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The extensive adoption of uniform pricing for branded variants is a puzzling phenomenon, considering that firms may improve profitability through price discrimination. In this paper, we incorporate consumers' concerns of peer-induced price fairness into a model of price competition and show that a uniform price for branded variants may emerge in equilibrium. Interestingly, we find that uniform pricing induced by consumers' concerns of fairness can actually help mitigate price competition and hence increase firms' profits if the demand of the product category is expandable. Furthermore, an individual firm may not have an incentive to unilaterally mitigate consumers' concerns of price fairness to its own branded variants, which suggests the long-run sustainability of the uniform pricing strategy. As a result, fairness concerns from consumers provide a natural mechanism for firms to commit to uniform pricing and enhance their profits.

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1. Introduction

Branded variants, i.e., horizontally differentiated stock-keeping units of a brand, are often sold at the same price; for example, the same price applies for both size 8 and size 12 athletic shoes, for both Diet Coke and regular Coke, and for both vanilla and strawberry Yoplait yogurts in a typical marketplace. Such practices of charging a uniform price to branded variants are, in fact, puzzling because consumer demand tends to be different across branded variants,[1] and standard economic theory would suggest differential prices in those situations. To understand this puzzling aspect of uniform pricing, researchers have proposed several explanations, two of which are particularly popular.[2] One explanation is based on consumers' concerns about price fairness. This suggests that nonuniform pricing on branded variants could be perceived by consumers as unfair and can thus reduce consumer demand for the differentially priced branded variants (Kahneman et al. 1986a, b). The other explanation is based on the cost–benefit trade-off of uniform pricing. This suggests that the benefit of differential pricing for branded variants might be too small compared with the menu costs of managing price changes (Levy et al. 1997, McMillan 2007).

We believe that the fairness-based explanation, even though it does not preclude other possible explanations, is the most appealing because of its ability to explain both the ubiquitous and the persistent nature of the uniform pricing practice on branded variants. First, the foundation of this explanation, i.e., the universal nature of consumers' fairness concerns about prices, is well documented in the psychology, economics, and marketing literature (Anderson and Simester 2004, 2008, 2010; Bolton et al. 2003; Charness and Rabin 2002; Fehr and Schmidt 1999; Ho and Su 2009; Kahneman et al. 1986a, b; Rabin 1993; Xia et al. 2004). Second, although the menu costs of making price changes are arguably much lower online, we do not observe that firms selling products online deviate from the uniform pricing practice on branded variants. As an illustration, Table 1 summarizes the adoption of uniform prices in 10 selected categories at Amazon.com. Such adoption suggests that firms may not adjust prices between branded variants with different demand popularities even when doing so incurs little menu cost online. Finally, although the origin of uniform pricing might be due to other reasons (Orbach and Einav 2007), uniform pricing tends to persist even after the original reasons behind it no longer exist, because consumers are likely to view the deviation from past pricing practice as unfair (Kahneman et al. 1986a, b; Patrick 2005).

In this paper, we investigate the impacts of consumers' fairness concerns on firms' competitive pricing strategies for their branded variants and the resultant profits using a formal economic modeling

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[1] For example, experience tells us that it is easier to find extra large T-shirts than medium-sized ones in end-of-season sales, which indicates different demand conditions for different sizes of T-shirts.

[2] Orbach and Einav (2007) provide a comprehensive review of various explanations for the uniform pricing phenomenon.

Table 1   Uniform Prices for 10 Selected Categories at Amazon.com

Category/brand[a]	No. of variants[b]
Bridal veils	
David's Bridal	2
Hot from Hollywood	2
Special Moments	2
The Little White Dress	2
USABride	3
Coffees	
Donut House	2
Gloria Jean's	2
Green Mountain	7
Senseo	5
Tully's	3
Eyeshadows	
Elf Cosmetics	2
geoGiRL	6
NARS	38
NP Set	4
NYX	28
Luggage	
Beverly Hills Country Club	5
eBags	6
Kenneth Cole Reaction	2
Rockland	4
Samsonite	2
Men's pants	
Armani Exchange	9
DGK	6
Diesel	8
French Connection	5
G-Star	9
Men's shoes	
ECCO	5
Polo Ralph Lauren	12
Rockport	28
Sebago	11
Timberland	24
Men's sweaters	
Armani Exchange	6
Ben Sherman	6
Geoffrey Beene	5
H.E. Homini Emerito	4
Quiksilver	5
Women's clothing	
BCBGMAXAZRIA	4
Democracy	4
French Connection	7
MICHAEL Michael Kors	5
Shelli Segal	5
Women's scarves	
Capelli New York	3
Dahlia	4
Fossil	5
G by GUESS	2
LibbySue	7
Women's shoes	
Crocs	7
Kate Spade	13
FitFlop	7
Jessica Simpson	17
UGG	5

[a]We pick the top five brands with the highest popularity in each category chosen. Popularity at Amazon.com is determined by the sorting system under Amazon Best Sellers.

[b]The branded variants differ in size for clothing, pants, shoes, and sweaters; in color for bridal veils, eyeshadows, luggage, and scarves; and in flavor for coffees.

approach. There are three main ways of modeling fairness in literature. Rabin (1993) formalizes the notion of procedural fairness to explain the phenomenon that people tend to be nice to those who are nice to them and mean to those who are mean to them. Fehr and Schmidt (1999) model distributive fairness between players by incorporating people's aversion to inequality in their utility function. More recently, Ho and Su (2009) develop peer-induced fairness to explain the phenomenon that people may look to their peers as a reference to evaluate their own payoffs. Because the practice of uniform pricing can be viewed as a pricing policy opposite to the practice of price discrimination, in which a firm charges different prices for its branded variants sold to different consumers, peer-induced fairness is most likely to play a critical role in understanding uniform price. Ho and Su (2009) have suggested that peer-induced fairness can induce a monopoly firm to offer uniform prices. In this paper, we focus on the competitive context by incorporating peer-induced fairness into consumers' utility function to study how such concerns affect firms' competitive pricing strategies for their branded variants and the resultant profits.

Specifically, we are interested in addressing the following research questions. First, although it is expected that uniform pricing will arise in equilibrium as a result of consumers' fairness concerns, we are interested in understanding the implications of uniform pricing on firms' profits. Can uniform pricing be more profitable for firms than differentiated pricing, and, if so, under what conditions? Second, we further examine whether a firm has an incentive to unilaterally deviate from uniform pricing if it can mitigate consumers' fairness concerns to its prices by emphasizing the cost difference among its branded variants. These two questions are important because they are related to the long-run sustainability of uniform pricing.

Our analysis shows that uniform pricing of branded variants resulting from peer-induced consumers' fairness concerns can lead to higher profits for firms compared with nonuniform pricing in the absence of consumers' fairness concerns. Interestingly, we also find that a firm may not deviate from uniform pricing unilaterally, even if it can mitigate consumers' fairness concerns to its prices at no cost. Those findings suggest the sustainability of uniform pricing and further indicate that firms may benefit from consumers' fairness concerns on prices and may even want to facilitate such concerns for strategic reasons. Therefore, consumers' concerns of price fairness can act as a commitment device to enforce a uniform price equilibrium.

The main intuition behind our results is that uniform pricing may increase total demand of all

branded variants in the product category compared with nonuniform pricing in the absence of consumers' fairness concerns. This occurs when the high-price variant under nonuniform pricing has higher category demand elasticity than the low-price variant under nonuniform pricing. Because uniform pricing is between the high and low prices under nonuniform pricing, the adoption of uniform pricing will increase the demand of the higher-priced variant in a greater degree than reducing the demand of the lower-priced variant. Thus, the overall effect suggests an increase in total demand of all branded variants, which benefits both firms directly. Furthermore, the competition among firms is softened as firms take advantage of the category demand expansion by setting higher margins under uniform pricing than the average margins under nonuniform pricing. Consequently, the positive effects on firms' profits from uniform pricing can make it more profitable than nonuniform pricing in the absence of consumer fairness concerns and can also reduce firms' incentives to deviate from such pricing unilaterally, even if no extra communication cost is incurred.

This research complements the literature on the causes of uniform pricing for branded variants (Blinder et al. 1998, Dogan et al. 2010, Litman 1998, McMillan 2007, Orbach and Einav 2007) by further showing the profitability and sustainability of this practice as the result of consumers' fairness concerns on price. It also extends the literature that suggests that uniform pricing can be more profitable than the third-degree price discrimination or customized pricing in a competitive environment (Bester and Petrakis 1996; Chen 1997; Corts 1998; Holmes 1989; Shaffer and Zhang 1995, 2002; Taylor 2003; Villas-Boas 1999). A common feature of the papers in this literature is that a firm will have incentives to deviate from charging uniform pricing if the cost of doing so is small enough. Firms are thus engaged in the so-called prisoner's dilemma by charging nonuniform pricing, although doing so makes them worse off. We show that uniform pricing can rise in equilibrium and give firms higher profits than nonuniform pricing, even if firms can unilaterally charge nonuniform pricing at no extra cost. For instance, Holmes (1989) shows that uniform pricing can be more profitable than the third-degree discrimination for product variants. Although he obtained a necessary condition for such an outcome under linear demand assumption, we provide the elaborated conditions in our analysis. More importantly, we go beyond the simple profit comparison by showing that the fairness concerns of consumers provide a natural mechanism for firms to commit to uniform pricing, even when the firms could choose nonuniform pricing in the absence of consumers' fairness concerns. Moreover, firms may

not want to unilaterally deviate from uniform pricing, even if there is no cost. We view this as an important contribution to the literature because the commitment mechanism to uniform pricing is a critical but understudied research issue.

The only paper that we are aware of regarding the credibility of firms' commitment to uniform pricing is Corts (1998). He shows that committing to uniform pricing can emerge credibly in equilibrium if competing firms have asymmetric best-response functions to each other's prices and if price discounts are feasible only to certain segments of consumers, such as senior citizens or people with a low cost of using coupons. In contrast, we show that firms can credibly commit to uniform pricing by not unilaterally mitigating consumers' fairness concerns on prices. This occurs in equilibrium even if discounts can be given to any consumer segment.

More broadly speaking, our research also adds to the growing literature on incorporating behavioral theory-based assumptions into quantitative models to generate deep insights on marketing phenomena and firms' strategic marketing decisions (e.g., Amaldoss and Jain 2005; Bradlow et al. 2004a, b; Chen et al. 2010; Cui and Mallucci 2012; Cui et al. 2007; Feinberg et al. 2002; Goldfarb et al. 2012; Hardie et al. 1993; Haruvy et al. 2007; Ho and Zhang 2008; Lim and Ho 2007; Meyer et al. 2010; Orhun 2009; Syam et al. 2008).

The rest of this paper is organized as follows. In §2, we lay out the basic model for this research and present the conditions for firms to adopt uniform pricing and be better off from it. In §3, we extend our basic model to examine firms' incentives to deviate from uniform pricing through changing consumers' perceptions of fairness. We also show the robustness of our main results under more flexible demand assumptions. Finally, §4 summarizes the main findings from our analysis and points out directions for future research.

2. Basic Model and Analysis

In this section, we present the basic model of our study, derive our main results from it, and discuss the intuitions behind those results. We start with the case where consumers' fairness concerns on prices are absent, followed by the case where the fairness concerns are present.

Consider two competing firms, Firm 1 and Firm 2, each selling two products (branded variants) in a product category. In the context of our model, the two firms can be two competing retailers facing the same wholesale prices, or they can be two competing manufacturers selling directly to consumers through an integrated channel or with nonstrategic retailers that set fixed markups to wholesale prices. The two products have the same production costs that are

normalized to zero for both firms. Assume that there are two segments of consumers. Consumers in segment A, with size $0 < \gamma_A < 1$, purchase branded variant A, and consumers in segment B, with size $\gamma_B = 1 - \gamma_A$, purchase branded variant B. In §3, we extend the model so consumers in a segment can purchase from the other segment and show that the main results from our basic model are robust.

Consumers purchasing branded variant A are located uniformly on a Hotelling line bounded between 0 and 1. Firm 1's branded variant A is located at 0, and Firm 2's branded variant A is located at 1 (Hotelling 1929). Consumers purchasing branded variant B are located uniformly on a Hotelling line bounded between -1 and 2. Firm 1's branded variant B is located at m, and Firm 2's branded variant B is located at $1 - m$, where $0 < m < 1/2$. The parameter m captures the difference in the firms' relative positioning for the two product variants. For example, the taste of fat-free yogurt (variant B) may be more similar across different brands than the taste of regular yogurt (variant A) across brands because of the constraint of ingredients. Given that $0 < m < 1/2$, the difference in lengths of the Hotelling line for different product variants reflects the expandability of the category demand for the product variants. For example, suppose that, unlike consumers of regular yogurt, some potential consumers of fat-free yogurt might not like all of the competing brands in the category because of the poor taste of the product, even though they might still prefer one brand to the other. Consequently, those consumers might not buy from the category. In our model, those would be the consumers located near the two ends of the Hotelling line for the fat-free yogurt segment, which would be longer than the Hotelling line for the regular yogurt segment.

A consumer who purchases branded variant A incurs a mismatching disutility of $t \cdot s$ if she purchases a product from a firm located s away from the her, where t is the unit mismatch cost that measures the magnitude of disutility incurred from the mismatch between her ideal product and the product offered by a firm. The surplus of a consumer in segment A from the consumption of branded variant A from a firm is given by $V - t \cdot s - p$, where p is the price of the product from the firm. The surplus of a consumer in segment B is calculated similarly, but the unit mismatching cost is given by 1. In this paper, we focus the analysis on the case of $0 < t < 1$. This constraint on t, as we show later, is necessary to ensure that the equilibrium prices for variant B are higher than the equilibrium prices of variant A in the absence of consumers' fairness concerns.

Based on Ho and Su (2009), the consumer may incur some negative utility if other consumers pay a lower price for a product from the same firm; that is,

there are peer-induced fairness concerns.[3] Xia et al. (2004) suggest that a consumer may explicitly compare the price she pays with the price paid by others, and price unfairness perceptions will occur when the consumer pays a higher price than others. We use i to refer to the branded variant and use j to refer to the firm. Let $\bar{i}$ denote B when $i = A$ and denote A when $i = B$, and let $\bar{j}$ denote 1 when $j = 2$ and denote 2 when $j = 1$. Following the specification used in Ho and Su (2009), we capture the peer-induced fairness concern with an additional term, $-z_{i\bar{i}j} = -\theta\delta_{i\bar{i}j}(p_{ij} - p_{\bar{i}j})$, in a consumer's utility function, where $\delta_{i\bar{i}j} = 1$ if $p_{ij} > p_{\bar{i}j}$ and $\delta_{i\bar{i}j} = 0$ if otherwise. Parameter θ captures a consumer's aversion from getting a higher price with a firm when compared with consumers in the other segment.

We have the following utility specification for consumer x in segment A or segment B buying from Firm j:

$$
\begin{aligned}
u_{A1} &= V - p_{A1} - t \cdot x - z_{A1} \\
&= V - p_{A1} - t \cdot x - \theta\delta_{AB1}(p_{A1} - p_{B1}), \\
u_{A2} &= V - p_{A2} - t \cdot (1-x) - z_{A2} \\
&= V - p_{A2} - t \cdot (1-x) - \theta\delta_{AB2}(p_{A2} - p_{B2}), \quad (1)\\
u_{B1} &= V - p_{B1} - |x-m| - z_{B1} \\
&= V - p_{B1} - |x-m| - \theta\delta_{BA1}(p_{B1} - p_{A1}), \\
u_{B2} &= V - p_{B2} - |1-m-x| - z_{B2} \\
&= V - p_{B2} - |1-m-x| - \theta\delta_{BA2}(p_{B2} - p_{A2}).
\end{aligned}
$$

The marginal consumers between both firms in segments A and B are respectively given by

$$
\begin{aligned}
\bar{x}_A &= \frac{1}{2} + \frac{1}{2t}[p_{A2} - p_{A1} + \theta\delta_{AB2}(p_{A2} - p_{B2}) \\
&\qquad\qquad - \theta\delta_{AB1}(p_{A1} - p_{B1})], \quad (2)
\end{aligned}
$$

$$
\begin{aligned}
\bar{x}_B &= \frac{1}{2} + \frac{1}{2}[p_{B2} - p_{B1} + \theta\delta_{BA2}(p_{B2} - p_{A2}) \\
&\qquad\qquad - \theta\delta_{BA1}(p_{B1} - p_{A1})].
\end{aligned}
$$

This leads to the following demand functions:

$$
\begin{array}{ll}
q_{A1} = \gamma_A \cdot \bar{x}_A, & q_{B1} = \gamma_B \cdot (\bar{x}_B - \bar{x}_1), \quad (3)\\
q_{A2} = \gamma_A \cdot (1 - \bar{x}_A), & q_{B2} = \gamma_B \cdot (\bar{x}_2 - \bar{x}_B),
\end{array}
$$

where $\bar{x}_1 = m - [V - p_{B1} - \theta\delta_{BA1}(p_{B1} - p_{A1})]$ and $\bar{x}_2 = 1 - m + V - p_{B2} - \theta\delta_{BA2}(p_{B2} - p_{A2})$.[4] To reduce the number of parameters without changing the insights from the model, we let $\gamma_A = \gamma_B = 1/2$.[5]

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[4] Consumers located at $\bar{x}_1$ and $\bar{x}_2$ get zero surplus from Firm 1 and Firm 2, respectively. The derivations are straightforward and available from the authors upon request.

[5] It can be shown that the main results still hold for $\gamma_A \neq 1/2$, but the analysis is more tedious.

Given the derivations above, we now consider the case where there is no fairness concern.

2.1. When Fairness Concerns Are Absent

In the absence of fairness concerns of consumers, i.e., $\theta = 0$, the marginal consumer between both firms in segments A and B is given by

$$\bar{x}_A = \frac{1}{2} + \frac{1}{2t}(p_{A2} - p_{A1}), \quad \bar{x}_B = \frac{1}{2} + \frac{1}{2}(p_{B2} - p_{B1}). \quad (4)$$

Notice that Equation (4) implies that the demands of a firm's two branded variants are independent. It is applicable to situations within firms such as firms selling shoes with different sizes or baby clothes for different genders.

Firms compete with a simultaneous move game where Firm j sets p_{Aj} and p_{Bj} simultaneously to maximize the total profits from its two branded variants:

$$\pi_1 = \pi_{A1} + \pi_{B1} = \tfrac{1}{2}\bar{x}_A p_{A1} + \tfrac{1}{2}(\bar{x}_B - \bar{x}_1)p_{B1},$$
$$\pi_2 = \pi_{A2} + \pi_{B2} = \tfrac{1}{2}(1 - \bar{x}_A)p_{A2} + \tfrac{1}{2}(\bar{x}_2 - \bar{x}_B)p_{B2}. \quad (5)$$

It is straightforward to show that the equilibrium prices, demand, and profits are given, respectively, by

$$p_{A1}^* = p_{A2}^* = p_A^{NU} = t,$$
$$p_{B1}^* = p_{B2}^* = p_B^{NU} = \tfrac{1}{5}(2V + 1 - 2m);$$
$$q_{A1}^* = q_{A2}^* = q_A^{NU} = \tfrac{1}{4},$$
$$q_{B1}^* = q_{B2}^* = q_B^{NU} = \tfrac{1}{20}(3 + 6V - 6m); \quad (6)$$
$$\pi_1^* = \pi_2^* = \pi_{NU}$$
$$= \tfrac{1}{100}\left[12V^2 + 12V(1 - 2m) + 25t + 3 - 12m(1 - m)\right].$$

In the following discussion, we focus on the case $m < \min\{(2V + 1 - 5t)/2, 1/2\}$, which ensures that product variant B has a higher price than product variant A.[6] Because both firms' products are located within the Hotelling line for branded variant B but at the ends of the line for branded variant A, the assumption $m < \min\{(2V + 1 - 5t)/2, 1/2\}$ implies that the product variant with a higher price has higher category demand elasticity than the other product variant. This is analogous to the findings in Blattberg and Wisniewski (1989), which show that the cross-price elasticities among premium brands are higher than those among lower-priced brands and that premium brands are more likely to gain sales from lower-tier brands in price promotion than vice versa.

For ease of future discussion, we call product variant B the *strong product variant* and product variant A

[6] The lower bound of parameter m is given by $m \geq \max\{1/2 - (3/7)V, \ (V - 1 + 3tV - 7t)/(1 + 3t), \ (1 - 2V - 6tV + 9t)/(2 + 14t)\}$, which ensures that the marginal consumers located between both firms will get nonnegative surplus; i.e., there is no consumer uncovered between firms. For the same reason, we also assume that $V \geq (3/2)t$.

the *weak product variant*, following the tradition in the literature (Holmes 1989). It is quite intuitive for firms to charge different prices for two product variants in the absence of consumers' fairness concerns. Because the demands of the two product variants are different, setting uniform prices will not be an optimal strategy.

2.2. When Fairness Concerns Are Present

In the presence of consumers' fairness concerns, when a firm charges different prices to different branded variants (e.g., athletic shoes with sizes 8 and 12 or undergarments with sizes small and large), a consumer may feel that the prices are unfair. In the presence of peer-induced fairness, we can solve for firms' equilibrium prices and profits given the demand function from Equation (3) under $\theta > 0$. Lemma 1 summarizes the results.

LEMMA 1. *If*

$$\theta \geq \underline{\theta} = \frac{2V + 1 - 2m - 5t}{6t(V + 1 - m)},$$

both firms choosing uniform pricing is a unique equilibrium, and firms' equilibrium prices, demand, and profits are given, respectively, by

$$p_{ij}^* = p_U = \frac{2t(V + 1 - m)}{1 + 5t};$$
$$q_{A1}^* = q_{A2}^* = q_A^U = \frac{1}{4},$$
$$q_{B1}^* = q_{B2}^* = q_B^U = \frac{1}{4} + \frac{V - m + t(3V - 2 - 3m)}{2(1 + 5t)}; \quad (7)$$
$$\pi_1 = \pi_2 = \pi_U = \frac{t(1 + 3t)(V + 1 - m)^2}{(1 + 5t)^2}.$$

If $\theta < \underline{\theta}$, both firms choosing nonuniform pricing is a unique equilibrium, and firms' equilibrium prices, demand, and profits are given by

$$p_{Aj}^* = \frac{t(5 + 6V\theta + 8\theta - 6m\theta)}{5 + 5\theta - 6t\theta^2},$$
$$p_{Bj}^* = \frac{2V + 1 - 2m + 2t\theta}{5 + 5\theta - 6t\theta^2};$$
$$q_{A1}^* = q_{A2}^* = \frac{1}{4},$$
$$q_{B1}^* = q_{B2}^* = \frac{3(1 + \theta)(1 - 2m + 2V + 2t\theta)}{4(5 + 5\theta - 6t\theta^2)}; \quad (8)$$
$$\pi_1^{NN} = \pi_2^{NN} = \frac{t(5 + 6V\theta + 8\theta - 6m\theta)}{4(5 + 5\theta - 6t\theta^2)}$$
$$+ \frac{3(1 + \theta)(2V + 1 + 2t\theta - 2m)^2}{4(5 + 5\theta - 6t\theta^2)^2}.$$

PROOF. Please see the appendix.[7]

Lemma 1 shows that if consumers' concerns of price fairness are strong, i.e., $\theta \geq \underline{\theta}$, then firms will adopt a uniform pricing strategy in equilibrium. Firms face trade-offs when making pricing decisions with the presence of consumers' fairness concerns. On one hand, they have an incentive to charge different prices to their branded variants based on different consumer demand. On the other hand, they have to close the gap between prices charged for different product variants in order to minimize the negative impact of consumers' fairness concerns on the demand of the higher-priced product variant. When θ is large, the force to reduce the price gap dominates so that firms adopt uniform pricing.

It is easy to verify that $p_A^{NU} < p_U < p_B^{NU}$, which is intuitive. From Lemma 1, $\partial \underline{\theta}/\partial m < 0$, $\partial \underline{\theta}/\partial t < 0$, and $\partial \underline{\theta}/\partial V > 0$; i.e., uniform pricing is more likely to occur in equilibrium when m and t increase or V decreases. The intuition for these comparative statics is as follows. A higher m or lower V implies that the category demand for variant B (the higher-priced variant) is more expandable with a lower price because a larger portion near the two ends of the Hotelling line is not covered in this case. Because uniform pricing lowers the prices for variant B compared with the case of nonuniform pricing, the benefits of uniform pricing to firms' profits as a result of category demand expansion are thus higher with a higher m or a lower V. Regarding the impact of t on $\underline{\theta}$, a higher t results in higher prices of variant A so that the prices of variant A are closer to those of variant B. Consequently, the benefits of price discrimination are reduced so that uniform pricing is more likely to be optimal.

Notice that $p_B^{NU} - p_A^{NU} = (2V + 1 - 2m - 5t)/5$. Obviously, we also have $\partial(p_B^{NU} - p_A^{NU})/\partial m < 0$, $\partial(p_B^{NU} - p_A^{NU})/\partial t < 0$, and $\partial(p_B^{NU} - p_A^{NU})/\partial V > 0$; i.e., those comparative statics are of the same signs as the corresponding comparative statics on $\underline{\theta}$. This implies that firms are more likely to choose uniform pricing when the equilibrium price difference between the two product variants is smaller in the absence of consumers' fairness concerns. This result is intuitive because the benefit of setting differential prices diminishes when $p_A^{NU} - p_B^{NU}$ is small.

Lemma 1 also shows that if consumers' concerns of price fairness are not very strong, i.e., $\theta < \underline{\theta}$, then firms will still adopt a nonuniform pricing strategy in equilibrium. In this scenario, we have $\partial p_{Aj}^*/\partial\theta > 0$ and $\partial p_{Bj}^*/\partial\theta < 0$. That is, firms will reduce the gap

between the prices of their branded variants by moving prices toward the middle as consumers' fairness concerns become stronger. As θ increases, firms' profits from variant A increase as prices increase. Firms' profits from variant B, however, may go up or down, because they are facing the trade-off between higher category demand and lower prices. Consequently, the total profit π_j^{NN} can either increase or decrease as θ goes up. In particular, when $\theta \to \underline{\theta}$, we have $\partial \pi_j^{NN}/\partial\theta > 0$ for a sufficiently large m and $\partial \pi_j^{NN}/\partial\theta < 0$ for a sufficiently small m and large t. In the former case, the potential of category demand expansion is large so that the overall impact on profits with an increase in θ is positive. In the latter case, the potential of category demand expansion is limited, and the increase in prices to variant A is small compared with the situation where fairness concerns are absent. Thus, firms' profits decrease in θ in this case.

An interesting question regarding uniform pricing is its profit implications to firms. Without fairness concerns from consumers, firms will set nonuniform prices and get profits of $\pi_{NU} = (1/100)[12V^2 + 12V \cdot (1 - 2m) + 25t + 3 - 12m(1 - m)]$, as shown in Equation (6). From Lemma 1, the change of firms' profits from nonuniform pricing to uniform pricing as a result of the presence of fairness concerns (i.e., from $\theta = 0$ to $\theta \geq \underline{\theta}$) is given by

$$\pi_U - \pi_{NU} = \frac{2V + 1 - 2m - 5t}{100(1 + 5t)^2}[6m + 10tm - 3 - 6V$$
$$+ 30t - 10tV + 125t^2]. \quad (9)$$

Figure 1 shows how the sign of $\pi_U - \pi_{NU}$ changes with m and t for $V = 1$. The precise condition is given in Proposition 1.[8]

PROPOSITION 1. *Firms' equilibrium profits in the presence of consumers' concerns of fairness are higher than those in the absence of consumers' concerns of fairness if* (i) *firms adopt uniform pricing in equilibrium and* (ii) $(6V + 3 - 30t + 10tV - 125t^2)/(2(3 + 5t)) = \bar{m} < m < \min\{(2V + 1 - 5t)/2, 1/2\}$.

Figure 1 and Proposition 1 suggest that firms' profits with a uniform pricing strategy can actually be *higher* when consumers care about price fairness than when they do not demand fairness at all. The conditions in Proposition 1 are more likely to hold when m and t are both large (but given that the assumption $m < \min\{(2V + 1 - 5t)/2, 1/2\}$ is met).

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[7] Unless otherwise stated, the proofs of lemmas and propositions can be found in the appendix.

[8] Note that because π_{NU} are firms' equilibrium profits at $\theta = 0$, the sign of $\pi_U - \pi_{NU}$ is not necessarily the same as the sign of $\partial \pi_j^{NN}/\partial\theta$, as discussed after Lemma 1.

Figure 1 Value of $\pi_U - \pi_{NU}$ with Uniform Pricing as the Equilibrium Strategy
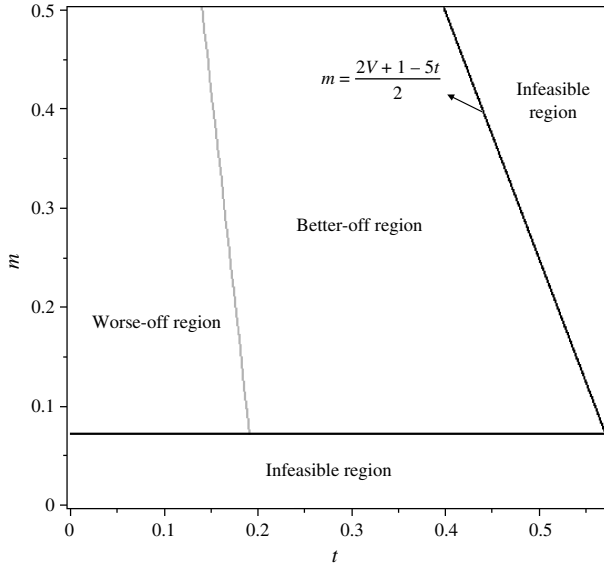
Note. The infeasible region refers to the regions in which the conditions in Proposition 1 do not hold.

To understand the intuition behind this result, we rewrite Equation (9) as

$$\pi_U - \pi_{NU} = -\frac{p_A^{NU} - p_B^{NU}}{2}(q_A^{NU} - q_B^{NU})$$
$$+ p_U(q_A^U - q_A^{NU} + q_B^U - q_B^{NU})$$
$$+ \left(p_U - \frac{p_A^{NU} + p_B^{NU}}{2}\right)(q_A^{NU} + q_B^{NU}). \quad (10)$$

From Equation (10), we can see that there are three effects on profits when firms shift from nonuniform pricing in the absence of fairness concerns to uniform pricing as a result of consumers' fairness concerns. First, uniform pricing takes away the ability of firms to price discriminate among consumers. This has a negative impact on firms' profits and is reflected by the first term on the right-hand side of Equation (10). Second, there is a category demand expansion effect. Although the demand of the weak product variant stays the same, the demand of the strong product variant increases as its price falls with uniform pricing. This has a positive impact on firms' profits and is shown by the second term on the right-hand side of Equation (10). Finally, there can be an increase in the average price with uniform pricing, which has a positive impact on firms' profits and is reflected by the third term on the right-hand side of Equation (10). This effect is the consequence of category demand expansion, as firms have an incentive to increase their overall prices (i.e., soften competition) in order to take advantage of the expanded category demand when such demand expansion is large.

When t increases, the price difference between the two product variants becomes smaller under nonuniform pricing. Therefore, the negative impact of uniform pricing on profits reduces so that it is likely to be more profitable than nonuniform pricing when t is large. When m increases, as we discussed following Lemma 1, the category demand for variant B (the higher-priced variant) is more expandable with a lower price. Thus, the benefits of uniform pricing compared with nonuniform pricing are larger with a larger m because of the category expansion effect.

The intuition for Proposition 1 shows that the demand expansion of the product category under uniform pricing is critical for uniform pricing to be more profitable than nonuniform pricing.[9] Category demand expandability is rather ubiquitous; it can be a result of consumption flexibility for categories such as soft drinks and yogurt (Guo 2010) or a result of nonnegligible income effects, which may apply to categories subject to consumer discretionary spending, such as clothes and shoes (Klayman 2010).

Finally, it is important to point out that consumers' concerns about peer-induced price fairness are crucial for uniform pricing to be the equilibrium outcome, although such fairness concerns do not affect the equilibrium profits under uniform pricing. In essence, consumers' fairness concerns provide a mechanism device for firms to credibly commit to uniform pricing in equilibrium, even when (in a standard model without fairness) the firms would choose to price discriminate and overcompete in price. It is such a commitment device that makes consumers' fairness concerns attractive for firms under the conditions given in Proposition 1. In addition, as will be shown in §3, firms will have no incentives to unilaterally deviate from adopting uniform pricing strategies under certain conditions. This further confirms that consumers' fairness concerns can act as a commitment device. Therefore, in the absence of consumers' fairness concerns, firms will end up in a prisoner's dilemma situation by adopting nonuniform pricing, even though both firms would be better off if they could commit to uniform pricing when condition (ii) in Proposition 1 holds.

3. Extensions
In this section, we further investigate the robustness and generalizability of the main results obtained from

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[9] In previous versions of this paper, we considered two different model setups and obtained similar results. The key intuition is similar: uniform pricing rises in equilibrium because of fairness concerns, and it can be more profitable than nonuniform pricing in the absence of fairness concerns if, as the consequence of adopting uniform pricing, the category demand gain of the strong product variant is higher than the category demand loss of the weak product variant.

the basic model through several model extensions. In §3.1, we extend the basic model by allowing firms to strategically influence consumers' fairness concerns on prices. We show the robustness of our findings from the basic model by letting the product variants be substitutes in §3.2 and by allowing the other firm's pricing strategy to affect a consumer's concerns of fairness in §3.3.

3.1. Firms' Incentives of Influencing Consumers' Fairness Concerns

In the basic model discussed in §2, consumers' concerns on price fairness are assumed to be exogenous. In many circumstances, however, firms may be able to influence consumers' perceptions of price fairness through marketing communication or product design. For example, a firm may emphasize the cost difference among its branded variants to mitigate peer-induced fairness concerns and justify nonuniform pricing (Bolton et al. 2003, Xia et al. 2004).

In this section, we explicitly examine two firms' incentives of influencing consumers' fairness perceptions through a two-stage game setup. In the first stage, both firms simultaneously decide whether to influence consumers' fairness concerns so that charging different prices for branded variants by the same firm will not be perceived as unfair.[10] Without qualitatively affecting the results presented below, we assume that firms can change consumers' fairness concerns at no cost if they choose to do so. In the second stage, the firms simultaneously choose prices to maximize the total profits from their branded variants. An interesting question to address in this analysis is whether a firm has an incentive to unilaterally mitigate consumers' fairness concerns on prices if it comes with no communication cost.

We solve for the subgame-perfect equilibrium of this two-stage game using backward induction. We first derive the equilibrium results for the asymmetric case where only one firm mitigates consumers' fairness concerns. Without loss of generality, we consider the case where Firm 1 mitigates consumers' fairness concerns but Firm 2 does not. The case in which Firm 2 mitigates but Firm 1 does not can be solved in a similar fashion. When only Firm 1 mitigates consumers' fairness concerns on prices, the demand function is as in Equation (3) with $\delta_{AB1} = \delta_{BA1} = 0$ always. The equilibrium results are summarized in Lemma 2.

LEMMA 2. *When only Firm 1 mitigates consumers' fairness concerns on prices, Firm 2 will choose uniform pricing if $\theta \geq \underline{\theta}_e = (14V + 7 - 14m - 35t)/(4t(7V + 8 - 7m))$.*

Firms' equilibrium prices and profits are given in the appendix. It can be easily verified that $\underline{\theta}_e > \underline{\theta}$. In the following discussion, we will focus on the cases where $\theta \geq \underline{\theta}_e$ so that uniform pricing can occur in equilibrium as long as at least one firm is facing price fairness concerns from consumers. Figure 2 shows firms' equilibrium strategies in the first stage of the game for the appropriate parameter ranges of m and t. We formalize this in Proposition 2.

PROPOSITION 2. *Firms will have no incentive to unilaterally mitigate consumers' concerns of price fairness when* (i) $\theta \geq \underline{\theta}_e$ *and* (ii) $\underline{m}_M < m < \min\{(2V + 1 - 5t)/2, 1/2\}$, *where*

$$\underline{m}_M = \big(54V + 27 + t(40 + 494V) - t^2(1166 - 1562V) \\ - t^3(5000 - 1890V) - 6125 \cdot t^4\big)$$

$$\cdot (54 + 494 \cdot t + 1562 \cdot t^2 + 1890 \cdot t^3)^{-1}.$$

Interestingly, Figure 2 and Proposition 2 show that the case in which neither firm mitigates consumers' fairness concerns can occur in equilibrium, even if each firm could do that unilaterally without any cost. Therefore, the profit enhancement result of uniform pricing shown in Proposition 1 can hold even when consumers' fairness concerns can be strategically influenced by each firm.

Figure 2 **Equilibrium Strategies for $\theta \geq \theta_e$ When Firms Can Mitigate Consumers' Fairness Concerns on Prices**
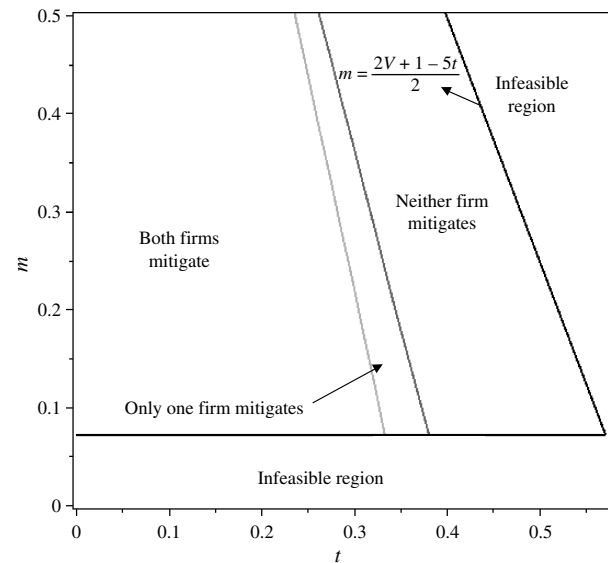
Note. The infeasible region refers to the regions in which the conditions in Proposition 1 do not hold.

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[10] If firms have incentives to influence consumers' fairness perceptions in the first stage in equilibrium, this will form a new equilibrium. We call such a move in the first stage "unilateral mitigation" in the paper. We thank an anonymous reviewer for pointing this out to us.

In addition, Proposition 2 and Figure 2 suggest that neither firm has any incentive to mitigate consumers' fairness concerns when both m and t are large (given that the assumption $m < \min\{(2V + 1 - 5t)/2, 1/2\}$ is met). The intuition is as follows. When a firm unilaterally deviates from uniform pricing by mitigating consumers' fairness concerns on differentiated prices, it can compete more effectively than it would have prior to deviation because it gains the flexibility of setting two different prices. As a response to this deviation, the competing firm will have to lower the uniform price it charges to both product variants. When t is large, the response from the competing uniform pricing firm will be very aggressive; it has a strong incentive to protect its share of the weak product variant because its profit potential is large (t is large), and the deviating firm can set a low price just for this product variant. Consequently, this competitive reaction reduces the potential gain to the deviating firm. When m is large, the benefit toward the deviating firm will also be small because in such a case, the total category demand loss will be large for the firm that switches to nonuniform pricing. Hence, the incentive for a firm to deviate from uniform pricing by mitigating consumers' fairness concerns is lower when m and t are larger.

The results of Proposition 2 are based on the assumption that the production costs of the two product variants are the same. When the strong product variant incurs a higher product cost than the weak product variant, firms will have a natural "excuse" to let consumers believe that it is fair to charge a higher price for the product with a higher production cost (Bolton and Alba 2006). Even under this circumstance, we can show that firms may not have an incentive to unilaterally disclose the cost differences for the two product variants. This occurs as an equilibrium when the cost difference is small, m is large, and t is large. The details of the derivation can be found in the appendix. This result offers an explanation for the frequently observed phenomena that branded variants, which are likely to have different production costs, are charged with the same price.

3.2. Substitution Between Product Variants

In our basic model, we assume that the demand of the two product variants is nonsubstitutable. This assumption applies to product categories such as shoes with different sizes or baby clothes for different genders, for example. However, in many other circumstances, the demand of different product variants tends to be substitutable.

To allow the possibility of demand substitution between product variants and also incorporate consumers fairness concerns into consumers' utility, we assume that there are six segments of consumers.

Consumers in the first two segments A and B, each with size $0 < \gamma < 1/2$, purchase branded variants A and B, respectively. These two segments are similar to the segments A and B in the basic model. Consumers in the third segment, AB, are choose between the branded variant A from Firm 1 that is located at 0 and the branded variant B from Firm 2 that is located at $1 - m$. Consumers in the fourth segment, BA, choose between the branded variant B from Firm 1 that is located at m and the branded variant A from Firm 2 that is located at 1. Consumers in each of the first four segments are uniformly distributed along the Hotelling line, defined similarly as in the basic model for each branded variant. The unit disutility cost for consumers in segments AB and BA is given by $0 < h < 1$. The last two segments, each with size $0 < \varpi < 1/2$, are defined as segment 1 and segment 2, respectively. Consumers in segment i ($i = 1, 2$) purchase from Firm i only. They are uniformly distributed along the Hotelling line of unit length with a unit disutility cost of $0 < k < 1$. Each firm's branded variants are located at $y = 0$ and $y = 1$, respectively. That is, each consumer in any of the last two segments buys from one firm only, and consumers in the same segment have horizontally differentiated preferences to branded variants from the firm. Here, the parameters h and k capture the substitution effect—the impact that the price of one branded variant has on the demand of another branded variant.

Given firms' prices p_{ij}, and with fairness concerns captured by the term $-z_{ii\bar{j}} = -\theta \delta_{ii\bar{j}}(p_{ij} - p_{i\bar{j}})$ as in the basic model, the marginal consumer in each segment is given by

$$\bar{x}_A = \frac{p_{A2} - p_{A1} + z_{AB2} - z_{AB1} + t}{2t},$$

$$\bar{x}_B = \frac{p_{B2} - p_{B1} + z_{BA2} - z_{BA1} + 1}{2};$$

$$\bar{x}_{AB} = \frac{p_{B2} - p_{A1} + z_{AB2} - z_{AB1} + h(1 - m)}{2h},$$

$$\bar{x}_{BA} = \frac{p_{A2} - p_{B1} + z_{AB2} - z_{BA1} + h(1 + m)}{2h};$$

$$\bar{y}_1 = \frac{p_{B1} - p_{A1} + k}{2k}, \quad \bar{y}_2 = \frac{p_{B2} - p_{A2} + k}{2k}.$$

Firms' profits are given by

$$\pi_1^s = p_{A1}\big[\gamma \cdot \bar{x}_A + \delta \cdot \bar{x}_{AB} + \varpi \cdot \bar{y}_1\big]$$
$$+ p_{B1}\big[\gamma(\bar{x}_B - \bar{x}_1), + \delta(\bar{x}_{BA} - \bar{x}_{BA1}) + \varpi(1 - \bar{y}_1)\big]; \quad (11)$$
$$\pi_2^s = p_{A2}\big[\gamma(1 - \bar{x}_A) + \delta(1 - \bar{x}_{BA}) + \varpi \cdot \bar{y}_2\big]$$
$$+ p_{B2}\big[\gamma(\bar{x}_2 - \bar{x}_B) + \delta(\bar{x}_{AB2} - \bar{x}_{AB}) + \varpi(1 - \bar{y}_2)\big],$$

where $\bar{x}_1, \bar{x}_2, \bar{x}_{BA1},$ and $\bar{x}_{AB2}$ refer to the locations of the consumers whose surpluses are given by zero from

purchasing a branded variant B from a firm. The equilibrium prices and profits for both the benchmark case without fairness concerns and the case of having fairness concerns can be solved in a similar fashion as in the basic model.[11]

When consumers have sufficiently strong concerns of price fairness, both firms will adopt uniform pricing, and the equilibrium prices and profits are summarized in Lemma 3.

LEMMA 3. *If*

$$\theta \geq \underline{\theta}_s = \frac{tV + h(2V + 2tV - 8t) + h^2(4V + 4 - 5m - 20t + 5tm)}{t(1 + 2h)(V + 4h + 2hV - 3hm)},$$

both firms choosing uniform pricing is a unique equilibrium. Firms' prices and profits in equilibrium are given by

$$p_{ij}^{s*} = p_U^s = \frac{t(V + 2hV + 4h - 3hm)}{3t + h + 5th},$$

$$\pi_1^s = \pi_2^s = \pi_U^s \tag{12}$$

$$= \frac{t(V + 2hV + 4h - 3hm)^2(2t + h + 3th)}{8h(3t + h + 5th)^2}.$$

Moreover, similar to Proposition 1, we can show that both firms can be better off with uniform pricing than with nonuniform pricing, although the results are more tedious than the basic model. Hence, the main results from our basic model are robust when we consider the substitution effects between product variants.

3.3. Fairness Concerns Across Firms

In our basic model, we assume that a consumer with peer-induced fairness concerns does not care whether the other firm is charging different prices for its branded variants. In this section, we consider the case where the other firm's pricing strategy also affects a consumer's concerns of fairness. More specifically, we capture the concerns of fairness with a term, $-z_{ij} = -\theta \delta_{i\bar{i}j}(p_{ij} - p_{\bar{i}j}) - \alpha \theta(1 - \delta_{i\bar{i}j})\delta_{i\bar{i}\bar{j}}(p_{ij} - p_{\bar{i}\bar{j}})$, in the consumer's utility function, where $\delta_{i\bar{i}j} = 1$ if $p_{ij} > p_{\bar{i}j}$ and $\delta_{i\bar{i}j} = 0$ if otherwise, and $\delta_{i\bar{i}\bar{j}} = 1$ if $p_{ij} > p_{\bar{i}\bar{j}}$ and $\delta_{i\bar{i}\bar{j}} = 0$ if otherwise. Here, we still let $\bar{i}$ denote B when $i = A$ and denote A when $i = B$, and let $\bar{j}$ denote 1 when $j = 2$ and denote 2 when $j = 1$. The additional term $-\alpha \theta(1 - \delta_{i\bar{i}j})\delta_{i\bar{i}\bar{j}}(p_{ij} - p_{\bar{i}\bar{j}})$ implies that a consumer incurs additional negative utility if other consumers pay a lower price for a product from the same firm while, at the same time, the other firm is charging uniform prices. It is reasonable to assume that a consumer's fairness concerns about the prices of the

other firm's products are weaker than fairness concerns about the prices of the firm from which the consumer buys a product; this leads to Lemma 4, where we assume $0 \leq \alpha < 1$.

LEMMA 4. *If $\theta \geq \underline{\theta}_\alpha = (2V + 1 - 2m - 5t)/(6t(1 + \alpha) \cdot (V + 1 - m))$, both firms choosing uniform pricing is a unique equilibrium, and firms' equilibrium prices, demand, and profits are given by Equation (7).*

Lemma 4 suggests that firms will still choose uniform prices with fairness concerns across firms as long as the fairness concerns are strong enough. Interestingly, as such concerns become stronger (i.e., α becomes larger), the threshold value of θ for firms to choose uniform pricing becomes smaller, $\partial \underline{\theta}_\alpha / \partial \alpha < 0$ for $m < \min\{(2V + 1 - 5t)/2, 1/2\}$. Hence, the existence of fairness concerns across firms will make them more willing to choose uniform pricing in the equilibrium.

4. Conclusion

It may seem puzzling that uniform pricing could be widely adopted in the retailing industry because it seems instead that retailers might improve profitability with variable pricing to exploit the difference in product demand. In this paper, we show that a uniform pricing policy can emerge as an equilibrium result in a model of price competition that incorporates consumers' concerns of price fairness.[12] More interestingly, we find that uniform pricing of branded variants can help mitigate price competition and thus increase firms' profits. In this sense, consumers' fairness concerns may provide a natural mechanism for firms to commit to uniform pricing and maintain high profits.

In addition, we show that a firm may not have any incentive to unilaterally mitigate consumers' concerns of fairness so that consumers believe that it is "fair" for the firm to charge nonuniform prices. This holds true even if the firm incurs no communication cost to mitigate consumers' fairness concerns on price. Furthermore, even if different product variants may have different costs so that consumers, if informed with such information, may feel it is fair for a firm

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[11] The proof is omitted here for the sake of brevity and is available from the authors upon request.

[12] The concept of fairness may help explain the phenomenon of "uniform offering" in more than just the domain of price. For example, it is common for online retailers to offer free shipping services to consumers without varying the delivery time based on a consumer's total purchase amount. One example is the uniform "FREE Super Saver Shipping on selected orders of $25 and over" by Amazon. Similarly, when a frequent flyer passenger takes a flight with an airline, the usual conversion rate for an economy ticket is one reward mile per mile of flight; such a conversion rate does not change based on the popularity (i.e., demand condition) of the flight. We thank Eric Bradlow for suggesting the applicability of the main idea of this paper for multiple domains.

to charge different prices to its branded variants, the firm may still prefer that consumers perceive the costs to be the same and feel that it is unfair for the firm to charge nonuniform prices. These results suggest the sustainability and persistency of the uniform pricing strategy.

The main intuition behind our findings is that uniform pricing, induced by consumers' fairness concerns, may increase the total demand of all branded variants in comparison to nonuniform pricing. This occurs when a higher-priced variant under nonuniform pricing has higher category demand elasticity than a lower-priced variant under nonuniform pricing. Because uniform pricing is between the high and low prices under nonuniform pricing, the adoption of uniform pricing will increase the demand of the higher-priced variant to a greater degree than reducing the demand of the lower-priced variant. Thus, the overall effect suggests an increase in the total demand of all branded variants, which benefits both firms directly. In addition, the category demand expansion effect reduces firms' incentive to engage in intensive price competition, which again benefits firms.

It is important to point out limitations in our study that can be examined in future research. First, we have not examined how consumers' fairness concerns may affect firms' decisions on product assortments. Because the demand of a product could be dependent on the prices of other branded variants by the same firm, it might be optimal for a firm to reduce its product assortments in order to prevent consumers from comparing the prices of branded variants and perceiving prices as unfair. Future research may explicitly model product assortment decisions along with pricing decisions given consumers' fairness concerns with prices.

Second, our model applies to two contexts—one where two competing retailers face the same wholesale prices and another where two competing manufacturers sell directly to consumers (through an integrated channel or with nonstrategic retailers that set fixed markups to manufacturers). It will be interesting to study how consumers' concerns of fairness may affect firms' choices of channel structures as well as channel coordination when selling branded variants. Future study on those issues will complement Cui et al. (2007), who examine the impact of fairness concerns in channels where each firm offers a single product.

Third, we incorporate peer-induced fairness concerns into individual utility function and derive the corresponding linear demand function, and we suggest that firms will charge uniform prices when consumers have strong concerns of fairness. It is possible that firms may set a high price for a branded variant

to influence consumers' reference price for the product category or signal product quality. We suspect that this consideration in pricing branded variants is more likely to be important for new product categories, where consumers are still forming their perceptions to the branded variants. We leave the formal investigation of such an issue to future research.

Fourth, this paper provides insights on the uniform pricing phenomenon through an analytical modeling framework. Future empirical and experimental studies on the issue of uniform pricing may generate additional insights into the underlying rationale behind it. In particular, as we mentioned in §1, the explanation of the uniform pricing phenomenon based on consumers' fairness concerns on prices is just one of many possible explanations proposed in the literature. It will be important for future research to examine the relative explanatory powers of the various theories on uniform pricing.

Acknowledgments

Appendix

Proof of Lemma 1. When both firms are charging uniform prices, the profit function of firm j is

$$\pi_j = \pi_{Aj} + \pi_{Bj} = q_{Aj}p_{Uj} + q_{Bj}p_{Uj}, \tag{13}$$

where q_{ij} is given by Equation (3). Firms set uniform prices p_{Uj} simultaneously to maximize their profits as given in (13), which leads to the following solution:

$$p_{ij}^* = p_U = \frac{2t(V+1-m)}{1+5t};$$

$$q_{A1}^* = q_{A2}^* = q_A^U = \frac{1}{4}, \tag{14}$$

$$q_{B1}^* = q_{B2}^* = q_B^U = \frac{1}{4} + \frac{V-m+t(3V-2-3m)}{2(1+5t)};$$

$$\pi_1 = \pi_2 = \pi_U = \frac{t(1+3t)(V+1-m)^2}{(1+5t)^2}.$$

For the results in (14) to be equilibrium, we need to check firms' incentive to deviate from such a uniform pricing

strategy. Without loss of generality, we examine the case where Firm 2 deviates from uniform prices to nonuniform prices $\tilde{p}_{B2} > \tilde{p}_{A2}$ given Firm 1's strategy as in (14). Using the demand function given by Equation (3), we obtain the following results regarding the optimal deviating prices and Firm 2's profit change $\tilde{\pi}_2^{UU} - \pi_2^{UU}$:

$$\tilde{p}_{A2} = \big(t[4V + 6 - 4m + 10t + \theta(6V + 7 - 6m)$$
$$+ t\theta(12V + 17 - 12m)]\big)$$
$$\cdot \big((1+5t)(4+4\theta - 3t\theta^2)\big)^{-1},$$

$$\tilde{p}_{B2} = \big(4V + 2 - 4m + 2t(12V + 7 - 12m)$$
$$+ 5t\theta(2V + 3 - 2m + 5t)\big) \qquad (15)$$
$$\cdot \big(3(1+5t)(4+4\theta - 3t\theta^2)\big)^{-1},$$

$$\tilde{p}_{B2} - \tilde{p}_{A2} = \frac{(1+3t)\big[2V + 1 - 2m - 5t - 6t\theta(V+1-m)\big]}{3(1+5t)(4+4\theta - 3t\theta^2)},$$

$$\tilde{\pi}_2^{UU} - \pi_2^{UU} = \frac{(1+3t)\big[2V + 1 - 2m - 5t - 6t\theta(V+1-m)\big]^2}{12(1+5t)^2(4+4\theta - 3t\theta^2)}.$$

For (14) to be equilibrium, we must have $\tilde{\pi}_2^{UU} - \pi_2^{UU} < 0$ or $\tilde{p}_{B2} \leq \tilde{p}_{A2}$, which results in $\theta \geq \underline{\theta} = (2V + 1 - 2m - 5t)/(6t(V+1-m))$. Similarly, it is easy to show that Firm 2 has no incentive to deviate to $\tilde{p}_{B2} < \tilde{p}_{A2}$ for any $\theta > 0$. Therefore, for any $\theta \geq \underline{\theta}$, neither firm will have any incentive to deviate from (14). We can further show that the equilibrium described in (14) is unique for $\theta \geq \underline{\theta}$. We have shown that (14) is the unique equilibrium when both firms set uniform prices and when $\theta \geq \underline{\theta}$, so we just need to prove that both firms setting nonuniform prices or only one firm setting a nonuniform price cannot be equilibrium for $\theta \geq \underline{\theta}$. Because of space limitations, we omit the details of the proof but use the scenario that both firms charge higher prices for product variant B than for product variant A as an example to illustrate the proof. The proofs under the other scenarios can be obtained similarly.

When both firms charge higher prices for product variant B than for product variant A, we can solve for the firms' optimal prices and the resultant profits as given below using the demand specification in Equation (3):[13]

$$p_{A1} = p_{A2} = \frac{t(5 + 6V\theta + 8\theta - 6m\theta)}{5 + 5\theta - 6t\theta^2},$$

$$p_{B1} = p_{B2} = \frac{2V + 1 - 2m + 2t\theta}{5 + 5\theta - 6t\theta^2};$$

$$p_{B1} - p_{A1} = \frac{2V + 1 - 2m - 5t - 6t\theta(V+1-m)}{5 + 5\theta - 6t\theta^2}; \qquad (16)$$

$$\pi_1^{NN} = \pi_2^{NN} = \frac{t(5 + 6V\theta + 8\theta - 6m\theta)}{4(5 + 5\theta - 6t\theta^2)}$$
$$+ \frac{3(1+\theta)(2V + 1 + 2t\theta - 2m)^2}{4(5 + 5\theta - 6t\theta^2)^2}.$$

For $\theta < \underline{\theta}$, we have $p_{B1} > p_{A1}$ always. In addition, we can show that the constraint of $\bar{x}_1 \geq -1$ is always satisfied for any $\theta < \underline{\theta}$.

[13] The condition for the profit function to be concave is given by $\theta \leq (2+2\sqrt{1+3t})/(3t)$. It can be shown that $\underline{\theta} = (2V+1-2m-5t)/(6t(V+1-m)) < (2+2\sqrt{1+3t})/3t$ always.

Then we solve for Firm 2's optimal pricing strategy if it deviates to uniform pricing strategy. The resultant profits $\tilde{\pi}_2^{NN}$ and profits change $\pi_2^{NN} - \tilde{\pi}_2^{NN}$ are given by

$$\tilde{\pi}_2^{NN} = \big(t[12V + 16 - 12m + \theta(18V + 19 - 18m - 3t)$$
$$- 18t\theta(V+1-m)]^2\big)$$
$$\cdot \big(16(1+3t)(5+5\theta - 6t\theta^2)^2\big)^{-1}, \qquad (17)$$

$$\pi_2^{NN} - \tilde{\pi}_2^{NN}$$
$$= \frac{3(4+4\theta - 3t\theta^2)[2V + 1 - 2m - 5t - 6t\theta(V+1-m)]^2}{16(1+3t)(5+5\theta - 6t\theta^2)^2}.$$

It is easy to show that for $\theta \geq \underline{\theta}$, we have either $p_{B1} \leq p_{A1}$ or $\pi_2^{NN} - \tilde{\pi}_2^{NN} < 0$. Hence, (16) cannot be equilibrium. With the similar approach, we can show that no scenario except that given in (14) can be equilibrium for $\theta \geq \underline{\theta}$. Hence Lemma 1 is proved.   Q.E.D.

PROOF OF PROPOSITION 1. From Equation (9) and Lemma 1, we have

$$\pi_U - \pi_{NU} = 2V + 1 - 2m - 5t100(1+5t)^2$$
$$\cdot [6m + 10tm - 3 - 6V + 30t - 10tV + 125t^2].$$

Furthermore, $\pi_U - \pi_{NU} > 0$ and $m < \min\{(2V + 1 - 5t)/2, 1/2\}$ lead to $\bar{m} < m < \min\{(2V + 1 - 5t)/2, 1/2\}$, where $\bar{m}$ is defined as $\bar{m} = (6V + 3 - 30t + 10tV - 125t^2)/(2(3+5t))$. Q.E.D.

PROOF OF LEMMA 2. The proof of Lemma 2 is similar to that of Lemma 1. When Firm 1 sets nonuniform prices and Firm 2 charges uniform prices, solving for both firms' profit maximization problems based on the demand function as in Equation (3) leads to the following results:

$$p_{A1}^{e*} = \frac{t(14V + 25 - 14m + 35t)}{2(9+35t)},$$

$$p_{B1}^{e*} = \frac{6V + 3 - 6m + t(28V + 17 - 28m)}{2(9+35t)};$$

$$p_{A2}^{e*} = p_{B2}^{e*} = p_U^{eN} = \frac{2t(7V + 8 - 7m)}{9+35t};$$

$$\pi_1^{eN} = \frac{t(14V + 25 - 14m + 35t)^2}{16(9+35t)^2} \qquad (18)$$
$$+ \frac{3[6V + 3 - 6m + t(28V + 17 - 28m)]^2}{16(9+35t)^2};$$

$$\pi_2^{eN} = \frac{t(1+3t)(7V + 8 - 7m)^2}{(9+35t)^2} \cdot [4pt]$$

If Firm 2 deviates from $p_{A2} = p_{B2}$ to $\tilde{p}_{B2} > \tilde{p}_{A2}$, we have the following results:

$$\tilde{p}_{A2} = \frac{7t[5 + \theta(4V + 7 - 4m)]}{35 + 35\theta - 34t\theta^2},$$

$$\tilde{p}_{B2} = \frac{14V + 7 - 14m + 17t\theta}{35 + 35\theta - 34t\theta^2}; \qquad (19)$$

$$\tilde{p}_{B2} - \tilde{p}_{A2} = \frac{14V + 7 - 14m - 35t - 4t\theta(7V + 8 - 7m)}{35 + 35\theta - 34t\theta^2}.$$

Similar to the proof for Lemma 1, we can show that (18) gives the unique equilibrium for $\theta \geq \underline{\theta}_e = (14V + 7 - 14m - 35t)/(4t(7V + 8 - 7m))$, where $\underline{\theta}_e$ is the threshold value of θ that makes $\tilde{p}_{B2} - \tilde{p}_{A2} = 0$ binding.   Q.E.D.

PROOF OF PROPOSITION 2. From Lemma 1 and Lemma 2, we have that $\pi_1^{eN} < \pi_U$ and $m < \min\{(2V + 1 - 5t)/2, 1/2\}$ lead to $\underline{m}_M < m < \min\{(2V + 1 - 5t)/2, 1/2\}$, where

$$\underline{m}_M = \big(54V + 27 + t(40 + 494V) - t^2(1166 - 1562V)$$
$$- t^3(5000 - 1890V) - 6125 \cdot t^4\big)$$
$$\cdot \big(54 + 494 \cdot t + 1562 \cdot t^2 + 1890 \cdot t^3\big)^{-1}. \quad \text{Q.E.D.}$$

Analysis of Unequal Production Costs for Branded Variants

Assume that the production cost for the strong product variant B is given by $w > 0$, and the production cost for the weak product variant A is given by 0. The proof is similar to that of Proposition 2.

When neither firm mitigates and both firms charge uniform prices, firms set uniform prices simultaneously to maximize their profits, which leads to the following solution:

$$p_{A1}^{eN} = p_{A2}^{eN} = p_{B1}^{eN} = p_{B2}^{eN} = p_U^{eN} = \frac{t(2V + 2 - 2m + 3w)}{1 + 5t},$$

$$\pi_1^{eN} = \pi_2^{eN} = \pi_U^{eN}$$
$$= (t \cdot [t(2V + 2 - 2m - 2w) - w] \cdot [2V + 1 - 2m \quad (20)$$
$$+ t(6V + 1 - 6m - 6w)]) \cdot (4(1 + 5t))^{-1}$$
$$+ \frac{t(2V + 2 - 2m + 3w)}{4(1 + 5t)}.$$

For the results in (20) to be equilibrium, we need to check firms' incentives to deviate from such a nonmitigating strategy. Without loss of generality, we examine the case where Firm 1 mitigates and charges nonuniform prices but Firm 2 does not mitigate and charges uniform prices. Using the demand function in the paper, we obtain the following results regarding the optimal prices and profits for both firms:

$$p_{A1}^{e1} = \frac{t(14V + 25 - 14m + 21w + 35t)}{2(9 + 35t)},$$

$$p_{B1}^{e1} = \frac{6V + 3 - 6m + 9w + t(28V + 17 - 28m + 42w)}{2(9 + 35t)},$$

$$p_{A2}^{e1} = p_{B2}^{e1} = \frac{t(14V + 16 - 14m + 21w)}{9 + 35t}, \quad (21)$$

$$\pi_1^{e1} = \frac{t(14V + 25 - 14m + 21w + 35t)^2}{16(9 + 35t)^2}$$
$$+ \frac{3[6V + 3 - 6m - 9w + t(28V + 17 - 28m - 28w)]^2}{16(9 + 35t)^2},$$

$$\pi_2^{e1} = \frac{t(14V + 16 - 14m + 21w) \cdot (11 - 14V + 14m - 21w + 105t)}{8(9 + 35t)^2}$$
$$+ (3[t(14V + 16 - 14m - 14w) - 9w]$$
$$\cdot [14V + 7 - 14m + 3w + t(28V - 3 - 28m - 28w)])$$
$$\cdot (8(9 + 35t)^2)^{-1}.$$

For (20) to be equilibrium, we must have $\pi_1^{e1} - \pi_1^{eN} \leq 0$, which results in $m \geq \underline{m}_w$ or $w \leq \bar{w}$. The threshold values $\underline{m}_w$ and $\bar{w}$ are given by

$$\underline{m}_w = \big(54V + 27 + 81w + t(494V + 40 - 813w)$$
$$+ t^2(1562V - 1166 + 2983w)\big)$$
$$\cdot \big(2(27 + 247 \cdot t + 781 \cdot t^2 + 945 \cdot t^3)\big)^{-1}$$
$$+ \frac{t^3(1890V - 5000 + 4235w) - 6125 \cdot t^4}{2(27 + 247 \cdot t + 781 \cdot t^2 + 945 \cdot t^3)}, \quad (22)$$

$$\bar{w} = \big(-54V - 27 + 54m - t(494V + 40 - 494m)$$
$$- t^2(1562V - 1166 - 1562m)\big)$$
$$\cdot \big(81 + 813 \cdot t + 2983 \cdot t^2 + 4235 \cdot t^3\big)^{-1}$$
$$- \frac{t^3(1890V - 5000 - 1890m) - 6125 \cdot t^4}{81 + 813 \cdot t + 2983 \cdot t^2 + 4235 \cdot t^3}.$$

Therefore, for any $m \geq \underline{m}_w$ or $w \leq \bar{w}$, neither firm will have any incentive to deviate from uniform pricing in (20). Q.E.D.

PROOF OF LEMMA 3. The analysis of Lemma 3 is similar to that of Lemma 1. When both firms are charging uniform prices, both firms will set uniform prices simultaneously to maximize their profits, which leads to the solution

$$p_{ij}^{s*} = p_U^s = \frac{t(V + 2hV + 4h - 3hm)}{h + 5th + 3t},$$

$$\pi_1^s = \pi_2^s = \pi_U^s = \frac{t(h + 3th + 2t)(V + 2hV + 4h - 3hm)^2}{8h(h + 5th + 3t)^2}. \quad (23)$$

For the results in (23) to be equilibrium, we need to check firms' incentives to deviate from such a uniform pricing strategy. Without loss of generality, we examine the case where Firm 2 deviates from uniform prices to nonuniform prices $\tilde{p}_{B2}^s > \tilde{p}_{A2}^s$ given Firm 1's strategy in (23).

We obtain the following results regarding Firm 2's price difference $\tilde{p}_{B2}^s - \tilde{p}_{A2}^s$:

$$\tilde{p}_{B2}^s - \tilde{p}_{A2}^s = \frac{-4(h + 3th + 2t)}{\phi(h + 5th + 3t)}$$
$$\cdot [t\theta(1 + 2h)(V + 2hV + 4h - 3hm) - \varphi], \quad (24)$$

where $\phi = tk(12 - 4\theta - \theta^2) + h(24k + 24tk + 8k\theta + 8kt\theta + 16t - 4tk\theta^2) + h^2(48k + 16k\theta + 8 + 24t - 4th\theta^2) > 0$ for small t, and $\varphi = tV + h(2V + 2tV - 8t) + h^2(4V + 4 - 20t + 5tm - 5m)$.

For (23) to be equilibrium, we must have $\tilde{\pi}_2^s - \pi_2^s \leq 0$ or $\tilde{p}_{A2}^s \leq \tilde{p}_{B2}^s$, which results in $\theta \geq \underline{\theta}_s = (tV + h(2V + 2tV - 8t) + h^2(4V + 4 - 20t + 5tm - 5m))/(t(1 + 2h)(V + 2hV + 4h - 3hm))$. Similarly, it is easy to show that Firm 2 has no incentive to deviate to $\tilde{p}_{B2}^s < \tilde{p}_{A2}^s$ for any $\theta > 0$. Therefore, for any $\theta \geq \underline{\theta}_s$, neither firm will have any incentive to deviate from (23). We can further show that the equilibrium described in (23) is unique. The proof is similar to that in Lemma 1 and is omitted here.   Q.E.D.

PROOF OF LEMMA 4. When both firms are charging uniform prices, firms' prices and profits are given by Equation (14). For the results in (14) to be equilibrium, we need to check firms' incentives to deviate from such a uniform

pricing strategy when consumers care about both peer-induced fairness within the same firm and price fairness across firms. Without loss of generality, we examine the case where Firm 2 deviates from uniform prices to nonuniform prices $\tilde{p}_{B2\alpha} > \tilde{p}_{A2\alpha}$ given Firm 1's strategy as in (14). Using the demand function given by Equation (3), we obtain the following results regarding the optimal deviating prices and Firm 2's profit change $\tilde{\pi}_{2\alpha}^{UU} - \pi_{2\alpha}^{UU}$:

$$\tilde{p}_{A2\alpha} = \big(t\big[4V + 6 - 4m + 10t + \theta(1+\alpha)(6V + 7 - 6m)$$
$$+ t\theta(1+\alpha)(12V + 17 - 12m)\big]\big)$$
$$\cdot \big((1+5t)\big[4 + 4(1+\alpha)\theta - 3t(1+\alpha)^2\theta^2\big]\big)^{-1},$$

$$\tilde{p}_{B2\alpha} = \big(4V + 2 - 4m + 2t(12V + 7 - 12m)$$
$$+ 3t\theta(1+\alpha)(2V + 3 - 2m + 5t)\big)$$
$$\cdot \big(3(1+5t)\big[4 + 4(1+\alpha)\theta - 3t(1+\alpha)^2\theta^2\big]\big)^{-1}, \quad (25)$$

$$\tilde{p}_{B2\alpha} - \tilde{p}_{A2\alpha}$$
$$= \big((1+3t)\big[2V + 1 - 2m - 5t - 6t\theta(1+\alpha)(V + 1 - m)\big]\big)$$
$$\cdot \big(3(1+5t)\big[4 + 4(1+\alpha)\theta - 3t(1+\alpha)^2\theta^2\big]\big)^{-1},$$

$$\tilde{\pi}_{2\alpha}^{UU} - \pi_{2\alpha}^{UU}$$
$$= \frac{(1+3t)[2V + 1 - 2m - 5t - 6t\theta(1+\alpha)(V + 1 - m)]^2}{12(1+5t)^2[4 + 4(1+\alpha)\theta - 3t(1+\alpha)^2\theta^2]}.$$

For (14) to be equilibrium, we must have $\tilde{\pi}_{2\alpha}^{UU} - \pi_{2\alpha}^{UU} < 0$ or $\tilde{p}_{B2\alpha} \leq \tilde{p}_{A2\alpha}$, which results in $\theta \geq \underline{\theta}_\alpha = (2V + 1 - 2m - 5t)/(6t(1+\alpha)(V + 1 - m))$. Similarly, it is easy to show that Firm 2 has no incentive to deviate to $\tilde{p}_{B2\alpha} < \tilde{p}_{A2\alpha}$ for any $\theta > 0$. Therefore, for any $\theta \geq \underline{\theta}_\alpha$, neither firm will have any incentive to deviate from (14). The proof of uniqueness of such an equilibrium can be done in a similar fashion as in the proof of Lemma 1; hence it is omitted here.   Q.E.D.

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