost expectation changes instantly and coincides with the suppliers' actual decisions on c. Finally, under a mixture of beliefs, with probability ψ, consumers' cost expectation does not change with the suppliers' decisions on c and, with probability $1 - \psi$, their cost expectation changes instantly and coincides with the suppliers' actual decisions on c. Thus, an analysis under a mixture of beliefs reflects a continuous case between the two extremes.

Given the consumers' belief, we derive that the indifferent consumer is located at

$$\hat{v} = \frac{p + p\lambda(2 - b(1 - \psi)) - \lambda(a(1 - \psi) + c_0\psi)}{1 + \lambda}. \tag{16}$$

Given cost c, the manufacturer chooses p to maximize

$$\pi = (1 - \hat{v})(p - c).$$

Assuming that $b < \frac{1+2\lambda}{\lambda(1-\psi)}$ (again, we omit the trivial equilibrium in which $b = \frac{1+2\lambda}{\lambda(1-\psi)}$), this yields that

$$p = \frac{1 + c + c\lambda(2 - b(1 - \psi)) + \lambda(1 + a - a\psi + c_0\psi)}{2 + 2\lambda(2 - b(1 - \psi))}. \tag{17}$$

The consistency of beliefs requires that $a + bp = c$, which yields that

$$a = -\frac{1 + \lambda + c_0\lambda\psi}{1 + \lambda + \lambda\psi}, \ b = 2. \tag{18}$$

Next, we solve the suppliers' profit optimization problem and come up with

$$c_j = \frac{1 + \lambda + c_0\lambda\psi}{(1 + K)(1 + \lambda + \lambda\psi)}, \ c = \frac{K(1 + \lambda + c_0\lambda\psi)}{(1 + K)(1 + \lambda + \lambda\psi)}.$$

The consistency of beliefs requires that $c_0 = c$, which yields that

$$c_0 = \frac{K(1+\lambda)}{(1+K)(1+\lambda)+\lambda\psi}. \tag{19}$$

The equilibrium outcome follows immediately.

C Equilibrium Refinement

In our game, we apply refine criteria including passive beliefs and linear beliefs instead of using the standard refinement approaches for exogenous signaling games (e.g., the intuitive criterion). Below, we briefly describe the difficulty of applying a standard refinement approach to our game.

In an exogenous signaling game, nature draws the manufacturer's cost (i.e., its type). For instance, suppose that the manufacturer's cost is either c_H or c_L with nonzero probabilities, where $c_H > c_L$. Then, the high-cost manufacturer wants to distinguish itself from the low-cost manufacturer while the low-cost manufacturer wants to mimic the high-cost manufacturer. In this case, the high-cost manufacturer may choose a high price that signals its private cost information. However, if the manufacturer's cost is deterministic (i.e., its cost is always $c = c^*$), then there is no need to signal.

Our setting, however, is more complex. Suppose that there exists a pure-strategy equilibrium in which the manufacturer's cost is always $c = c^*$. In equilibrium, the manufacturer need not distinguish itself from any other type, because the manufacturer's type is always c^*, which is known to consumers. Of course, if the manufacturer receives an off-equilibrium input price $c \neq c^*$, it may want to signal this off-equilibrium cost information to consumers, but it is unclear how such a game can be solved. This issue has been discussed in extant literature. For example, Eguia et al. (2013) study a game of imperfect information and state, "*refinements that are useful for signaling games such as the intuitive criterion have no bite in this context, because the lack of information is about the upstream firm's actions, not about their type (the game is one of imperfect information, not incomplete information; players' types are known).*"

D Manufacturing Costs

In the basic model, we normalize the exogenous costs (e.g., the manufacturer's manufacturing costs) to zero. We show that this assumption is made without loss of generality. Formally, suppose that in addition to its procurement cost, the manufacturer incurs a fixed cost c_M for each unit of product it produces, which is common knowledge in the market. The remainder of the model is unchanged. We solve for the equilibrium outcomes, which are summarized in Table 3.

Table 3: Equilibrium Outcome

	Transparency Regime	Non-transparency Regime		
		Passive Beliefs	Linear Beliefs	Mixture of Beliefs
c	$\frac{(1-c_M)K}{1+K}$	$\frac{(1-c_M)K(1+\lambda)}{1+K+(2+K)\lambda}$	$\frac{(1-c_M)K}{1+K}$	$\frac{(1-c_M)K(1+\lambda)}{1+K+\lambda+K\lambda+\lambda\psi}$
p	$\frac{1+c_M+2K+\lambda+3c_M\lambda+4K\lambda}{2(1+K)(1+2\lambda)}$	$\frac{(1+\lambda)(1+2K)+(1+3\lambda)c_M}{2(1+K+(2+K)\lambda)}$	$\frac{1+c_M+2K}{2(1+K)}$	$\frac{(1+2K)(1+\lambda)+(1+\lambda+2\lambda\psi)c_M}{2(1+K+\lambda+K\lambda+\lambda\psi)}$
D	$\frac{1-c_M}{2(1+K)}$	$\frac{(1-c_M)(1+2\lambda)}{2(1+K+(2+K)\lambda)}$	$\frac{1-c_M}{2(1+K)(1+\lambda)}$	$\frac{(1-c_M)(1+2\lambda\psi)}{2(1+K+\lambda+K\lambda+\lambda\psi)}$
Π_j	$\frac{(1-c_M)^2}{2(1+K)^2}$	$\frac{(1-c_M)^2(1+\lambda)(1+2\lambda)}{2(1+K+(2+K)\lambda)^2}$	$\frac{(1-c_M)^2}{2(1+K)^2(1+\lambda)}$	$\frac{(1-c_M)^2(1+2\lambda\psi)}{2(1+K+\lambda+K\lambda+\lambda\psi)^2}$
π	$\frac{(1-c_M)^2(1+\lambda)}{8(1+K)^2(1+2\lambda)}$	$\frac{(1-c_M)^2(1+\lambda)(1+2\lambda)}{4(1+K+(2+K)\lambda)^2}$	$\frac{(1-c_M)^2}{4(1+K)^2(1+\lambda)}$	$\frac{(1-c_M)^2(1+\lambda)(1+2\lambda\psi)}{4(1+K+\lambda+K\lambda+\lambda\psi)^2}$

It follows immediately that the suppliers' and manufacturer's profits are scaled by a factor of $(1-c_M)^2$, and that their relative profit advantages are not affected by c_M. As such, all our main results go through when the manufacturer incurs a manufacturing cost. Similarly, one can verify that our results are not affected when the suppliers incur an exogenous cost in producing the outputs for the manufacturer.

E Ex Post Disclosure

Section 5.3 considers the case of ex ante disclosure, i.e., the manufacturer pre-commits to a disclosure policy prior to observing its input prices. In this section, we consider the case of ex post disclosure, i.e., the manufacturer decides whether to disclose its cost *after* that cost is set by the suppliers. We show that a pure-strategy equilibrium may fail to exist under ex post disclosure.

To establish the nonexistence result, it suffices to consider a special case in which $K = 1$ (i.e., there is only one supplier) and $\psi = 1$ (i.e., consumers adopt passive beliefs). Assume for contradiction that there exists a pure-strategy equilibrium in which the manufacturer's cost is c^*.

We next specify consumers' beliefs upon observing the manufacturer's nondisclosure. There are two cases to consider: (1) If nondisclosure is along the equilibrium path, then consumers' beliefs must be $\tilde{c} = c^*$ upon nondisclosure (i.e., consumers' belief must be consistent with the equilibrium strategy), and (2) if nondisclosure is off the equilibrium path, under passive beliefs, consumers will interpret the unexpected nondisclosure as the manufacturer's tremble and, thus, do not change their belief about c upon nondisclosure. In other words, consumers continue to hold the belief that $\tilde{c} = c^*$ upon nondisclosure. Combing both cases, consumers' beliefs must be $\tilde{c} = c^*$ upon nondisclosure under any equilibrium.

It follows that the manufacturer's disclosure decision will be rather simple: It discloses the cost when $c > c^*$, and withholds its cost when $c < c^*$. Finally, when $c = c^*$, the manufacturer is indifferent about whether or not to disclose it.

We now consider the supplier's incentive to deviate. If the supplier deviates and charges a low price $c < c^*$, the manufacturer will withhold the cost information, and the indifferent consumer is given by

$$\hat{v} = p + \frac{\lambda}{1+\lambda}(p - c^*).$$

Optimizing the manufacturer's profit, we come up with

$$p = \frac{1 + c + \lambda + 2c\lambda + c^*\lambda}{2(1+2\lambda)},$$

and that the supplier's profit is

$$\Pi = \frac{c(1 + \lambda + c^*\lambda - c(1+2\lambda))}{2(1+\lambda)}.$$

To make sure that the supplier has no incentive to charge a price $c < c^*$, we have

$$\frac{\partial \Pi}{\partial c}\Big|_{c=c^*} = \frac{1 - 2c^* + \lambda - 3c^*\lambda}{2+2\lambda} \geq 0,$$

or equivalently,

$$c^* \leq \frac{1+\lambda}{2+3\lambda}. \tag{20}$$

On the other hand, if the supplier deviates and charges a price $c > c^*$, the manufacturer will disclose the cost information so that consumers know the manufacturer's actual cost, and in this case, the indifferent consumer is given by

$$\hat{v} = p + \frac{\lambda}{1+\lambda}(p-c).$$

Optimizing the manufacturer's profit, we come up with

$$p = \frac{1+c+\lambda+3c\lambda}{2(1+2\lambda)},$$

and that the supplier's profit is

$$\Pi = \frac{c(1-c)}{2}.$$

To make sure that the supplier has no incentive to charge a price $c > c^*$, we have

$$\left.\frac{\partial \Pi}{\partial c}\right|_{c=c^*} = \frac{1}{2} - c^* \leq 0,$$

or equivalently,

$$c^* \geq \frac{1}{2}, \tag{21}$$

which contradicts with (20). Therefore, we prove that a pure-strategy equilibrium may not exist under ex post disclosure.