Price Discrimination Under Asymmetric Access to Consumer Data*

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January 2026

Abstract

A platform-affiliated retailer competes in prices with third-party sellers over two periods. After the first period, the affiliate has access to market-wide purchase data and an informational advantage. Third-party sellers either do not obtain data (exclusive data use) or obtain only data on their own past customers (shared data use). Data access enables price discrimination by consideration in the second period. With exclusive data use, price discrimination benefits all retailers compared to uniform pricing. The affiliate benefits more than third-party sellers. However, third-party sellers' lack of data limits the extent to which the affiliate can use its superior information. With shared data use, all retailers benefit equally from price discrimination compared to uniform pricing. Mandatory sharing of past customer data does not harm the affiliate, although it reduces its informational advantage, and benefits third-party sellers. However, while leveling the playing field on the supply side, it harms consumers.

Keywords: consumer data, consideration sets, price discrimination, asymmetric data access, price competition, retail platforms

JEL classification: L11; L13; D43; D82; D83

*Support from the Leverhulme Trust (Research Fellowship RF-2022-078) is gratefully acknowledged. This paper was previously circulated as 'Hybrid Price Discrimination on a Vertically Integrated Platform'. I thank the audiences at Loughborough, IIOC (Boston), NIE (WBS), 'Theory and Policy in the Digital Economy' Workshop (Durham), 'BETEcon' Workshop (St Andrews), Oligo Workshop (Cambridge), EARIE (Valencia), NUBS, Tinbergen Institute 'Platform Economics' Workshop (Amsterdam), and LIEN (Paris) for valuable feedback. Any errors are my own.

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1 Introduction

Price discrimination is a prevalent practice that has been enabled and shaped by the increased availability of consumer data, particularly in online retail markets.[1] Consumer information has implications for retailers' discriminatory pricing strategies, competition, and market outcomes. Detailed data on consumers' preferences or consideration sets allows retailers to better target their prices - for instance, by offering discounts to specific customer groups - and use refined forms of price discrimination.[2]

Some digital platforms not only operate marketplaces, but also participate in them, through affiliated retailers, alongside third-party competitors (e.g., Amazon, Apple, Google). A platform-affiliated retailer has an informational advantage over third-party sellers, as the platform controls the extent to which it shares consumer data with independent firms. Asymmetric access to information may support price discrimination regimes where the affiliate has either exclusive (or better) access to data and can price discriminate (more granularly), while third-party sellers use uniform prices (or discriminate only coarsely).

Starting from these observations, this paper studies the role of asymmetric access to information when firms price discriminate depending on consumers' consideration sets, exploring the following questions. What is the impact of price discrimination by consideration on market outcomes in this context? How does exclusive data use compare to shared data use, and what is the impact of different data access arrangements on price discrimination and outcomes? Does the affiliate have incentives to share data? Do third-party sellers benefit from data sharing? What are the implications of asymmetric access to data compared to symmetric access to data arrangements? What is the impact of mandatory data sharing regulation or of fair use of data requirements or commitments?

Some of these questions are motivated by recent regulatory and policy developments. EU's Digital Market Act requires digital platforms designated as 'gatekeepers' to provide business users with effective and free access to data generated on their platforms. As part of its investigation of Amazon's UK Marketplace, the Competition and Markets Authority has accepted the platform's commitment not to use third-party sellers' data 'to gain unfair advantage over other sellers'.[3]

This analysis models a homogeneous product market with probabilistic consideration to examine the role of asymmetric access to consumer data for consideration-based price discrimination. A platform affiliate competes in prices with two third-party sellers over two periods. Probabilistic consideration underpins heterogeneity in consumers' consideration sets. Consumers' first-period

[1] For a discussion of the role of fine-tuned consumer information for price discrimination, see Armstrong (2006).

[2] The reports by the AEMC (2018), the OECD (2018), and *Which?* (2018) provide evidence and related discussion. In digital retail, targeted discounts often lack transparency.

[3] See Art. 6(10) of the DMA 2022/1925 (`https://bit.ly/3RsgDVV`) and CMA's commitments decision in 2023 (`https://bit.ly/3QGjcST`). In 2024, the British Independent Retailers Association (BIRA) sued Amazon over alleged misuse of UK retailers' data on its marketplace. In the £1bn collective action, BIRA alleged that access to retailers' data allowed Amazon, among others, to decide how to price and what customers to target (`http://bit.ly/45vRP5r`). Following a carriage dispute, the Competition Appeal Tribunal decided in 2025 that the collective action would continue under a different representative and with £2.5bn claimed damages.

choices reveal information on their consideration sets. This information enables, in the second period, price discrimination between customer groups that differ in their degree of contestability.

In the first period, retailers compete in uniform prices and consumers purchase the cheapest product in their consideration set. The platform collects market-wide data on consumers' first period choices and shares it with its subsidiary. Depending on the regime, the platform can retain exclusive use of consumer data, in which case it does not share any information with third-party sellers, or it may share with them only information on their own past customers.[4] In either case, the subsidiary has an informational advantage over its rivals, which underpins 'hybrid' forms of price discrimination.

Under hybrid price discrimination with exclusive data use, in the second period, third-party sellers choose uniform prices while the platform subsidiary could discriminate depending on a customer's past supplier (i.e., granularly). Under hybrid price discrimination with shared data use, third-party sellers can discriminate between new and past customers (i.e., coarsely), while the platform can discriminate granularly. The latter regime could be regarded as the result of mandatory data-sharing regulation.

The analysis characterizes subgame perfect equilibria in these price discrimination regimes, using backward induction, when identical third-party sellers use symmetric pricing strategies. Given the frictions between extracting surplus from captive consumers and competing for contested consumers, in equilibrium, retailers use mixed pricing strategies (so that there is price dispersion) in both periods and make positive expected profits.

Hybrid discrimination regimes are compared to different benchmarks where retailers have symmetric access to consumer data.[5] If data is not collected or used, or there is a ban on price discrimination, all retailers choose uniform prices in both periods. Under 'coarse discrimination', the platform shares only past customer data with all retailers (including its subsidiary) and they can discriminate between new and past customers. Under 'granular discrimination', the platform shares market-wide data with all retailers, so they can all discriminate depending on a customer's past supplier.

Regardless of whether information is used exclusively or shared, hybrid price discrimination benefits all retailers and harms consumers, compared to uniform pricing. With exclusive data use, third-party sellers' lack of information limits the subsidiary's ability to make use of its informational advantage. The subsidiary has incentives to share own customer data with third-party sellers. This levels the playing field on the supply side in terms of payoffs, but comes at the expense of consumers: compared to exclusive data use, it makes all retailers better off (not only the subsidiary).

Consider hybrid price discrimination with exclusive data use. Compared to uniform pricing,

[4]In a survey on British retailers' experience of digital marketplaces, 51% of the respondents identified the use of available sales data as one of the main services provided by platforms. See BEIS (2021).

[5]Here (a)symmetry refers to the information *structure* rather than to information content. Even when the structure is symmetric (e.g., if all retailers have access only to their own customer data), the content may be different. In price discrimination regimes with symmetric information, firms' strategies are symmetric in period one but not in period two where they depend on the ranking of period one prices, which determines the extent to which firms can make use of data.

the subsidiary obtains larger incremental profit than third-party sellers. The subsidiary makes the same expected profit as under coarse discrimination (where all retailers have access only to past customer data). This is because, in the second period equilibrium, the subsidiary only uses data on its own past customers (and discriminates coarsely, not granularly), so the subsidiary's access to more refined data is inconsequential.

Consider hybrid price discrimination with shared data use. All retailers obtain the same expected profits as in a granular discrimination regime (where all retailers have access to market-wide data). When the subsidiary has access to market-wide data, sharing market-wide data or sharing only their own past customer data with third-party sellers are outcome-equivalent. This is noteworthy as hybrid (like coarse) discrimination does not require information to be shared among rivals and therefore is less likely to raise competition concerns.

These comparisons indicate that, in this setting, mandatory data sharing that gives third-party sellers access to past customer data, without restricting subsidiary's access, does not harm the platform affiliate and benefits third-party sellers. Fair use of data arrangements that lead to symmetric information access do not harm the subsidiary or third-party sellers and may benefit the industry. However, an increase in expected industry profit is associated with lower expected consumer surplus.

The remainder of this section reviews related literature. Next section introduces the model. Section 3 analyzes hybrid price discrimination with exclusive data use and provides a comparison to uniform pricing, while Section 4 analyzes hybrid price discrimination with shared data use and provides comparisons to exclusive data and uniform pricing. Section 5 compares hybrid price discrimination regimes, rooted in asymmetric access to data, to symmetric price discrimination regimes, and provides a summary. Final conclusions are presented in Section 6. Proofs missing from the text are relegated to the Appendix.

1.1 Related Literature

This work contributes to the analysis of price discrimination in competitive markets - see Armstrong (2006) and Stole (2007) for comprehensive reviews. It examines a homogeneous product oligopoly with probabilistic consideration where past purchase data enables consideration-based price discrimination. It is related to studies of price discrimination in oligopoly, e.g., to the single-stage models in Thisse and Vives (1988) and Corts (1998), and the dynamic models of discrimination by purchase history in Caminal and Matutes (1990), Chen (1997), Villas-Boas (1999), and Fudenberg and Tirole (2000).

The model used here adapts the probabilistic consideration framework in Butters (1977), Ireland (1993), and McAfee (1994).[6] Armstrong and Vickers (2022) explore the role of consideration set heterogeneity in a static oligopoly market where sellers compete in uniform prices. They identify a pattern of consideration (symmetric interactions) that generalizes existing results, study

[6]See also Varian (1980), Burdett and Judd (1983), and Narasimhan (1988).

asymmetric interaction patterns, including an oligopoly model with 'nested reach', and provide a complete equilibrium characterization in triopoly.

Armstrong and Vickers (2019) analyze price discrimination between captive and contested consumers in a homogeneous product duopoly. Consumers are better off (worse off) under uniform pricing than under price discrimination if sellers are symmetric (sufficiently asymmetric). The consumer surplus is a concave function of profit and a trade-off between an increase in aggregate profit and greater profit variance across consumer groups underpins their results.

Albrecht (2020) examines consumer optimal information structures in a duopoly where firms receive signals on a consumer's type, which is a pair of binary valuations for firms' products. When signals are public, access to complete data supports perfect price discrimination and maximizes consumer surplus. When signals are private, giving one firm exclusive access to complete data supports unilateral perfect price discrimination and may harm consumers.

Using a static oligopoly model with nested reach where a firm's product matches a consumer's preferences with an exogenous probability, Chioveanu (2025) examines price discrimination by consideration. Firms face pricing trade-offs due to heterogeneity in consumers' consideration sets. Price discrimination alleviates these trade-offs, but it intensifies competition. In sufficiently asymmetric markets with nested reach, price discrimination harms firms and benefits consumers.

This paper uses a dynamic model of price competition with probabilistic consideration, where the ranking of first-period prices affects a firm's ability to price discriminate in the second period; see also De Nijs (2017) and Chioveanu (2024). A distinctive feature of this model is that one firm, a platform subsidiary, has an informational advantage over third-party sellers, as the platform controls the extent to which it shares data with these firms. Firms' second-period pricing strategies are shaped both by the ranking of first-period prices and by the data-sharing regime. This analysis's contribution is to examine the role of ex-ante asymmetric information structures that support hybrid price discrimination in a dynamic setting.

More broadly, this work is related to the growing literature on the economics of personal data; for reviews, see Acquisti et al. (2016) and Bergemann and Bonatti (2019). It complements work on 'personalized pricing' where consumer data provides information on preferences (rather than consideration sets); see, for instance, Choe et al. (2018), Belleflamme et al. (2020), Anderson et al. (2023), Jullien et al. (2023), Rhodes and Zhou (2024), and Choe et al. (2024).[7]

2 Model

A platform-affiliated retailer and two identical third-party sellers supply a homogeneous product and compete in prices over two periods. There is a unit mass of consumers who buy at most one unit of the product in each period and have a common valuation $v = 1$. Retailers have a constant marginal cost $c = 0$ and in each period choose prices simultaneously and independently.

[7]For examples and a discussion of policy concerns, see OECD (2018). For a discussion of legal and regulatory frameworks, see Voss (2025). While personalized pricing is a form of first-degree price discrimination, consideration-based price discrimination is a form of third-degree price discrimination.

Consumers consider any given retailer with probability $\alpha \in (0,1)$.[8] In each period, they choose the cheapest product they consider. Due to probabilistic consideration, the model accommodates the full range of consideration sets. A consumer considers exactly $k \in \{1,2,3\}$ firms with probability $\alpha^k(1-\alpha)^{3-k}$, which is unique up to the identity of the firms (there are $C(3,k)$ such combinations); see Figure 1 for an illustration. Consumers' consideration sets are stable over the two periods.

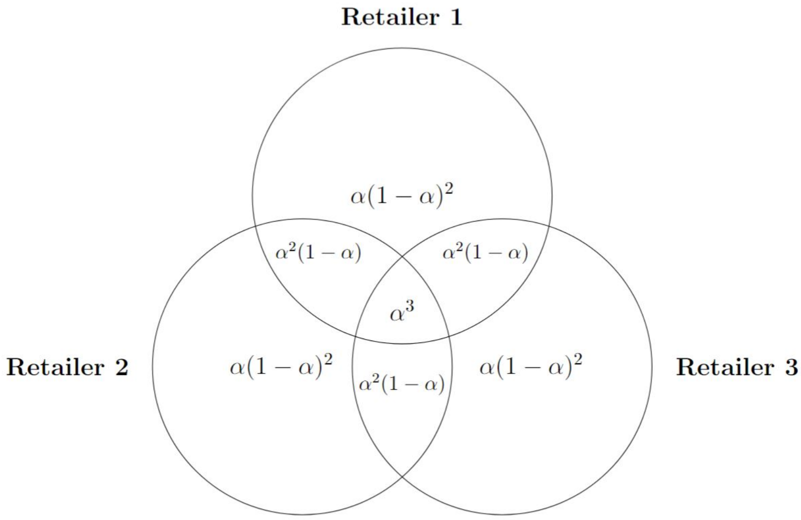

Figure 1: Consumers' Consideration Sets.

Each retailer has $\alpha(1-\alpha)^2$ captive consumers and could charge them the monopoly price ($p = 1$). Each retailer also has contestable consumers and competes à la Bertrand for them. The tension between the incentive to extract all surplus from captives and the incentive to compete for contestable consumers rules out the existence of pure strategy price equilibria in either period. This analysis characterizes mixed strategy equilibria.

In the first period, retailers compete in uniform prices. After the first period, the platform collects information on consumers' choices, shares market-wide data with its subsidiary, and it may or may not share information on their past customers with third-party sellers. The subsidiary always has an informational advantage, as it has exclusive or better access to consumer data. In the second period, (asymmetric) access to consumer data enables 'hybrid' price discrimination. As the subsidiary has access to market-wide data, it can discriminate granularly, based on a customer's past supplier.

Two hybrid price discrimination regimes are analyzed. Under hybrid price discrimination with exclusive data use, third-party sellers do not have access to data and use uniform prices in both periods. Under hybrid price discrimination with shared data use, third-party sellers have access to data on their own past customers and may be able to discriminate between past customers and new customers in the second period. Analyzing an oligopoly with at least three firms is essential for distinguishing between coarse and granular discrimination - and, by extension, between the

[8]Consideration symmetry may be due to a ban on self-preferencing on a dominant digital platform. Article 6(5) of EU's DMA prohibits 'gatekeepers' from treating their own products more favorably than third-party products.

two hybrid discrimination regimes considered here - and offers novel insights.[9]

Consumers do not explicitly take into account retailers' use of past purchase data. However, their behavior - that is, purchasing from the cheapest firm in their consideration set in the first period - is consistent with surplus-maximization, given sellers' second period pricing. If a consumer chose instead a relatively more expensive retailer from her consideration set in the first period, this would signal that the consumer is less contestable. As sellers compete less aggressively for relatively less contestable consumers, the consumer would end up paying a higher price in the first period and paying no less (and possibly more) in the second period.[10]

As third-party sellers are ex-ante identical, in the first period they choose prices according to a symmetric cumulative distribution function (hereafter, c.d.f.). An implication of this is that third-party sellers' c.d.f. must be atomless. If the c.d.f. had an atom, then there would be a positive probability of a tie and any third-party seller would have a unilateral incentive to deviate to a slightly lower price, as this would lead to a jump up in demand and so would be profitable.[11] As third-party sellers' symmetric c.d.f.s are atomless, there is a strict ranking of retailers' realized prices in the first period:

$$p_1 < p_2 < p_3 \ .$$

The notation refers to this ranking: in period one retailer 1 (R_1) is the cheapest, retailer 2 (R_2) is the second cheapest, and retailer 3 (R_3) is the most expensive.

First period. R_1 serves all the consumers who consider it, a group of measure α. R_2 serves the consumers who consider it but do not consider R_1, a group of measure $\alpha(1-\alpha)$. The consumers who consider both R_2 and R_1 buy from R_1 as it is cheaper. R_3 serves only its $\alpha(1-\alpha)^2$ captives: consumers who consider it but do not consider any of the rivals. The consumers who consider R_3 and at least one of its rivals prefer the rival as it is cheaper. For an illustration, see Figure 2.

Second period. Even if it has access to consumer data, R_1 cannot distinguish between its customer groups depending on what other retailers they consider. So, R_1 sets only one price, regardless of the pricing regime. R_2 can infer that its new customers bought from R_1 in the first period, so this is a group of measure α^2. This is because the consumers who bought from R_3 in the first period do not consider R_2. If it has access to past customer data, R_2 can price discriminate between its new and its past customers. R_3 can infer that its past customers are captive. If it has access to past customer data, R_3 can price discriminate and charge its past customers the monopoly price. Its new customers purchased either from R_1 or from R_2 in the first period. With

[9]In a duopoly market, access to market-wide data is equivalent to access to own past customer data, and a firm can at most discriminate coarsely.

[10]For further discussion, see Section 3. While in this model consumer 'myopia' is consistent with surplus maximization, in practice consumers may not consider the implications of their first period choices because they do not understand to what extent or how data is used. Moreover, in equilibrium, the complexity of firms' mixed strategies may hinder their ability to anticipate future prices.

[11]The probability of a tie should be zero in any equilibrium. In a symmetric model with independent reach (like the first period here), any pair of firms competes for some consumers that consider only this pair and if the firms tie, regardless of the tie break rule, there would be a unilateral incentive to deviate.

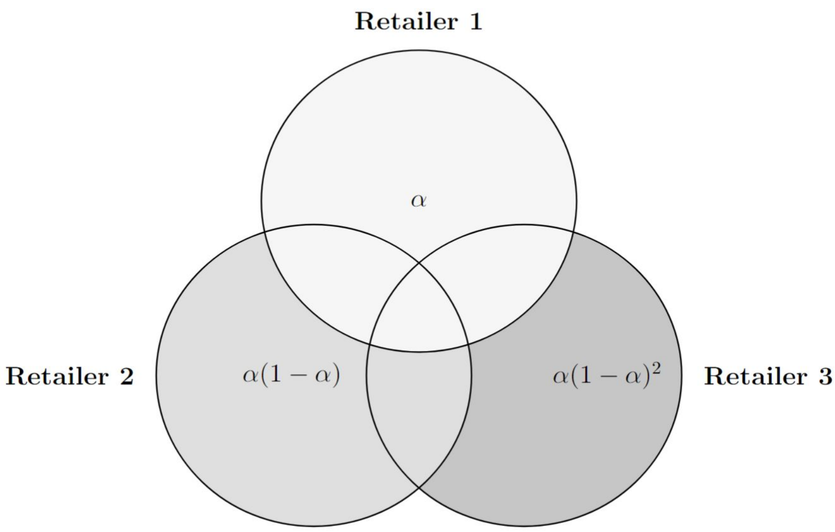

Figure 2: Consumers' First Period Choices.

access to past customer data only, R_3 charges all its new customers the same price. With access to market-wide data, R_3 can also discriminate between new customers by their past supplier.

3 Hybrid Price Discrimination: Exclusive Data Use

Suppose that in the second period only the affiliated retailer has access to consumer data. The informational asymmetry between this retailer and third-party sellers has implications for retailers' pricing in both periods. In the first period, the subsidiary (denoted by S), anticipating its informational advantage, chooses its price according to a c.d.f. $F^S(p)$. The two (identical) third-party sellers draw their prices according to a (symmetric and atomless) c.d.f. $F^T(p)$.

3.1 Second Period Analysis

Given the ranking of retailers' first period prices ($p_1 < p_2 < p_3$), there are three scenarios (unique up to the identity of third-party sellers). The expected profit of S is identified by adding a subscript to the ranking of its first period price.

Notation. $0 < p_L \equiv (1-\alpha)^2 < p_M \equiv (1-\alpha) < 1$

(a) If S offers the lowest price in the first period, it sells to all customers who consider it and cannot refine its pricing strategy in the second period. As first period information is not used, retailers compete in uniform prices in the second period. Ireland (1993) and McAfee (1994) characterize mixed strategy price equilibrium and Armstrong and Vickers (2022) prove uniqueness.[12]

Retailers draw their prices from a symmetric price distribution $F^{UP}(p)$. This c.d.f. must be atomless on its support. Otherwise, there is a positive probability of a tie at the price where there

[12] Ireland (1993) and McAfee (1994) analyze asymmetric models of price competition, but their results apply to the symmetric stage game examined here. See also Stahl II (1994) for a symmetric model. Armstrong and Vickers (2022) characterize unique price equilibrium under 'symmetric interactions', which subsumes this setting. For uniqueness, see also Johnen and Ronayne (2021).

is an atom, and a unilateral deviation to a marginally lower price is profitable because it leads to a jump up in demand. As all retailers have captives, the monopoly price belongs to the pricing support. At a price p in the support of $F^{UP}(p)$, retailer i for $i \in \{1,2,3\}$ sells to consumers who consider it, provided that any rival is more expensive or not considered. The expected profit of retailer i at price p is presented below and, in a mixed strategy equilibrium, it must be constant over the pricing support.

$$E\pi_i(p) = p\alpha(1-\alpha F^{UP}(p))^2 = \alpha(1-\alpha)^2 = E\pi_i(1)$$

Lemma 1. *Under uniform pricing, in the second period, there exists a unique equilibrium where retailers' expected profits are equal to their captive profits:* $E\pi_{S1} = E\pi_2 = E\pi_3 = \alpha(1-\alpha)^2$*. Each retailer chooses its price from the interval* $[p_L, 1]$*, according to the continuous c.d.f.* $F^{UP}(p) = [1-(1-\alpha)p^{-\frac{1}{2}}]/\alpha$*.*

At the end of this section, the result in Lemma 1 will be recalled to characterize unique sequential equilibrium in a uniform pricing regime (where firms do not use data and the two periods are identical) and provide comparative results.

(b) If S offers the second lowest price in the first period (it is now R_2), it uses its informational advantage to discriminate in the second period between its $\alpha(1-\alpha)$ past customers and its α^2 new customers who bought previously from R_1. Let $F_2^e(p)$ be S's c.d.f. for past customers and $F_2^d(p)$ its c.d.f. for new customers. Some of its past customers are captive, so S does not have an incentive to offer these customers a price below p_M, as any such price is dominated by choosing $p = 1$ and serving only its captives. In contrast, all of S's new customers are contestable. Therefore, S's information partially segments the market, and the competitive pressure is greater in the segment formed of R_1's past customers than in the segment formed of S's past customers.

Third-party sellers do not have access to information and each of them charges all its customers one price. Let $F_i(p)$ be R_i's price distribution, for $i \in \{1,3\}$. Although ex-ante identical, R_1 and R_3 are affected differently by the partial segmentation of the market. R_3 anticipates that S will compete less aggressively for its past customers (as some of them are captive) than for its new customers (who also consider R_1 for sure). As a result, R_3 has a choice between 'specializing' in the less competitive segment formed of S's past customers or competing aggressively for all customers in its reach. If R_3 specializes, it attracts customers who bought from R_1 in the first period only if they do not consider S and R_1 is more expensive. In contrast, R_1 does not have the option of specializing, as it cannot attract consumers who bought in the first period from S.

Retailers' expected profits at a price p that is assigned positive density are presented below. $E\pi_i(p)$ is retailer i's expected profit, for $i \in \{1,3\}$. $E\pi_2^e(p)$ and $E\pi_2^d(p)$ are S's expected profits from past customers and new customers, respectively. Next result shows that in equilibrium R_3 chooses to specialize.

$$E\pi_1(p) = p\alpha(1-\alpha F_2^d(p))(1-\alpha F_3(p))$$

$$\begin{aligned} E\pi_2^e(p) &= p\alpha(1-\alpha)(1-\alpha F_3(p)) \qquad E\pi_2^d(p) = p\alpha^2(1-F_1(p))(1-\alpha F_3(p)) \\ E\pi_3(p) &= p[\alpha^2(1-\alpha F_2^d(p))(1-F_1(p)) + \alpha^2(1-\alpha)(1-F_2^e(p)) + \alpha(1-\alpha)^2] \\ &= p[\alpha^2(1-\alpha F_2^d(p))(1-F_1(p)) + \alpha(1-\alpha)(1-\alpha F_2^e(p))] \end{aligned}$$

Lemma 2. *If S is the second cheapest in the first period, in the second period there exists a mixed strategy price equilibrium where: R_1 draws its price from $[p_L, 1]$; R_3 draws its price from $[p_M, 1)$; and S draws its price for new customers from $[p_L, p_M]$ and draws its price for past customers from $[p_M, 1)$. Firms' pricing c.d.f.s and their expected profits are given in (1) and (2). The third-party seller with a higher first period price (R_3) benefits from an informational spillover.*

$$1 - F_1(p) = 1 - \alpha F_2^d(p) = (1-\alpha)^2 p^{-1} \text{ and } 1 - F_2^e(p) = 1 - F_3(p) = (1-\alpha)\alpha^{-1}(1-p)p^{-1} \quad (1)$$

$$E\pi_1 = \alpha(1-\alpha)^2 \ , \quad E\pi_{S2} = \alpha(1-\alpha)^2(1+\alpha) \ , \quad \text{and} \quad E\pi_3 = \alpha(1-\alpha)^2 \left[1 + \alpha(1-\alpha)\right] \quad (2)$$

It is easy to verify that all c.d.f.s are well-defined on their supports and, except for $F_1(p)$, are atomless; $F_1(p)$ has a mass point at $p = 1$, $1 - F_1(1) = (1-\alpha)^2 \in (0, 1)$. Unilateral deviations to $p < p_L$ are dominated by setting $p = p_L$, while unilateral deviations to $p > 1$ yield zero profit. Appendix 7.1 verifies that S cannot profitably deviate to $p \in [p_L, p_M)$, when making an offer to past customers, or to $p \in (p_M, 1]$ when making an offer to new customers, and that R_3 cannot profitably deviate to $p \in [p_L, p_M)$.

Lemma 2 does not prove uniqueness but a natural conjecture is that this equilibrium is indeed unique and a heuristic argument is presented in Appendix 7.1. Figure 3 illustrates the retailers' equilibrium c.d.f.s.

A noteworthy feature of the equilibrium in Lemma 2 is that there is an informational spillover from S to the third-party rival that was more expensive in period one (R_3) but not to the third-party rival that was cheaper (R_1). When trying to retain its past customers, R_1 faces an aggressive competitor in S, which in this segment does not have captives. The consumers who consider both S and R_1 purchased from R_1 before and are in S's new customer segment where this firm competes aggressively as it has no captives.

This analysis focuses on a triopoly, but the mechanism identified here would play a role in larger oligopolies too as cheaper period one firms face an aggressive rival in S, while more expensive period one firms have a choice between all-out competition and specialization in a less competitive segment formed of S's past customers. The informational spillover effect, however, is not present in duopolies: there, when a third-party seller charges a higher price in the first period, S cannot use its superior information in the second period and so there is no spillover source either.

In Lemma 2, both S's and R_3's expected profits are strictly larger than their captive profits. S benefits from its informational advantage and R_3 benefits from the informational spillover. However, the benefit from the informational advantage is greater than the benefit from the informational spillover.

Finally, a consumer who considers both R_1 and S buys from R_1 in period one and is offered by

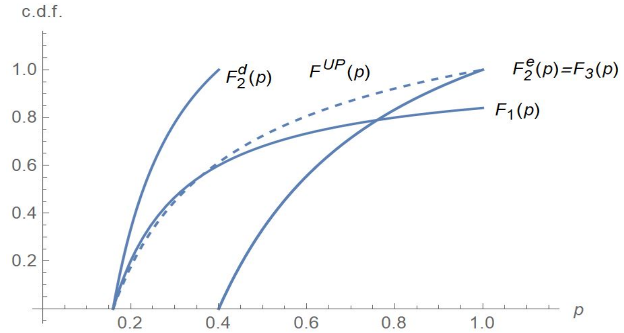

Figure 3: Exclusive Data ($\alpha = 0.6$): Equilibrium c.d.f.s in case (a) - dashed - and case (b) - solid.

S a price drawn from $F_2^d(p)$ in period two. If the consumer buys instead from S, this firm will offer in period two a price drawn from $F_2^e(p)$, which is strictly higher than a price drawn from $F_2^d(p)$. If a consumer who considers both S and R_3, buys from R_3 instead, it will be offered a price drawn from the same distribution, as $F_3(p) = F_2^e(p)$. If a consumer who considers both R_1 and R_3, buys from R_3 instead, it will be offered a price drawn from $F_3(p)$: using the equilibrium c.d.f.s in (1), it is easy to check that, for any $\alpha \in (0, 1)$, the expected price offered by R_3 is strictly higher than the expected price offered by R_1 (i.e., $\int_{p=p_L}^{1} pdF_1 < \int_{p=p_M}^{1} pdF_3$). Given the order of period one prices, consumers are better off choosing the cheapest retailer they consider.

(c) If S is the most expensive retailer in the first period (it is R_3), it fully identifies its captives and charges them the monopoly price ($p = 1$). Moreover, it could in principle discriminate in the second period between new customers depending on their past supplier. Let $F_3^{d\ 1}(p)$ be S's c.d.f. for new customers who bought from R_1 in the first period and $F_3^{d\ 2}(p)$ be its c.d.f. for new customers who bought from R_2. The third-party retailers (R_1 and R_2) do not have access to data and set uniform prices. Let $F_1(p)$ and $F_2(p)$ be R_1's and R_2's c.d.f.s.

Retailers' expected profits at a price p that is assigned positive density are given below. $E\pi_i(p)$ is retailer i's expected profit, for $i \in \{1, 2\}$. $E\pi_3^{d\ 1}(p)$ and $E\pi_3^{d\ 2}(p)$ are S's expected profits from new customers that bought previously from R_1 and new customers that bought from R_2, respectively. S's profit from its past customers is equal to its captive profit.

$$E\pi_1(p) = p\alpha(1 - \alpha F_2(p))(1 - \alpha F_3^{d\ 1}(p)) \tag{3}$$

$$E\pi_2(p) = p\alpha[\alpha(1 - F_1(p))(1 - \alpha F_3^{d\ 1}(p)) + (1 - \alpha)(1 - \alpha F_3^{d\ 2}(p))] \tag{4}$$

$$E\pi_3^{d\ 1}(p) = p\alpha^2(1 - F_1(p))(1 - \alpha F_2(p)) \qquad E\pi_3^{d\ 2}(p) = p\alpha^2(1 - \alpha)(1 - F_2(p)) \tag{5}$$

While third-party sellers anticipate that S will use its superior information to segment the market, in this scenario none of them can take advantage of this. S competes aggressively for its new customers (regardless of their past supplier) as they are contestable. Therefore, third-party sellers face an aggressive competitor when targeting customers in their reach and have identical pricing incentives. As the next result shows, third-party sellers' lack of information limits the extent to which S can use its informational advantage.

Notation. $p_N = [\sqrt{\alpha^2(2-\alpha)^2+4} - \alpha(2-\alpha)]/2 \in (p_M, 1) \Leftrightarrow \sqrt{p_N^2 + p_N\alpha(2-\alpha)} = 1$

Lemma 3. *If S is the most expensive in the first period, in the second period there exists a mixed strategy price equilibrium where: R_1 and R_2 draw their prices from $[p_L, 1)$, and $F_1(p) = F_2(p)$ and S discriminates only coarsely: it charges its past customers the monopoly price and draws its price for new customers from $[p_L, p_N]$ with $F_3^d(p) \equiv F_3^{d\ 1}(p) = F_3^{d\ 2}(p)$. Firms' c.d.f.s and expected profits are given in (6) and (7).*

$$1 - \alpha F_1(p) = 1 - \alpha F_2(p) = \begin{cases} (1-\alpha)\sqrt{p^2 + p\alpha(2-\alpha)}p^{-1} \text{ for } p \in [p_L, p_N] \\ (1-\alpha)p^{-1} \text{ for } p \in (p_N, 1] \end{cases} \tag{6}$$

$$1 - \alpha F_3^d(p) = (1-\alpha)\left[\sqrt{p^2 + p\alpha(2-\alpha)}\right]^{-1} \text{ for } p \in [p_L, p_N]$$

$$E\pi_1 = E\pi_2 = \alpha(1-\alpha)^2 \quad \text{and} \quad E\pi_{S3} = \alpha(1-\alpha)^2\left[2 - (1-\alpha)^2\right] \tag{7}$$

It is easy to verify that all c.d.f.s are well-defined on their supports and atomless. Unilateral deviations to $p < p_L$ are dominated by setting $p = p_L$, while unilateral deviations to $p > 1$ are unprofitable as they yield zero profit. Appendix 7.2 verifies that S cannot profitably deviate (i) to $p \in (p_N, 1]$, or (ii) to a more granular form of discrimination where it offers a different price to new customers, depending on where they bought from before. It is trivial that S does not have incentives to deviate from the monopoly price in its past customer segment. Appendix 7.2 also shows that the equilibrium payoffs in Lemma 3 are unique. Figure 4 illustrates retailers' equilibrium price c.d.f.s.

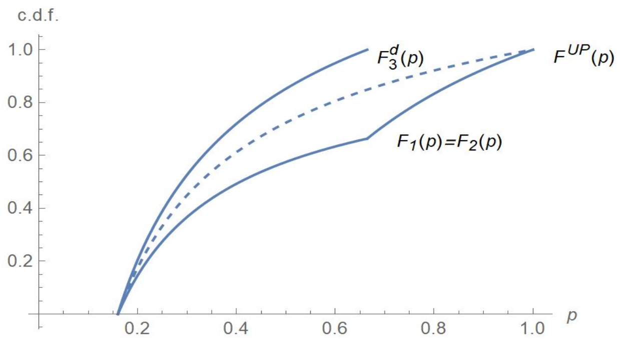

Figure 4: Exclusive Data ($\alpha = 0.6$): Equilibrium c.d.f.s in case (a) - dashed - and case (c) - solid.

Next result shows that in any equilibrium S can only discriminate coarsely, as third-party sellers' lack of information hinders S's ability to make full use of access to consumer data.[13]

Lemma 4. *With exclusive data use, in any second period equilibrium, although S has market-wide purchase history data, it only uses its own past customer data when discriminating on prices.*

As S offers the highest price in period one, its informational advantage does not spill over to third-party sellers. This is different from Lemma 2, but consistent, as there the cheaper period

[13] This can be regarded as a rationale for sharing some data with third-party retailers, like in the next section.

one firm does not benefit from an informational spillover either. S's informational advantage can only spillover to a more expensive first period rival, provided that S makes use of the data (i.e., it is not the cheapest seller in the first period).

Finally, a consumer who considers both R_1 and R_2 buys from R_1 in period one. Buying from R_2 instead makes no difference in period two as R_1 and R_2 choose prices from symmetric c.d.f.s. A consumer who considers R_i and S buys from R_i in period one. If the consumer buys instead from S, this firm will offer in period two the monopoly price, which is strictly higher than a price drawn from $F_i(p)$ or from $F_3^d(p)$. Given the order of period one prices, consumers are better off choosing the cheapest retailer they consider.

Combining Lemmas 1, 2, and 3, next result follows.

Proposition 1. *In the second period, under hybrid price discrimination with exclusive data use, there exists a price equilibrium where S's expected profit is π_{Sk} when it is the k-th cheapest firm in the first period (R_k) and a third-party seller's expected profit is π_k when it is R_k in the first period, for $k \in \{1, 2, 3\}$. Expected profits π_{Sk} and π_k are presented in Table 1.*

Table 1: Exclusive Data Use - Second Period Equilibrium Payoffs

	S	T
R_1	$\pi_{S1} = \alpha(1-\alpha)^2$	$\pi_1 = \alpha(1-\alpha)^2$
R_2	$\pi_{S2} = \alpha(1-\alpha)^2(1+\alpha)$	$\pi_2 = \alpha(1-\alpha)^2$
R_3	$\pi_{S3} = \alpha(1-\alpha)^2[2-(1-\alpha)^2]$	$\pi_3 = \begin{cases} \alpha(1-\alpha)^2 & \text{if } S = R_1 \\ \alpha(1-\alpha)^2[1+\alpha(1-\alpha)] & \text{if } S = R_2 \end{cases}$

Corollary 1. *Consider the equilibrium in Proposition 1. (i) S makes weakly larger expected profit than a third-party seller, regardless of the order of period one prices. (ii) Conditional on being the k-th cheapest in period one, S makes weakly larger expected profit than a third-party seller. (iii) S's expected profit strictly increases in its period one price. (iv) Expected industry profit ($\equiv E\pi_T$) is the same when S is the second cheapest and when it is the most expensive in period one, and it is larger than when S is the cheapest.*

Proof. (i) In (a) $\pi_{S1} = \pi_2 = \pi_3$, in (b) $\pi_1 < \pi_3 < \pi_{S2}$, and in (c) $\pi_1 < \pi_2 < \pi_{S3}$. (ii) For any k, $\pi_{Sk} \geq \pi_k$. (iii) $\pi_{S1} < \pi_{S2} < \pi_{S3}$. (iv) In scenarios (b) and (c) $E\pi_T = 3\alpha(1-\alpha)^2 + \alpha(2-\alpha)$, while in scenario (a) $E\pi_T = 3\alpha(1-\alpha)^2$. □

Next result draws on Lemma 4 to provide an equivalence result under hybrid discrimination with exclusive data use.

Corollary 2. *Suppose that third-party sellers do not have access to data in the second period. A hybrid discrimination regime where S has access to market-wide data is outcome equivalent to a hybrid discrimination regime where S has access only to past customer data. In both cases, the result in Proposition 1 applies.*

Proof. Suppose S has access only to its own past customer data. The analyses in (a) and (b) carry over unchanged. The analysis in (c) carries over by Lemma 4. Then, the result in Proposition 1 applies. □

3.2 First Period Analysis and Sequential Equilibrium

A retailer's overall expected profit aggregates its expected profit in the first period and its expected profit in the second period (which accounts for the order of first period prices). A notable feature of the reduced form game studied here is that a third-party retailer's expected profit may depend not only on the rivals' pricing distributions but also on the ranking of the rivals realized prices (see π_3 in Table 1). This is due to the asymmetry introduced by the subsidiary's superior access to information and, in particular, by the associated informational spillover (see Lemma 2).

Consider a putative equilibrium where third-party sellers choose prices from $[p_0, 1]$, where $p_0 > 0$, according to an atomless c.d.f. $F^T(p)$, and the subsidiary (S) chooses its price from $[p_1, 1]$, where $p_1 \in (p_0, 1]$, according to a c.d.f. $F^S(p)$.

Consider first a price $p \in [p_0, p_1)$. Only a third-party retailer may set price p in the first period and, when it does, its product is cheaper than S's product for sure. Its second period expected profit (see Proposition 1) is $\alpha(1-\alpha)^2$ and its expected profit in reduced-form game is:

$$\begin{aligned}\bar{\Pi}_T(p) &= p\alpha(1-\alpha F^T(p))(1-\alpha F^S(p)) + \alpha(1-\alpha)^2 \\ &= p\alpha(1-\alpha F^T(p)) + \alpha(1-\alpha)^2 = \bar{\Pi}_T(p_0) = p_0\alpha + \alpha(1-\alpha)^2 \equiv \bar{\Pi}_T \ .\end{aligned}$$

Then, the equilibrium constant profit condition $\bar{\Pi}_T(p) = \bar{\Pi}_T(p_0)$ implies that

$$1 - \alpha F^T(p) = \frac{p_0}{p} \text{ for } p \in [p_0, p_1) \ . \quad (8)$$

Consider now a price $p \in [p_1, 1]$ that both S and third-party sellers may set in the first period. As third-party sellers choose their prices from symmetric and atomless c.d.f.s, it must be that $\lim_{p\to 1} F^T(p) = 1$.

When S sets price p, using Proposition 1 and Table 1, its expected second period profit is:

$$\sum_{k=1}^{3} \alpha(1-\alpha)^2[2-(1-\alpha)^{k-1}]C(2,k-1)F^T(p)^{k-1}(1-F^T(p))^{3-k} = \alpha(1-\alpha)^2[2-(1-\alpha F^T(p))^2] \ .$$

Then, S's expected profit in the reduced-form game is

$$\begin{aligned}\bar{\Pi}_S(p) &= p\alpha(1-\alpha F^T(p))^2 + \alpha(1-\alpha)^2[2-(1-\alpha F^T(p))^2] \\ &= \bar{\Pi}_S(1) = \alpha(1-\alpha)^2 + \alpha(1-\alpha)^2[2-(1-\alpha)^2] \\ &= \alpha(1-\alpha)^2[3-(1-\alpha)^2] \equiv \bar{\Pi}_S \ .\end{aligned}$$

It follows that

$$1-\alpha F^T(p) = (1-\alpha)\left[\frac{1-(1-\alpha)^2}{p-(1-\alpha)^2}\right]^{\frac{1}{2}} \text{ for } p \in [p_1, 1] \ . \tag{9}$$

Using (8) and (9), the requirement that $F^T(p)$ be continuous at $p = p_1$ implies that

$$p_0 = (1-\alpha)p_1\left[\frac{1-(1-\alpha)^2}{p_1-(1-\alpha)^2}\right]^{\frac{1}{2}} \ . \tag{10}$$

It must be the case that S does not have an incentive to deviate to a price $p \in [p_0, p_1)$. Using $\bar{\Pi}_S(p)$, as $(1-\alpha F^T(p)) = p_0/p$ for $p \in [p_0, p_1)$, the expected deviation profit is given below.

$$\bar{\Pi}_S^D(p) = p\alpha\frac{p_0^2}{p^2} + \alpha(1-\alpha)^2\left(2-\frac{p_0^2}{p^2}\right) = \alpha p_0^2\frac{[p-(1-\alpha)^2]}{p^2} + 2\alpha(1-\alpha)^2 \tag{11}$$

$\bar{\Pi}_S^D(p)$ is strictly increasing iff $p < 2(1-\alpha)^2$. When $\alpha \leq 0.293$, $2(1-\alpha)^2 \geq 1$, and it is straightforward to rule out the deviation: $\bar{\Pi}_S^D(p) < \lim_{p\to 1}\bar{\Pi}_S^D(p) = \bar{\Pi}_S$.

Let $\alpha \leq 0.293$ and consider first a putative equilibrium where $p_1 = 1$. By condition (10), $p_0 = (1-\alpha)$. A third-party seller's c.d.f. is implicitly defined in (8). It is a well-defined c.d.f. as $F^T(p_0) = 0$, $F^T(1) = 1$, and $F^T(p)$ is strictly increasing on $[p_0, 1]$. There are no unilateral incentives to deviate. A deviation to a price $p > 1$ results in zero profit and is strictly dominated by setting $p = 1$. A third-party seller does not have an incentive to deviate to a price $p < p_0$ as this is strictly dominated by setting $p = p_0$. As shown above, S does not have incentives to deviate to a price $p < p_1 = 1$ as this is strictly dominated by setting $p = 1$.

Therefore, when $\alpha \leq 0.293$, there exists an equilibrium where S chooses $p = 1$ for sure in the first period. However, when $\alpha > 0.293$, $2(1-\alpha)^2 < 1$ and $\bar{\Pi}_S^D(p)$ in (11) is decreasing for $p \in [\max\{p_0, 2(1-\alpha)^2\}, 1)$. In this case, S has an incentive to unilaterally deviate to $p < p_1 = 1$ and, as a result, an equilibrium where F^S is degenerate at $p = 1$ does not exist.

Suppose that $\alpha > 0.293$ and consider a putative equilibrium with $p_1 = 2(1-\alpha)^2$. By (10),

$$p_0 = p_1(1-\alpha)\left[\frac{1-(1-\alpha)^2}{p_1-(1-\alpha)^2}\right]^{\frac{1}{2}} = 2(1-\alpha)^2[1-(1-\alpha)^2]^{\frac{1}{2}} \ .$$

It is easy to check that $(1-\alpha)^2 < p_0 < \min\{(1-\alpha), 2(1-\alpha)^2\}$.

Consider a price $p \in [p_1, 1]$. A third-party seller's expected second period profit is

$$\alpha(1-\alpha)^2 + \alpha^2(1-\alpha)^3 \int_{p_S=p_1}^{p} F^T(p_S)dF^S(p_S) \ ,$$

where p_T is the other third-party seller's price and p_S is S's price. In the second period, this third-party seller has a guaranteed profit of $\alpha(1-\alpha)^2$ and an additional expected profit of $\alpha^2(1-\alpha)^3$ whenever it offers the highest price in the first period and S offers the second cheapest price - the probability of which is given by the integral term; see Proposition 1 and Table 1.

Then, when setting price $p \in [p_1, 1]$ in the first period, this third-party seller's expected profit in reduced-form game is

$$\bar{\Pi}_T(p) = p\alpha(1-\alpha F^T(p))(1-\alpha F^S(p)) + \alpha(1-\alpha)^2 + \alpha^2(1-\alpha)^3 \int_{p_S=p_1}^{p} F^T(p_S)dF^S(p_S) \ .$$

Evaluating at p_1, where the integral term is zero and $F^S(p_1) = 0$ must hold, it follows that

$$\bar{\Pi}_T(p_1) = p_1\alpha(1-\alpha F^T(p_1)) + \alpha(1-\alpha)^2 \equiv \bar{\Pi}_T \ .$$

After simplification, the constant profit condition $\bar{\Pi}_T(p) = \bar{\Pi}_T(p_1)$ gives the integral equation below that defines implicitly the unknown function $F^S(p)$ and where $F^T(p)$ is known from (9).

$$\alpha p(1-\alpha F^T(p))(1-\alpha F^S(p)) + \alpha^2(1-\alpha)^3 \int_{p_S=p_1}^{p} F^T(p_S)dF^S(p_S) = \alpha p_1(1-\alpha F^T(p_1)) \tag{12}$$

Using this equation, the analytical steps below show that a well-defined c.d.f. $F^S(p)$ exists and is unique.

Step 1 verifies that $F^S(1) < 1$. Dividing (12) by $\alpha > 0$ and evaluating at $p = 1$, the equation can be re-written as

$$\alpha(1-\alpha)^3 \int_{p_S=p_1}^{1} F^T(p_S)dF^S(p_S) = p_1(1-\alpha F^T(p_1)) - (1-\alpha)(1-\alpha F^S(1)) \ .$$

▶ Take the LHS. As $F^T(p_S) < 1$ and $F^S(p_1) = 0$ must hold, the integral satisfies:

$$\int_{p_S=p_1}^{1} F^T(p_S)dF^S(p_S) < \int_{p_S=p_1}^{1} dF^S(p_S) = F^S(1) - F^S(p_1) = F^S(1) \ .$$

▶ Take the RHS. Substituting $F^T(p)$ from expression (9) and evaluating at $p_1 = 2(1-\alpha)^2$, it becomes $2(1-\alpha)^2 \left[1-(1-\alpha)^2\right]^{\frac{1}{2}} - (1-\alpha)(1-\alpha F^S(1))$.

Combining these observations, for $\alpha > 0.293$:

$$\alpha(1-\alpha)^3 F^S(1) > 2(1-\alpha)^2 \left[1-(1-\alpha)^2\right]^{\frac{1}{2}} - (1-\alpha)(1-\alpha F^S(1)) \Leftrightarrow$$

$$F^S(1) < \frac{1 - 2(1-\alpha)[1-(1-\alpha)^2]^{\frac{1}{2}}}{\alpha[1-(1-\alpha)^2]} \in (0,1) \ .$$

Step 2 shows that a solution ($F^S(p)$) to the integral equation in (12) exists and is unique, and that $F^S(p)$ is strictly increasing on its support.

Using integration by parts, as $F^S(p_1) = 0$ must hold, the LHS in equation (12) becomes:

$$\alpha p(1-\alpha F^T(p))(1-\alpha F^S(p)) + \alpha^2(1-\alpha)^3 F^S(p)F^T(p) - \alpha^2(1-\alpha)^3 \int_{p_S=p_1}^{p} F^S(p_S)dF^T(p_S) \ .$$

Notation. *$G^i(p) \equiv (1-\alpha F^i(p))$, $g^i(p) \equiv dG^i(p)/dp$, and $H(p) \equiv \alpha p G^T(p) - (1-\alpha)^3(1-G^T(p))$*

With the notation above, the LHS of (12) can be re-arranged as below.

$$\begin{aligned} \alpha p G^T(p)G^S(p) + (1-\alpha)^3(1-G^T(p))(1-G^S(p)) + (1-\alpha)^3 \int_{p_S=p_1}^{p} (1-G^S(p_S))g^T(p_S)dp_S = \\ G^S(p)H(p) + (1-\alpha)^3(1-G^T(p)) + (1-\alpha)^3 \int_{p_S=p_1}^{p} (1-G^S(p_S))g^T(p_S)dp_S = \\ G^S(p)H(p) + (1-\alpha)^3(1-G^T(p_1)) - (1-\alpha)^3 \int_{p_S=p_1}^{p} G^S(p_S)g^T(p_S)dp_S \end{aligned}$$

Noting that $H(p) > 0$, as $p \geq p_1 = 2(1-\alpha)^2$ and $G^T(p) \in ((1-\alpha), 1)$, and using the expression above, equation (12) becomes:

$$G^S(p) - (1-\alpha)^3 \int_{p_S=p_1}^{p} G^S(p_S)\frac{g^T(p_S)}{H(p)}dp_S = \frac{H(p_1)}{H(p)} \ . \tag{13}$$

This is a linear Volterra integral equation of the second kind. As the kernel (the ratio in the integrand) is continuous on $(p_S, p) \subset [p_1, 1]$ and the ratio on the RHS is continuous for $p \in [p_1, 1]$, the equation has a unique solution $G_S(p)$ that is continuous on $[p_1, 1]$; see Theorem 1.2.3 in Brunner (2017). Moreover, this integral equation can be transformed into an ordinary differential equation that is separable in p and G^S. This is done below to verify that $G^S(p)$ is strictly decreasing (or, equivalently, that $F^S(p)$ is strictly increasing on its support).

It is convenient to multiply expression (13) by $H(p) > 0$. Differentiating the resulting expression with respect to p and using Leibniz's Rule, it follows that:

$$g^S(p) = -\frac{G^S(p)[H'(p) - (1-\alpha)^3 g^T(p)]}{H(p)} \Leftrightarrow g^S(p) = -\frac{\alpha G^S(p)(G^T(p) + pg^T(p))}{H(p)} \ .$$

Using (9), it can be checked that $(G^T(p) + pg^T(p)) > 0$ iff $p > 2(1-\alpha)^2$. Then,

$$sign\left[\frac{dF^S(p)}{dp}\right] = -sign[g^S(p)] = sign[G^S(p)] = sign(1-\alpha F^S(p)) \ ,$$

and the initial condition $F^S(p_1) = 0$ implies that $F^S(p)$ is strictly increasing for $p \in [p_1, 1]$.

Subsidiary's c.d.f. $F^S(p)$ solves equation (13), satisfies $F^S(p_1) = 0$, $F^S(1) < 1$, and it is strictly increasing on its support.

Third-party sellers' c.d.f. $F^T(p)$ is identified piece-wise in (8) and (9). It satisfies $F^T(p_0) = 0$, $F^T(1) = 1$, it is continuous as condition (10) holds, and it is strictly increasing over its support.

Furthermore, there are no unilateral deviations from the proposed equilibrium strategies. As $p_1 = 2(1-\alpha)^2$, a deviation by S to a price in $[p_0, p_1]$ is not profitable, as deviation profit is strictly increasing over this range; see expression (11). No retailer has an incentive to deviate to a price $p < p_0$ (as this is strictly dominated by setting $p = p_0$) or to a price $p > 1$ (as this is strictly dominated by setting $p = 1$).

This completes the characterization of retailers' first period equilibrium strategies. The findings are summarized below and underpin the next proposition.

- When $\alpha > 0.293$, there exists a sequential equilibrium where in the first period S draws its price from $[p_1, 1]$, where $p_1 = 2(1-\alpha)^2$, according to the c.d.f. $F^S(p)$ defined in (12), and each third-party retailer draws its price from $[p_0, 1]$, where $p_0 = 2(1-\alpha)^2\sqrt{1-(1-\alpha)^2} < (1-\alpha)$, according to the c.d.f. $F^T(p)$ defined piece-wise in (8) and (9). When α increases in this region, both p_0 and p_1 decrease.

- When $\alpha \leq 0.293$, as $p_1 = 2(1-\alpha)^2 \geq 1$, the result above does not apply. In this case there is a corner solution. There exists a sequential equilibrium where in the first period S sets the monopoly price $p = 1$ for sure, and each third-party retailer chooses prices randomly from $[p_0, 1]$, where $p_0 = (1-\alpha)$, according to the c.d.f. $F^T(p)$ defined implicitly in (8).

Proposition 2. *Consider hybrid price discrimination with exclusive data use. There exists a sequential equilibrium where a third-party seller's and the subsidiary's aggregate expected profits over the two periods are given below.*

$$\bar{\Pi}_T = \begin{cases} \bar{\Pi}_T^H = \alpha(1-\alpha)^2[2\sqrt{1-(1-\alpha)^2}+1] & \text{for } \alpha > 0.293 \\ \bar{\Pi}_T^L = \alpha(1-\alpha)(2-\alpha) & \text{for } \alpha \leq 0.293 \end{cases}$$

$$\bar{\Pi}_S = \alpha(1-\alpha)^2[3-(1-\alpha)^2]$$

Corollary 3. *Consider the result in Proposition 2. In sequential equilibrium, the subsidiary obtains larger expected profit than third-party sellers.*

Proof. Follows immediately as $\bar{\Pi}_S > \bar{\Pi}_T^H$ for $\alpha > 0.293$ and $\bar{\Pi}_S > \bar{\Pi}_T^L$ for $\alpha \leq 0.293$. □

Intuitively, in the first period, S has an incentive to set a higher (average) price: although it makes lower (expected) profit than third-party sellers, this allows it to make better use of its superior data in the second period, where it makes higher expected profit than third-party sellers. This is easy to see when $\alpha \leq 0.293$, as in the first period, S's price is deterministic ($p = 1$) and it is higher than a third-party seller's (stochastic) price. S makes lower profit than a third-party seller in the first period: $\alpha(1-\alpha)^2 < \alpha(1-\alpha)$; see expression (7) and the expected profits in Proposition 2. This allows S to make use of its informational advantage in the second period, where it obtains larger expected profit than its rivals - see (7), and its incremental expected profit more than offsets the first period difference.

3.3 Comparison to a Uniform Pricing Regime

Under uniform pricing, retailers do not use past purchase data when setting second period prices. In each period, each firm charges one price to all its customers. The two periods are identical and independent of each other. Lemma 1 implies that a retailer's expected profit in unique symmetric sequential equilibrium is

$$\Pi^{UP} = 2\alpha(1-\alpha)^2 \ . \tag{14}$$

S's expected profit is larger under hybrid price discrimination with exclusive data in Proposition 2 than under uniform pricing:

$$\bar{\Pi}_S - \Pi^{UP} = \alpha(1-\alpha)^2[1-(1-\alpha)^2] > 0 \ .$$

A third-party seller's expected profit is larger under hybrid price discrimination with exclusive data in Proposition 2 than under uniform pricing.

$$\begin{aligned}
\bar{\Pi}_T^H - \Pi^{UP} &= \alpha(1-\alpha)^2[2\sqrt{1-(1-\alpha)^2} - 1] > 0 \text{ when } \alpha > 0.293 \\
\bar{\Pi}_T^L - \Pi^{UP} &= \alpha^2(1-\alpha) > 0 \text{ when } \alpha \leq 0.293
\end{aligned}$$

Total surplus is fixed and determined by the consideration probability α, so higher expected industry profit translates into lower expected consumer surplus.

Corollary 4. *Hybrid price discrimination with exclusive data use results in larger expected profits for all retailers, compared to uniform pricing. The incremental profit of the subsidiary is larger than the incremental profit of a third-party seller. Consumers are better off under uniform pricing.*

Under uniform pricing, in each period, the retailers obtain their captive profits.

Under hybrid discrimination, in the second period, (exclusive) consumer data allows S to benefit from its informational advantage through market segmentation. In addition to its captive profit, S obtains positive expected profit in asymmetric market segments. This is easiest to see in Lemma 3 where S offers the highest price in the first period and, as a result, in the second period it separates its past consumers in a sub-market where it obtains its captive profit and also makes positive expected profit in its new customer sub-market (formed of third-party sellers' past customers).

Under hybrid discrimination, the higher the ranking of S's price is in the first period, the more S benefits from consumer data in the second period. When α is high enough, in the second period, there is an additional effect as with positive probability, S's informational advantage spills over to a third-party seller. S's informational advantage, together with the informational spillover when α is high enough, reduces competitive pressure and increases expected industry profit in the first period. Nevertheless, a third-party seller benefits less from the availability of data than the subsidiary because its lack of access to data limits its ability to take advantage of market segmentation in the second period.

4 Hybrid Discrimination: Shared Use of Data

In a hybrid discrimination with shared data use regime, after the first period, S has access to market-wide consumer data, like in section 3, and can discriminate based on a consumer's past supplier. However, in contrast to section 3, third-party sellers have access to information on their past customers and can also price discriminate (albeit more coarsely), between new and past customers. While third-party sellers are better informed in this regime, S still has an informational advantage and this has implications for retailers' price strategies in both periods.

In the first period, S chooses its price according to a c.d.f. $\hat{F}^S(p)$. Third-party sellers choose their first period prices according to a (symmetric and atomless) c.d.f. $\hat{F}^T(p)$.

4.1 Second Period Analysis

Given the ranking of retailers' first period realized prices ($p_1 < p_2 < p_3$), there are three relevant scenarios (unique up to the identity of third-party sellers). As before, S's expected profit is identified by using subscript S, and $p_L \equiv (1-\alpha)^2$ and $p_M \equiv (1-\alpha)$.

(a) If S is the cheapest in the first period (it is R_1), it cannot discriminate in the second period (it cannot not use its data), so it chooses a uniform price. Let $F_1(p)$ be S's c.d.f. Third-party sellers (R_2 and R_3) have access to their own past customer data and can discriminate between new and past customers in the second period. Let $F_i^e(p)$ and $F_i^d(p)$, for $i \in \{2,3\}$, be R_i's c.d.f.s for past and new customers, respectively.

While R_3's past customers are captive (so R_3 can charge the monopoly price in this segment), some of R_2's past customers are contested by R_3.

R_2's new customers are contested, as they bought from S before, so R_2 competes aggressively in this segment. However, S has some captives in this segment and, as a result, it does not charge prices below p_L here.

R_3's new customers are also contested as they bought either from S or from R_2 before, so R_3 also has incentives to compete aggressively for new customers. However, competitive pressure in the segment formed of R_2's past customers is lower than competitive pressure in the segment formed of S's past customers. Some of R_2's past customers consider both R_2 and R_3, while others are captive to R_2. So R_2 does not charge prices below p_M here. Some of S's past customers are targeted by all the retailers and S may charge prices in $[p_L, p_M)$ here. Due to this difference in competitive pressure, R_3 has two options. It can specialize in attracting new customers that bought from R_2. Or, it can target new customers regardless of where they bought from before.[14] Next result shows that in equilibrium R_3 chooses to specialize.

Retailers' expected profits at a price p that is assigned positive density are presented below. $E\pi_1(p)$ is R_1's expected profit. $E\pi_2^e(p)$ is R_2's expected profit from past customers. R_3's profit from its past customers is equal to its captive profit. $E\pi_i^d(p)$ is R_i's expected profits from new customers, for $i \in \{2,3\}$. Next result shows that in equilibrium R_3 chooses to specialize.

$$\begin{aligned}
E\pi_1(p) &= p\alpha(1-\alpha F_2^d(p))(1-\alpha F_3^d(p)) = \alpha(1-\alpha)^2 \\
E\pi_2^e(p) &= p\alpha(1-\alpha)(1-\alpha F_3^d(p)) = \alpha(1-\alpha)^2 \\
E\pi_2^d(p) &= p\alpha^2(1-F_1^e(p))(1-\alpha F_3^d(p)) = \alpha^2(1-\alpha)^2 \\
E\pi_3^d(p) &= p\alpha[\alpha(1-F_1^e(p))(1-\alpha F_2^d(p)) + \alpha(1-\alpha)(1-F_2^e(p))] = \alpha^2(1-\alpha)^2(2-\alpha)
\end{aligned}$$

Lemma 5. *If S is the cheapest in the first period, in the second period there exists a family of payoff-equivalent mixed strategy price equilibria, indexed by $x \in [p_M, 1]$, where: R_3 charges its past customers $p = 1$ and draws its price for new customers from $[p_M, 1)$; R_2 draws its price for past customers from $[p_M, 1]$ and its price for new customers from $[p_L, p_M)$; and S draws its price from $[p_L, x) \cup \{1\}$. Firms' c.d.f.s and their expected profits are given in (15) and (16).*

$$1 - F_1^e(p) = (1-\alpha)^2 p^{-1} \quad \text{for} \quad p \in [p_L, x] \quad \text{with } 1 - F_1^e(1) = 1 - F_1^e(x)$$

$$1 - F_2^e(p) = \begin{cases} (1-\alpha)p^{-1} & \text{for} \quad p \in [p_M, x] \\ (1-\alpha)(2-\alpha)p^{-1} - (1-\alpha)^2 x^{-1} & \text{for} \quad p \in (x, 1] \end{cases} \tag{15}$$

$$1 - \alpha F_2^d(p) = (1-\alpha)^2 p^{-1} \quad \text{for} \quad p \in [p_L, p_M) \qquad 1 - \alpha F_3^d(p) = (1-\alpha)p^{-1} \quad \text{for} \quad p \in [p_M, 1)$$

$$\pi_{S1} = \alpha(1-\alpha)^2 \text{ and } \pi_k = \alpha(1-\alpha)^2 \left[2 - (1-\alpha)^{k-1}\right] \quad \text{where} \quad k \in \{2,3\}\ . \tag{16}$$

It is straightforward to check that the c.d.f.s are well-defined on their supports; $F_2^e(p)$ is continuous at $p = x$, $F_2^e(1) \in (0,1)$, and $F_1^e(1) \in (0,1)$. The proof is completed by ruling out unilateral profitable deviations in Appendix 7.4, where Figure 6 illustrates retailers' equilibrium price c.d.f.s. for extreme values of x.

In all equilibria characterized in Lemma 5, there is duopolistic interaction in the price interval $[p_L, p_M)$, where R_2 competes for new customers with S, and these retailers' c.d.f.s are the same, adjusting for consideration. This is driven by R_3's choice to specialize in attracting new customers that bought from R_2 before.

Multiplicity of equilibria stems from retailers' pricing in the interval $[p_M, 1)$. Duopolistic interaction can be supported in this interval too, when R_3 (targeting new customers) competes with R_2 (targeting past customers); this is the case when $x = (1-\alpha)$. However, equilibria where S

[14] If it specializes, R_3 serves new customers that bought from S only if S is more expensive and either they do not consider R_2 or it is more expensive. This case is similar to case (b) in section 3.1. However, there R_3 chooses a uniform price, while here it discriminates on prices.

chooses prices from this interval can also be supported, in which case interaction is, at least at some prices, triopolistic. This can be related to the results in Baye et al. (1992).

(b) If S is the second cheapest in the first period, then in the second period it discriminates between new and past customers but it cannot use its informational advantage to discriminate granularly. R_1 sets one price only. R_3 price discriminates between new and past customers. Adjusting for the identity of the firms, competitive interaction is the same as in part (a) and second period expected equilibrium profits follow from Lemma 5.

$$\pi_{S2} = \alpha(1-\alpha)^2(1+\alpha) \text{ and } \pi_k = \alpha(1-\alpha)^2\left[2-(1-\alpha)^{k-1}\right] \quad \text{where} \quad k \in \{1,3\} .$$

(c) If S is the most expensive in the first period, its informational advantage allows it to discriminate granularly in the second period: it charges $p = 1$ to its past customers, and it charges different prices to new customers depending on their past supplier. R_2 discriminates between new and past customers, while R_1 charges only one price. S's ability to discriminate granularly leads to a complete segmentation of the market.

- In the segment formed of S's past customers, S sets the unique monopoly price $p = 1$ and makes profit $\alpha(1-\alpha)^2$.
- In the segment formed of R_2's past customers, R_2 competes only with S. R_2 is considered for sure, while S is considered with probability α. This is an asymmetric duopoly 'model of sales' à la Narasimhan (1988) and the unique price equilibrium characterized there applies: R_2's and S's expected profits are $\alpha(1-\alpha)^2$ and $\alpha^2(1-\alpha)^2$, respectively.[15]
- In the segment formed of R_1's past customers (of measure α), all retailers compete. R_1 is considered for sure, while R_2 and S are considered with probability α. This an 'independent reach' triopoly model and the equilibrium characterization in Ireland (1993) and McAfee (1994) applies. Uniqueness follows from Armstrong and Vickers (2022), as in this segment there is symmetric interaction. R_2's and S's expected profit is $\alpha^2(1-\alpha)^2$, while R_1's is $\alpha(1-\alpha)^2$.

Retailers' equilibrium c.d.f.s in this subgame are presented in Appendix 7.5, where there is also a graphical illustration. Aggregating over the three segments, retailers' second period expected equilibrium profits are presented below.

$$\pi_{S3} = \alpha(1-\alpha)^2(1+2\alpha) \text{ and } \pi_k = \alpha(1-\alpha)^2\left[2-(1-\alpha)^{k-1}\right] \quad \text{for} \quad k \in \{1,2\} .$$

Combining the results in (a), (b), and (c), next result follows.

[15] There is a measure $\alpha(1-\alpha)$ of consumers, of which $\alpha(1-\alpha)^2$ are captive to retailer 2 and $\alpha^2(1-\alpha)$ are contested by both firms.

Proposition 3. *In the second period, under a hybrid price discrimination with shared data use, there exists a price equilibrium where S makes expected profit $\pi_{Sk} = \alpha(1-\alpha)^2[1+(k-1)\alpha]$ and a third-party seller makes expected profit $\pi_k = \alpha(1-\alpha)^2\left[2-(1-\alpha)^{k-1}\right]$, when it is the k-th cheapest in the first period.*

Corollary 5. *Consider the price equilibrium in Proposition 3. (i) S's second period expected profit is larger than third-party sellers' expected profits only if it offers the most expensive period one price. (ii) Conditional on being the k-the cheapest in period one, S makes weakly larger expected profit than a third-party retailer. (iii) S's expected profit strictly increases in its period one price. (iv) Expected industry profit ($\equiv \tilde{E}\pi_T$) is the same when S is the cheapest or the second cheapest and is smaller than when S is the most expensive.*

Proof. (i) $\pi_{S3} > \pi_2 > \pi_1$; $pi_1 < \pi_{S2} < \pi_3$; and $\pi_{S1} < \pi_2 < \pi_3$. (ii) For any k, $\pi_{Sk} \geq \pi_k$. (iii) $\pi_{S3} = \alpha(1-\alpha)^2(1+2\alpha) > \pi_{S2} = \alpha(1-\alpha)^2(1+\alpha) > \pi_{S1} = \alpha(1-\alpha)^2$. (iv) In (a) and (b), $\tilde{E}\pi_T = \alpha(1-\alpha)^2[3+3\alpha-(1+\alpha)(1-\alpha)]$, while in (c) $\tilde{E}\pi_T = \alpha(1-\alpha)^2(3+3\alpha)$ □

4.2 First Period Analysis and Sequential Equilibrium

A retailer's overall expected profit is the sum of its expected profit in the first period and its expected profit in the second period (which takes into account the order of first period prices).

Given S's first period price p and third-party sellers' c.d.f. $\hat{F}^T(p)$, in the first period S's price is the k-th lowest with probability $\hat{F}^T(p)^{k-1}(1-\hat{F}^T(p))^{3-k}$, so in the second period S makes expected profit $\pi_{Sk} = \alpha(1-\alpha)^2[1+(k-1)\alpha]$; see Proposition 3. Then, S's aggregate second period expected profit is given by,

$$\sum_{k=1}^{3} \pi_{Sk} C(2,k-1)\left(\hat{F}^T(p)\right)^{k-1}\left(1-\hat{F}^T(p)\right)^{3-k} = \alpha(1-\alpha)^2\left(1+2\alpha\hat{F}^T(p)\right) .$$

Given a third-party seller's first period price p, the other third-party seller's c.d.f. $\hat{F}^T(p)$, and S's c.d.f. $\hat{F}^S(p)$, the third-party seller's aggregate expected profit in the second period is presented below. The expression uses Proposition 3: when p is the k-th lowest price, the third-party seller makes expected profit $\pi_k = \alpha(1-\alpha)^2\left[2-(1-\alpha)^{k-1}\right]$.

$$\begin{aligned} &\pi_1(1-\hat{F}^T(p))(1-\hat{F}^S(p)) + \pi_2[\hat{F}^S(p)(1-\hat{F}^T(p)) + \hat{F}^T(p)(1-\hat{F}^S(p))] + \pi_3\hat{F}^T(p)\hat{F}^S(p) \\ &= \alpha(1-\alpha)^2[2-(1-\alpha\hat{F}^T(p))(1-\alpha\hat{F}^S(p))] . \end{aligned}$$

A retailer's overall expected profit in the reduced form game is the sum of its expected profit in the first period and its aggregate expected profit in the second period.

Given third-party sellers' first period price c.d.f. $\hat{F}^T(p)$, S's overall expected profit at a price $p \in [\hat{p}_0, 1]$ is

$$\hat{\Pi}_S(p) = p\alpha(1-\alpha\hat{F}^T(p))^2 + \alpha(1-\alpha)^2\left(1+2\alpha\hat{F}^T(p)\right) = 2\alpha(1-\alpha)^2(1+\alpha) \equiv \hat{\Pi}_S .$$

S has captive consumers and so it assigns positive density to $p = 1$ in any equilibrium. As $\hat{F}^T(1) = 1$, the last equality follows.

A third-party seller's c.d.f., which solves $\hat{\Pi}_S(p) = \hat{\Pi}_S$, is:

$$\hat{F}^T(p) = \frac{1}{\alpha}\left[1 - \frac{(1-\alpha)^2 + \sqrt{(1-\alpha)^4 + p(1-\alpha)^2(2\alpha-1)}}{p}\right] . \tag{17}$$

It is easy to verify that $\hat{F}^T(p)$ is well-defined on $[p_0^T, 1]$ with $p_0^T = (1-\alpha)^2(1+2\alpha)$.

Given the first period price c.d.f.s of the other third-party seller ($\hat{F}^T(p)$) and the subsidiary ($\hat{F}^S(p)$), a third-party seller's overall expected profit at a price p in its c.d.f.'s support is

$$\hat{\Pi}_T(p) = p\alpha(1-\alpha\hat{F}^T(p))(1-\alpha\hat{F}^S(p)) + \alpha(1-\alpha)^2[2-(1-\alpha\hat{F}^T(p))(1-\alpha\hat{F}^S(p))] .$$

As the lowest price in the support of $\hat{F}^T(p)$ is p_0^T (i.e., $\hat{F}^T(p_0^T) = 0$), it must be that $\hat{F}^S(p_0^T) = 0$ (that is, $p_0^S \geq p_0^T$). Otherwise, S would have incentives to deviate to a slightly higher price. Then, evaluating $\hat{\Pi}_T(p)$ at $p_0^T = (1-\alpha)^2(1+2\alpha)$ and substituting in $\hat{F}^T(p_0^T) = \hat{F}^S(p_0^T) = 0$, yields a third-party seller's expected profit in equilibrium:

$$\hat{\Pi}_T = 2\alpha(1-\alpha)^2(1+\alpha) .$$

The equilibrium constant profit condition ($\hat{\Pi}_T(p) = \hat{\Pi}_T$) together with (17) defines $\hat{F}^S(p)$:

$$\hat{F}^S(p) = \frac{1}{\alpha}\left\{1 - \frac{2\alpha\left[(1-\alpha)^2 - \sqrt{(1-\alpha)^4 + p(1-\alpha)^2(2\alpha-1)}\right]}{(1-2\alpha)\left[p-(1-\alpha)^2\right]}\right\} . \tag{18}$$

The support of $\hat{F}^S(p)$ is $[p_0^S, 1]$ where $p_0^S = p_0^T = (1-\alpha)^2(1+2\alpha)$. It can be verified that $\hat{F}^S(p)$ is a well-defined c.d.f. and also that it first order stochastically dominates the c.d.f. used by third-party seller, that is, $\hat{F}^S(p) < \hat{F}^T(p)$.

Unilateral deviations are straightforward to rule out. No retailer has incentives to choose a price strictly below $p_0^S = p_0^T$ as there is no market share gain (compared to choosing $p = p_0^S = p_0^T$) but only a loss from the lower price. No retailer has incentives to deviate to a price above $p = 1$ as it makes no sales. Therefore, the first period price c.d.f.s in (17) and (18) are part of the subgame perfect equilibrium. These findings are summarized below.

Proposition 4. *Under hybrid discrimination with shared data use, there exists a sequential equilibrium where each retailer obtains expected profit* $2\alpha(1-\alpha)^2(1+\alpha)$ *and where in the first period, third-party sellers draw prices from the atomless c.d.f.* $\hat{F}^T(p)$ *in (17) and* S *draws its price from the c.d.f.* $\hat{F}^S(p)$ *in (18), which has an atom at* $p = 1$*. Both* $\hat{F}^T(p)$ *and* $\hat{F}^S(p)$ *are defined on* $[(1-\alpha)^2(1+2\alpha), 1]$.

Figure 5 illustrates retailers' first period price c.d.f.s in sequential equilibrium.

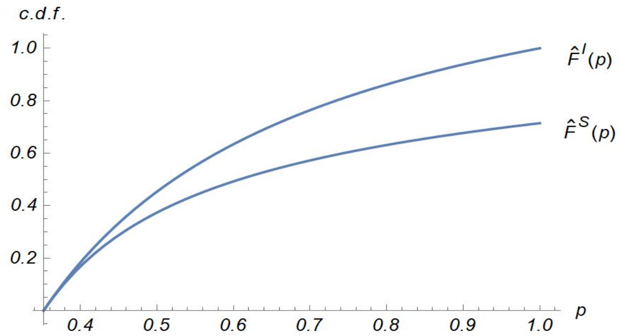

Figure 5: Shared Data: Equilibrium c.d.f.s in period 1 for $\alpha = 0.6$

Take a price $p \in [(1-\alpha)^2(1+2\alpha), 1]$. A retailer's expected profit in sequential equilibrium is the sum of (i) its expected profit from first period sales and (ii) its expected profit from second period sales. Although, overall, S and third-party sellers obtain the same expected profit in sequential equilibrium, the first period pricing introduces an asymmetry. In terms of (i), S's profit is lower than a third-party seller's profit:

$$p\alpha(1-\alpha\hat{F}^T(p))^2 < p\alpha(1-\alpha\hat{F}^T(p))(1-\alpha\hat{F}^S(p)) \ .$$

In terms of (ii), S's profit is larger than a third-party seller's profit:

$$\alpha(1-\alpha)^2(1+2\alpha\hat{F}^T(p)) > \alpha(1-\alpha)^2[2-(1-\alpha\hat{F}^T(p))(1-\alpha\hat{F}^S(p))] \ .$$

A higher first period price allows S to make better use of its informational advantage in period two, but comes at the cost of a lower expected profit from period one sales. Despite the information asymmetry, however, all retailers make the same expected profit in sequential equilibrium.

4.3 Comparison with Hybrid Discrimination with Exclusive Data Use

Comparing the equilibrium results in Propositions 2 and 4, retailers' expected profits are larger under hybrid price discrimination with shared data use than under hybrid price discrimination with exclusive data use.

$$\hat{\Pi}_S - \bar{\Pi}_S = \alpha^3(1-\alpha)^2 > 0$$
$$\hat{\Pi}_T - \bar{\Pi}_T^H = \frac{\alpha(1-\alpha)^2(1+2\alpha^2)}{2\sqrt{1-(1-\alpha)^2}+1+2\alpha} > 0$$
$$\hat{\Pi}_T - \bar{\Pi}_T^L = \alpha^2(1-\alpha)^2 > 0$$

Combining these findings with Corollary 4, next result follows.

Corollary 6. *Consider hybrid price discrimination with shared data. Compared to uniform pricing, all retailers make larger expected profits and benefit equally. Compared to hybrid price discrim-*

ination with exclusive data, all retailers make larger expected profits but third-party sellers benefit more than the subsidiary.

The economic intuition that underpins this result is related to the effects discussed below Corollary 4. There, exclusive data use makes both the subsidiary and third-party sellers better off under hybrid discrimination, compared to uniform prices. However, in the second period, third-party sellers may only benefit through indirect spillovers and their lack of information limits the subsidiary's ability to make use of its data. In contrast, with shared data, the subsidiary can make use of market-wide data and third-party sellers benefit directly from access to past customer data.

Compared to exclusive data, shared data reduces in both periods the asymmetry between third-party sellers and the subsidiary and this levels the playing field on the supply side. While data sharing benefits the industry, it harms consumers.

5 Price Discrimination: Symmetric vs Asymmetric Information

This section compares hybrid price discrimination - where the subsidiary has an informational advantage over third-party sellers - to two price discrimination regimes where retailers have symmetric access to information. It then provides an overview of the results and summarizes the main insights.

Under coarse price discrimination, all retailers have (only) data on their past customers after the first period. Under granular price discrimination, all retailers have access to market-wide past purchase data after the first period. De Nijs (2017) provides a triopoly analysis of these symmetric benchmarks and the relevant results are recalled below and used to assess the role of asymmetric access to information.[16]

Coarse Discrimination. All retailers can discriminate in the second period between new and past customers. There exists a symmetric sequential equilibrium where in the first period each retailer chooses its price from $[p_0^{CD}, 1]$, with $p_0^{CD} = (1-\alpha)^2 \left[2 - (1-\alpha)^2\right] > 0$, according to the c.d.f. $F^{CD}(p) = F^T(p)$, where $F^T(p)$ is presented in expression (9), and makes expected profit $\Pi^{CD} = \alpha(1-\alpha)^2 \left[3 - (1-\alpha)^2\right]$.

Granular Discrimination. All retailers can discriminate in the second period depending on a customer's past supplier. There exists a unique symmetric sequential equilibrium where in the first period each retailer chooses a random price from $[p_0^{GD}, 1]$, with $p_0^{GD} = (1-\alpha)^2 (1+2\alpha)$, using the c.d.f. $F^{GD}(p) = \hat{F}^T(p)$, where $\hat{F}^T(p)$ is presented in expression (17), and makes expected profit $\Pi^{GD} = 2\alpha(1-\alpha)^2 (1+\alpha)$.

Comparing coarse and granular price discrimination to uniform pricing - see expression (14), a

[16] In De Nijs (2017), coarse and granular discrimination are referred to a behavior based price discrimination without and with information sharing. Under both regimes, although the information structure is ex-ante symmetric, ex-post (in the second period) a retailer's ability to make use of consumer data depends on the order of first period prices. However, in the first period retailers use symmetric strategies. Considering an oligopoly with an arbitrary number of firms, Chioveanu (2024) characterizes unique sequential equilibrium under granular discrimination.

retailer's expected profit in sequential equilibrium satisfies

$$\Pi_L \equiv \Pi^{UP} < \Pi^{CD} \equiv \Pi_M < \Pi^{GD} \equiv \Pi_H \ .$$

In the first period, the lower bounds of the price supports satisfy $p_0^{UP} < p_0^{CD} < p_0^{GD}$ and c.d.f.s satisfy $F^{UP}(p) \geq F^{CD}(p) \geq F^{GD}(p)$, with strict inequality if they are strictly positive and $p < 1$.

Using a third-party seller's expected equilibrium profit under hybrid discrimination with exclusive data, $\bar{\Pi}_T^H$ and $\bar{\Pi}_T^L$ defined in Propositions 2, let

$$\Pi_m \equiv \begin{cases} \bar{\Pi}_T^H & \text{for} \quad \alpha > 0.293 \\ \bar{\Pi}_T^L & \text{for} \quad \alpha \leq 0.293 \end{cases} .$$

Corollary 7. *Consider hybrid price discrimination with exclusive data use. Compared to coarse discrimination, the subsidiary obtains the same expected equilibrium profit (Π_M), while third-party sellers make strictly lower expected equilibrium profits ($\Pi_m < \Pi_M$). Compared to granular discrimination, all retailers are worse off ($\Pi_M < \Pi_H$).*

Proof. Subsidiary's payoffs in sequential equilibria in Proposition 2 and under coarse discrimination are the same ($\bar{\Pi}_S = \Pi_M = \Pi^{CD}$). Third-party sellers' payoffs are lower by Corollary 3. Moreover, subsidiary's payoffs in sequential equilibria in Proposition 2 are lower than under granular discrimination. □

Corollary 8. *Consider hybrid price discrimination with shared data use. Compared to granular discrimination, all retailers obtain the same expected profit (Π_H). Sharing market-wide data only with the subsidiary is outcome-equivalent to sharing it with all retailers, so long as third-party sellers have access to own past customer data.*

Proof. The payoffs in sequential equilibrium in Proposition 4 and under granular discrimination are the same ($\hat{\Pi}_T = \hat{\Pi}_S = \Pi_H = \Pi^{GD}$). □

Table 2 presents the expected equilibrium profit (Π) of the subsidiary (S), a third-party seller (T), and expected consumer surplus (CS) across all pricing regimes considered in this analysis. Using Corollary 4, $\Pi_L < \Pi_m < \Pi_M < \Pi_H$. Expected consumer surplus equals total surplus - $\left[1-(1-\alpha)^3\right]$ - minus expected industry profit, therefore $CS_H > CS_M > CS_m > CS_L$.

The main insights from the comparisons across regimes are summarized below.

- If third-party sellers do not have access to data, giving the subsidiary access to its own past customer data makes all retailers better off ($\Pi_M > \Pi_m > \Pi_L$). However, once the subsidiary has access to its own past customer data, giving it access to market-wide data is inconsequential.
- If the subsidiary has access to its own past customer data, giving third-party sellers access to own past customer data is inconsequential for the subsidiary and makes third-party sellers better off, compared to the case where third-party sellers have no access to data ($\Pi_M > \Pi_m$).

Table 2: Payoff Comparisons Across Pricing Regimes

	UP	**HD - Exclusive**		**CD**	**HD - Shared**	**GD**
	T: no data	T: no data		T: own data	T: own data	T: all data
	S: no data	S: own data	S: all data	S: own data	S: all data	S: all data
S	Π_L	Π_M	Π_M	Π_M	Π_H	Π_H
T	Π_L	Π_m	Π_m	Π_M	Π_H	Π_H
CS	CS_H	CS_M	CS_M	CS_m	CS_L	CS_L

HD: Hybrid Discrimination (S Has an Informational Advantage);
UP: Uniform Pricing; **CD:** Coarse Discrimination; **GD:** Granular Discrimination

- If the subsidiary has access to market-wide data, giving third-party sellers access to own customer data makes all retailers better off, compared to the case where third-party sellers have no access to information ($\Pi_H > \Pi_M$).
- If the subsidiary has access to market-wide data and third-party sellers have access to own customer data, giving third-party sellers access to market-wide data is inconsequential.
- Sharing data only with the subsidiary benefits all retailers but harms consumers.
- Mandatory sharing of own customer data with third-party sellers benefits these firms, may benefit the subsidiary, but harms consumers.
- Mandatory sharing of market-wide customer data with third-party sellers or fair use of data (i.e., symmetric access to information) does not harm retailers and it may benefit them, but when it benefits the industry it harms consumers.

6 Conclusions

On many digital platforms, affiliated retailers compete with third-party sellers. The increase in the market power of some platforms has raised public and policy concerns regarding the impact of vertical integration on participating third-party sellers and consumers. Several practices have come under scrutiny, including the use of third-party seller data.[17] In its investigation of Amazon's UK Marketplace platform, the CMA raised 'concerns that Amazon's access to commercially sensitive data relating to third-party sellers helped its retail business to [...] set prices'; see fn. 3.

The expansion of online retail and improvement in data analytics increased significantly the availability of consumer information. A platform-affiliated retailer has an informational advantage

[17] See, for instance, EU's DMA 2022 (https://bit.ly/418HJF5), the American Innovation and Choice Online Act (US) 2021-2023 (https://bit.ly/3S85cDM), and EC's Google Search (Shopping) Decision, 2017 (https://bit.ly/40bJ50I). Other concerns relate to self-preferencing, product imitation by the platform, and the impact of integration on innovation incentives.

over third-party sellers, and this is likely to have an impact on competition and market outcomes, especially when consumer data enables price discrimination (e.g., targeted discounts).

This paper examines price discrimination based on consumers' consideration sets on a retail platform where a subsidiary with better access to consumer data competes with third-party sellers. This informational advantage underpins 'hybrid' price discrimination. With exclusive data use, only the subsidiary has access to data and can price discriminate, while third-party sellers set uniform prices in both periods. With shared data use, third-party sellers have access to their own past customer data and can price discriminate between new and past customers in the second period, while the subsidiary has market-wide data and can discriminate by customers' past suppliers.

This analysis shows that a platform's interests are aligned with those of third-party sellers.[18] Compared to uniform pricing, all retailers benefit from hybrid price discrimination: under exclusive data use, the subsidiary benefits more than third-party sellers, while under shared data use, all retailers benefit equally. Compared to hybrid discrimination with exclusive data use, data sharing makes all retailers better off (but benefits third-party sellers more). In contrast, there is a conflict between consumers' and retailers' interests.

With exclusive data use, third-party sellers' lack of information limits the extent to which the subsidiary can use its informational advantage. If third-party sellers do not have access to information, the subsidiary can only use its past customer data. With shared data, the subsidiary can make better use of its superior information (although its informational advantage is reduced); therefore, it has incentives to share past customers data with third-party sellers.

Mandatory data sharing regulation giving third-party sellers access to own past customer data does not harm the subsidiary and benefits third-party sellers, but it is detrimental to consumers. The intervention levels the playing field on the supply side but reduces consumer surplus. Fair use of data requirements or commitments that support symmetric access to information do not harm the platform or third-party sellers but harm consumers whenever they benefit the industry.[19]

This analysis examines a market where all retailers are equally likely to be considered, and where, in the data sharing regime, third-party sellers have access to the same type of information. Future research could explore consumer steering and asymmetric data sharing, and their implications for consideration-based price discrimination and market outcomes.

[18]The model presented here is consistent with a platform where consumer participation is free and where third-party sellers pay a fixed participation fee.

[19]Symmetric information benchmarks with price discrimination that underpin these comparisons can be interpreted as a setting where vertical integration is banned but platforms can supply data to participating retailers.

7 Appendix

7.1 Proof of Lemma 2

R_3's expected deviation profit when $p \in [p_L, p_M)$ is a convex function:

$$E\pi_3^D(p) = p\left\{\alpha^2\left[\frac{(1-\alpha)^2}{p}\right]^2 + \alpha^2(1-\alpha) + \alpha(1-\alpha)^2\right\} = \alpha(1-\alpha)\left[\frac{\alpha(1-\alpha)^3}{p} + p\right]$$

maximized when $p \to p_M$ where it converges to the equilibrium level as

$$E\pi_3^D((1-\alpha)^2) = \alpha(1-\alpha)^2 < \lim_{p\to(1-\alpha)} E\pi_3^D((1-\alpha)) = E\pi_3 \ .$$

Therefore, this deviation is not profitable.

R_2's expected deviation profit to $p \in [p_L, p_M)$, when making an offer to past customers, is strictly increasing in p and so strictly lower than expected equilibrium profit:

$$E\pi_2^{e\ D}(p) = p\alpha(1-\alpha) < p_M\alpha(1-\alpha) = E\pi_2^e \ .$$

R_2's expected deviation profit to $p \in (p_M, 1]$, when making an offer to new customers, is strictly decreasing in p and so strictly lower than expected equilibrium profit:

$$E\pi_2^{d\ D}(p) = p\alpha^2\left[\frac{(1-\alpha)^2}{p}\right]\left[\frac{(1-\alpha)}{p}\right] = \frac{\alpha^2(1-\alpha)^3}{p} < \alpha^2(1-\alpha)^2 = E\pi_2^d \ .$$

Uniqueness

Take R_1's past customers. R_1 cannot discriminate and does not price below $(1-\alpha)^2$ as some consumers are captive; S targets new customers and competes aggressively as none of them are captive; R_3 cannot discriminate and, if it chose to compete head-to-head with R_1, it would not price below $(1-\alpha)^2$ either, as it has some captives. This pins down the expected profits of R_1 (overall) and of S (from new customers), and also a putative expected overall profit for R_3.

Take S's past customers. S has some captive consumers and will not offer a price below $(1-\alpha)$. If R_3 specializes in targeting this group, even if it does not sell to R_1's past customers, it can still obtain its 'putative' profit mentioned above. However, as it may still attract 'residual' consumers that bought previously from R_1, it does better by specializing. This pins down the expected profits of R_3 (overall) and of S (from past customers).

7.2 Proof of Lemma 3

In equilibrium R_3 discriminates coarsely, so $F_3^{d\ 1}(p) = F_3^{d\ 2}(p) = F_3^d(p)$ and

$$E\pi_3^d(p) = p\alpha[\alpha(1-F_1(p))(1-\alpha F_2(p)) + \alpha(1-\alpha)(1-F_2(p))] \ .$$

In this case, R_3's expected profit from a unilateral deviation to $p \in (p_N, 1]$ is strictly decreasing in p and so strictly lower than expected equilibrium profit:

$$E\pi_3^{d\ D}(p) = p\alpha\left(\frac{1-\alpha}{\alpha}\right)\left(\frac{1-p}{p}\right)\left[\alpha\left(\frac{1-\alpha}{p}\right) + \alpha(1-\alpha)\right] .$$

If R_3 discriminates more granularly, its expected profits from new customers that bought from R_1 and new customers that bought from R_2, respectively, are given in (5).

If R_3 offers a price $p \in (p_N, 1]$ only to customers who bought from R_1, the expected deviation profit is strictly decreasing and so strictly lower than corresponding expected equilibrium profit:

$$E\pi_3^{d\ 1\ D}(p) = p\alpha^2(1 - F_1(p))(1 - \alpha F_2(p)) = p\alpha^2\left(\frac{1-\alpha}{\alpha}\right)\left(\frac{1-p}{p}\right)\left(\frac{1-\alpha}{p}\right) .$$

If R_3 offers a price $p \in (p_N, 1]$ only to customers who bought from R_2, the expected deviation profit is strictly decreasing and so strictly lower than corresponding expected equilibrium profit:

$$E\pi_3^{d\ 2}(p) = p\alpha^2(1-\alpha)\left(\frac{1-\alpha}{\alpha}\right)\left(\frac{1-p}{p}\right) .$$

This rules out such deviations.

Equilibrium Payoff Uniqueness

S's past customers form a separate segment, monopolized by this firm, so payoff uniqueness is trivial in this sub-market. Third-party sellers' past customers are pooled together in a competitive segment where all firms are active: here, third-party sellers face both captives and contestable consumers, while S faces only contestable consumers.

The competitive segment is a separate triopoly sub-market where firms compete in uniform prices. In their characterization of triopoly uniform price equilibria under consideration heterogeneity, Armstrong and Vickers (2022) derive a condition that is necessary and sufficient for all firms to use the same lowest price in equilibrium (that is equal to the highest captive-to-reach ratio among the firms in the market). When this condition holds, equilibrium payoffs are uniquely determined. Lemma 3 shows that, in the scenario analyzed here, an equilibrium where all firms use the same lower bound exists and therefore, their results imply that equilibrium payoffs are uniquely determined in the competitive segment, too.

If the market is not sufficiently symmetric, only equilibria characterized by duopoly interactions exist (i.e., any price that is assigned positive density in equilibrium is used by exactly two firms). See Armstrong and Vickers (2022), Proposition 5 on p. 173. Using their notation, $\sigma_1 = \sigma_2 = \alpha > \sigma_3 = \alpha^2(2-\alpha)$, $\gamma = \gamma_{13} = \gamma_{23} = [\alpha(2-\alpha)]^{-1} > \gamma_{12} = 1$, and condition (21) holds.

7.3 Proof of Lemma 4

Suppose that R_3 discriminates granularly. Then, conditional on being considered, it would be identical to R_1 in the segment formed by R_1's past customers and it would be identical to R_2 in the segment formed of R_2's past customers. Therefore it should hold that $(1 - \alpha F_3^{d\ i}(p)) = (1 - F_i(p))$ for $i \in \{1, 2\}$. Starting from this observation, the proof proceeds in two steps. Step 1 shows that the supports of R_1's and R_2's c.d.f.s cannot overlap and step 2 shows that, if they do not overlap, a mixed strategy equilibrium cannot be supported. As pure strategy equilibria do not exist, it follows that in any equilibrium R_3 discriminates coarsely.

Step 1: If the supports of $F_1(p)$ and $F_2(p)$ overlap over a range of prices, expressions (3), (4), and (5) should hold simultaneously at those prices. These expression can be re-written as

$$k_1 \equiv \frac{E\pi_1}{\alpha} = \frac{E\pi_3^{d\ 1}}{\alpha^2} = p(1 - F_1(p))(1 - \alpha F_2(p)) \ ,$$
$$k_2 \equiv \frac{E\pi_2}{\alpha} = p[\alpha(1 - F_1(p))^2 + (1 - \alpha)(1 - F_2(p))] \ ,$$
$$k_3 \equiv \frac{E\pi_3^{d\ 2}}{\alpha^2(1 - \alpha)} = p(1 - F_2(p)) \ ,$$

where k_1, k_2, and k_3 are positive constants, proportional to the expected profit levels in this putative equilibrium. But this implies that $F_1(p)$ should satisfy, over a non-trivial range of prices, both

$$(1 - F_1(p)) = \frac{k_1}{\alpha k_3 + p(1 - \alpha)} \text{ and } (1 - F_1(p))^2 = \frac{k_2 - (1 - \alpha)k_3}{p\alpha} \ .$$

A contradiction.

Step 2: Then, it must be that the supports of $F_1(p)$ and $F_2(p)$ do not overlap. Suppose that this is indeed the case and let $F_i(p)$'s (and implicitly $F_3^{d\ i}(p)$) lower bound be p_i. Then, R_3's constant profit condition when targeting R_2's past customers - see second expression in (5) - implies that

$$(1 - F_2(p)) = \frac{p_2}{p} \ ,$$

while R_2's constant profit condition in (4) implies that

$$(1 - \alpha F_3^{d\ 2}(p)) = \frac{p_2[\alpha k + (1 - \alpha)]}{p(1 - \alpha)} - \frac{\alpha k}{(1 - \alpha)} \ ,$$

where $k = (1 - F_1(p))(1 - \alpha F_3^{d\ 1}(p))$ is a non-negative constant. Then $(1 - F_2(p)) = (1 - \alpha F_3^{d\ 2}(p))$ holds iff $k = 0$, that is, iff the support of $F_1(p)$ is higher. This implies that $(1 - F_2(p)) = (1 - \alpha F_3^{d\ 2}(p)) = p_2/p$ so the $F_2(p)$ and $F_3^{d\ 2}(p)$ are defined on $[p_2, \hat{p}]$, where $\hat{p} = p_2/[\alpha + (1 - \alpha)^2]$, and $F_2(p)$ has a mass point at $\hat{p}$, which has been identified using (4).

Then, for $F_1(p)$'s support to be higher, it must be that $p_1 \geq \hat{p}$. However, this cannot be part of an equilibrium: if $p_1 > \hat{p}$, there is a gap between $F_1(p)$'s and $F_2(p)$'s supports and R_2 can move the mass up; if $p_1 = \hat{p}$, there is a positive probability of a tie at $\hat{p}$ with R_2, and R_1 is better off choosing a slightly lower price.

7.4 Proof of Lemma 5

Unilateral profitable deviations are ruled out below.

If R_3 offers a price $p < 1$ to past customers, this is clearly dominated by offering $p = 1$ as these customers are captive. If R_3 offers a price $p \in [p_L, p_M)$ to its new customers, its expected deviation profit is

$$p\alpha[\alpha(1 - F_1^e(p))(1 - \alpha F_2^d(p)) + \alpha(1-\alpha)(1 - F_2^e(p))] = \frac{\alpha^2(1-\alpha)^4}{p} + p\alpha^2(1-\alpha)$$

which is convex in p and so maximized either as $p \to p_M$ - where it reaches the equilibrium level - or at p_L. As the expected deviation profit is the same at p_L and at p_M, there is no gain from this deviation.

If R_2 offers a price $p \in [p_L, p_M)$ to its past customers, its expected deviation profit,

$$p\alpha(1-\alpha)(1 - \alpha F_3^d(p)) = p\alpha(1-\alpha) \ ,$$

is strictly increasing and maximized as $p \to p_M$, where it is the same as the expected equilibrium profit from past customers. Therefore, this deviation is not profitable.

If R_2 offers its new customers a price $p \in (p_M, 1]$ where firm 1 puts positive probability, its expected deviation profit is

$$p\alpha^2(1 - F_1^e(p))(1 - \alpha F_3^d(p)) = p\alpha^2 \frac{(1-\alpha)^2}{p} \frac{(1-\alpha)}{p} \ ,$$

and it is strictly decreasing in p and so it is maximized as $p \to p_M$ where it is equal to the firm's expected equilibrium profit from new customers.

If R_2 offers its new customers a price $p \in (p_M, 1]$ where R_1 does not put positive probability, its expected deviation profit is

$$p\alpha^2(1 - F_1^e(p))(1 - \alpha F_3^d(p)) = p\alpha^2 \frac{(1-\alpha)^2}{x} \frac{(1-\alpha)}{p} \ ,$$

and is weakly lower than the firm's expected equilibrium profit from new customers (with equality if $x = (1-\alpha)$), so there a loss (or no gain) from this deviation.

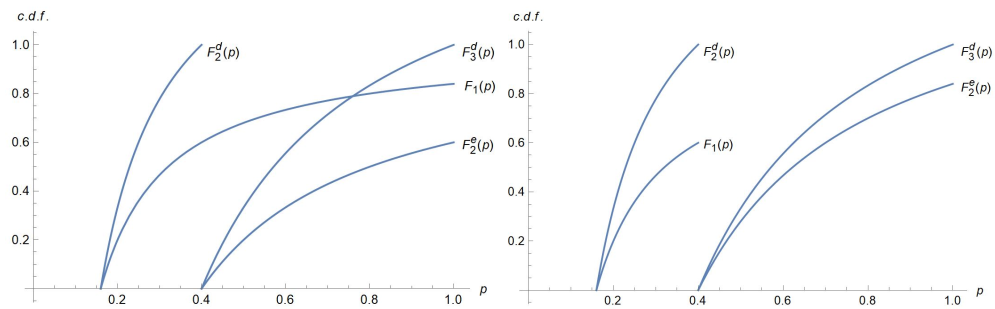

Figure 6: Shared Data Use: Equilibrium c.d.f.s in case (a) for $x = 1$ (L) and $x = (1-\alpha)$ (R) when $\alpha = 0.6$

Consider equilibria where $x < 1$. If R_1 deviates to a price $p \in (x, 1)$, its expected deviation profit is

$$p\alpha(1-\alpha F_2^d(p))(1-\alpha F_3^d(p)) = p\alpha(1-\alpha)\frac{(1-\alpha)}{p} = \alpha(1-\alpha)^2$$

and is equal to the firm's expected equilibrium profit so there is no gain from this deviation.

For all retailers, a deviation to a price $p < p_L$ is dominated by setting $p = p_L$, which is either part of the equilibrium strategy or dominated (as shown above). A deviation to a price $p > 1$ results in zero profit and so it is not profitable either.

7.5 Shared Data: Second Period - C.D.F.s in Case (c)

R_3's c.d.f. for past customers is degenerate, as it charges $p = 1$ for sure. R_3 chooses its price for new customers that bought from R_2 from $F_3^{d\ 2}(p)$ defined on $[p_M, 1]$ and its price for new customers that bought from R_1 from $F_3^{d\ 1}(p)$ defined on $[p_L, 1]$. R_2 chooses its price for past customers from $F_2^e(p)$ defined on $[p_M, 1]$ and its price for new customers that bought from R_1 from $F_2^{d\ 1}(p)$ defined on $[p_L, 1]$. R_1 chooses its price from $F_1(p)$ defined on $[p_L, 1]$. The c.d.f.s are presented and illustrated below.

$$F_2^e(p) = \alpha F_3^{d\ 2}(p) = 1-(1-\alpha)p^{-1} \quad \text{and} \quad F_1(p) = \alpha F_2^{d\ 1}(p) = \alpha F_3^{d\ 1}(p) = 1-(1-\alpha)p^{-\frac{1}{2}}$$

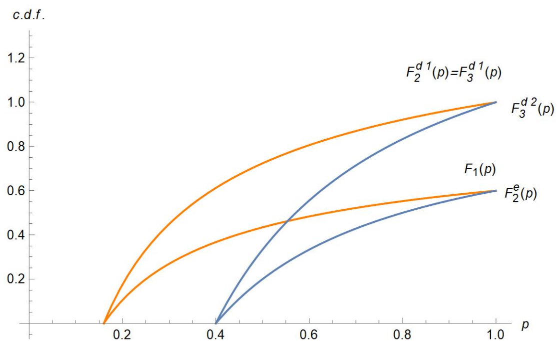

Figure 7: Shared Data: Equilibrium c.d.f.s in case (c) for $\alpha = 0.6$.

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