Navigating Social Comparison: Optimizing Product Offerings through Balancing Exclusivity and Conformity

Enfeng Xing[a], Jianxiong Zhang[a], Jennifer Shang[b], Guowei Liu[c,*]

[a] *College of Management and Economics, Tianjin University, Tianjin 300072, China*
[b] *Katz Graduate School of Business, University of Pittsburgh, Pittsburgh, Pennsylvania 15260, US*
[c] *International Business School, Hainan University, Haikou, Hainan 570228, China*

Abstract

Pricing and segmentation strategies traditionally focus on maximizing the functional utility of goods for consumers, emphasizing aspects like usability and efficiency. However, the literature on social comparison psychology highlights the importance of exclusivity and conformity in shaping consumer behavior. These factors add complexity to understanding consumer preferences and pose fresh challenges for market segmentation and product offerings. To tackle these complexities, we propose an analytical model wherein a monopolist sells status goods to a diverse consumer base. We examine how social comparison impacts product offering, profitability, consumer surplus, and social welfare. We begin by showing that social comparison can significantly reshape a firm's product offerings. When exclusivity is low and conformity is high, the firm may introduce high-end products surpassing the first-best (optimal) quality level, alongside offering low-end products at the optimal level. Second, despite existing literature indicating that consumer heterogeneity may diminish a firm's profit, we uncover that social comparison creates a non-monotonic relationship between profitability and consumer heterogeneity. Third, contrary to conventional wisdom, high-type consumers are not the only ones who receive surplus. Depending on social comparison levels, low-type consumers may also gain surplus, or neither consumer type may receive any. Finally, we show that even with incomplete knowledge of consumer valuation, social comparison can facilitate perfect price discrimination and achieve optimal social efficiency.

Keywords: Supply chain management; Product offerings; Exclusivity; Conformity; Incomplete information;

1. Introduction

Companies in industries like automotive, fashion, and high-end sectors often diversify their product portfolios across various price and quality tiers to meet different market demands. For example, Mercedes-Benz offers the A-Class Sedan at $32,500 for affordability and the iconic S-Class Sedan

*Corresponding author. Email: gwliu@hainanu.edu.cn
Email addresses: `efxing@tju.edu.cn` (Enfeng Xing), `jxzhang@tju.edu.cn` (Jianxiong Zhang), `shang@katz.pitt.edu` (Jennifer Shang), `gwliu@hainanu.edu.cn` (Guowei Liu)

starting at $114,500 for premium buyers[1]. Similarly, Apple markets the iPhone 16 Pro Max at $1,199 for high-end consumers and the iPhone SE at $429 for budget-conscious buyers[2]. By offering premium products with superior quality at higher prices, these companies attract affluent customers seeking top performance, resulting in substantial profit margins. They also appeal to price-conscious consumers with affordable options, thereby broadening their market reach. Premium products elevate brand prestige and appeal to a wider consumer base, whereas lower-tier products bolster market share. Therefore, firms benefit from offering a wide range of products across different price points and performance levels.

Consumers are susceptible to social group influences, especially when using products like cars, watches, or cellphones, which have multiple lines and serve as publicly consumed status symbols (Gao et al., 2023a). For example, elite consumers often favor products that set them apart from the general population, as they seek to convey social status through distinctiveness. Thus, many ordinary consumers tend to emulate the choices of the elite, believing that elite-endorsed items hold greater brand value (Bryson, 1996; Amaldoss and Jain, 2008, 2010). This phenomenon, termed "social comparison", evokes varied emotional responses: elite consumers may feel negative emotions when the masses adopt the same brands, as it diminishes their ability to signal distinctive tastes and social status. Conversely, the masses often experience positive emotions from increased product adoption, particularly when endorsed by the elite, as it fosters a sense of status affiliation.

The concept of consumer exclusivity, driven by the desire for unique products, often leads individuals to avoid widely adopted products, resulting in decreased willingness to buy (WTB) when a brand becomes too commonplace. This phenomenon is referred to as the "snob effect" (Amaldoss and Jain, 2005; Arifoğlu et al., 2020). For example, consumers seeking exclusivity are more likely to prefer the limited-edition and pricy Hermes Birkin bags over the more prevalent Picotin bags, as the Birkin collection is typically linked to higher social status. However, if the Hermes brand were to oversaturate the market, its ability to symbolize exclusivity and social prestige would likely diminish, resulting in a decline in consumer demand.

On the other hand, consumer conformity, the tendency to follow the crowd, can lead to increased WTB as more people adopt a product, a phenomenon known as the "follower effect" (Amaldoss and Jain, 2005; Arifoğlu and Tang, 2023). This behavior arises from the desire for status identification when consumers witness widespread product adoption, especially among the affluent (Cialdini and Goldstein, 2004). For instance, consumers driven by conformity tend to favor Hermes bags to elevate their social standing, yet they often opt for the more affordable Picotin bags due to budget concern[3]. Similarly, Mercedes-Benz introduced the budget-friendly A-Class series to appeal to consumers influenced by

[1]https://www.mbusa.com/en/all-vehicles#vbg-sedans-wagons. Accessed on January 13, 2024.
[2]https://www.apple.com/shop/buy-iphone. Accessed on October 22, 2024.
[3]https://www.gittemary.com/2024/02/why-hermes-wont-sell-you-a-birkin-bag-a-cultural-and-environmental-analysis. Accessed on December 20, 2024.

conformity psychology—those aspiring to the luxury brand's prestige but have financial constrains. These contrasting effects of social comparison pose a dilemma for companies: targeting elite consumers can boost demand among the masses, but catering to the masses may deter the elite buyers. In markets for luxury (status) goods, firms can leverage consumer conformity to raise WTB and prices, thus enhancing profit margins. However, the exclusivity sought by elite consumers may reduce their WTB, necessitating firms to invest heavily in retaining this segment. Thus, striking a balance between these opposing forces presents significant challenges for firms in the luxury goods industry, especially when striving to offer optimal product assortments across various lines.

In markets with diverse consumers who place varying importance on quality, a company equipped with comprehensive knowledge of consumer preferences can tailor its offerings to suit each consumer segment. This deep understanding typically results in an equilibrium outcome that achieves Pareto optimality, known as the first-best outcome. Such an outcome represents a socially efficient allocation, maximizing the utility of each representative consumer within their segment, while accounting for the firm's cost of serving that consumer (Moorthy, 1984; Villas-Boas, 1998). However, when a firm lacks complete information about consumer valuations, the revelation principle (Myerson, 1979) suggests that the optimal strategy is to design a direct truth-telling mechanism. This approach allows consumers to select from a range of offerings that align with their preferences. In the traditional principal-agent model, high-type consumers may mimic the purchasing behavior of low-type consumers. To deter such imitation, firms must offer information rents to high-type consumers, enabling effective market segmentation. Under conditions of incomplete information, firms often adjust their product offerings, deviating from the first-best outcome to achieve this market segmentation (Li et al., 2023). This distortion leads to a second-best equilibrium characterized by social inefficiencies. In markets for status goods, however, social comparison plays a critical role in shaping consumer behavior and, consequently, firms' product strategies. One could argue that at certain levels of social comparison intensity, consumers of both types may naturally gravitate towards offerings tailored to their specific type, potentially reducing the need for product design distortions. Conversely, social comparison could incentivize both consumer types to imitate each other's purchasing behavior, complicating market segmentation and further reducing market efficiency. This dilemma raises a critical question: how should a firm design its product offerings in status-driven markets where social comparison plays a pivotal role?

Building on the discussions above, our research addresses the following questions regarding consumer valuation under incomplete information: (i) How does social comparison impact the firm's optimal product offerings? (ii) What strategies does the firm use to adjust its product lines in response to different levels of exclusivity and conformity? (iii) How does social comparison change the effect of consumer heterogeneity on the firm's profitability? (iv) What ramifications does social comparison have on consumer surplus and social welfare? To address these inquiries, we employ a game-theoretic model focusing on a monopoly firm that sells status goods to consumers engaged in social comparison and holding private valuations information. Our study examines how social comparison influences the firm's product offerings, financial performance, consumer surplus, social welfare, and the value of information. Additionally, we expand our study to includes the firm's decisions on product line to explore the impact of social comparison. Our research findings can be outlined as follows:

(i) Traditional strategies recommend the firm to offer high-end products at first-best (optimal) quality and lower low-end product quality when consumer valuation is private information known only to the consumer. However, social comparison changes this viewpoint. To counter consumer imitation, the firm should raise high-end product quality above optimal level while maintaining low-end products at optimal when exclusivity is low and conformity is high.

(ii) Higher exclusivity prompts frequent product line adjustments, as it drives consumers to shift their purchase intentions and requires the firm to maintain effective market segmentation. When exclusivity is low, increased conformity redirects the firm's focus from low-end to high-end products, as high-end consumers stop mimicking low-end behavior, while low-end consumers aspire to high-end consumption. When exclusivity is high, the firm needs to adjust its product lines simultaneously to preserve effective market segmentation as higher exclusivity motivates both consumer types to deviate from their original purchase intentions.

(iii) Social comparison shapes how consumer heterogeneity impacts profitability. Low exclusivity and conformity reduce profits, while high levels of either increase it. At high exclusivity or conformity, consumer heterogeneity has a non-monotonic effect on profitability. Profits first decline and then rise, reflecting the balance between higher pricing for low-end products to capitalize on heightened consumer demand and the increased costs required to effectively segment the market. Intensified social comparison reduces group differentiation between consumers, complicating segmentation and consumer identification, further challenging this trade-off.

(iv) We find that social comparison reshapes the distribution of consumer surplus: when both conformity and exclusivity are low (high), high-end (low-end) consumers gain surplus, while low-end (high-end) consumers receive none. Alternatively, neither group obtains surplus, as social comparison influences the firm's information rent (i.e., market segmentation cost).

We further explore how social comparison affects information value and uncover new insights. While incomplete information often causes social inefficiency, our study shows that social comparison enables perfect price discrimination, achieving efficiency close to the first-best outcome. Additionally, we examine the firm's product line decisions, finding that it produces a single product when exclusivity is high and conformity is low. Our research provides important managerial insights into pricing, quality, and product line strategies shaped by social comparison dynamics.

The remainder of the paper is organized as follows. In Section 2, we review the literature most relevant to this study. Section 3 formalizes the problem and discusses the model setup. Section 4 analyzes the game equilibria and highlights the main conclusions. In Section 5, we examine consumer surplus, social welfare, and the value of information. Section 6 extends the analysis to address product line decision. The concluding remarks are given in Section 7.

2. Literature Review

Table 1: Summary of Related Literature

References	Product offering	Social comparison		Principal-agent theory
		Exclusivity	Conformity	
Cialdini and Goldstein (2004)			✓	
Martimort and Piccolo (2010)				✓
Guo and Zhang (2012)	✓			✓
Cvitanić et al. (2013)				✓
Amaldoss and Jain (2015)		✓	✓	
Jain and Li (2018)	✓			
Li (2019)	✓	✓		
Arifoğlu et al. (2020)		✓		
Liu et al. (2021)	✓			✓
Fruchter et al. (2022)			✓	
Fabra and Montero (2022)	✓			
Yan et al. (2022)	✓			
Zhang et al. (2022)		✓	✓	
Arifoğlu and Tang (2023)		✓	✓	
Li et al. (2023)				✓
Balseiro et al. (2024)				✓
Mamadehussene (2024)	✓			✓
This paper	✓	✓	✓	✓

This research involves three streams of literature. First, it explores product offerings in the status product market. Second, it examines social comparison psychology, focusing on how exclusivity and conformity influence product decisions. Finally, it applies principal-agent theory, particularly regarding adverse selection under incomplete information. See Table 1 for a summary.

Product offerings. Firms increasingly offer vertically differentiated products (Kim and Chhajed, 2002; Ke et al., 2023) to foster consumer identification (Mamadehussene, 2024) and market segmentation (Villas-Boas, 1998; Desai, 2001). This helps mitigate competition (Moorthy and Png, 1992; Rhee, 1996), or enhancing consumer surplus and social welfare (Jain and Li, 2018). Mamadehussene (2024) finds that a multi-product firm effectively implemented price discrimination by offering discounts based on consumer redemption costs. Jain and Li (2018) explore how firms selling secondary products adjust their prices and product designs to cater to consumers with self-control issues and obesity. They find that offering lower-quality products can boost profits while benefiting consumers and public health. Similarly. Zou et al. (2020) show that heightened consumer expectations of regret drive firms to increase quality differentiation to maximize profits. This raises a critical question: how should firms determine product offerings for diverse consumers?

Notably, much of the existing research focuses on optimizing high-end product offerings. For example, Xu and Dukes (2019) explore product line design under consumer perceptual errors, and find that signal transmission costs drive firms to prioritize high-quality products. Liu et al. (2021) observe greater quality distortion in low-quality crowdfunding products compared to traditional sales. Yan et al. (2022) show that reference prices narrow the optimal quality range as the importance of price comparison increases. While prior research centers on product line design and high-end product, our study emphasizes strategic product offerings, focusing on optimizing high-end products and effectively configuring low-end markets to enhance segmentation.

Social comparison. The psychology of exclusivity and conformity increasingly influences consumer purchasing behavior (Arifoğlu et al., 2020). Research has examined the impact of social comparison on pricing strategies and firm profitability, both theoretically and empirically. For instance, Long and Nasiry (2020) investigate how social comparison affects sales agents' effort levels and collaboration incentives. Zhang et al. (2024) analyze the effects of social comparison generated by quality difference on pricing, quality, and product line strategies among competing firms, and find that higher consumer social-comparison benefits can boost profits and enhance quality differentiation by reducing price competition. Gao et al. (2023b) develop an analytical model to study the role of social technologies in luxury product pricing along a distribution channel.

Arifoğlu and Tang (2023) develop a game-theoretic model to examine luxury brand licensing in a decentralized setting by incorporating opposite social comparison. Sun et al. (2022) investigate how firms leverage reference-group effects (RGEs) during product upgrades. They highlight RGEs' dual impacts on leaders' upgrading and followers' adoption. Li (2019) examines vertical line extension decisions for status goods, focusing on consumer status preferences. Amaldoss and Jain (2015) investigate social effects and market structure on conspicuous goods branding. Zhang et al. (2022) study optimal market-targeting strategies for fast-fashion brands that market co-branded products by incorporating social influences.

The literature has explored the role of social comparison in pricing. However, limited attention has been given to how consumers' exclusivity and conformity psychology affect product offerings. Our study bridges this gap by examining how these psychological factors shape firms' product strategies.

Adverse selection under incomplete information. Our model is rooted in the principal-agent framework, addressing information asymmetry and adverse selection in contract theory (Laffont and Martimort, 2002). In this framework, the agent holds private information about its type, while the principal designs contracts to segment the market and maximize revenue (Moorthy, 1984; Tirole, 1988; Martimort and Piccolo, 2010). Laffont and Martimort (2002) explore various incentive mechanisms, focusing on how principals use screening contracts to induce truthful disclosure from agents. Similarly, Cvitanić et al. (2013) investigate optimal dynamic contracts under moral hazard and adverse selection, and compare the efficiency of shutdown and screening contracts relative to the agent's reservation utility.

Several studies have studied optimal allocation under information asymmetry using mechanism design. For example, Balseiro et al. (2024) explore a seller's problem with a single buyer holding private valuations. They examine optimal selling mechanisms that are approximately incentive-compatible. Similarly, Pavlov et al. (2022) characterize optimal contracts for agents with inequity aversion under private information. A common theme in the literature is that equilibrium outcomes in principal-agent models with incomplete information are generally suboptimal: while high-end allocations are efficient, low-end allocations often suffer inefficiencies from distortions (Bolton and Dewatripont, 2005).

We find that social comparison in status product markets significantly changes established findings. Unlike the conventional adverse selection model, where distortions mainly push low-end offerings downward, we find that distortions can shift both upward and downward. Additionally, our model reveals that separating equilibria may yield zero information rents, diverging from the classical adverse selection model, which assumes reservation payoffs depend on consumer type.

3. The Model

Consider a monopoly firm selling products (e.g., cars, watches) in a status goods market. The firm provides two product categories: high-end products with quality q_H and low-end products with quality q_L, where $q_L < q_H$. To capture the production costs of manufacturing a unit of product quality $q_i, i \in \{H, L\}$, we utilize a quadratic cost function represented by $c_i = \frac{1}{2}q_i^2$. The quadratic formulation reflects the increasing marginal cost of quality, a concept prevalent in previous research (Guo and Zhang, 2012; Mamadehussene, 2024).

The firm serves a unit mass of consumers, each demanding at most one product, with an outside option normalized to zero. Consumer j's utility from purchasing a product with quality q_i is expressed as $\theta_j q_i - p_i$, where p_i is the price of product i and $\theta_j, j \in \{H, L\}$ reflects the consumers' willingness to pay for product quality. Consumers differ in their willingness to pay: a fraction $\lambda \in (0, 1)$ of consumers are high-type $\theta_j = \theta_H$, whereas the remaining fraction $1 - \lambda$ are low-type consumers $\theta_j = \theta_L$, where $\theta_H > \theta_L > 0$. We assume that high-type consumers are less prevalent than low-type consumers (i.e., $\lambda < \frac{1}{2}$), which is consistent with real-world observations. For simplicity, we normalize $\theta_H = 1$ and $\theta_L = \theta \in (0, 1)$. As such, the parameter θ also captures consumer heterogeneity, with a smaller θ implying greater heterogeneity among consumers.

In status goods markets, consumers derive utility not only from the product itself but also from the status it conveys, which depends on its demand among others. Elite consumers seeking exclusivity tend to avoid products favored by the masses, while conformity-driven consumers prefer widely adopted products, particularly those purchased by high-end buyers (Zhang et al., 2022). Evidence indicates that individuals prioritizing product quality often exhibit a strong preference for exclusivity, whereas low-type consumers generally favor conformity. This behavior stems from low-type consumers' perception that purchases made by high-type consumers enhance the firm's brand value [4]. Therefore, we define

[4]https://flowstatebranding.com/insight/how-to-build-a-luxury-brand-strategy-to-market-to-high-end-consumers/

high-type consumers as those who seek exclusivity and low-type consumers as those who pursue conformity (Arifoğlu et al., 2020).

Similar to Rao and Schaefer (2013), we characterize the total utilities that high-type consumers derive from purchasing high-end and low-end products as

$$\begin{aligned} U_{HH} &= q_H - p_H - \beta_{HH} d_L, \\ U_{HL} &= q_L - p_L - \beta_{HL} d_L, \end{aligned} \tag{1}$$

where β_{HH} and β_{HL} ($\beta_{HH} > 0, \beta_{HL} > 0$) signify the exclusivity level of high-type consumers when purchasing high-end and low-end products, respectively; and d_L denotes the demand from the low-end market. This formulation suggests that high-type consumers view the rising popularity of low-end products as a potential threat to their status. As low-end product sales rise, the disutility felt by high-type consumers grows. Since high-type consumers typically exhibit stronger exclusivity when purchasing high-end products compared to low-end products, we set $\beta_{HL} = 0$ to focus solely on their exclusivity toward low-end products, while assuming $\beta_{HL} = \beta_H$ for simplicity. To ensure that the firm continues offering high-end products, we assume $\beta_H < \frac{\theta(1-\theta)}{\lambda(1-\lambda)}$, as higher exclusivity levels would render serving these consumers unprofitable.

The total utilities for low-type consumers derived from purchasing high-end products and low-end products are

$$\begin{aligned} U_{LH} &= \theta q_H - p_H + \beta_{LH} d_H, \\ U_{LL} &= \theta q_L - p_L + \beta_{LL} d_H, \end{aligned} \tag{2}$$

respectively. Here, d_H denotes the demand from the high-end market, while β_{LH} and β_{LL} represent the conformity levels of low-type consumers when purchasing high-end and low-end products, respectively. For analytical simplicity, we assume $\beta_{LH} = \beta_{LL}$ and subsequently define it as β_L. We also assume that $\beta_L < 1$, signifying that consumers place less emphasis on product conformity than on price sensitivity.

Besides the direct impacts of exclusivity and conformity on the WTB of the two consumer types, it is essential to consider their indirect effects. First, exclusivity and conformity reduce differentiation among consumer groups, a phenomenon we termed the "reduced differentiation effect". By increasing WTB for low-type consumers and decreasing it for high-type consumers, the presence of exclusivity and conformity factors narrow the utility gap between the two consumer segments, making it harder to distinguish between them. Second, both exclusivity and conformity create an "indirect negative effect" on the WTB of the opposing consumer segment. The follower effect can boost demand in the low-end market, which reduces the WTB of high-type consumers due to the potential expansion of demand. The snob effect diminishes demand in the high-end market, thereby reducing brand value and the WTB of low-type consumers.

Accessed on April 20, 2024.

The monopoly firm offering a range of goods often finds it optimal to segment consumers, as market segmentation mitigates the risk of inter-product cannibalization, ultimately maximizing profitability. While selling high-end products to high-type consumers at an unconstrained monopoly price allows the firm to avoid leaving information rent for these consumers, it also sacrifices potential profits in the low-end market (Fabra and Montero, 2022). To address this, we introduce the assumption that $\theta > \lambda$ to ensure the firm prefers to offer two products to satisfy both consumer segments. This assumption implies that the valuation of low-type consumers cannot be too low, which is consistent with the characteristics of the status products market. If the valuation of low-type consumers is excessively low or if the proportion of high-type consumers is too high ($\theta \leq \lambda$), the firm would focus solely on serving high-type consumers, effectively excluding low-type consumers from the market. Since the firm lacks specific information about consumer types and only knows the distribution of these types, it needs to offer a menu of two products: a high-end product (q_H, p_H) targeting high-type consumers, and a low-end product (q_L, p_L) targeting low-type consumers. Therefore, the optimization problem can be formulated as follows:

$$
\begin{aligned}
&\max_{p_H, q_H, p_L, q_L} \quad \pi = d_H(p_H - c_H) + d_L(p_L - c_L) \\
&\text{s.t.} \quad q_H - p_H - \beta_H d_L \geq q_L - p_L \qquad (\mathrm{IC_H}) \\
&\qquad \theta q_L - p_L + \beta_L d_H \geq \theta q_H - p_H + \beta_L d_H \qquad (\mathrm{IC_L}) \\
&\qquad q_H - p_H - \beta_H d_L \geq 0 \qquad (\mathrm{IR_H}) \\
&\qquad \theta q_L - p_L + \beta_L d_H \geq 0 \qquad (\mathrm{IR_L})
\end{aligned}
\tag{3}
$$

Here, the constraints ($\mathrm{IC_H}$) and ($\mathrm{IC_L}$) are incentive compatibility conditions, which ensure that each consumer prefers the product designed for them. The constraints ($\mathrm{IR_H}$) and ($\mathrm{IR_L}$) are participation conditions, ensuring each consumer buys one of the two products, given that consumers derive zero utility from the outside option. In the following sections, we present the equilibrium results for a two-product offering and examine the impact of social comparison on product quality, pricing, firm profitability, consumer surplus, and social welfare. While the primary model omits product line decisions, we later examine them to better understand the impact of social comparison under incomplete information.

4. Equilibria Analysis

4.1. Strategic Product Offerings

We begin by analyzing the complete information benchmark, where the firm has perfect knowledge of consumer types. Under complete information, the firm can design type-specific contracts tailored to each consumer group: offering (q_H, p_H) for high-type consumers and (q_L, p_L) for low-type consumers. Lemma 1 summarizes the equilibrium outcomes, highlighting the effects of social comparison on pricing, quality, and the firm's profit. Equilibrium results under complete information are denoted by a superscript "$*$" on the corresponding variables. Proofs for all main results are provided in the Appendix.

Lemma 1. *Under complete information,*

(i) *The first-best outcomes are:* $q_H^* = 1, q_L^* = \theta, p_H^* = 1 - \beta_H(1-\lambda), p_L^* = \theta^2 + \beta_L\lambda, \pi^* = \frac{1}{2}(\lambda + (1-\lambda)\theta^2) + \lambda(1-\lambda)(\beta_L - \beta_H)$, $cs^* = 0$.

(ii) *Exclusivity reduces the price of high-end products and the firm's profit; however, it does not affect product quality (i.e.,* $\frac{\partial p_H^*}{\partial \beta_H} < 0, \frac{\partial \pi^*}{\partial \beta_H} < 0, \frac{\partial q_H^*}{\partial \beta_H} = 0$*).*

(iii) *Conformity increases the price of low-end products and the firm's profit; however, it does not impact product quality (i.e.,* $\frac{\partial p_H^*}{\partial \beta_L} > 0, \frac{\partial \pi^*}{\partial \beta_L} > 0, \frac{\partial q_H^*}{\partial \beta_L} = 0$*).*

The socially efficient quality level maximizes the utility of a representative consumer in each segment minus the firm's unit cost of serving that consumer. Formally, this is given by $q_H^* = \arg\max_{q_H} \left(q_H - p_H - \frac{1}{2}q_H^2\right) = 1$ for high-end products and $q_L^* = \arg\max_{q_L} \left(\theta q_L - p_L - \frac{1}{2}q_L^2\right) = \theta$ for low-end products. These outcomes, commonly referred to as the first-best results, are well established in the literature (Moorthy, 1984; Villas-Boas, 1998). Under complete information, where the firm knows consumer types perfectly, the quality levels of both high-end and low-end products are set at their socially efficient levels ($q_H^* = 1, q_L^* = \theta$). Consequently, the firm achieves perfect price discrimination, maximizing its profit to the first-best outcome and capturing the entire surplus from both consumer types.

Lemma 1(ii) and (iii) reveal that exclusivity hurts the firm by lowering the price of high-end products, while conformity benefits the firm by raising the price of low-end products. Specifically, the snob effect, driven by exclusivity psychology, decreases the WTB of high-type consumers, compelling the firm to reduce the price of its high-end products (i.e., $\frac{\partial p_H^*}{\partial \beta_H} < 0$). Consequently, the firm's profit decreases with the level of exclusivity (i.e., $\frac{\partial \pi^*}{\partial \beta_H} < 0$). Conversely, the follower effect induced by conformity psychology enhances the WTB of low-type consumers, enabling the firm to charge a higher price for its low-end products (i.e., $\frac{\partial p_L^*}{\partial \beta_L} > 0$). As a result, the firm's profit increases with the level of conformity (i.e., $\frac{\partial \pi^*}{\partial \beta_L} > 0$). Notably, social comparison does not affect the quality of either high-end or low-end products (i.e., $\frac{\partial q_H^*}{\partial \beta_H} = 0, \frac{\partial q_L^*}{\partial \beta_L} = 0$). This is because, with perfect knowledge of consumer types, the firm finds it more effective to adjust prices to attract consumers than altering product quality.

Next, we explore the firm's equilibrium product offerings when it lacks information about consumer types. Lemma 2 presents eight cases of equilibrium product offerings ($q_{ik}, p_{ik}, k \in [1, 8]$) based on the strengths of social comparison (i.e., β_H and β_L). Figure 1 visually illustrates these cases.

Lemma 2. *Under incomplete information, the equilibrium product offerings are given in Table 2.*

It's worth noting that the conventional view, without social comparison, posits that high-end products targeting high-type consumers are typically set at the socially efficient quality level (i.e., first-best level, $q_H = q_H^*$), while low-end products for low-type consumers are suboptimal in quality (i.e., $q_L = \frac{\theta-\lambda}{1-\lambda} < q_L^*$) (Moorthy and Png, 1992; Villas-Boas, 1998). This approach prioritizes high-type consumers with first-best quality while distorting low-end quality to mitigate internal cannibalization under incomplete information. Specifically, if pricing leaves both consumer segments with zero surplus, high-type consumers may prefer the low-end product, incentivizing imitation. To counter this, the firm distorts low-end quality to reduce this incentive and protect high-end sales. However, social comparison challenges this view, as shown in Proposition 1.

Table 2: Optimal offerings under incomplete information

Case k	q_{Hk}	q_{Lk}	p_{Hk}	p_{Lk}	Condition
1	1	$\frac{\theta-\lambda}{1-\lambda}$	$\frac{1-\theta+\theta(\theta-\lambda)}{1-\lambda}+\beta_L\lambda-\beta_H(1-\lambda)$	$\frac{\theta(\theta-\lambda)}{1-\lambda}+\beta_L\lambda$	$\beta_L \leq \beta_{L1}, \beta_H \leq \beta_{H1}$
2	$\theta+\frac{\beta_H(1-\lambda)^2}{1-\theta}$	$\theta-\frac{\beta_H\lambda(1-\lambda)}{1-\theta}$	$\theta^2+\beta_L\lambda+\frac{\theta(1-\lambda)^2\beta_H}{1-\theta}$	$\theta^2+\beta_L\lambda-\frac{\theta\beta_H\lambda(1-\lambda)}{1-\theta}$	$\beta_{H1}<\beta_H<\beta_{H2}$
3	1	$\frac{\beta_L\lambda}{1-\theta}$	$1-(1-\lambda)\beta_H$	$\frac{\beta_L\lambda}{1-\theta}$	$\beta_{L1}<\beta_L \leq \beta_{L2}$, $\beta_H \leq \beta_{H3}$
4	$\frac{\beta_L\lambda+\beta_H(1-\lambda)}{1-\theta}$	$\frac{\beta_L\lambda}{1-\theta}$	$\frac{\beta_L\lambda+\theta\beta_H(1-\lambda)}{1-\theta}$	$\frac{\beta_L\lambda}{1-\theta}$	$\beta_L<\beta_{L2}$, $\max\{\beta_{H2},\beta_{H3}\}\leq\beta_H\leq\beta_{H6}$
5	1	θ	$1-\beta_H(1-\lambda)$	$\theta^2+\beta_L\lambda$	$\beta_{L2} \leq \beta_L < \beta_{L3}$, $\beta_H \leq \beta_{H3}$
6	$\frac{\beta_H(1-\lambda)+\beta_L\lambda}{1-\theta}$	θ	$\frac{\theta\beta_H(1-\lambda)+\beta_L\lambda}{1-\theta}$	$\theta^2+\beta_L\lambda$	$\beta_{L2} < \beta_L < \max\{\beta_{L4}, 1\}$, $\beta_{H3} < \beta_H < \beta_{H4}$
7	$\frac{1-\theta(1-\lambda)}{\lambda}$	θ	$\frac{1-\theta(1-\lambda)}{\lambda}-\beta_H(1-\lambda)$	$\frac{1-\theta(2-\theta-\lambda)}{\lambda}-\beta_H(1-\lambda)$	$\beta_{H4}\leq\beta_H\leq\beta_{H5}$
8	$1+\frac{\beta_H(1-\lambda)^2}{1-\theta}$	$1-\frac{\beta_H\lambda(1-\lambda)}{1-\theta}$	$1+\frac{\beta_H(1-\lambda)(\theta-\lambda)}{1-\theta}$	$1-\frac{\beta_H\lambda(1-\lambda)}{1-\theta}$	$\beta_H>\max\{\beta_{H5},\beta_{H6}\}$

* Note: The detailed expressions of $\beta_{L1}\sim\beta_{L4}, \beta_{H1}\sim\beta_{H6}$ are given in Appendix.

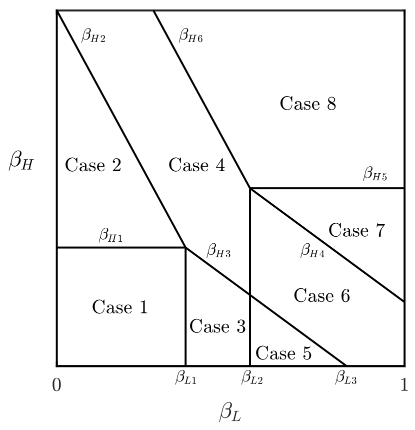


Figure 1: Equilibrium offering strategies based on β_H and β_L (with $\lambda = \frac{2}{5}$, $\theta = \frac{2}{3}$)

Proposition 1 (Distortion of product quality).

(i) *When exclusivity and conformity levels are low (i.e., $\beta_H < \min\{\beta_{H1}, \beta_{H3}\}, \beta_L < \beta_{L3}$), the firm keeps high-end product quality at the first-best level. Otherwise, it increases the quality of high-end products, with this upward distortion increasing with exclusivity and conformity rise (i.e., $\frac{\partial \Delta q_{Hk}}{\partial \beta_H} \geq 0$, $\frac{\partial \Delta q_{Hk}}{\partial \beta_L} \geq 0$[5]).*

(ii) *For low-end products, when exclusivity is low and conformity is high (i.e., $\beta_H < \beta_{H5}, \beta_L > \beta_{L2}$), quality remains at the first-best level. Otherwise, the firm reduces low-end product quality, with*

[5] $\Delta q_{Hk} = q_{Hk} - q_H^*, \Delta q_{Lk} = q_L^* - q_{Lk}$.

this downward distortion increasing with exclusivity and shrinking with conformity (i.e., $\frac{\partial \Delta q_{Lk}}{\partial \beta_H} \geq 0, \frac{\partial \Delta q_{Lk}}{\partial \beta_L} \leq 0$).

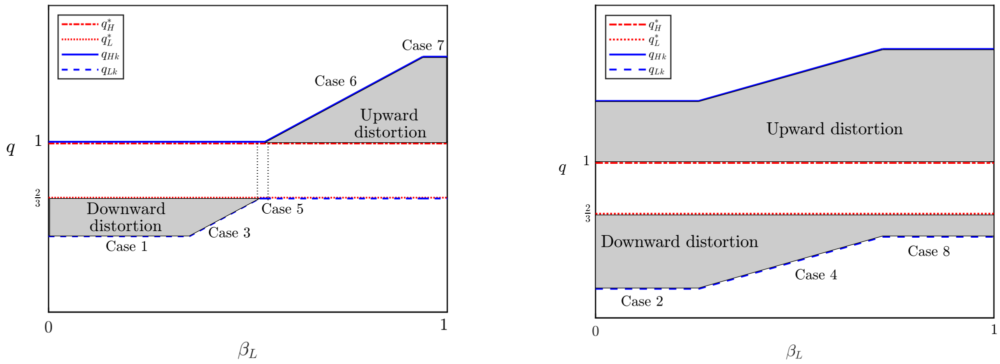
Traditionally, distortions in product offerings help firms reduce consumers' imitation, segment the market, and limit internal cannibalization (Moorthy and Png, 1992). When both exclusivity and conformity are low (i.e., $\beta_H < \min\{\beta_{H1}, \beta_{H3}\}, \beta_L < \beta_{L3}$, corresponding to Cases 1, 3, and 5), weak follower effect and reduced differentiated effect fail to shift low-type consumers' preferences to high-end products, leaving the firm with no incentive to distort high-end product quality to achieve market segmentation.

As conformity rises, the strengthened follower effect boosts low-type consumers' preference for high-end products. When exclusivity is high (i.e., $\beta_H > \min\{\beta_{H1}, \beta_{H3}\}$), the firm is compelled to improve high-end product quality to attract high-type consumers influenced by the strong snob effect. This improvement further increases low-type consumers' WTB for high-end products. Thus, in cases of high conformity or exclusivity (Cases 2, 4, 6, 7, and 8), low-type consumers are motivated to imitate high-type consumers' purchasing behavior. In such cases, the firm must enhance both the quality and price of high-end products to deter low-type consumers from purchasing them. Additionally, the intensified snob effect prompts the firm to further enhance the quality of high-end products to attract high-type consumers (i.e.,$\frac{\partial \Delta q_{Hk}}{\partial \beta_H} \geq 0$). The increased follower effect drives up low-type consumers' purchase intentions for high-end products, compelling the firm to further improve its offerings (i.e., $\frac{\partial \Delta q_{Hk}}{\partial \beta_L} \geq 0$).

When exclusivity is low and conformity is high (i.e., $\beta_H < \beta_{H5}, \beta_L > \beta_{L2}$, Cases 5, 6, 7), the indirect negative effect of β_L on the WTB of high-type consumers dominates. High-type consumers anticipate an influx of low-type consumers into the market, dissuading them from purchasing low-end products. This means, the firm does not need to compromise and lower the quality of its low-end products. Conversely, when exclusivity is high (i.e., Cases 2, 4, 8) or conformity is low (Cases 1, 3), the firm may reduce prices of low-end products to attract low-type consumers, who are either more susceptible to the indirect negative effect or have reduced WTB due to weak follower effect. This pricing strategy might prompt high-type consumers to choose low-end products over high-end ones. To counteract high-type consumers' tendency to imitate, the firm might reduce the quality of its low-end offerings.

As exclusivity increases, the snob effect reduces high-type consumers' motivation to purchase high-end products, making low-end offerings more attractive. Consequently, the firm may need to further lower the quality of low-end products to disincentivize imitation (i.e., $\frac{\partial \Delta q_{Lk}}{\partial \beta_H} \geq 0$). Conversely, as conformity rises, the firm can raise prices for low-end products, which reduces high-type consumers' motivation to imitate. This reduction in imitation among high-end consumers helps mitigate the quality distortion of the firm's low-end products (i.e., $\frac{\partial \Delta q_{Lk}}{\partial \beta_L} \leq 0$).

Figure 2 shows the quality distortions based on the strength of social comparison. Corollary 1 summarizes how social comparison affects the firm's product line adjustment strategy.



(a) When β_H is small ($\beta_H = \frac{7}{40}$) (b) When β_H is large ($\beta_H = \frac{3}{5}$)

Figure 2: Quality of both products (with $\lambda = \frac{2}{5}, \theta = \frac{2}{3}$)

Corollary 1 (Impact of social comparison on product lines adjustment).

(i) *When the level of exclusivity is low (i.e., $\beta_H < \bar{\beta}_H$)*[6]*, the firm adjusts at most one of the product lines. Specifically, when the level of conformity is low (high), the firm adjusts the low-end (high-end) line; when the level of conformity is moderate, the firm does not need to adjust the product line.*

(ii) *When the level of exclusivity is high (i.e., $\beta_H > \bar{\beta}_H$), the firm adjusts both product lines simultaneously.*

Corollary 1 indicates that higher exclusivity prompts the firm to adjust its product lines more frequently. As indicated by Proposition 1, when exclusivity is low, only high-type consumers are incentivized to imitate low-type consumers in low-conformity scenarios. To prevent this, the firm lowers the quality of low-end products (Figure 2(a), Cases 1 and 3). Conversely, in high conformity situations, low-type consumers tend to imitate high-type consumers, prompting the firm to lower the quality of high-end products to deter this behavior (as seen in Figure 2(a), Cases 6 and 7). When conformity is moderate, neither high-type nor low-type consumers imitate each other, allowing the firm to keep its product offerings unchanged (i.e., Case 5). However, in high exclusivity scenarios, the snob effect and indirect negative effect lower the WTB for both consumer types. To counter this, the firm improves high-end product quality to attract high-type consumers while lowering prices for low-end products to appeal to low-type consumers. This mutual imitation forces the firm to adjust both product lines simultaneously to mitigate imitation incentives (as shown in Figure 2(b), Cases 2, 4, 8).

Corollary 2. *Under incomplete information, the firm's product offering achieves the first-best level (i.e., $(q_{H5}, q_{L5}) = (q_H^*, q_L^*)$) when the level of exclusivity is low and conformity is moderate (i.e., $\beta_H < \beta_{H3}$, $\beta_{L2} < \beta_L < \beta_{L3}$).*

The traditional view suggests that a firm lacking consumer valuation information faces higher costs in identifying its consumers, as consumers with informational advantages may mimic each other's

[6] $\bar{\beta}_H = \begin{cases} \min\{\beta_{H1}, \beta_{H3}\} & \text{if } \beta_L < \beta_{L2}, \\ \beta_{H5} & \text{if } \beta_L > \beta_{L2}. \end{cases}$

purchasing behaviors (Zhang et al., 2021; Fan et al., 2023). This leads to inefficiencies under incomplete information. However, social comparison can mitigate this inefficient product offering, enabling the firm to offer the (first-best) optimal products when exclusivity is low and conformity is moderate. We elaborate on this intuition as follows. Under incomplete information, social inefficiency arises when product offerings deviate from the optimal level due to the firm's efforts to prevent consumer imitation. According to Proposition 1, when exclusivity is low and conformity is moderate (i.e., $\beta_H < \beta_{H3}$, $\beta_{L2} < \beta_L < \beta_{L3}$), neither high-type nor low-type consumers feel compelled to imitate each other's purchasing choices. Specifically, as conformity increases, the firm raises prices for low-end products, making them unattractive to high-type consumers at moderate conformity levels. For low-type consumers, although moderate conformity might increase their WTB, this follower effect is not strong enough to make them switch from low-end to high-end products. Consequently, the firm does not have to alter its product offerings since the market remains naturally divided. This suggests that the firm is not always disadvantaged by information asymmetry. In fact, in markets with low exclusivity and moderate conformity, the firm can achieve efficient product offerings and implement perfect price discrimination.

Proposition 2 (Impact of social comparison on price).

(i) *The price of low-end products is non-decreasing with the level of conformity (i.e., $\frac{\partial p_{LK}}{\partial \beta_L} \geq 0$) and is non-increasing with the level of exclusivity (i.e., $\frac{\partial p_{LK}}{\partial \beta_H} \leq 0$).*

(ii) *The price of high-end products is non-decreasing with the level of conformity (i.e., $\frac{\partial p_{HK}}{\partial \beta_L} \geq 0$) and exhibits a non-monotonic relationship with the level of exclusivity: it decreases initially and then increases (i.e., $\frac{\partial p_{HK}}{\partial \beta_H} < 0$ when $k = 1, 3, 5, 7$, and $\frac{\partial p_{HK}}{\partial \beta_H} > 0$ when $k = 2, 4, 6, 8$).*

Conformity psychology raises the WTB of low-type consumers, enabling the firm to charge higher prices for low-end products. This impact is consistent with complete information findings in Lemma 1. However, under incomplete information, exclusivity lowers low-end product prices. Specifically, when exclusivity is high and conformity is low Proposition 1(ii), the firm lowers low-end product quality to deter high-type consumers from purchasing them. This quality reduction intensifies with the level of exclusivity. Hence, the firm must lower the price of low-end products to retain low-type consumers. When both exclusivity and conformity are high (Cases 7 and 8), the intensified snob effect significantly lowers high-type consumers' WTB, while low-type consumers show greater interest in high-end products. As exclusivity rises, the firm must either reduce the price of high-end products or enhance their quality to increase high-type consumers' WTB, which in turn boosts low-type consumers' preferences for high-end options. Consequently, low-end product prices decrease to keep low-type consumers in the low-end market.

When conformity is low (Cases 1 and 2, as shown in Proposition 1), high-type consumers are incentivized to purchase low-end products. However, as conformity increases, the firm increases the prices of low-end products (i.e., $\frac{\partial p_{L1,2}}{\partial \beta_L} > 0$), reducing high-type consumers' motivation to imitate, which allows the firm to raise the prices of high-end products (i.e., $\frac{\partial p_{H1,2}}{\partial \beta_L} > 0$). When either conformity or exclusivity is high (i.e., Cases 4 and 6), the firm improves the quality of high-end products, justifying higher prices for these offerings. The non-monotonic impact of exclusivity on high-end product pricing stems from its influence on the firm's quality adjustment strategy. For instance, in Cases 1, 3, 5, and 7, increasing exclusivity does not alter high-end product quality. However, the intensified snob effect lowers high-type consumers' WTB, forcing price reduction. Conversely, in Cases 2, 4, 6, and 8, Proposition 1 indicates that high-end product quality rises with exclusivity (i.e., $\frac{\partial q_{Hk}}{\partial \beta_H} > 0$), allowing the firm to charge higher prices.

The managerial insights derived from strategic product offering are as follows. (a) When consumers' willingness to pay is private information, the firm should improve high-end product quality to increase high-type consumers' WTB, enabling higher prices to capture greater marginal profits. In the low-end market, the firm should lower prices to attract low-type consumers and subsequently reduce product quality to minimize marginal costs. This strategy reflects the distinctiveness of consumers: high-type consumers value quality, while low-type consumers are more price-sensitive. (b) The firm should adjust its product quality based on social comparison strength. In high-exclusivity markets, a significant quality gap between product lines is necessary, as seen in luxury markets. In low-exclusivity markets, such as daily necessities, the quality gap is smaller. (c) Firms facing information disadvantage must carefully assess social comparison effects on pricing. For example, exclusivity may lower low-end product prices while increasing high-end product prices. Therefore, the firm must balance these effects to develop an optimal pricing strategy.

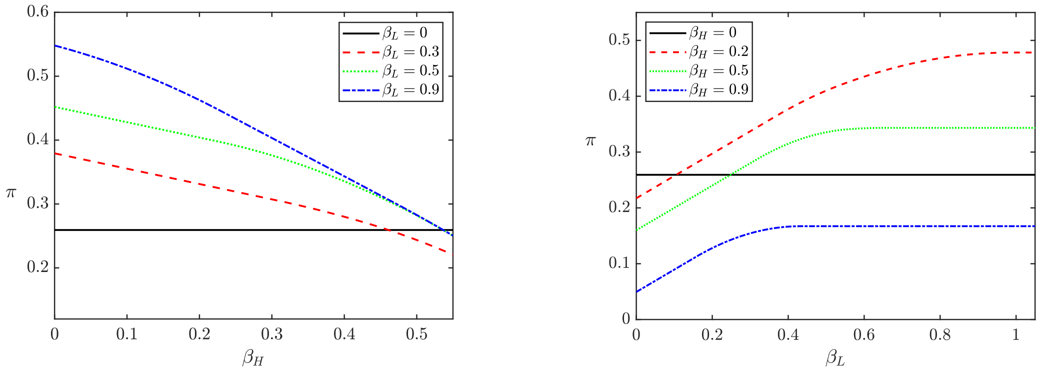
4.2. Firm's Profit

Lemma 3. *Under incomplete information,*

(i) *The optimal profit is shown in Table 3.*
(ii) *Firm's profit decreases with exclusivity and increases with conformity (i.e., $\frac{\partial \pi_k}{\partial \beta_H} < 0$, $\frac{\partial \pi_k}{\partial \beta_L} \geq 0$).*
(iii) *The firm achieves higher profits under lower exclusivity and higher conformity compared to scenarios without social comparison.*

Table 3: The optimal profits in different cases

Case k	π_k
1	$\frac{\theta^2-2\theta\lambda+\lambda}{2(1-\lambda)} + \beta_L\lambda - \beta_H\lambda(1-\lambda)$
2	$\frac{1}{2}(\theta^2 + 2\beta_L\lambda - \frac{\lambda\beta_H^2(1-\lambda)^3}{(1-\theta)^2})$
3	$\frac{\beta_L\lambda(1-\lambda)(2-2\theta-\beta_L\lambda)}{2(1-\theta)^2} + \frac{\lambda}{2} - \beta_H\lambda(1-\lambda)$
4	$\frac{\lambda(\beta_L(2-2\theta-\beta_L\lambda)-\beta_H^2(1-\lambda)^2-2\beta_H(1-\lambda)(\beta_L\lambda-\theta(1-\theta)))}{2(1-\theta)^2}$
5	$\frac{1}{2}(\lambda + (1-\lambda)\theta^2) + \lambda(1-\lambda)(\beta_L - \beta_H)$
6	$\frac{\theta^2(1-\lambda)(1-\theta)^2-\lambda\beta_H^2(1-\lambda)^2-2\beta_H\lambda(1-\lambda)(\beta_L\lambda-\theta(1-\theta))+2\beta_L\lambda(1-\theta)(1-\theta(1-\lambda))-\beta_L^2\lambda^3}{2(1-\theta)^2}$
7	$\frac{1-\theta(2-\theta)(1-\lambda)}{2\lambda} - \beta_H(1-\lambda)$
8	$\frac{1}{2}(1 - \beta_H\lambda(1-\lambda)(2 + \frac{\beta_H(1-\lambda)^2}{(1-\theta)^2}))$



(a) Impact of β_H

(b) Impact of β_L

Figure 3: Impact of social comparison on profit (with $\theta = \frac{2}{3}$, $\lambda = \frac{2}{5}$)

High exclusivity lowers WTB of high-type consumers by creating a perception of limited access, which discourages broader market participation. Decrease in WTB negatively impacts firm's profitability, as shown in Figure 3(a). Conversely, conformity fosters social alignment, increasing the WTB of low-type consumers who are more inclined to purchase popular or widely sold products. This increase in demand enhances the firm's profitability, as shown in Figure 3(b). Let π^N be the firm's profit in a market without social comparison, expressed as $\pi^N = \frac{\theta^2 - 2\theta\lambda + \lambda}{2(1-\lambda)}$. A comparison of profits across markets reveals that the firm is more profitable in environments characterized by high conformity and low exclusivity than in those without social comparison. Figure 3 illustrates this, with the black line consistently positioned lower when conformity is high and exclusivity is low. Next, we examine how social comparison changes the effect of consumer valuation on the firm's profitability, as outlined in Proposition 3.

Proposition 3 (Impact of consumer heterogeneity).

(i) *When both exclusivity and conformity are low (i.e.,*$\beta_H < \min\{\beta_{H1}, \beta_{H3}\}$*), the firm's profit decreases with consumer heterogeneity (i.e.,* $\frac{\partial \pi_{1,3,5}}{\partial \theta} > 0$*).*[7]

(ii) *When either exclusivity or conformity is relatively high (i.e.,* $\min\{\beta_{H1}, \beta_{H3}\} < \beta_H < \max\{\beta_{H4}, \beta_{H6}\}$*), the firm's profit first decreases and then increases with consumer heterogeneity (i.e.,* $\frac{\partial \pi_{2,4,6}}{\partial \theta} > 0$ *if* $\theta < \hat{\theta}$*; otherwise,* $\frac{\partial \pi_{2,4,6}}{\partial \theta} < 0$*).*[8]

(iii) *When at least one of exclusivity and conformity is high (i.e.,* $\beta_H > \max\{\beta_{H4}, \beta_{H6}\}$*), the firm's profit increases with consumer heterogeneity (i.e.,* $\frac{\partial \pi_{7,8}}{\partial \theta} < 0$*).*

Proposition 3 demonstrates how social comparison alters the impact of consumer heterogeneity on a firm's profitability. Consumer heterogeneity affects profit through two opposing effects. First, it positively influences profit by lowering market segmentation costs and reducing internal product line cannibalization (the positive effect). Second, increased heterogeneity diminishes the valuations of low-type consumers, thereby reducing the profit margins the firm can extract from this consumer

[7] An increase in θ means a decrease in consumer heterogeneity.
[8] The detailed expression of $\hat{\theta}$ is in Appendix.

segment (the negative effect). When both exclusivity and conformity levels are low, the positive effect—stemming from lower costs associated with market segmentation—is weaker since the distinction between the two consumer types is more pronounced. However, the negative effect, driven by decreased consumer valuations, dominates, leading to a decline in profitability as consumer heterogeneity increases (i.e., $\frac{\partial \pi_{1,3,5}}{\partial \theta} > 0$). In contrast, when either exclusivity or conformity is high, the differentiation between consumer types diminishes further, forcing the firm to incur higher segmentation costs. Under these conditions, increased consumer heterogeneity alleviates segmentation costs, strengthening the positive effect. Consequently, the positive effect outweighs the negative effect, resulting in increased profitability as consumer heterogeneity rises (i.e., $\frac{\partial \pi_{7,8}}{\partial \theta} < 0$).

When either exclusivity or conformity is relatively high, the moderately reduced differentiation effect complicates the firm's ability to effectively segment the market and identify consumer types. This creates a trade-off for the firm: it can either charge a higher price for the low-end product to leverage increased consumer valuation or invest more in enhancing the quality of the high-end product to mitigate internal product line cannibalization. The relative strength of these competing forces depends on the degree of consumer heterogeneity. When consumer heterogeneity is high, the benefits of raising the price of the low-end product outweigh the associated costs, resulting in higher profitability. However, when consumer heterogeneity is low, the costs of market separation surpass the benefits of increasing the low-end product's price. This creates a non-monotonic relationship between consumer heterogeneity and the firm's profitability, as reflected in $\frac{\partial \pi_{2,4,6}}{\partial \theta} > 0$ when $\theta < \hat{\theta}$ and $\frac{\partial \pi_{2,4,6}}{\partial \theta} < 0$ when $\theta > \hat{\theta}$.

From a managerial perspective, these findings suggest that the firm benefits from reducing consumer heterogeneity when both exclusivity and conformity levels are low. In contrast, the firm benefits from increasing consumer heterogeneity when at least one of these levels is high. These insights align with observed market trends: in markets driven by strong social comparison, such as luxury goods, consumer heterogeneity often exhibits significant variation. By contrast, in markets where social comparison is less influential, such as daily necessities, consumer heterogeneity tends to be more uniform.

5. Further Discussion

5.1. Consumer Surplus and Social Welfare

Table 4 summarizes the equilibrium consumer surplus and social welfare in relation to the strength of social comparison. The following analysis examines the impact of social comparison on consumer surplus and social welfare under incomplete information.

Table 4: Consumer surplus (cs) and social welfare (sw) in different offerings

Case k	cs	sw
1	$\frac{\lambda(1-\theta)(\theta-\lambda)}{1-\lambda}-\beta_L\lambda^2$	$\frac{2\theta\lambda^2+(1-2\lambda)(\lambda+\theta^2)-2\lambda(1-\lambda)^2(\beta_H-\beta_L)}{2(1-\lambda)}$
2	$\theta\lambda(1-\theta)+\lambda^2(\beta_L-\beta_H(1-\lambda))$	$\frac{1}{2}\theta(\theta+2\lambda(1-\theta))-\frac{\lambda\beta_H^2(1-\lambda)^3}{2(1-\theta)^2}-\lambda(1-\lambda)(\beta_H\lambda-\beta_L)$
3	0	$\frac{\beta_L\lambda(1-\lambda)(2-2\theta-\beta_L\lambda)}{2(1-\theta)^2}+\frac{\lambda}{2}-\beta_H\lambda(1-\lambda)$
4	0	$\frac{\lambda(\beta_L(2-2\theta-\beta_L\lambda)-\beta_H^2(1-\lambda)^2-2\beta_H(1-\lambda)(\beta_L\lambda-\theta(1-\theta)))}{2(1-\theta)^2}$
5	0	$\frac{1}{2}(\lambda+(1-\lambda)\theta^2)+\lambda(1-\lambda)(\beta_L-\beta_H)$
6	0	$\frac{\theta^2(1-\lambda)(1-\theta)^2-\lambda\beta_H^2(1-\lambda)^2-2\beta_H\lambda(1-\lambda)(\beta_L\lambda-\theta(1-\theta))+2\beta_L\lambda(1-\theta)(1-\theta(1-\lambda))-\beta_L^2\lambda^3}{2(1-\theta)^2}$
7	$(1-\lambda)(\beta_L\lambda+\beta_H(1-\lambda))-\frac{(1-\theta)(1-\lambda)(1-\theta(1-\lambda))}{\lambda}$	$\frac{2\lambda+\theta(1-\lambda)(2-\theta-2\lambda(1-\theta))+2\lambda^2(1-\lambda)(\beta_L-\beta_H)-1}{2\lambda}$
8	$\lambda(1-\lambda)(\beta_L+\beta_H(1-\lambda))-(1-\theta)(1-\lambda)$	$\theta+\lambda(1-\theta)+\lambda(1-\lambda)(\beta_L-\beta_H\lambda)-\frac{1}{2}-\frac{\lambda\beta_H^2(1-\lambda)^3}{2(1-\theta)^2}$

Proposition 4. *Under incomplete information,*

(i) *When both levels of conformity and exclusivity are relatively low (i.e., $\beta_L < \beta_{L1}$, $\beta_H < \beta_{H2}$), high-type consumers receive a positive surplus.*

(ii) *When both levels of conformity and exclusivity are relatively high (i.e., $\beta_H > \max\{\beta_{H4}, \beta_{H6}\}$), low-type consumers receive a positive surplus.*

(iii) *Otherwise, all consumers receive zero surplus.*

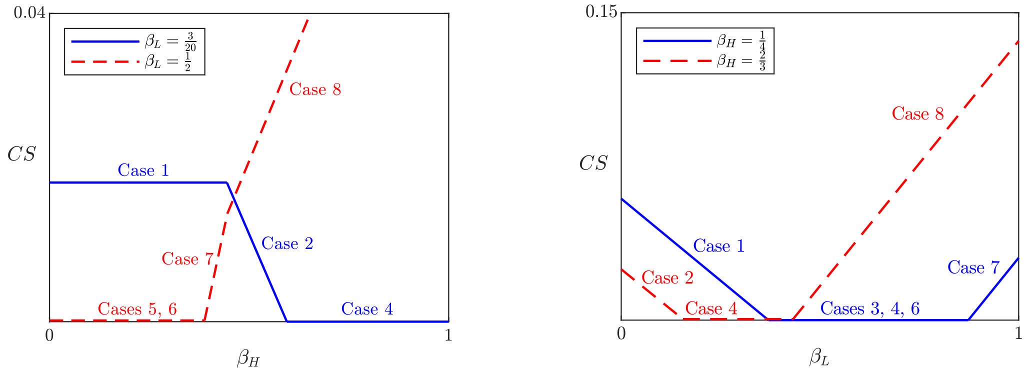
Conventionally, high-type consumers benefit from private information, as it motivates firms to pay information rent for market segmentation (Moorthy and Png, 1992). However, increased social comparison alters the distribution. Specifically, when conformity and exclusivity are high, Proposition 1 shows that low-type consumers imitate high-type consumers, forcing the firm to pay information rent and allowing low-type consumers to capture a surplus. Conversely, when exclusivity and conformity are moderate, this reduces the incentive for consumer imitation enabling the firm to avoid paying information rent and capture the entire surplus.

Proposition 5 (Impact of social comparison on consumer surplus).

(i) *When conformity and exclusivity are low, consumer surplus does not rise with β_H and β_L.*

(ii) *When conformity and exclusivity are high, consumer surplus rise with β_H and β_L.*

Proposition 5 and Figure 4 show the non-monotonic impact of social comparison on consumer surplus. When exclusivity and conformity levels are low (Case 1), the firm lowers prices for high-end products to reduce imitation among high-type consumers. The price decrease offsets the negative impact of exclusivity, keeping their overall surplus constant despite rising exclusivity (i.e., $\frac{\partial cs_1}{\partial \beta_H} = 0$). However, as exclusivity increases further in Case 2, the snob effect gradually takes over, causing a decline in high-type consumer surplus (i.e., $\frac{\partial cs_2}{\partial \beta_H} < 0$). The blue line in the left graph of Figure 4 shows the consumer surplus remains stable before decreasing with higher exclusivity (Cases 1, 2). Moreover, as conformity levels rise, the amplified follower effect prompts the firm to raise prices for low-end products, which reduces high-type consumers' motivation to imitate. In other words, the reduced information rent leads to a decrease in high-type consumer surplus (i.e., $\frac{\partial cs_{1,2}}{\partial \beta_L} < 0$). The blue line and



(a) Impact of β_H

(b) Impact of β_L

Figure 4: The impacts of β_H and β_L on cs ($\theta = \frac{2}{3}, \lambda = \frac{2}{5}$)

red dashed line in the right graph of Figure 4 depict the decline in consumer surplus with increasing conformity (Cases 1, 2).

When both conformity and exclusivity are high, low-type consumers gain a positive surplus. The snob effect of high exclusivity pushes the firm to enhance high-end product quality, thereby increasing low-type consumers' motivation to buy them. As a result, the firm incurs higher information rent as exclusivity rises. Moreover, the reduced differentiation effect from a higher β_H encourages the firm to lower the quality and prices of low-end products to prevent cannibalization. Hence, consumer surplus increases with exclusivity (i.e., $\frac{\partial cs_{7,8}}{\partial \beta_H} > 0$), as shown by the red dashed line in Figure 4(a) (Cases 7, 8). Regarding the conformity psychology, its direct impact on consumer surplus is reflected in the utility function of low-type consumers, leading to an increase in consumer surplus with the conformity level (i.e., $\frac{\partial cs_{7,8}}{\partial \beta_L} > 0$), as depicted by the red dashed line and blue line in Figure 4(b) (Cases 7, 8).

Corollary 3 (Impact of consumer valuation on consumer surplus).

(i) *When both conformity and exclusivity are relatively low, consumer surplus first increases and then decreases with θ.*

(ii) *When both conformity and exclusivity are relatively high, consumer surplus increases with θ.*

Intuitively, an increase in consumer valuation will enhance consumer surplus by directly benefiting low-type consumers. Our work confirms this intuition, as Proposition 5 shows that consumer surplus arises primarily from the information rent received by low-type consumers when both conformity and exclusivity are high. Moreover, we identify a non-monotonic effect of consumer valuation on consumer surplus when both conformity and exclusivity are relatively low.

Notably, consumer valuation plays a crucial role in determining the surplus of high-type consumers (i.e., information rent, $q_L - \theta q_L - \beta_L \lambda$) in two ways: it has a direct negative impact on information rent $-\theta q_L$ and a positive impact through the increased quality of low-end products, q_L. When θ is relatively small, the positive impact stemming from increased quality (i.e., $\frac{\partial q_{L1}}{\partial \theta} = \frac{1}{1-\lambda} > 0, \frac{\partial q_{L2}}{\partial \theta} = 1 - \frac{\beta_H \lambda(1-\lambda)}{(1-\theta)^2} > 0$ when $\theta < \frac{1}{2}$) dominates the negative impact, leading to an increase in consumer surplus with rising consumer valuation. However, as θ continues to increase, the direct negative impact on information rent begins to dominate, causing consumer surplus to decline. Therefore, when both levels of conformity and exclusivity are low, the surplus from high-type consumers first increases and then decreases with consumer valuation.

Corollary 4. *Social welfare declines as exclusivity increases, but it improves with greater conformity.*

Intuitively, as the psychology of exclusivity intensifies, it generates greater negative utility for high-type consumers, reducing their WTB and requiring the firm to offer higher incentives to stimulate their purchasing behavior. This exclusivity mindset reflects a reluctance to engage with the low-end market, hindering market expansion and harming overall social welfare. Conversely, conformity psychology increases the WTB of low-type consumers, making them more valuable to the firm. As exclusivity levels rise, the firm is motivated to broaden its market reach and consumers are willing to pay higher prices, thereby improving social welfare. Thus, social welfare decreases as exclusivity rises and increases with greater conformity.

5.2. Value of Information

In the following, we examine how social comparison affects the effect of information on the firm's profit, consumer surplus, and social welfare.

Corollary 5 (Impact of social comparison on the value of information).

(i) *In the absence of social comparison, incomplete information benefits high-type consumers, hurts the firm, and leads to social inefficiency.*

(ii) *With social comparison, incomplete information benefits low-type consumers and enables the firm to achieve perfect price discrimination without reducing social welfare.*

Typically, without social comparison, incomplete information forces the firm to pay information rent to high-type consumers to deter imitation, ensuring effective market segmentation and preventing product line cannibalization. Incomplete information thus benefits high-type consumers, reduces profitability and yields less efficient equilibrium outcomes compared to complete information (Moorthy and Png, 1992). However, as shown in Corollary 2, when exclusivity is low and conformity is moderate, the firm's product offering can achieve the first-best outcome, allowing for perfect price discrimination. In essence, exclusivity and conformity alters consumers' WTB, guiding them to select products that align with their preferences. This eliminates the need for costly market segmentation, as neither consumer type is incentivized to mimic the other. Consequently, the market naturally separates, enabling perfect price discrimination without reducing social welfare. Furthermore, as outlined in Proposition 4, high conformity and exclusivity allow low-type consumers to secure a positive surplus. This occurs because high conformity and exclusivity drive low-type consumers to mimic the purchasing behavior of high-type consumers. To maintain effective segmentation, the firm must offer information rents, enabling low-type consumers to capture additional surplus. Thus, social comparison reshapes the value of information for consumers, the firm, and overall social welfare.

6. Product Line Design

We just examined social comparison's impacts on a firm's product offerings, profit, consumer surplus, and social welfare for dual products under incomplete information. We now examine the firm's decision on product line extension in status goods market. We assume the firm initially offers only a high-end product with quality q_H, and needs to decide whether to diversify by introducing a low-end product with quality q_L. If the firm offers only one product type, social comparison does not occur and both consumer types derive utility solely from fundamental utility: $U_{Hi} = q_i - p_i$ for high-type consumers and $U_{Li} = \theta q_i - p_i$ for low-type consumers.

Given that the firm initially produces only a single high-quality product, we assume the optimal strategy is to serve the high-type consumers exclusively, satisfying the condition $\lambda > \theta^2$. This assumption aligns with the nature of status goods markets. As a result, the firm's profit function is $\pi = d_H(p_H - c_H)$. By virtue of the first-order conditions, the equilibrium price, quality, and profit are $p_{H0} = 1, q_{H0} = 1, \pi_{H0} = \frac{\lambda}{2}$. The subscript "$H0$" refers to the initial scenario of producing a single high-quality product, known as "Case 0".

Comparing the firm's profit between offering a single product for high-type consumers and two products tailored to each consumer type, Proposition 6 summarizes the firm's product line decision.

Proposition 6 (Product line decision). *There exists a threshold $\hat{\beta}_H$, such that when $\beta_H < \hat{\beta}_H$, the firm will expand to low-end product; otherwise (i.e., $\beta_H > \hat{\beta}_H$), the firm offers only the high-end product.*

$*$ *The expression of $\hat{\beta}_H$ is in Appendix.*

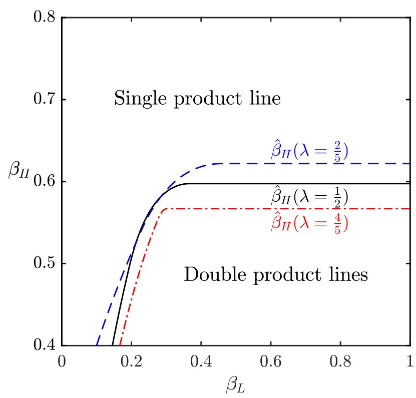


Figure 5: Product line selection region with respect to β_H and β_L ($\theta = \frac{2}{3}$)

Proposition 6 shows that the firm's product line extension hinges on social comparison dynamics. When exclusivity is high and conformity is low, the firm benefits from offering a single product for high-type consumers. Otherwise, the firm opts for two distinct product lines, each tailored to a specific consumer type. Proposition 6 is illustrated in Figure 5, with detailed analysis given below.

When exclusivity is high, the snob effect drives the firm to either improve the quality or reduce prices for high-end products to attract high-type consumers. Reduced differentiation effect further compels the firm to lower the quality of low-end products to enhance differentiation. This implies that exclusivity increases costs for producing two products. Meanwhile, low conformity limits price increases for low-end products. As a result, higher exclusivity and lower conformity negatively affect the firm's profitability in a two-product scenario, yielding lower profits compared to a single-product scenario. This outcome is shown in the top-left region of Figure 5, where the firm offers a single high-quality product for high-type consumers.

When conformity is not significantly low, the follower effect enhances profitability by enabling higher prices for low-end products. The positive impact of conformity outweighs the negative effect of exclusivity unless exclusivity is significantly high. Thus, the firm is incentivized to expand to low-end product when exclusivity is relatively low and conformity is not low. As illustrated in the bottom-right region of Figure 5, offering two product lines is more profitable than a single-product scenario under these conditions. However, with a higher proportion of high-type consumers, the firm favors a single product line strategy, indicating that larger high-end segments hinders product line extension.

In summary, the snob effect hinders a firm's downward product line expansion, as it diminishes the WTB of high-type consumers and compels the firm to invest more costs to retain this valuable consumer segment. Conversely, the follower effect encourages expansion by allowing higher prices, broader market reach, and increased profit margins. When the snob effect outweighs the follower effect, the firm offers a single product for high-type consumers. Alternatively, when the follower effect surpasses the snob effect, the firm offer two distinct product categories, each tailored to a specific consumer type. These findings suggest that in markets with heightened conformity, expanding the market and enhancing quality differentiation between product categories can boost profitability by addressing the needs of both consumer segments.

Next, we explore the impacts of social comparison on product quality after the firm establishes its product line. We find social comparison has a non-monotonic effect on product quality.

Table 5: Effects of social comparison on products' quality

Case k	0	1	2	3	4	5	6	7	8
$\frac{\partial q_H}{\partial \beta_H}$	/	/	$\frac{(1-\lambda)^2}{1-\theta}$	/	$\frac{1-\lambda}{1-\theta}$	/	$\frac{1-\lambda}{1-\theta}$	/	$\frac{(1-\lambda)^2}{1-\theta}$
$\frac{\partial q_H}{\partial \beta_L}$	/	/	/	/	$\frac{\lambda}{1-\theta}$	/	$\frac{\lambda}{1-\theta}$	/	/
$\frac{\partial q_L}{\partial \beta_H}$	/	/	$-\frac{\lambda(1-\lambda)}{1-\theta}$	/	/	/	/	/	$-\frac{\lambda(1-\lambda)}{1-\theta}$
$\frac{\partial q_L}{\partial \beta_L}$	/	/	/	$\frac{\lambda}{1-\theta}$	$\frac{\lambda}{1-\theta}$	/	/	/	/

Corollary 6 (Impact of social comparison on quality).

(i) *When $\beta_H < \hat{\beta}_H$, q_H exhibits a non-decreasing trend with both β_H and β_L, while q_L shows a non-decreasing trend with β_H but a non-increasing trend with β_L.*

(ii) *When $\beta_H > \hat{\beta}_H$, q_H remains unchanged regardless of β_H and β_L.*

Corollary 6 and Table 5 present the non-monotonic effects of β_H and β_L on product quality within the firm's product line strategy. Specifically, when $\beta_H < \hat{\beta}_H$ and the firm expands its product line downward, consumer exclusivity enhances high-end product quality but reduces low-end product quality, while consumer conformity improves the quality of both. Conversely, when $\beta_H > \hat{\beta}_H$ and the firm opts for a single product line, the absence of social comparison means neither consumer exclusivity nor conformity psychology affects product quality.

When the firm expands its product line downward (i.e., $\beta_H < \hat{\beta}_H$), the diminished snob effect limits the high-end product quality. As β_H increases, the firm improves high-end product quality to attract high-type consumers, while reducing the low-end product quality to mitigate inter-line competition. Consequently, the high-end quality roses, and the low-end quality declines.

Higher conformity increases low-type consumer value, leading to better product quality and higher prices. This conformity also drives high-end quality to reduce inter-line competition. As a result, both product categories show a non-decreasing quality trend with β_L. Nevertheless, when the firm opts for a single product line (i.e.,$\beta_H > \hat{\beta}_H$), the absence of social comparison does not affect the firm's quality decisions.

The analysis above provides important insights: At low social comparison, the firm can leverage increasing social comparison strength to enhance high-end product quality. For low-end products, the firm can offer higher-quality options as consumer conformity rises, while reducing quality as consumer exclusivity increases. These strategic quality decisions help mitigate competition and cannibalization among product lines, boosting profitability.

7. Conclusion

Social comparison is commonly observed in practice and has gained significant relevance in shaping consumer purchasing behavior. In this research, we analytically study the impact of social comparison using a game-theoretic model of a monopoly firm selling status goods to consumers who engage in social comparison. We find that social comparison changes the equilibrium product offerings, the firm's profitability, consumer surplus, and social welfare under incomplete information. Our analysis addresses several important managerial questions.

First, social comparison significantly alters the firm's optimal product offerings under incomplete information. Without social comparison, the firm provides high-end products at first-best quality while deliberately lowering the quality of low-end products below the first-best level. However, social comparison changes this dynamic. It leads the firm to enhance high-end product quality beyond the first-best level (upward distortion) and offer low-end products at first-best quality when exclusivity is low and conformity is high. In essence, these adjustments in product offerings help segment the market and reduce consumer imitation behavior.

Second, the firm's product line adjustments depend on exclusivity and conformity levels. When exclusivity is low, rising conformity level leads the firm's focus from low-end to high-end product adjustments. Conversely, when exclusivity is high, the firm must adjust both product lines simultaneously. At low exclusivity, only high-type consumers are motivated to imitate under low conformity, prompting the firm to adjust the low-end product line. As conformity rises, low-type consumers start imitating high-type consumers, while the imitation motivation for high-type consumers diminishes. Therefore, the firm only needs to adjust the high-end product line to achieve market segmentation. However, at high exclusivity, the firm faces a dual challenge and must enhance high-end product quality to attract high-type consumers while lowering low-end product prices to appeal to low-type consumers. This dual adjustment prevents excessive imitation and ensure effective market segmentation.

Third, social comparison significantly changes the impact of consumer heterogeneity on the firm's profit. As expected, consumer heterogeneity decreases (increases) the firm's profit when both exclusivity and conformity are low (when at least one of these levels is high). When either exclusivity or conformity is high, the firm's profit initially declines and then rises as consumer heterogeneity grows. This pattern is driven by the firm's trade-off between two factors: charging a higher price for the low-end product to capture the benefits of enhanced consumer valuation and incurring higher costs to effectively segment the market. Stronger social comparison further complicates this balance due to the reduced differentiation effect, which challenges the firm's ability to segment the market and identify consumers effectively. However, as consumer heterogeneity increases, the benefits of raising the low-end product's price eventually outweigh the segmentation costs, leading to a non-monotonic effect on the firm's profit.

Fourth, social comparison influences consumer surplus and social welfare in ways that diverge from conventional insights. Conventional perspectives without social comparison suggest that high-type consumers, being more valuable to the firm, typically benefit from incomplete information, while low-type consumers do not. This view holds true when both conformity and exclusivity levels are relatively low. However, when both conformity and exclusivity levels are high, low-type consumers, motivated to imitate the purchasing behavior of high-type consumers, experience a positive surplus. Otherwise, when social comparison strength is moderate, neither consumer type is incentivized to imitate the other's purchasing behavior. This relieves the firm from paying information rent for market segmentation, thereby preventing consumers from benefiting through private information. Furthermore, while conventional wisdom links incomplete information to social inefficiency, our findings indicate that social comparison may enable perfect price discrimination and achieve social efficiency comparable to the first-best outcome.

We further explore the role of information and discover that social comparison reshapes the value of information on the firm, consumer surplus, and social welfare. With social comparison, incomplete information does not always harm the firm or social welfare, nor does it always benefit consumers. Additionally, our extension on the product line decision reveals that the firm chooses to produce a single product when exclusivity is high and conformity is low. These findings offer practical managerial insights into pricing, quality decisions, and product line strategies in the context of social comparison.

Our research offers fresh insights into product offering and product-extension strategies for firms operating in status goods markets. In markets where consumer conformity outweighs exclusivity, firms should focus on offering low-end products at first-best quality while simultaneously enhancing the quality of high-end products. Conversely, in markets dominated by strong consumer exclusivity, firms should consider adjusting both product lines to either widen the quality gap or shrink the number of products offered. Furthermore, in markets where consumer conformity is moderate and exclusivity is low, firms can offer two products at first-best quality, thereby achieving natural market segmentation and perfect price discrimination. These findings shed light on real-world industrial practices, as elaborated earlier in the research.

To examine the strategic impact of social comparison on a firm's profitability, consumer surplus, and social welfare, we simplified our model with several assumptions. We assume that the exclusivity psychology of high-type consumers is directed solely at low-type consumers, while low-type consumers' conformity psychology arises only from the consumption patterns of the high-type segment. Future research could explore scenarios where high-type consumers exhibit exclusivity toward all consumer segments, and low-type consumers' conformity is influenced by the consumption behaviors of all groups. Additionally, this study focuses on a monopoly firm's pricing and quality decisions for its product line. One may obtain new insights by studying the role of social comparison in a competitive setting. Another potential avenue for future research is the experimental validation of the theoretical predictions outlined in this research.

References

Amaldoss, W. and Jain, S. (2005). Conspicuous consumption and sophisticated thinking. *Management Science*, 51(10):1449–1466.

Amaldoss, W. and Jain, S. (2008). Research note—trading up: A strategic analysis of reference group effects. *Marketing Science*, 27(5):932–942.

Amaldoss, W. and Jain, S. (2010). Reference groups and product line decisions: An experimental investigation of limited editions and product proliferation. *Management Science*, 56(4):621–644.

Amaldoss, W. and Jain, S. (2015). Branding conspicuous goods: An analysis of the effects of social influence and competition. *Management Science*, 61(9):2064–2079.

Arifoğlu, K., Deo, S., and Iravani, S. M. R. (2020). Markdowns in seasonal conspicuous goods. *Marketing Science*, 39(5):1016–1029.

Arifoğlu, K. and Tang, C. S. (2023). Luxury brand licensing: Competition and reference group effects. *Production and Operations Management*, 32(10):3227–3245.

Balseiro, S. R., Besbes, O., and Castro, F. (2024). Mechanism design under approximate incentive compatibility. *Operations Research*, 72(1):355–372.

Bolton, P. and Dewatripont, M. (2005). *Contract Theory*. MIT Press.

Bryson, B. (1996). "anything but heavy metal": Symbolic exclusion and musical dislikes. *American Sociological Review*, 61(5):884.

Cialdini, R. B. and Goldstein, N. J. (2004). Social influence: Compliance and conformity. *Annual Review of Psychology*, 55:591–621.

Cvitanić, J., Wan, X., and Yang, H. (2013). Dynamics of contract design with screening. *Management Science*, 59(5):1229–1244.

Desai, P. S. (2001). Quality segmentation in spatial markets: When does cannibalization affect product line design? *Marketing Science*, 20(3):265–283.

Fabra, N. and Montero, J.-P. (2022). Product lines and price discrimination in markets with information frictions. *Management Science*, 68(2):981–1001.

Fan, X., Chen, Y.-J., and Tang, C. S. (2023). Allocating scarce resources in the presence of private information and heterogeneous favoritism. *Production and Operations Management*, 32(7):2068–2086.

Fruchter, G. E., Prasad, A., and Van den Bulte, C. (2022). Too popular, too fast: Optimal advertising and entry timing in markets with peer influence. *Management Science*, 68(6):4725–4741.

Gao, S. Y., Lim, W. S., and Ye, Z. (2023a). Optimal channel strategy of luxury brands in the presence of online marketplace and copycats. *European Journal of Operational Research*, 308(2):709–721.

Gao, Y., Liu, S., Shen, B., and Tan, Y. R. (2023b). Social pricing of luxury products in a distribution channel. *Production and Operations Management*.

Guo, L. and Zhang, J. (2012). Consumer deliberation and product line design. *Marketing Science*, 31(6):995–1007.

Jain, S. and Li, K. J. (2018). Pricing and product design for vice goods: A strategic analysis. *Marketing Science*, 37(4):592–610.

Ke, T. T., Shin, J., and Yu, J. (2023). A model of product portfolio design: Guiding consumer search through brand positioning. *Marketing Science*, 42(6):1101–1124.

Kim, K. and Chhajed, D. (2002). Product design with multiple quality-type attributes. *Management Science*, 48(11):1502–1511.

Laffont, J.-J. and Martimort, D. (2002). *The Theory of Incentives: The Principal-Agent Model*. Princeton University Press.

Li, D., Mishra, N., and Netessine, S. (2023). Contracting for product support under information asymmetry. *Management Science*, 69(8):4627–4645.

Li, K. J. (2019). Status goods and vertical line extensions. *Production and Operations Management*, 28(1):103–120.

Liu, Q., Liu, X., and Balachander, S. (2021). Crowdfunding project design: Optimal product menu and funding target. *Production and Operations Management*, 30(10):3800–3811.

Long, X. and Nasiry, J. (2020). Wage transparency and social comparison in sales force compensation. *Management Science*, 66(11):5290–5315.

Mamadehussene, S. (2024). Rebates offered by a multiproduct firm. *Marketing Science*, 43(1):178–191.

Martimort, D. and Piccolo, S. (2010). The strategic value of quantity forcing contracts. *American Economic Journal: Microeconomics*, 2(1):204–229.

Moorthy, K. S. (1984). Market segmentation, self-selection, and product line design. *Marketing Science*, 3(4):288–307.

Moorthy, K. S. and Png, I. P. L. (1992). Market segmentation, cannibalization, and the timing of product introductions. *Management Science*, 38(3):345–359.

Myerson, R. B. (1979). Incentive compatibility and the bargaining problem. *Econometrica*, 47(1):61–73.

Pavlov, V., Katok, E., and Zhang, W. (2022). Optimal contract under asymmetric information about fairness. *Manufacturing & Service Operations Management*, 24(1):305–314.

Rao, R. S. and Schaefer, R. (2013). Conspicuous consumption and dynamic pricing. *Marketing Science*, 32(5):786–804.

Rhee, B.-D. (1996). Consumer heterogeneity and strategic quality decisions. *Management Science*, 42(2):157–172.

Sun, J., Xie, J., Chen, T., Li, F., and Wang, G. (2022). Managing reference-group effects in sequential product upgrades. *Production and Operations Management*, 31(2):442–456.

Tirole, J. (1988). *The Theory of Industrial Organization*. MIT Press.

Villas-Boas, J. M. (1998). Product line design for a distribution channel. *Marketing Science*, 17(2):156–169.

Xu, Z. and Dukes, A. (2019). Product line design under preference uncertainty using aggregate consumer data. *Marketing Science*, 38(4):669–689.

Yan, X., Zhao, W., and Yu, Y. (2022). Optimal product line design with reference price effects. *European Journal of Operational Research*, 302(3):1045–1062.

Zhang, J., Qi, L., and Tong, S. (2021). Dynamic contract under quick response in a supply chain with information asymmetry. *Production and Operations Management*, 30(5):1273–1289.

Zhang, Q., Chen, J., and Lin, J. (2022). Market targeting with social influences and risk aversion in a co-branding alliance. *European Journal of Operational Research*, 297(1):301–318.

Zhang, T., Choi, T.-M., and (Edwin) Cheng, T.-C. (2024). Competitive pricing and product strategies in the presence of consumers' social comparisons. *European Journal of Operational Research*, 312(2):573–586.

Zou, T., Zhou, B., and Jiang, B. (2020). Product-line design in the presence of consumers' anticipated regret. *Management Science*, 66(12):5665–5682.

Appendix

Proof of Lemma 1. Given the firm knows consumers' type perfectly, it only needs to satisfy the participation constraints for two types of consumers, i.e., the constraints ($\mathrm{IR_H}$) and ($\mathrm{IR_L}$) are blinding. Thus, the prices of the two products can be derived as

$$p_H = q_H - \beta_H(1-\lambda), p_L = \theta q_L + \beta_L \lambda. \tag{A.1}$$

Plugging p_H, p_L into the firm's profit, i.e., $\pi = \lambda(p_H - \frac{1}{2}q_H^2) + (1-\lambda)(p_L - \frac{1}{2}q_L^2)$. By the first-order conditions, we have the optimal quality of two products as $q_H^* = 1, q_L^* = \theta$. Therefore, the product prices, the firm's profit, consumer surplus, and social welfare in equilibrium can be derived as

$$\begin{aligned} &p_H^* = 1 - \beta_H(1-\lambda), p_L^* = \theta^2 + \beta_L\lambda, \pi^* = \frac{1}{2}(\lambda + (1-\lambda)\theta^2) - \lambda(1-\lambda)(\beta_H - \beta_L), \\ &cs_H^* = cs_L^* = 0, sw^* = \frac{1}{2}(\lambda + (1-\lambda)\theta^2) - \lambda(1-\lambda)(\beta_H - \beta_L). \end{aligned} \tag{A.2}$$

By taking the partial derivatives of the price and quality of the two types of products and the firm's profit with respect to β_H and β_L, we can get

$$\frac{\partial p_H^*}{\partial \beta_H} = -(1-\lambda) < 0, \frac{\partial q_H^*}{\partial \beta_H} = 0, \frac{\partial \pi^*}{\partial \beta_H} = -\lambda(1-\lambda) < 0, \frac{\partial p_L^*}{\partial \beta_L} = \lambda > 0, \frac{\partial q_L^*}{\partial \beta_L} = 0, \frac{\partial \pi^*}{\partial \beta_L} = \lambda(1-\lambda) > 0. \tag{A.3}$$

□

Proof of Lemma 2. Since consumer types are private information, the firm's problem is maximizing the total profit by developing two capable offerings, as shown in Equation 3. Depending on which constraints are binding for each type of consumer, there are four possible equilibrium outcomes. Specifically, the four scenarios are as follows. Scenario 1: ($\mathrm{IC_H}$) and ($\mathrm{IR_L}$) are binding; Scenario 2: ($\mathrm{IR_H}$) and ($\mathrm{IC_L}$) are binding; Scenario 3: ($\mathrm{IR_H}$) and ($\mathrm{IR_L}$) are binding; and Scenario 4: ($\mathrm{IC_H}$) and ($\mathrm{IC_L}$) are binding.

Figure A.1 presents the feasible region of the optimization problem. It turns out that there does not exist (p_H, p_L) which satisfies the scenario where both ($\mathrm{IC_H}$) and ($\mathrm{IC_L}$) are binding simultaneously. Hence, Scenario 4 will not happen in the equilibrium. Points 1, 2, and 3 in Figure A.1 represent the three remaining scenarios, which we discuss as follows.

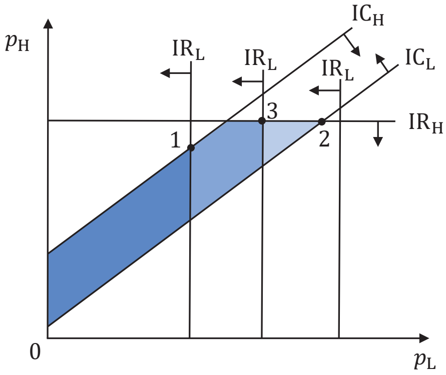


Figure A.1: Self-Selection Constraints

Scenario 1: (IC_H) and (IR_L) are binding.

In this scenario, the optimal prices are

$$p_H = q_H - q_L + \theta q_L + \beta_L\lambda - \beta_H(1-\lambda), p_L = \theta q_L + \beta_L\lambda. \tag{A.4}$$

For Scenario 1 to hold, we need to ensure that (IR_H) and (IC_L) are satisfied in equilibrium. Plugging (p_H, p_L) into (IR_H) and (IC_L), one can show that they are true if and only if $q_L \geq \frac{\beta_L\lambda}{1-\theta}$ and $q_H - q_L \geq \frac{\beta_H(1-\lambda)}{1-\theta}$. Therefore, after substituting (p_H, p_L) into the firm's profit, the problem of the firm can formulated as follows:

$$\begin{aligned} \max_{q_H, q_L} \pi &= -\frac{1}{2}\lambda q_H^2 - \frac{1}{2}(1-\lambda)q_L^2 + \lambda q_H + q_L(\theta - \lambda) + \lambda\left(\beta_L - \beta_H(1-\lambda)\right) \\ \text{s.t.} \quad & q_L \geq \frac{\beta_L\lambda}{1-\theta}, \\ & q_H - q_L \geq \frac{\beta_H(1-\lambda)}{1-\theta}. \end{aligned} \tag{A.5}$$

It is easy to see that the optimization problem (A.5) is a concave programming problem. We utilize the K-T condition to solve this optimization problem, which can be written as

$$\begin{aligned} \max \pi(q_H, q_L) &= -\frac{1}{2}\lambda q_H^2 - \frac{1}{2}(1-\lambda)q_L^2 + \lambda q_H + q_L(\theta - \lambda) + \lambda\left(\beta_L - \beta_H(1-\lambda)\right) \\ \text{s.t.} \quad & g_1(q_H, q_L) = q_L - \frac{\beta_L\lambda}{1-\theta} \geq 0, \\ & g_2(q_H, q_L) = q_H - q_L - \frac{\beta_H(1-\lambda)}{1-\theta} \geq 0. \end{aligned} \tag{A.6}$$

We formulate the Lagrange function as:

$$L(q_H, q_L) = \pi(q_H, q_L) + m g_1(q_H, q_L) + n g_2(q_H, q_L). \tag{A.7}$$

Therefore, we generate the following equations:

$$\begin{cases} \frac{\partial L(q_H,q_L)}{\partial q_H} = n+\lambda-\lambda q_H, \\ \frac{\partial L(q_H,q_L)}{\partial q_L} = m-n+\theta-\lambda-q_L(1-\lambda), \\ mg_1(q_H,q_L)=0, ng_2(q_H,q_L)=0, m\geq 0, n\geq 0, \end{cases} \tag{A.8}$$

where m, n are the K-T multipliers of $g_1(q_H,q_L)$ and $g_2(q_H,q_L)$. There arise four possible scenarios, depending on the quality constraints $g_1(q_H,q_L)\geq 0$ and $g_2(q_H,q_L)\geq 0$.

Scenario 1.1 When $m=0, n=0$, the quality constraints are loose (i.e., $g_1(q_H,q_L)>0$, $g_2(q_H,q_L)>0$). In this scenario, the first-order conditions $\frac{\partial L}{\partial q_H}=0$ and $\frac{\partial L}{\partial q_L}=0$ render $q_H=1, q_L=\frac{\theta-\lambda}{1-\lambda}$. Substituting p_H, p_L into the quality constraints, we have $\beta_L\leq\beta_{L1}\triangleq\frac{(\theta-\lambda)(1-\theta)}{\lambda(1-\lambda)}$, $\beta_H\leq\beta_{H1}\triangleq\frac{(1-\theta)^2}{(1-\lambda)^2}$, which can satisfy $g_1(q_H,q_L)>0$ and $g_2(q_H,q_L)>0$. Correspondingly, the prices and the profit of the firm can be computed as

$$p_H=\frac{1-\theta+\theta(\theta-\lambda)}{1-\lambda}+\beta_L\lambda-\beta_H(1-\lambda), p_L=\frac{\theta(\theta-\lambda)}{1-\lambda}+\beta_L\lambda, \pi=\frac{\theta^2-2\theta\lambda+\lambda}{2(1-\lambda)}+\beta_L\lambda-\beta_H\lambda(1-\lambda). \tag{A.9}$$

Scenario 1.2 When $m>0, n>0$, the quality constraints are binding (i.e., $g_1(q_H,q_L)=0$, $g_2(q_H,q_L)=0$), which gives $q_H=\frac{\beta_L\lambda+\beta_H(1-\lambda)}{1-\theta}$ and $q_L=\frac{\beta_L\lambda}{1-\theta}$. In this scenario, the first-order conditions $\frac{\partial L}{\partial q_H}=0$ and $\frac{\partial L}{\partial q_L}=0$ render $m=\frac{\theta^2-\theta-\beta_H\lambda^2+\beta_H\lambda+\beta_L\lambda}{1-\theta}$, $n=\frac{\lambda(\beta_L\lambda+\beta_H(1-\lambda)-(1-\theta))}{1-\theta}$. Solving $m>0, n>0$, we have ($\beta_L\leq\beta_{L1}, \beta_H\geq\beta_{H2}\triangleq\frac{\theta(1-\theta)-\beta_L\lambda}{\lambda(1-\lambda)}$) or ($\beta_{L1}<\beta_L<\beta_{L3}\triangleq\frac{1-\theta}{\lambda}, \beta_H\geq\beta_{H3}\triangleq\frac{1-\theta-\beta_L\lambda}{1-\lambda}$) or $\beta_L\geq\beta_{L3}$. Correspondingly, the prices and the profit of the firm can be computed as

$$\begin{aligned} &p_H=\frac{\beta_L\lambda+\theta\beta_H(1-\lambda)}{1-\theta}, p_L=\frac{\beta_L\lambda}{1-\theta}, \\ &\pi=\frac{\lambda(\beta_L(2-2\theta-\beta_L\lambda)-\beta_H^2(1-\lambda)^2-2\beta_H(1-\lambda)(\beta_L\lambda-\theta(1-\theta)))}{2(1-\theta)^2}. \end{aligned} \tag{A.10}$$

Scenario 1.3 When $m=0, n>0$, the first quality constraint is loose (i.e., $g_1(q_H,q_L)>0$), while the other is binding (i.e., $g_2(q_H,q_L)=0$). In this scenario, the first-order conditions $\frac{\partial L}{\partial q_H}=0$, $\frac{\partial L}{\partial q_L}=0$ and $m=0$ render $q_H=\theta+\frac{\beta_H(1-\lambda)^2}{1-\theta}$, $q_L=\theta-\frac{\beta_H\lambda(1-\lambda)}{1-\theta}$, $n=\frac{\lambda\left(\beta_H(1-\lambda)^2-(1-\theta)^2\right)}{1-\theta}$. Substituting q_L into $g_1(q_H,q_L)$ and Solving $g_1(q_H,q_L)>0$, we have $\beta_L<\beta_{L1}, \beta_{H1}\leq\beta_H\leq\beta_{H2}$. Correspondingly, the prices and the profit of the firm can be computed as

$$p_H=\theta^2+\beta_L\lambda+\frac{\theta\beta_H(1-\lambda)^2}{1-\theta}, p_L=\theta^2+\beta_L\lambda-\frac{\theta\beta_H\lambda(1-\lambda)}{1-\theta}, \pi=\frac{1}{2}\left(\theta^2+2\beta_L\lambda-\frac{\lambda\beta_H^2(1-\lambda)^3}{(1-\theta)^2}\right). \tag{A.11}$$

Scenario 1.4 When $m>0, n=0$, the first quality constraint is binding (i.e., $g_1(q_H,q_L)=0$), while the other is loose (i.e., $g_2(q_H,q_L)>0$). In this scenario, the first-order conditions $\frac{\partial L}{\partial q_H}=0$,

$\frac{\partial L}{\partial q_L}=0$ and $n=0$ render $q_H=1$, $q_L=\frac{\beta_L\lambda}{1-\theta}$, $m=\frac{\theta(\theta-\lambda 1)+\beta_L\lambda(1-\lambda)}{1-\theta}$. Substituting q_H and q_L into $g_2(q_H,q_L)$ and Solving $g_2(q_H,q_L)>0$, we have $\beta_{L1}\leq\beta_L<\beta_{L3},\beta_H\leq\beta_{H3}$. Correspondingly, the prices and the profit of the firm can be computed as

$$p_H=1-\beta_H(1-\lambda),p_L=\frac{\beta_L\lambda}{1-\theta},\pi=\frac{\beta_L\lambda(1-\lambda)(2-2\theta-\beta_L\lambda)}{2(1-\theta)^2}+\frac{\lambda}{2}-\beta_H\lambda(1-\lambda). \tag{A.12}$$

Thus we obtain four equilibrium outcomes in Scenario 1.

For Scenarios 2 and 3, the solving process is similar to Scenario 1, thus we omit it here. For further details, please refer to the online notebook host at `https://github.com/efxing/Online_Matching_Platform`.

Scenario 2: ($\mathrm{IR_H}$) and ($\mathrm{IC_L}$) are binding.

In this scenario, the optimal prices are

$$p_H=q_H-\beta_H(1-\lambda),p_L=q_H+\theta(q_L-q_H)-\beta_H(1-\lambda). \tag{A.13}$$

For Scenario 2 to hold, we need to ensure that ($\mathrm{IC_H}$) and ($\mathrm{IR_L}$) are satisfied in equilibrium. Plugging (p_H,p_L) into ($\mathrm{IC_H}$) and ($\mathrm{IR_L}$), one can show that they are true if and only if $q_H\leq\frac{\beta_H(1-\lambda)+\beta_L\lambda}{1-\theta}$ and $q_H-q_L\geq\frac{\beta_H(1-\lambda)}{1-\theta}$. Therefore, after substituting (p_H,p_L) into the firm's profit, the problem of the firm can formulated as follows:

$$\begin{aligned}
\max_{q_H,q_L}\pi &= -\frac{1}{2}\lambda q_H^2-\frac{1}{2}(1-\lambda)q_L^2+q_H(1-\theta(1-\lambda))+q_L\theta(1-\lambda)-\beta_H(1-\lambda)\\
\text{s.t.}\quad & q_H\leq\frac{\beta_H(1-\lambda)+\beta_L\lambda}{1-\theta},\\
& q_H-q_L\geq\frac{\beta_H(1-\lambda)}{1-\theta}.
\end{aligned} \tag{A.14}$$

It is easy to see that the optimization problem (A.14) is a concave programming problem. We also utilize the K-T condition to solve this optimization problem, the solving process is similar to Scenario 1, thus we omit it here.

The four equilibrium outcomes in Scenario 2 are as follows:

Scenario 2.1 When ($\beta_{L2}\triangleq\frac{\theta(1-\theta)}{\lambda}\leq\beta_L\leq\beta_{L4}\triangleq\frac{(1-\theta)(1-\theta+\theta\lambda)}{\lambda^2},\beta_{H4}\triangleq\frac{(1-\theta)(1-\theta+\theta\lambda)-\beta_L\lambda^2}{\lambda(1-\lambda)}\leq\beta_H\leq\beta_{H5}\triangleq\frac{(1-\theta)^2}{\lambda(1-\lambda)}$) or ($\beta_L>\beta_{L4},\beta_H\leq\beta_{H5}$), the equilibrium quality, price, and the profit of the firm can be derived as

$$\begin{aligned}
&q_H=\frac{1-\theta+\theta\lambda}{\lambda},\ q_L=\theta,p_H=\frac{1-\theta(1-\lambda)}{\lambda}-\beta_H(1-\lambda),\\
&p_L=\frac{1-\theta(2-\theta-\lambda)}{\lambda}-\beta_H(1-\lambda),\pi=\frac{1-\theta(2-\theta)(1-\lambda)}{2\lambda}-\beta_H(1-\lambda).
\end{aligned} \tag{A.15}$$

Scenario 2.2 When $\beta_L \le \beta_{L2}, 0 < \beta_H \le \beta_{H6} \triangleq \frac{1-\theta-\beta_L\lambda}{\lambda(1-\lambda)}$, the equilibrium quality, price, and the profit of the firm can be derived as

$$\begin{aligned}
&q_H = \frac{\beta_H(1-\lambda)+\beta_L\lambda}{1-\theta},\ q_L = \frac{\beta_L\lambda}{1-\theta}, p_H = \frac{\theta\beta_H(1-\lambda)+\beta_L\lambda}{1-\theta},\ p_L = \frac{\beta_L\lambda}{1-\theta} \\
&\pi = \frac{\lambda(\beta_L(2-2\theta-\beta_L\lambda)-\beta_H^2(1-\lambda)^2-2\beta_H(1-\lambda)(\beta_L\lambda-\theta(1-\theta)))}{2(1-\theta)^2}.
\end{aligned} \tag{A.16}$$

Scenario 2.3 When ($\beta_L \le \beta_{L2}, \beta_H \ge \beta_{H6}$) or ($\beta_L > \beta_{L2}, \beta_H \ge \beta_{H5}$), the equilibrium quality, price, and the profit of the firm can be derived as

$$\begin{aligned}
&q_H = 1 + \frac{\beta_H(1-\lambda)^2}{1-\theta}, q_L = 1 - \frac{\beta_H\lambda(1-\lambda)}{1-\theta}, p_H = 1 + \frac{\beta_H(1-\lambda)(\theta-\lambda)}{1-\theta}, \\
&p_L = 1 - \frac{\beta_H\lambda(1-\lambda)}{1-\theta}, \pi = \frac{1}{2}(1-\beta_H\lambda(1-\lambda)(2+\frac{\beta_H(1-\lambda)^2}{(1-\theta)^2})).
\end{aligned} \tag{A.17}$$

Scenario 2.4 When $\beta_{L2} \le \beta_L < \beta_{L4}, \beta_H \le \beta_{H4}$, the equilibrium quality, price, and the profit of the firm can be derived as

$$q_H = \frac{\beta_H(1-\lambda)+\beta_L\lambda}{1-\theta}, q_L = \theta, p_H = \frac{\theta\beta_H(1-\lambda)+\beta_L\lambda}{1-\theta}, p_L = \theta^2+\beta_L\lambda, \tag{A.18}$$
$$\pi = \frac{(1-\lambda)\theta^2(1-\theta)^2-\lambda\beta_H^2(1-\lambda)^2-2\beta_H\lambda(1-\lambda)(\beta_L\lambda-\theta(1-\theta))+2\beta_L\lambda(1-\theta)(1-\theta(1-\lambda))-\beta_L^2\lambda^3}{2(1-\theta)^2}.$$

Scenario 3: ($\mathrm{IR_H}$) and ($\mathrm{IR_L}$) are binding.

In this scenario, the optimal prices are

$$p_H = q_H - \beta_H(1-\lambda), p_L = \beta_L\lambda + \theta q_L. \tag{A.19}$$

For Scenario 3 to hold, we need to ensure that ($\mathrm{IC_H}$) and ($\mathrm{IC_L}$) are satisfied in equilibrium. Plugging (p_H, p_L) into ($\mathrm{IC_H}$) and ($\mathrm{IC_L}$), one can show that they are true if and only if $q_H \ge \frac{\beta_H(1-\lambda)+\beta_L\lambda}{1-\theta}, q_L \le \frac{\beta_L\lambda}{1-\theta}$. Therefore, after substituting (p_H, p_L) into the firm's profit, the problem of the firm can formulated as follows:

$$\begin{aligned}
&\max_{q_H, q_L} \pi = -\frac{1}{2}\lambda q_H^2 - \frac{1}{2}(1-\lambda)q_L^2 + \lambda q_H + \theta q_L(1-\lambda) + \lambda(1-\lambda)(\beta_L - \beta_H) \\
&\text{s.t.} \qquad\qquad q_H \ge \frac{\beta_H(1-\lambda)+\beta_L\lambda}{1-\theta}, \\
&\qquad\qquad\qquad q_L \le \frac{\beta_L\lambda}{1-\theta}.
\end{aligned} \tag{A.20}$$

It is easy to see that the optimization problem (A.20) is a concave programming problem. We also utilize the K-T condition to solve this optimization problem, the solving process is similar to Scenario 1, thus we omit it here.

The four equilibrium outcomes in Scenario 3 are as follows:

Scenario 3.1 When $\beta_{L2} \leq \beta_L < \beta_{L3}, \beta_H \leq \beta_{H3}$, the equilibrium quality, price, and the profit of the firm can be derived as

$$q_H = 1, q_L = \theta, p_H = 1 - \beta_H(1-\lambda), p_L = \theta^2 + \beta_L \lambda, \pi = \frac{1}{2}(\lambda + (1-\lambda)\theta^2) + \lambda(1-\lambda)(\beta_L - \beta_H). \tag{A.21}$$

Scenario 3.2 When $\beta_L \leq \beta_{L2}, \beta_H \geq \beta_{H3}$, the equilibrium quality, price, and the profit of the firm can be derived as

$$\begin{aligned} q_H &= \frac{\beta_H(1-\lambda) + \beta_L\lambda}{1-\theta}, q_L = \frac{\beta_L\lambda}{1-\theta}, p_H = \frac{\theta\beta_H(1-\lambda) + \beta_L\lambda}{1-\theta}, p_L = \frac{\beta_L\lambda}{1-\theta}, \\ \pi &= \frac{\lambda(\beta_L(2-2\theta-\beta_L\lambda) - \beta_H^2(1-\lambda)^2 - 2\beta_H(1-\lambda)(\beta_L\lambda - \theta(1-\theta)))}{2(1-\theta)^2}. \end{aligned} \tag{A.22}$$

Scenario 3.3 When $\beta_L \leq \beta_{L2}, \beta_H \leq \beta_{H3}$, the equilibrium quality, price, and the profit of the firm can be derived as

$$q_H = 1, q_L = \frac{\beta_L\lambda}{1-\theta}, p_H = 1 - \beta_H(1-\lambda), p_L = \frac{\beta_L\lambda}{1-\theta}, \pi = \frac{\beta_L\lambda(1-\lambda)(2-2\theta-\beta_L\lambda)}{2(1-\theta)^2} + \frac{\lambda}{2} - \beta_H\lambda(1-\lambda). \tag{A.23}$$

Scenario 3.4 When $(\beta_{L2} \leq \beta_L < \beta_{L3}, \beta_H \leq \beta_{H3})$ or $(\beta_L > \beta_{L3})$, the equilibrium quality, price, and the profit of the firm can be derived as

$$\begin{aligned} q_H &= \frac{\beta_H(1-\lambda) + \beta_L\lambda}{1-\theta}, q_L = \theta, p_H = \frac{\theta\beta_H(1-\lambda) + \beta_L\lambda}{1-\theta}, p_L = \theta^2 + \beta_L\lambda, \\ \pi &= \frac{(1-\lambda)\theta^2(1-\theta)^2 - \lambda\beta_H^2(1-\lambda)^2 - 2\beta_H\lambda(1-\lambda)(\beta_L\lambda - \theta(1-\theta)) + 2\beta_L\lambda(1-\theta)(1-\theta(1-\lambda)) - \beta_L^2\lambda^3}{2(1-\theta)^2}. \end{aligned} \tag{A.24}$$

We refine the above twelve equilibrium outcomes in three scenarios to ultimately derive eight refined equilibrium outcomes, as detailed in Table 2. Notably, we denote the case where $\beta_L \leq \beta_{L1}, \beta_H \leq \beta_{H1}$ as Case 1, the case where $\beta_L \leq \beta_{L1}$, $\beta_{H1} < \beta_H < \beta_{H2}$ as Case 2, the case where $\beta_{L1} < \beta_L \leq \beta_{L2}$, $\beta_H \leq \beta_{H3}$ as Case 3, the case where $\beta_L < \beta_{L2}$, $\max\{\beta_{H2}, \beta_{H3}\} + \leq \beta_H \leq \beta_{H6}$ as Case 4, the case where $\beta_{L2} \leq \beta_L < \beta_{L3}$, $\beta_H \leq \beta_{H3}$ as Case 5, the case where $\beta_{L2} < \beta_L < \beta_{L4}$, $\beta_{H3} < \beta_H < \beta_{H4}$ as Case 6, the case where $\beta_{H4} \leq \beta_H \leq \beta_{H5}$ as Case 7, and the case where $\beta_H > \max\{\beta_{H5}, \beta_{H6}\}$ as Case 8. □

Proof of Proposition 1. With social comparison, we compute the quality deviation compared to the first-best quality in 8 cases, where the quality distortion of the high-end product is denoted by $\Delta q_{Hk} \triangleq q_{Hk} - q_H^*$ (the subscript i denotes the Case i), and the quality distortion of the low-end product is denoted by $\Delta q_{Lk} \triangleq q_L^* - q_{Lk}$.

$$
\begin{aligned}
&\Delta q_{H1} = 0, \Delta q_{L1} = \frac{\lambda(1-\theta)}{1-\lambda} > 0, \Delta q_{H2} = \frac{\beta_H(1-\lambda)^2}{1-\theta} - 1 + \theta > 0, \Delta q_{L2} = \frac{\beta_H\lambda(1-\lambda)}{1-\theta} > 0,\\
&\Delta q_{H3} = 0, \Delta q_{L3} = \theta - \frac{\beta_L\lambda}{1-\theta} > 0, \Delta q_{H4} = \frac{\beta_L\lambda + \beta_H(1-\lambda) - 1 + \theta}{1-\theta} > 0, \Delta q_{L4} = \theta - \frac{\beta_L\lambda}{1-\theta} > 0,\\
&\Delta q_{H5} = 0, \Delta q_{L5} = 0, \Delta q_{H6} = \frac{\beta_L\lambda + \beta_H(1-\lambda) - 1 + \theta}{1-\theta} > 0, \Delta q_{L6} = 0, \Delta q_{H7} = \frac{(1-\theta)(1-\lambda)}{\lambda} > 0,\\
&\Delta q_{L7} = 0, \Delta q_{H8} = \frac{\beta_H(1-\lambda)^2}{1-\theta} > 0, \Delta q_{L8} = \frac{\beta_H\lambda(1-\lambda)}{1-\theta} - 1 + \theta > 0.
\end{aligned}
\tag{A.25}
$$

By taking the partial derivatives of the quality distortions of the two types of products with respect to β_L and β_H, we can get

$$
\begin{aligned}
&\frac{\partial \Delta q_{L1}}{\partial \beta_L} = 0, \frac{\partial \Delta q_{L1}}{\partial \beta_H} = 0, \frac{\partial \Delta q_{H1}}{\partial \beta_L} = 0, \frac{\partial \Delta q_{H1}}{\partial \beta_H} = 0,\\
&\frac{\partial \Delta q_{L2}}{\partial \beta_L} = 0, \frac{\partial \Delta q_{L2}}{\partial \beta_H} = \frac{\lambda(1-\lambda)}{1-\theta} > 0, \frac{\partial \Delta q_{H2}}{\partial \beta_L} = 0, \frac{\partial \Delta q_{H2}}{\partial \beta_H} = \frac{(1-\lambda)^2}{1-\theta} > 0,\\
&\frac{\partial \Delta q_{L3}}{\partial \beta_L} = -\frac{\lambda}{1-\theta} < 0, \frac{\partial \Delta q_{L3}}{\partial \beta_H} = 0, \frac{\partial \Delta q_{H3}}{\partial \beta_L} = 0, \frac{\partial \Delta q_{H3}}{\partial \beta_H} = 0,\\
&\frac{\partial \Delta q_{L4}}{\partial \beta_L} = -\frac{\lambda}{1-\theta} < 0, \frac{\partial \Delta q_{L4}}{\partial \beta_H} = 0, \frac{\partial \Delta q_{H4}}{\partial \beta_L} = \frac{\lambda}{1-\theta} > 0, \frac{\partial \Delta q_{H4}}{\partial \beta_H} = \frac{1-\lambda}{1-\theta} > 0,\\
&\frac{\partial \Delta q_{L5}}{\partial \beta_L} = 0, \frac{\partial \Delta q_{L5}}{\partial \beta_H} = 0, \frac{\partial \Delta q_{H5}}{\partial \beta_L} = 0, \frac{\partial \Delta q_{H5}}{\partial \beta_H} = 0,\\
&\frac{\partial \Delta q_{L6}}{\partial \beta_L} = 0, \frac{\partial \Delta q_{L6}}{\partial \beta_H} = 0, \frac{\partial \Delta q_{H6}}{\partial \beta_L} = \frac{\lambda}{1-\theta} > 0, \frac{\partial \Delta q_{H6}}{\partial \beta_H} = \frac{1-\lambda}{1-\theta} > 0,\\
&\frac{\partial \Delta q_{L7}}{\partial \beta_L} = 0, \frac{\partial \Delta q_{L7}}{\partial \beta_H} = 0, \frac{\partial \Delta q_{H7}}{\partial \beta_L} = 0, \frac{\partial \Delta q_{H7}}{\partial \beta_H} = 0,\\
&\frac{\partial \Delta q_{L8}}{\partial \beta_L} = 0, \frac{\partial \Delta q_{L8}}{\partial \beta_H} = \frac{\lambda(1-\lambda)}{1-\theta} > 0, \frac{\partial \Delta q_{H8}}{\partial \beta_L} = 0, \frac{\partial \Delta q_{H8}}{\partial \beta_H} = \frac{(1-\lambda)^2}{1-\theta} > 0.
\end{aligned}
\tag{A.26}
$$

□

Proof of Corollary 1. The subsequent tables depict the distortion of product quality concerning levels of conformity and exclusivity. From these tables, the following insights can be obtained: (1) When the level of exclusivity is low (i.e., $\beta_H \leq \frac{(1-\theta)^2}{1-\lambda}$), there are five optimal offerings: Cases 1, 3, 5, 6, 7. Among these cases, low levels of conformity result in a downward distortion of the quality of low-end items (i.e., Cases 1, 3), while high conformity levels lead to an upward distortion in the quality of high-end products (i.e., Cases 6, 7). Otherwise, product quality remains unchanged (i.e., Case 5). (2) When the level of exclusivity is high (i.e., $\beta_H \geq \max\{\beta_{H1}, \beta_{H5}\}$), there exists the remaining three optimal offerings: Cases 2, 4, 8. In these instances, the quality of high-end products is distorted upward, and that of low-end products is distorted downward. (3) When the level of exclusivity is moderate (i.e.,

$\frac{(1-\theta)^2}{1-\lambda} < \beta_H < \max\{\beta_{H1}, \beta_{H5}\}$), the optimal offerings and quality distortions represent a mixture of the aforementioned cases: (Cases 1, 3, 4, 6, 7 when $\frac{(1-\theta)^2}{1-\lambda} < \beta_H \le \min\{\beta_{H1}, \beta_{H5}\}$), (Cases 2, 4, 6, 7 when $\beta_{H1} < \beta_H < \beta_{H5}$), (Cases 1, 3, 4, 8 when $\beta_{H5} < \beta_H < \beta_{H1}$).

Table A.1: Distortion of quality when β_H is small or large

β_H	$\beta_H \le \frac{(1-\theta)^2}{1-\lambda}$			$\beta_H \ge \max\{\beta_{H1}, \beta_{H5}\}$
β_L	$\beta_L \le \beta_{L2}$	$\beta_{L2} < \beta_L < \beta_{L3}$	$\beta_L \ge \beta_{L3}$	$0 < \beta_L < 1$
q_H	$-$	$-$	$\uparrow$	$\uparrow$
q_L	$\downarrow$	$-$	$-$	$\downarrow$

Note: "$\uparrow$" Upward distortion; "$\downarrow$" Downward distortion; "$-$" No distortion.

Table A.2: Distortion of quality when β_H is moderate

β_H	$\frac{(1-\theta)^2}{1-\lambda} < \beta_H \le \min\{\beta_{H1}, \beta_{H5}\}$			$\min\{\beta_{H1}, \beta_{H5}\} < \beta_H < \max\{\beta_{H1}, \beta_{H5}\}$			
β_L	$\beta_L \le \beta_{L5}$	$\beta_{L5} < \beta_L < \beta_{L2}$	$\beta_L \ge \beta_{L2}$	$\beta_L \le \beta_{L2}$	$\beta_L > \beta_{L2}$	$\beta_L \le \beta_{L5}$	$\beta_L > \beta_{L5}$
q_H	$-$	$\uparrow$	$\uparrow$	$\uparrow$	$\uparrow$	$-$	$\uparrow$
q_L	$\downarrow$	$\downarrow$	$-$	$\downarrow$	$-$	$\downarrow$	$\downarrow$

Note: $\beta_{L5} \triangleq \frac{1-\theta-(1-\lambda)\beta_H}{\lambda}$.

□

Proof of Corollary 2. The equilibrium outcome observed in Case 5 aligns consistently with the outcome established under complete information as demonstrated in Lemma 1. □

Proof of Proposition 2. Compared to the first-best outcome outlined in Lemma 1, we compute the price deviation in 8 cases, where the price distortion of the high-end product is denoted by $\Delta p_{Hk} \triangleq p_{Hk} - p_H^*$, and the price distortion of the low-end product is denoted by $\Delta p_{Lk} \triangleq p_{Lk} - p_L^*$.

$$
\begin{aligned}
&\Delta p_{H1} = \beta_L\lambda - \frac{(1-\theta)(\theta-\lambda)}{1-\lambda} < 0, \Delta p_{L1} = -\frac{\lambda\theta(1-\theta)}{1-\lambda} < 0, \Delta p_{H2} = \theta^2 + \frac{\beta_H(1-\lambda)(1-\theta\lambda)}{1-\theta} + \beta_L\lambda - 1 > 0,\\
&\Delta p_{L2} = -\frac{\beta_H\theta\lambda(1-\lambda)}{1-\theta} < 0, \Delta p_{H3} = 0, \Delta p_{L3} = -\theta\left(\theta - \frac{\beta_L\lambda}{1-\theta}\right) < 0, \Delta p_{H4} = \frac{\beta_L\lambda + \beta_H(1-\lambda) - (1-\theta)}{1-\theta} > 0,\\
&\Delta p_{L4} = -\theta(\theta - \frac{\beta_L\lambda}{1-\theta}) < 0, \Delta p_{H5} = 0, \Delta p_{L5} = 0, \Delta p_{H6} = \frac{\beta_L\lambda + \beta_H(1-\lambda) - (1-\theta)}{1-\theta} > 0, \Delta p_{L6} = 0,\\
&\Delta p_{H7} = \frac{(1-\theta)(1-\lambda)}{\lambda} > 0, \Delta p_{L7} = \frac{(1-\theta)(1-\theta(1-\lambda))}{\lambda} - \beta_H(1-\lambda) - \beta_L\lambda < 0,\\
&\Delta p_{H8} = \frac{\beta_H(1-\lambda)^2}{1-\theta} > 0, \Delta p_{L8} = 1-\theta^2 - \frac{\beta_H\lambda(1-\lambda)}{1-\theta} - \beta_L\lambda < 0.
\end{aligned}
\tag{A.27}
$$

□

Proof of Lemma 3. By substituting the equilibrium quality and price into the firm's profit, we can obtain the equilibrium profit as shown in Table 3. □

Proof of Proposition 3. By taking the partial derivatives of the profit of the firm with respect to θ, we can get

$$\begin{aligned}
&\frac{\partial \pi_1}{\partial \theta} = \frac{\theta-\lambda}{1-\lambda} > 0, \frac{\partial \pi_3}{\partial \theta} = \frac{\beta_L\lambda(1-\lambda)(1-\theta-\beta_L\lambda)}{(1-\theta)^3} > 0, \frac{\partial \pi_5}{\partial \theta} = \theta(1-\lambda) > 0,\\
&\frac{\partial \pi_2}{\partial \theta} = \theta - \frac{\lambda\beta_H^2(1-\lambda)^3}{(1-\theta)^3} \begin{cases} > 0, & \theta < \theta_1 \\ < 0, & \theta > \theta_1 \end{cases},\\
&\frac{\partial \pi_4}{\partial \theta} = \frac{\lambda\left(\beta_H(1-\lambda)\left(1-\theta-2\beta_L\lambda\right)+\beta_L\left(1-\theta-\beta_L\lambda\right)-\beta_H^2(1-\lambda)^2\right)}{(1-\theta)^3} \begin{cases} >0, & \text{if } \theta<\theta_2 \\ <0, & \text{if } \theta>\theta_2 \end{cases}, \qquad \text{(A.28)}\\
&\frac{\partial \pi_6}{\partial \theta} = \theta(1-\lambda) + \frac{\lambda\left(\beta_L\lambda+\beta_H(1-\lambda)\right)\left(1-\theta-\beta_H(1-\lambda)-\beta_L\lambda\right)}{(1-\theta)^3} \begin{cases} >0, & \text{if } \theta<\theta_3 \\ <0, & \text{if } \theta>\theta_3 \end{cases},\\
&\frac{\partial \pi_7}{\partial \theta} = -\frac{(1-\theta)(1-\lambda)}{\lambda} < 0, \frac{\partial \pi_8}{\partial \theta} = -\frac{\lambda\beta_H^2(1-\lambda)^3}{(1-\theta)^3} < 0.
\end{aligned}$$

Where $\theta_1 \triangleq \mathrm{Root}[\theta^4-3\theta^3+3\theta^2-\theta+\lambda\beta_H^2(1-\lambda)^3, 2]$, $\theta_2 \triangleq \frac{\beta_H^2(1-\lambda)^2-\beta_H(1-\lambda)(1-2\beta_L\lambda)-\beta_L(1-\lambda\beta_L)}{-\beta_H(1-\lambda)-\beta_L}$, $\theta_3 \triangleq \mathrm{Root}[(1-\lambda)(-\theta^4+3\theta^3-3\theta^2)+\theta\left(1-\beta_H\lambda(1-\lambda)-\beta_L\lambda^2\right)+\lambda\left(\beta_H(1-\lambda)+\beta_L\lambda\right)\left(1-\beta_H(1-\lambda)-\beta_L\lambda\right), 2]$.[9]

Therefore, $\hat{\theta} = \begin{cases} \theta_1, & \text{if } \beta_L \leq \beta_{L1},\ \beta_{H1}<\beta_H<\beta_{H2},\ \text{i.e., Case 2;} \\ \theta_2, & \text{if } \beta_L<\beta_{L2},\ \max\{\beta_{H2},\beta_{H3}\}\leq\beta_H\leq\beta_{H6},\ \text{i.e., Case 4;} \\ \theta_3, & \text{if } \beta_{L2}<\beta_L<\beta_{L4},\ \beta_{H3}<\beta_H<\beta_{H4},\ \text{i.e., Case 6.} \end{cases}$

□

Proof of Proposition 4. In equilibrium, the surplus for high-type consumers can be expressed as $cs_{Hk} = \lambda(q_{Hk} - p_{Hk} - \beta_H(1-\lambda))$, the surplus for low-type consumers is represented by $cs_{Lk} = (1-\lambda)(\theta q_{Lk} - p_{Lk} + \beta_L\lambda)$. By computing the total surplus $cs_k = cs_{Hk} + cs_{Lk}$, we derive the following outcomes:

$$\begin{aligned}
&cs_1 = \frac{\lambda(1-\theta)(\theta-\lambda)}{1-\lambda} - \beta_L\lambda^2, cs_2 = \lambda\theta(1-\theta) + \lambda^2(\beta_L - \beta_H(1-\lambda)), cs_{3\sim6} = 0,\\
&cs_7 = (1-\lambda)(\beta_L\lambda+\beta_H(1-\lambda)) - \frac{(1-\theta)(1-\lambda)(1-\theta(1-\lambda))}{\lambda}, \qquad \text{(A.29)}\\
&cs_8 = \lambda(1-\lambda)(\beta_L + \beta_H(1-\lambda)) - (1-\theta)(1-\lambda).
\end{aligned}$$

Given that $sw_k = \pi_k + cs_k$, we can obtain the social welfare as detailed in Table 4.

□

Proof of Proposition 5. By taking the partial derivatives of consumer surplus cs_k with

[9] $\mathrm{Root}[f, k]$ represents the exact k^{th} root of the polynomial equation $f[x] = 0$.

respect to β_H, β_L, we can get

$$
\begin{aligned}
&\frac{\partial cs_1}{\partial \beta_H} = 0, \frac{\partial cs_1}{\partial \beta_L} = -\lambda^2 < 0, \frac{\partial cs_2}{\partial \beta_H} = -(1-\lambda)\lambda^2 < 0, \frac{\partial cs_2}{\partial \beta_L} = -\lambda^2 < 0, \\
&\frac{\partial cs_3}{\partial \beta_H} = 0, \frac{\partial cs_3}{\partial \beta_L} = 0, \frac{\partial cs_4}{\partial \beta_H} = 0, \frac{\partial cs_4}{\partial \beta_L} = 0, \frac{\partial cs_5}{\partial \beta_H} = 0, \frac{\partial cs_5}{\partial \beta_L} = 0, \frac{\partial cs_6}{\partial \beta_H} = 0, \frac{\partial cs_6}{\partial \beta_L} = 0, \\
&\frac{\partial cs_7}{\partial \beta_H} = (1-\lambda)^2 > 0, \frac{\partial cs_7}{\partial \beta_L} = \lambda(1-\lambda)^2 > 0, \frac{\partial cs_8}{\partial \beta_H} = \lambda(1-\lambda) > 0, \frac{\partial cs_8}{\partial \beta_L} = \lambda(1-\lambda) > 0.
\end{aligned}
\tag{A.30}
$$

□

Proof of Corollary 3. By taking the partial derivatives of consumer surplus cs_k with respect to θ, we have

$$
\begin{aligned}
&\frac{\partial cs_1}{\partial \theta} = \frac{\lambda(1+\lambda-2\theta)}{1-\lambda} \begin{cases} > 0, & \text{if } \theta < \frac{1+\lambda}{2}, \\ < 0, & \text{if } \theta > \frac{1+\lambda}{2}. \end{cases}, \frac{\partial cs_2}{\partial \theta} = \lambda(1-2\theta) \begin{cases} > 0, & \text{if } \theta < \frac{1}{2}, \\ < 0, & \text{if } \theta > \frac{1}{2}. \end{cases}, \\
&\frac{\partial cs_7}{\partial \theta} = \frac{(1-\lambda)(2-\lambda-2\theta(1-\lambda))}{\lambda} > 0, \frac{\partial cs_8}{\partial \theta} = 1-\lambda > 0.
\end{aligned}
\tag{A.31}
$$

□

Proof of Corollary 4. By taking the partial derivatives of consumer surplus sw_k with respect to β_H, β_L, we obtain

$$
\begin{aligned}
&\frac{\partial sw_1}{\partial \beta_H} = -\lambda(1-\lambda) < 0, \frac{\partial sw_1}{\partial \beta_L} = \lambda(1-\lambda) > 0, \frac{\partial sw_2}{\partial \beta_H} = -\lambda(1-\lambda)(\lambda + \frac{(1-\lambda)^2\beta_H}{(1-\theta)^2}) < 0, \frac{\partial sw_2}{\partial \beta_L} = \lambda(1-\lambda) > 0, \\
&\frac{\partial sw_3}{\partial \beta_H} = -\lambda(1-\lambda) < 0, \frac{\partial sw_3}{\partial \beta_L} = \frac{\lambda(1-\lambda)\,(1-\theta-\beta_L\lambda)}{(1-\theta)^2} > 0, \frac{\partial sw_4}{\partial \beta_H} = -\frac{\lambda(1-\lambda)\,(\beta_H(1-\lambda)+\beta_L\lambda-\theta(1-\theta))}{(1-\theta)^2} < 0, \\
&\frac{\partial sw_4}{\partial \beta_L} = \frac{\lambda\,(1-\theta-\beta_H\lambda(1-\lambda)-\beta_L\lambda)}{(1-\theta)^2} > 0, \frac{\partial sw_5}{\partial \beta_H} = -\lambda(1-\lambda) < 0, \frac{\partial sw_5}{\partial \beta_L} = \lambda(1-\lambda) > 0, \\
&\frac{\partial sw_6}{\partial \beta_H} = -\frac{\lambda(1-\lambda)\,(\beta_H(1-\lambda)+\beta_L\lambda-\theta(1-\theta))}{(1-\theta)^2} < 0, \frac{\partial sw_6}{\partial \beta_L} = \frac{\lambda\left((1-\theta)(1-\theta(1-\lambda))-\beta_H\lambda(1-\lambda)-\beta_L\lambda^2\right)}{(1-\theta)^2} > 0, \\
&\frac{\partial sw_7}{\partial \beta_H} = -\lambda(1-\lambda) < 0, \frac{\partial sw_7}{\partial \beta_L} = \lambda(1-\lambda) > 0, \frac{\partial sw_8}{\partial \beta_H} = -\lambda(1-\lambda)(\lambda + \frac{(1-\lambda)^2\beta_H}{(1-\theta)^2}) < 0, \frac{\partial sw_8}{\partial \beta_L} = \lambda(1-\lambda) > 0.
\end{aligned}
\tag{A.32}
$$

□

Proof of Corollary 5. Compared to the first-best outcome under complete information, we can prove that $\pi_5 = \pi^*$, $sw_5 = sw^*$, $\pi_{1,2,3,4,6,7,8} < \pi^*$, and $sw_{1,2,3,4,6,7,8} < sw^*$. □

Proof of Proposition 6. Through a comparative analysis of a firm's profit derived from producing a single product π_{H0}, with the optimal profits resulting from producing two different products $\pi_i, i \in \{1, 8\}$, we establish that $\pi_{H0} < \pi_i$ when $\beta_H < \hat{\beta}_H$. Conversely, when $\beta_H > \hat{\beta}_H$, $\pi_{H0} > \pi_i$. The specific value of $\hat{\beta}_H$ is detailed in the following table.

Table A.3: The specific value of $\hat{\beta}_H$

Case	$\hat{\beta}_H$
1	$\frac{(\theta-\lambda)^2+2\beta_L\lambda(1-\lambda)}{2\lambda(1-\lambda)^2}$
2	$\frac{(1-\theta)\sqrt{\lambda(1-\lambda)(\theta^2-\lambda+2\beta_L\lambda)}}{\lambda(1-\lambda)^2}$
3	$\frac{\beta_L(2-2\theta-\beta_L\lambda)}{2(1-\theta)^2}$
4	$\frac{\theta(1-\theta)-\lambda\beta_L+\sqrt{2\beta_L(1-\theta)(1-\theta\lambda)-\lambda(1-\lambda)\beta_L^2-((1-\theta^2)(1-\theta)^2)}}{1-\lambda}$
5	$\frac{1-\theta-\beta_L\lambda}{1-\lambda}$
6	$\frac{\lambda\theta(1-\theta)+(1-\theta)\sqrt{\lambda(\theta^2-\lambda+2\beta_L\lambda)}-\beta_L\lambda^2}{\lambda(1-\lambda)}$
7	$\frac{\lambda+(1-\theta)^2}{2\lambda}$
8	$\frac{(1-\theta)\sqrt{\lambda(1-\lambda(1-\lambda+\theta(2-\theta)))}-\lambda(1-\theta)^2}{\lambda(1-\lambda)^2}$

□

Proof of Corollary 6. By taking the partial derivatives of product quality with respect to β_H and β_L in both single-product and dual-product scenarios, we get the effects of social comparison on product's quality, as shown in Table 5. □