Platform Coherence Policies with a Multiproduct Seller

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Abstract

I study a vertically differentiated product market intermediated by a monopoly platform. A monopoly seller offers a low- and a high-quality product to consumers with heterogenous preferences to purchase through the platform rather than directly from the seller. Absent any restrictions imposed by the platform, the seller may draw consumers to purchase directly through differences in product prices and product availability between its direct and platform selling channels. I characterize the strategic pricing and assortment decisions made by the seller. Strategic assortment can substantially lessen the platform's ability to monetize the access it provides in buyer-seller interactions. The platform always finds it optimal to implement both cross-channel price and availability coherence policies if feasible. In contrast to general optimality of price coherence in similar markets supplied by a single-product seller, the platform may optimally allow for cross-channel price flexibility if it cannot enforce cross-channel availability coherence.

Keywords: platform markets, price coherence, showrooming, availability coherence, strategic assortment

1 Introduction

A growing number of platforms like Amazon.com and Booking.com play a fundamental role in facilitating discovery between sellers and consumers in many industries. Consumers begin product search through platforms, which admits participating sellers to wide market reach with little or no independent investment in marketing. A price coherence clause prohibits a seller from listing any platform-listed product for a lower price in other selling channels. Platforms have controversially imposed price coherence clauses in attempt to monetize the market access they provide to sellers. They argue that without such policies in place, sellers would undercut their own intermediated prices with direct prices that induce "showrooming" by consumers—sellers would gain awareness through

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the platform but transact directly to avoid platform imposed selling fees. Competition authorities and many authors have investigated platforms' use of price coherence policies, and antitrust policies have been implemented to restrict this practice in numerous markets.[1] While much of the discussion of platform coherence policies has centered around platform and seller pricing behaviors, most sellers offer multiple products and may thus strategically vary the menu of products they list among selling channels in addition to strategically varying product prices among selling channels. For example, hoteliers generally offer both basic rooms and luxury suites for booking. They may list only one room type through an online travel agency to gain awareness and list the other room type only directly to avoid paying selling fees on those rooms. Sellers on Amazon.com indeed participate in this strategic cross-channel menu choice, as documented in the Harvard Business Review:

> Selling on Amazon does not have to be an all-or-nothing decision. Some brands sell a few products on Amazon while also encouraging customers to buy directly from their own website. This hybrid strategy allows them to use Amazon to build awareness and acquire customers but also drives purchasers to their own website … companies must make strategic assortment decisions, choosing *which* products to offer on the platform and which to sell on their own website.[2] (Israeli et al., 2022)

Considering sellers' strategic assortment decisions, a platform may impose another type of cross-channel coherence policy, an availability coherence clause, as well as a price coherence clause. An availability coherence clause requires sellers to list any product listed directly also through the platform. Some platforms do enforce forms of availability coherence in practice, although it may be infeasible in some settings due to technical or regulatory reasons. In its early years the online ticketing platform Ticketmaster often required that event managers supply Ticketmaster with their full inventory of publicly available tickets in order to sell any tickets through the platform (Budnick and Baron, 2012; pg. 62). Online travel agencies like Booking.com implement less extreme forms of availability coherence, requiring hotels to list a minimum share of available rooms in order to list any rooms through the platforms (Hunold et al., 2018). In this paper, I investigate the role that cross-channel assortment and assortment restriction behaviors play in platform markets in addition to the cross-channel pricing and pricing restriction behaviors typically analyzed in the literature.

To model this behavior, I consider a monopoly platform that intermediates a vertically differentiated product market. A monopoly seller offers a low- and a high-quality product to consumers. The seller obtains a higher margin on sales of the high-quality product gross of any

[1] See Baker and Morton (2018) for a review of recent antitrust approaches taken to regulate platform use of price coherence policies.

[2] Basic online product searches yield specific examples of strategic assortment in vertically differentiated product markets. The following come from February 22, 2023 search results. The "Gap Store" on Amazon.com offers 29 men's jeans options, each listed for no more than $69.99, but the "Gap" direct website offers 176 men's jeans options, with 60 options listed for at least $70. For a March 24-26, 2023 stay, "Quality Inn University" in Lansing, Michigan lists a "King Room" and a "Double Room" through Booking.com, but their direct booking website offers these rooms in addition to a "Poolside King Suite."

selling fees. It can offer each product through the platform, directly, or through both selling channels. Consumers are unaware of the seller if it has no presence on the platform, but in the absence of any restrictions imposed by the platform, the seller can draw consumers to purchase directly through cross-channel differences in product prices and availability. The seller provides an inferior purchasing experience to consumers through direct sales relative to platform-intermediated sales. Consumers incur heterogenous costs to directly purchase a product listed both directly and through the platform, and they incur these and additional costs to locate and directly purchase a product not listed through the platform. The platform may restrict the seller's cross-channel pricing and assortment decisions by enforcing price coherence and/or availability coherence clauses. The platform charges an ad valorem fee to the seller for each intermediated transaction.

I first characterize the seller's pricing and assortment decisions when faced with various fees and platform policies. The seller's assortment choice of which products to sell through each channel depends critically on the relative cost-intensity of production of each product, where the cost-intensity of production is defined as the ratio of the unit cost of a product to consumers' valuation for that product. If a product becomes more cost-intensive, then an increasing ad valorem fee more quickly cuts into the seller's realized margin on intermediated sales of that product. Thus, even though the seller obtains a higher gross margin on the high-quality product, it may prefer to sell the low-quality product through the platform when faced with a sufficiently high fee depending on the relative product margins and cost structures. Under price coherence, the seller loses its ability to make direct sales of any product it lists through the platform. If platform-selling fees are too high, the seller gains consumer awareness by only listing the low-quality product through the platform and induces buyers to purchase the high-quality product directly.

I next consider the platform's choice of coherence policies and selling fee. The platform always prefers to enforce both price and availability coherence. The number of intermediated transactions at any fee level is decreasing in the viability of the seller's outside sales option. When availability coherence is not enforced, the seller retains the ability to draw consumers to purchase directly through either cross-channel price or availability variety. Price and availability coherence eliminates both mechanisms for the seller to induce sales outside of the platform. This leaves the platform only with a seller participation constraint on its fee level, and the platform maximizes the revenue it earns per transaction, crucially, on *all* consumer transactions. Without either a price or availability coherence policy in place, the platform must either lower its fee to tax all consumer transactions or tax fewer transactions to maintain its optimal price and availability coherence fee level.

While the platform always prefers price and availability coherence, this strong policy imposition may face regulatory limitations in some industries since it effectively eliminates any off-platform selling option. A platform may also find it infeasible to implement in some cases due to monitoring or commitment failures. In contrast to numerous results that demonstrate general optimality of price coherence in a single-product setting, the platform does not necessarily prefer to implement price coherence with a multiproduct seller when availability coherence cannot be implemented. I numerically solve the model for varying cost-intensity levels of the low-quality product relative to the high-quality product to demonstrate why the platform may optimally allow for cross-channel price flexibility. Some basic intuition for this result is as follows. While the platform is concerned with both the number of intermediated sales and the per-sale revenue it earns from each intermediated sale, the seller is mainly concerned with the transaction-weighted average margin it earns between intermediated and direct sales. Price flexibility only changes the margin the seller earns through intermediated sales, but price coherence restricts the margin the seller earns through both intermediated and direct sales depending on its assortment choice. The platform must compensate the seller for this difference with a lower selling fee in order to tax the high-surplus product in intermediated sales under price coherence. Once the platform induces intermediated sale of the high-surplus product, however, the seller induces less marketplace leakage to direct sales under price coherence because its outside sales option becomes less profitable. When implementing price coherence, the platform thus faces a tradeoff between lower per-intermediated-transaction revenue and a larger number of intermediated transactions. Price coherence may be suboptimal if the seller retains a sufficiently profitable outside sales option from direct-only product listings to induce a significant number of direct sales.

The rest of the paper proceeds as follows. Section 2 reviews the relevant literature. Section 3 outlines the model. Section 4 analyzes the model, beginning by deriving the seller's optimal assortment and pricing strategies given arbitrary platform coherence policies and transaction fee levels, and proceeding to characterize equilibrium platform decisions under various implementable policy sets. Propositions are proven in the main text, and Appendix A contains proofs of all lemmas. Section 5 concludes.

2 Related Literature

This paper relates to a large literature that studies the economic effects of price coherence policies in platform markets. Edelman and Wright (2015) consider a market in which firms can make both intermediated and direct sales to consumers who have heterogenous costs to join a platform yet receive positive convenience benefits from intermediated transactions. Price coherence allows platforms to raise selling fees that are passed through to all consumers whether they join the platform or not. Wang and Wright (2020) and Wang and Wright (2016) model price coherence when platforms act as search engines for products. While a price coherence clause allows a platform to fully monetize the search cost reduction it provides to consumers, it harms consumers through higher prices and is not necessary to prevent showrooming. Hagiu and Wright (2023) study a variety of strategies platforms may use to prevent marketplace transaction leakage to direct sales. Their baseline model is closely related to mine in that a monopoly platform intermediates sales between a monopoly seller and consumers who incur heterogenous costs to purchase directly. A common result in these models so far discussed is that monopoly platforms always find it optimal to enforce price coherence.[3]

[3] Hagiu and Wright (2023) do show price coherence may be suboptimal in an extension of their baseline model, as discussed further below.

In contrast to general optimality of price coherence found by the above authors, I find that a monopoly platform need not prefer to implement price coherence. Other authors find similar results when platforms compete instead of monopolize intermediated product markets. Boik and Corts (2016) and Carlton and Winter (2018) find that price coherence policies tend to raise platform imposed selling fees and equilibrium product prices, and they may raise prices so high that price coherence hurts platform profits depending on the elasticity of aggregate demand. Johansen and Vergé (2017) and Calzada et al. (2020) come to a similar conclusion but focus on the constraint that a seller's options to delist from a platform in response to a price coherence clause imposes on transaction fees. Aside from a driving role of competing platforms, some authors identify separate reasons why price coherence may lower a monopoly platform's profits. Liu et al. (2021) show that price coherence may be suboptimal when the platform provides a convenience benefit to some consumer transactions but a share of consumers only ever consider purchasing directly. Price coherence increases the number of intermediated transactions but lowers the fee the platform charges for intermediated transactions because all consumers must realize this fee through their purchase price, not only those who transact through the platform. The authors show that the latter effect dominates under certain demand conditions. Mariotto and Verdier (2020) demonstrate how price coherence may be suboptimal for a monopoly platform when the platform provides heterogenous *seller*-side benefits and, like in Liu et al. (2021), the platform is not necessary for seller profitability. Finally, Hagiu and Wright (2023) show that price coherence may be suboptimal when buyers do not depend on the platform to discover the seller and the platform is uncertain about the nature of consumer preferences for intermediated transactions. I identify a new mechanism for why price coherence may be suboptimal for a monopoly platform, related to the presence of a multiproduct seller rather than a single-product seller on the platform.

None of the above-mentioned papers consider multiproduct sellers, and no papers that I am aware of study the relationship between multiproduct firms and price coherence. Miao (2022) studies seller strategic pricing in a related setting in which multiproduct firms sell a basic good and an ancillary good directly or through a platform. This could apply, for example, to airlines who sell tickets through online travel agencies and collect baggage fees directly on-site. He shows that with ad valorem fees sellers have incentives to shift revenue to the less taxed good. Miao (2022) takes the platform fee levels and the seller assortment decisions as exogenously given, whereas I endogenize and focus on these elements. He also considers platform fees that vary between the basic and ancillary good, whereas I consider a single platform fee that applies to both goods sold. I consider a single fee because I study vertically differentiated goods rather than complementary goods, and platforms tend to set a single fee that applies to all goods in a given product category. Wang and Wright (2017) study platform fee choice when a platform taxes with a single fee many independent products of various consumer valuations. Each product is sold by a single-product seller. They show that with a fixed per-transaction fee, the price elasticity of demand is too high for low-value goods and too low for high-value goods since the fee takes up a larger percentage of costs for low-value goods. An ad valorem fee alleviates this problem and can implement price discrimination. Wang and Wright (2017) assume that firms may only sell through the platform and do not have their own direct sales channels. My results suggest that the efficiency of an ad valorem fee may be dampened when sellers have a direct sales channel and market power. With the product structure of Wang and Wright (2017) and a direct sales channel, sellers have more incentive to sell high-value goods directly than they do for low-value goods. An ad valorem fee implements price discrimination when high value goods are sold through the platform, but it introduces per-product participation constraints on the platform's fee that tighten for higher value products.

Several authors have empirically studied the (non-assortment) effects of price coherence clauses following their ban in several European countries. Hunold et al. (2018) use travel metasearch data from the price comparison website Kayak to study effects of price coherence clauses on hotel pricing behaviors and their use of online travel agencies. They show that in Germany more hotels listed any rooms through online travel agencies, hotels more frequently undercut their intermediated prices with direct prices, and hotels listed rooms more frequently through online travel agencies after the ban on price coherence clauses relative to countries without any restriction of price coherence clauses. Montovani et al. (2020) use a natural experiment in France to investigate hotel pricing effects of Booking.com's price parity clause. They show that removal of the clause brought about a decrease in the average intermediated hotel listing price in the short run but had a less significant effect in the medium run. Ivaldi et al. (2023) use hotel-level transaction data to analyze changes in pricing behavior in European countries in response to the ban of price coherence clauses on Booking.com and Expedia. They find that hotel chains directly undercut the online travel agency listed prices without a price coherence clause in mid-level and luxury hotels but somewhat surprisingly not in budget hotels. In their analysis, Ivaldi et al. (2023) study the average price of each room booking through each channel in their main outcome variables but do not account for or consider different room types that make up that average. Undercutting direct prices with intermediated prices for a given room does not match economic theory, but considering how price coherence changes the menu of rooms offered through direct and intermediated selling channels as well as the prices of those rooms, as this paper calls attention to, may clarify their unexpected result.

3 Model

A monopoly seller S sells two vertically differentiated products, L and H, in a market intermediated by a monopoly platform M. There is a unit mass of buyers, each of whom wants to purchase at most one unit of L or one unit of H. S incurs per-unit costs c_L and $c_H \geq c_L$ to produce goods L and H, respectively. Buyers have homogenous valuations v_L and $v_H \geq v_L$ for goods L and H, respectively, where $v_H - c_H \geq v_L - c_L$. Consumers are completely unaware of S if it has no presence on M. S may however list products either through M, directly, or both, and it can draw consumers to products listed directly through its presence on M. Similarly to Hagiu and Wright (2023), each consumer incurs a cost s to directly purchase any product listed both through M and listed directly, where s is distributed over $[0, \bar{s}]$ according to a distribution function G with associated probability density function g. Each consumer incurs a search and switching cost $s(1 + \psi)$ to directly purchase any product listed only directly when S has presence on M. To match the pricing structure typically practiced by platforms that tax multiple goods in a given product class with a single fee,

M sets an ad valorem fee τ to be paid by S for each intermediated transaction. M enacts price and availability restriction policies $(\mathcal{P}, \mathcal{A}) \in \{PF, PC\} \times \{AF, AC\}$. A *price flexibility* policy $\mathcal{P} = PF$ places no cross-channel restriction on product prices, whereas a *price coherence* policy $\mathcal{P} = PC$ mandates that any product listed through M must exhibit its lowest price through M. Equivalently price coherence requires that if a product is listed both through M and directly, then the direct price must be at least as large as the intermediated price for that product. An *availability flexibility* policy $\mathcal{A} = AF$ places no cross-channel restriction on product availability, whereas an *availability coherence* policy $\mathcal{A} = AC$ mandates that any product listed directly must also be listed through M.

The timing of the game is as follows:

1. M enacts price and availability policies $(\mathcal{P}, \mathcal{A})$ and sets its fee τ.
2. S chooses which products to sell through M and directly. S chooses intermediated prices p_K^m for each product $K \in \{L, H\}$ listed through M and direct prices p_K^d for each product $K \in \{L, H\}$ listed directly. All choices adhere to policies $(\mathcal{P}, \mathcal{A})$.
3. Consumers draw their switching costs s. They choose whether to buy, through which channel to buy, and which product to buy.
4. All payoffs are realized.

3.1 Discussion of Assumptions

Homogenous valuations. The main mechanisms and results identified from the analysis of the model are robust to heterogenous consumer tastes for product quality. As written, the model allows for two interpretations due to its assumption of homogenous consumer tastes for quality. From a strict interpretation, production of L has mainly strategic assortment motivations because S would only make sales of the high-margin product H without any need for M. An alternative and preferred interpretation is that of a stylized model of more general buyer-platform-seller relationships which allow for heterogenous consumer valuations. From this latter interpretation in mind, $v_H - c_H \geq v_L - c_L$ is a very natural assumption because H would otherwise not be sold without any need for M. I present all results with the latter interpretation in mind. For example, S lists both L and H through the direct or intermediated selling channels in certain cases of equilibrium characterizations, even though it only makes sales of one product through each channel. This is because S would (depending on τ) make sales of both products through any channel that it lists multiple products through with heterogenous consumer tastes for quality. I maintain the assumption of homogenous valuations to keep the analysis tractable. Heterogenous valuations complicate formal analysis by introducing more feasible allocation and pricing strategies by S, but in Appendix C I show that the main mechanisms and results identified from analysis of the stylized model persist in a more general model that allows for heterogenous quality preferences.

Disutility from direct transactions. I follow Hagiu and Wright (2023) in assuming that consumers have heterogenous costs to purchase directly from S. These costs may be interpreted in many ways. In the model, consumers are unaware of S, and they begin their product search process through M. Thus, the disutility s may be interpreted as costs to switch channels and purchase directly. It may also encompass conveniences that M provides to reduce costs of transactions such as shipping services that reduce waiting time to receive a product, a sense of security from exposing oneself to financial privacy risks, and efficient checkout processes that reduce time spent inputting shipping and payment data. Consumers realize an extra cost ψs to directly purchase a product that is only listed directly. This may represent costs incurred to search for and evaluate products listed only through the direct channel once a consumer discovers the seller.

Ad valorem fees. I assume that M sets an ad valorem fee rather than a fixed fee to be paid by S in order to match the fee structure typically used in practice by platforms such as Amazon.com and Booking.com. These platforms set a single ad valorem fee that applies to all products sold from a given product category. Since I study a vertically differentiated product market, I thus consider a single ad valorem fee that applies to both product types L and H. Many authors assume that platforms set a fixed per-transaction fee to be paid by sellers to simplify analysis and argue that their results are robust to this choice of fee structure (e.g. Liu et al., 2022; Hagiu and Wright, 2023). The reason that ad valorem and fixed fees yield similar results in such analyses is because they consider (ex ante) homogenous single product sellers. Ad valorem fees differentially affect margins of products with different cost structures, and the results of this paper are closely tied to the underlying cost-structure of the two goods provided by S because of this.

Non-optional intermediary. M is necessary to facilitate discovery between buyers and sellers such that S cannot operate without at least partial presence on M. The strategic mechanisms identified in this paper would persist if M was "optional" to S's operation, but this would introduce another set of economic forces already studied by other authors (Johansen and Vergé (2017) and Calzada et al. (2020) in settings with competing platforms and Liu et al. (2021) and Mariotto and Verdier (2020) in settings with monopoly platforms). These authors study economic outcomes of price coherence and show that it may be a suboptimal pricing policy due to fee constraints imposed by sellers' abilities to delist and operate without presence on a platform. I assume that presence on M is necessary for buyer-seller discovery to isolate the role of strategic assortment by a multiproduct seller separately from the role of an optional intermediary.

4 Analysis

I proceed by backward induction to solve for subgame perfect NE. Sections 4.1-4.3 solve for S's optimal assortment and pricing strategies for given fee level τ and relevant policy choices $(\mathcal{P}, \mathcal{A})$. Section 4.4 characterizes M's optimal fee level and policy choices under various implementable policy sets.

4.1 Price and Availability Coherence

As a benchmark I consider the most stringent platform policy demands. Let $(\mathcal{P}, \mathcal{A}) = (PC, AC)$. M enforces both price and availability coherence (PAC). PAC effectively eliminates any direct selling option for S since S must gain consumer awareness through the intermediary to operate. AC makes S's assortment decision an all-or-nothing decision. Consumers prefer to purchase directly due to switching costs, so PC ensures that no consumer will purchase directly. Thus S will list both products through M as long as it is profitable to do so, and it will make only intermediated sales if it makes any sales. It will make intermediated sales only of the product for which it earns a higher intermediated margin after adjustment for τ.

Intermediated sale of a product $K \in \{L, H\}$ is profitable if and only if $(1-\tau)v_K - c_K \geq 0$, or $\tau \leq \frac{v_K - c_K}{v_K}$. Intermediated sale of product H is more profitable than that of L if and only if $(1-\tau)v_H - c_H \geq (1-\tau)v_L - c_L$, or $\tau \leq \tilde{\tau} \equiv \frac{(v_H - v_L)-(c_H - c_L)}{v_H - v_L}$. As formalized in Lemma 1, these two facts and the preceding logic demonstrate that S's assortment decision under PAC depends both on τ and the relative *cost-intensity* of production of each good.

Definition. The *cost-intensity* of good $K \in \{L, H\}$ is given by the ratio of its unit-cost to consumers' valuation for the good, $\frac{c_K}{v_K}$. Good H if *more cost-intensive* than good L if and only if $\frac{c_H}{v_H} \geq \frac{c_L}{v_L}$.

Note that H may be more cost-intensive than L even though $v_H - c_H \geq v_L - c_L$ by assumption. Let $\bar{\tau} \equiv \max\left\{\frac{v_L - c_L}{v_L}, \frac{v_H - c_H}{v_H}\right\}$ so that $\bar{\tau}$ is the maximal fee level for which S finds it profitable to make sales of either L or H through M. Recall that $\tilde{\tau}$ is the maximal fee level for which S finds it more profitable to sell H than L through M. Simple algebra verifies that $\tilde{\tau} \leq \bar{\tau}$ if and only if H is more cost-intensive than L. We obtain the following result.

Lemma 1 (*Assortment and Pricing Under PAC*). Suppose $(\mathcal{P}, \mathcal{A}) = (PC, AC)$. If $\tau \leq \bar{\tau}$, then S lists both products through M and all consumers purchase through M. Moreover:
(i) If H is more cost-intensive than L, then S sets price $p_{L,PAC} > v_L$ for L and $p_{H,PAC} = v_H$ for H for all $\tau \in [0, \tilde{\tau}]$; S sets $p_{L,PAC} = v_L$ and $p_{H,PAC} > v_H$ for all $\tau \in (\tilde{\tau}, \bar{\tau}]$.
(ii) If L is more cost-intensive than L, then S sets $p_{L,PAC} > v_L$ and $p_{H,PAC} = v_H$ for all $\tau \in [0, \bar{\tau}]$.

Appendix A contains proofs of all lemmas. A change in fee level τ differentially affects the profitability of an intermediated sale depending on how cost-intensive a product is to produce. S's profit from an intermediated sale of product $K \in \{L, H\}$ can be written as $(1-\tau)(v_K - \frac{c_K}{1-\tau})$, so S effectively faces convex costs in τ. A decrease in cost c_K relative to valuation v_K makes S's margin less sensitive to changes in τ at each fee level and allows intermediated sale of product K to yield higher profits at higher levels of τ. Thus, even though H provides a higher gross margin to S, S prefers to sell L through M at sufficiently high fee levels when H is more cost-intensive than L. S's multi-product listing behavior when H is more cost-intensive than L introduces a tradeoff that remains with M throughout the analysis: M must choose between implementing lower fees in order to tax higher value products and implementing higher fees in order to tax lower value products.

It is immediate that intermediated sales are not profitable for S under any price and availability policies if $\tau > \bar{\tau}$,. If S lists any products through M in this case, then it will price above valuations to avoid negative profit, gain awareness, or eliminate additional location costs ψs for a product listed directly. M then makes zero profit by setting a fee $\tau > \bar{\tau}$ and will not do so in equilibrium. I thus restrict all analysis in this and the following sections to the case when $\tau \leq \bar{\tau}$.

4.2 Price Flexibility

Now suppose $\mathcal{P} = PF$ so that M does not regulate cross-channel prices. If S does not make sales of a given product through M, then it can always list that product through M at a price higher than consumers' valuations for it to eliminate additional search costs ψs faced by any direct buyers and weakly increase profit. The equilibrium outcome then does not depend on the availability restriction policy $\mathcal{A} \in \{AF, AC\}$ when $\mathcal{P} = PF$. The following lemma simplifies further analysis under price flexibility.

Lemma 2 (*Assortment and Pricing Under PF*). Suppose $\mathcal{P} = PF$. S lists both L and H both through M and directly. Moreover:
(i) If H is more cost-intensive than L, then S sets $p^m_{L,PF} > v_L$ and $p^m_{H,PF} = v_H$ for all $\tau \in [0, \tilde{\tau}]$; S sets $p^m_{L,PF} = v_L$ and $p^m_{H,PF} > v_H$ for all $\tau \in (\tilde{\tau}, \bar{\tau}]$.
(ii) If L is more cost-intensive than L, then S sets $p^m_{L,PF} > v_L$ and $p^m_{H,PF} = v_H$ for all $\tau \in [0, \bar{\tau}]$.
(iii) S sets $p^d_{L,PF} \geq v_L$ and $p^d_{H,PF} < v_H$ whenever $\tau > 0$.

Lemma 2 states that S only ever make sales of one product through each channel. Like in the *PAC* case, whether S makes sales of L or H through M depends on the level of τ and the relative cost-intensity of producing L and H. S prices at consumers' valuations through M to minimize consumers' option outside of direct sales. Giving consumers a positive surplus from purchasing through M makes it more costly for S to induce direct sales and lowers the margin earned through intermediated sales. S always induces a positive amount of marketplace leakage through direct sales of the higher margin product H. With no leakage induced, S could marginally decrease the direct price of H from v_H to earn a discontinuous increase in margin of τv_H from direct sale to low switching cost consumers while keeping overall demand constant. The fact that S makes sales of only a single product in either channel is a result of the assumption that consumers have homogenous tastes for quality. This assumption maintains tractability of the model by limiting consumer heterogeneity to only one source, switching costs, but the main results hold with heterogenous quality preferences as shown in Appendix C. With homogenous quality preferences, the analysis under price flexibility simplifies similarly to that in the single-product baseline case from Hagiu and Wright (2023), with an ad valorem instead of a fixed transaction fee and with differing products sold in each channel depending on the fee level and relative cost-intensities.

Consumers earn zero surplus through intermediated sales, so a consumer purchases H directly if and only if $s \leq v_H - p^d_H$. When S sells H in any intermediated sales, it chooses a direct price for H to solve

$$\max_{p^d_H} [(1-\tau)v_H - c_H][1 - G(v_H - p^d_H)] + (p^d_H - c_H)G(v_H - p^d_H).$$

Conditions on τ and relative cost-intensities under which this case applies are characterized by Lemma 2. As in Hagiu and Wright (2023), assume G is well behaved so that there is a unique solution to S's first order conditions. A sufficient condition is that $\frac{G(x)}{g(x)}$ is increasing, which is ensured, for example, by assuming g is weakly decreasing and continuous over its support. Let $p^d_{HH,PF}(\tau)$ denote the optimal direct price of H when S sells H in any intermediated sales under PF. The first order condition for $p^d_{HH,PF}(\tau)$ is

$$p^d_{HH,PF}(\tau) = (1-\tau)v_H + \frac{G\left(v_H - p^d_{HH,PF}(\tau)\right)}{g\left(v_H - p^d_{HH,PF}(\tau)\right)}.$$

When S sells L in any intermediated sales, it chooses a direct price for H to solve

$$\max_{p^d_H}[(1-\tau)v_L - c_L][1 - G(v_H - p^d_H)] + (p^d_H - c_H)G(v_H - p^d_H).$$

Conditions on τ and relative cost-intensities under which this case applies are characterized by Lemma 2. Let $p^d_{LH,PF}(\tau)$ denote the optimal direct price of H when S sells L in any intermediated sales under PF. The first order condition for $p^d_{LH,PF}(\tau)$ is

$$p^d_{LH,PF}(\tau) = (1-\tau)v_L + (c_H - c_L) + \frac{G\left(v_H - p^d_{LH,PF}(\tau)\right)}{g\left(v_H - p^d_{LH,PF}(\tau)\right)}.$$

Lemma 2 along with $p^d_{HH,PF}(\tau)$ and $p^d_{LH,PF}(\tau)$ characterize S's assortment and pricing response under price flexibility to any $\tau \in [0, \bar{\tau}]$. Note that as $p^d_{LH,PF}(\tau)$ and $p^d_{LH,PF}(\tau)$ decrease in τ, S more aggressively induces leakage in response to larger fee levels.

4.3 Price Coherence

Suppose $(\mathcal{P}, \mathcal{A}) = (PC, AF)$ so that M enforces price coherence but does not restrict cross-channel availability. S must list at least one product through M to gain consumer awareness and avoid a zero profit. S may list only L through M, only H through M, or both L and H through M. If both L and H are listed through M, then S will only make intermediated sales of one product so that removing the other product from M to have the opportunity to induce leakage through direct sales weakly increases S's profits. Then S exclusively lists either L or H through M, and all (if any) sales of that product will be made through M due to PC and the existence of switching costs. As in the PF case, S will minimize consumers' option outside of direct sales and maximize its intermediated profit margin by setting the intermediated product's price equal to consumers' valuation for that product. Under price coherence, S earns respective profits from listing only L or only H through M of

$$\max_{p_H^d}[(1-\tau)v_L - c_L]\left[1 - G\left(\frac{v_H - p_H^d}{1+\psi}\right)\right] + (p_H^d - c_H)G\left(\frac{v_H - p_H^d}{1+\psi}\right),$$
$$\max_{p_L^d}[(1-\tau)v_H - c_H]\left[1 - G\left(\frac{v_L - p_L^d}{1+\psi}\right)\right] + (p_L^d - c_L)G\left(\frac{v_L - p_L^d}{1+\psi}\right).$$

First order conditions for the optimal direct product price when S lists only L or only H through M are respectively

$$p_{H,PC}^d(\tau) = (1-\tau)v_L + (c_H - c_L) + (1+\psi)\frac{G\left(\frac{v_H - p_{H,PC}^d(\tau)}{1+\psi}\right)}{g\left(\frac{v_H - p_{H,PC}^d(\tau)}{1+\psi}\right)},$$
$$p_{L,PC}^d(\tau) = (1-\tau)v_H - (c_H - c_L) + (1+\psi)\frac{G\left(\frac{v_L - p_{L,PC}^d(\tau)}{1+\psi}\right)}{g\left(\frac{v_L - p_{L,PC}^d(\tau)}{1+\psi}\right)}.$$

These first order conditions characterize S's pricing decision under its two possible assortment decisions. As in the *PF* case, S sets a direct price to be its opportunity cost of an intermediated sale with an additional markup.

Now consider S's assortment decision. When $\tau = 0$, no leakage is optimal, and S will only sell H, the product with the highest realized margin, through M; when $\tau = \bar{\tau}$, only direct sales make positive profits, so S will gain awareness by listing L through M and making direct sales of H, the product with the highest realized margin. This idea extends to relatively high and low fee levels $\tau \in [0, \bar{\tau}]$ beyond the endpoints $\tau = 0$ and $\tau = \bar{\tau}$, as Lemma 3 formalizes.

Lemma 3 (*Assortment Under PF*). There exists a cutoff fee level $\tau^* \in (0, \bar{\tau})$ such that S lists only H through M for all $\tau \in [0, \tau^*]$ and S lists only L through M for all $\tau \in (\tau^*, \bar{\tau}]$.

S finds it more profitable to list only the higher margin product H through M when M does not extract too much of the surplus from these transactions. S relies relatively more on H than L to earn profit. The proof of Lemma 3 shows that this makes S's profit more sensitive to τ when H is listed through M compared to when L is listed through M, and there is a single crossing between profit functions from each of these assortment strategies.

4.4 Platform Policy and Fee Choice

4.4.1 Unrestricted Policy Set

Having solved for S's stage two assortment and pricing responses, consider M's stage one policy and fee choice. When all policies are available for M to implement, *PAC* strictly dominates *PF* and *PC*.

Proposition 1 (*Optimality of PAC*). M optimally chooses $(\mathcal{P}, \mathcal{A}) = (PC, AC)$.
(i) If H is more cost-intensive than L, then M's optimal fee is given by

$$\tau^{PAC} = \begin{cases} \tilde{\tau} & \text{if } \tilde{\tau} v_H \geq \bar{\tau} v_L, \\ \bar{\tau} & \text{if } \tilde{\tau} v_H < \bar{\tau} v_L. \end{cases}$$

(ii) If L is more cost-intensive than H, then M's optimal fee is given by $\tau^{PAC} = \bar{\tau}$.

The optimal fee τ^{PAC} maximizes per-intermediated-transaction revenue and follows from Lemma 1. M chooses τ just small enough to make S's sale of M's targeted intermediated product profitable and more profitable than the untargeted product. Once τ satisfies this targeted product participation constraint, all consumers purchase the targeted product through M since *PAC* effectively eliminates any outside sales option for S. Without either *PC* or *AC*, S retains a feasible direct sales option, and the maximal per-intermediated-transaction revenue achieved by τ^{PAC} can only be achieved by inducing positive leakage through direct sales. Thus, *PAC* is optimal.

4.4.2 Restricted Policy Set

With some exceptions, *AC* may not be prevalently observed due to enforcement or regulatory limitations. Consider the case when M cannot implement *AC*. Reduction of τ below τ^{PAC} under *AF* lowers M's per-intermediated-transaction revenue but may also have the positive effect of increasing the volume of intermediated transactions.

Before studying M's optimal policy and fee choice under *AF*, it is useful to consider how a fixed exogenous fee level τ performs across policies *PF* and *PC*. Recall that S makes intermediated sales of H under *PF* if $\tau \leq \tilde{\tau}$. S makes intermediated sales of H under *PC* if $\tau \leq \tau^*$. It is easily verified that $\tau^* \leq \tilde{\tau}$. Thus $\tau \leq \tau^*(\leq \tilde{\tau})$ achieves the same per-intermediated-transaction revenue for M under both pricing policies *PF* and *PC*. However, for $\tau \leq \tau^*(\leq \tilde{\tau})$ S makes direct sales of H under *PF* but of L under *PC*, so S's outside sales option, and its incentive to induce leakage through direct sales, decreases under *PC*. M prefers *PC* over *PF* for a fixed fee $\tau \leq \tau^*$ because it earns the same per-transaction revenue on weakly more transactions under *PC*. M also prefers *PC* over *PF* for a fixed fee level $\tau \geq \tilde{\tau}(\geq \tau^*)$ because S sells L through M under both policies but consumers incur additional costs ψs to purchase H directly under *PC*.

Now consider a fee $\tau \in (\tau^*, \tilde{\tau})$ fixed across *PF* and *PC*. Such a fee induces S to make intermediated sales of H under *PF* but of L under *PC*, so M earns a lower per-intermediated-transaction revenue under *PC*. S experiences an ambiguous change in incentives to induce leakage through direct sales when faced with a policy shift from *PF* to *PC*. On one hand, S has an increased incentive to shift sales directly because its intermediated sales option changes from H to L and becomes relatively less attractive, while its direct sales option remains the same. However, it becomes more costly for S to induce direct sales of H because consumers incur switching and location costs $s(1+\psi)$ under *PC* compared to s under *PF*. Depending on the additional costs ψs to locate an unlisted product off-platform, S may induce more or less leakage under *PC* compared to *PF*. For a fixed fee level in this case, S's strategic assortment decision may negate any profitable effects of the cost imposition M places on S to induce direct sales under PC. These results on leakage across policies at a fixed fee level are summarized by Lemma 4.

Lemma 4 (*Leakage Across PF and PC*). Suppose $\mathcal{A} = AF$ and fix a fee level τ across price restriction policies PF and PC.
(i) If $\tau \in [0, \tau^*] \cup [\tilde{\tau}, \bar{\tau}]$, then S induces more leakage under PF than it does under PC.
(ii) If $\tau \in (\tau^*, \tilde{\tau})$ then there exists a cutoff value $\psi^*(\tau)$, increasing in τ, such that S induces more leakage under PF than it does under PC if and only if $\psi > \psi^*(\tau)$.

Of course, M does not necessarily choose the same fee level across policies, but Lemma 4 remains useful when studying M's optimal fee and policy choice under AF. Let τ^{PF} and τ^{PC} denote M's optimal fee choices when $\mathcal{P} = PF$ and $\mathcal{P} = PC$, respectively. These are given by

$$\tau^{PF} = \arg\max_{\tau \in [0,\bar{\tau}]} \begin{cases} 1_{\tau\in[0,\tilde{\tau}]} \cdot \tau v_H \left[1 - G\left(v_H - p^d_{HH,PF}(\tau)\right)\right] + 1_{\tau\in(\tilde{\tau},\bar{\tau}]} \cdot \tau v_L \left[1 - G\left(v_H - p^d_{LH,PF}(\tau)\right)\right] & \text{if } \dfrac{c_H}{v_H} \geq \dfrac{c_L}{v_L}, \\ \tau v_H \left[1 - G\left(v_H - p^d_{HH,PF}(\tau)\right)\right] & \text{if } \dfrac{c_H}{v_H} < \dfrac{c_L}{v_L}, \end{cases}$$

$$\tau^{PC} = \arg\max_{\tau} 1_{\tau\in[0,\tau^*]} \cdot \tau v_H \left[1 - G\left(\frac{v_H - p^d_{H,PC}(\tau)}{1+\psi}\right)\right] + 1_{\tau\in(\tau^*,\bar{\tau}]} \tau v_L \left[1 - G\left(\frac{v_L - p^d_{L,PC}(\tau)}{1+\psi}\right)\right].$$

Unlike many results in the literature on general optimality of PC, M may optimally implement PF in certain cases.

Proposition 2 (*Optimal Pricing Restriction Under AF*). Suppose M cannot implement $\mathcal{A} = AC$.
(i) If $\tau^{PF} \leq \tau^*$, then M optimally implements $\mathcal{P} = PC$.
(ii) If $\tau^{PF} > \tau^*$, then $\mathcal{P} = PC$ need not be M's optimal price restriction policy.

To see Proposition 2(i), suppose $\tau^{PF} \leq \tau^*$. Then S sells H through M under PF and continues to do so under PC at $\tau = \tau^{PF}$. S induces less leakage under PC by Lemma 4(i), so switching from PF to PC at $\tau = \tau^{PF}$ maintains M's per-transaction revenue and increases the number of intermediated transactions. Since M's profit can be improved by PC at τ^{PF}, the fee that maximizes M's profit under PF, M's optimal profit under PC must be greater than that under PF. I verify Proposition 2(ii) with the numerical example in Section 4.4.3. Some basic intuition for why the optimal pricing restriction policy may be ambiguous is as follows. While M is concerned with both the number of intermediated sales and the revenue it earns from each intermediated sale, S is mainly concerned with the transaction-weighted average margin it earns between intermediated and direct sales because it always makes sales to every consumer. PF only changes the margin S earns through intermediated sales, but PC restricts the margin S earns through both intermediated and direct sales when S makes intermediated sales of H. M must compensate S for this difference in order to tax H in intermediated sales. This compensation may be suboptimal if S retains a sufficiently profitable outside sales option and induces a significant number of direct sales.

4.4.3 Numerical Example

To illustrate M's tradeoff between PF and PC and to verify Proposition 2(ii), I numerically solve the model with uniform switching costs. I keep specific choices of v_H, v_L, c_H, $\bar{s}$, and ψ constant, and I vary c_L over the interval $[v_L - (v_H - c_H), c_H]$, which includes all permissible values for c_L such that $c_L \leq c_H$. As c_L varies over this interval, the difference in cost intensities $\frac{c_L}{v_L} - \frac{c_H}{v_H}$ varies symmetrically about zero. Figure 1 shows the results from this exercise. Appendix B demonstrates robustness of these results to the fixed parameter choices.

A main observation from Figure 1 is that M prefers PC for low and high levels of c_L, but it prefers PF for intermediate levels of c_L. This is driven by a tradeoff M faces between per-intermediated-transaction revenue and number of intermediated transactions. Notice that M sets $\tau^{PC} \leq \tau^{PF}$ whenever it induces sale of the same product under both pricing restriction policies. In such situations, it earns lower per-intermediated-transaction revenue under PC; however, it taxes more intermediated sales under PC because S is taxed by a weakly lower fee, it must account for extra costs ψs experienced by consumers to induce direct sales, and it may sell the relatively lower margin product L in direct sales. Below I explain in detail these and all other aspects of Figure 1.

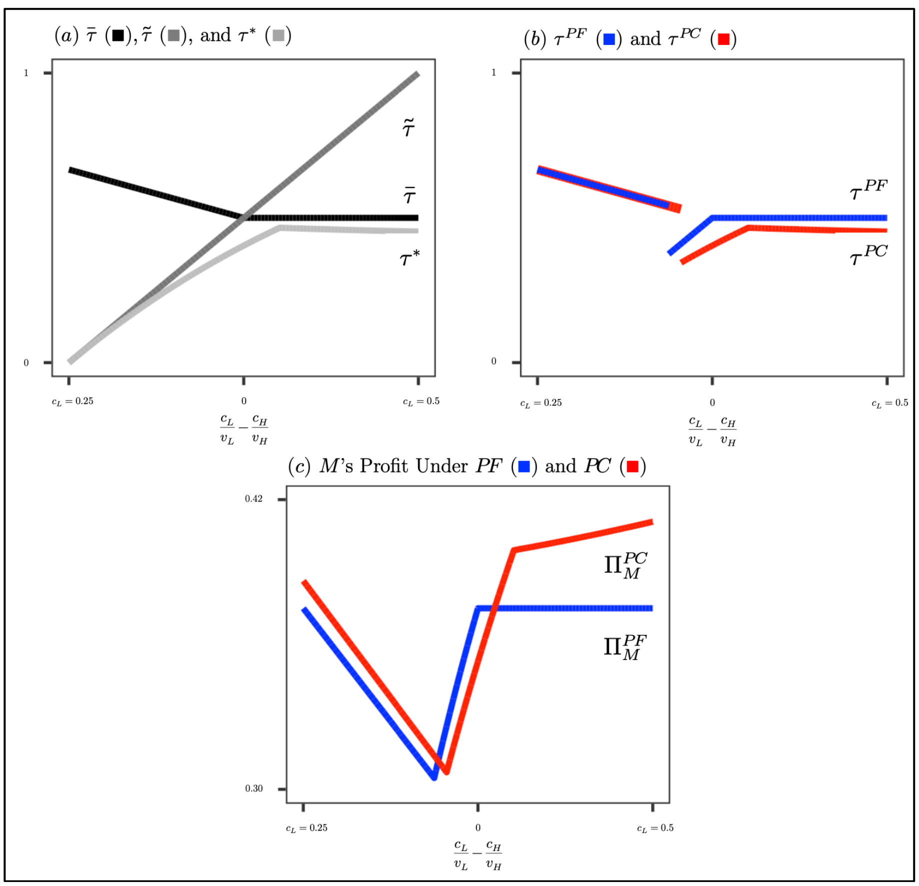

Figure 1

Parameters: $s \sim U[0, \bar{s} = 1], v_H = 1, v_L = 0.75, c_H = 0.5, \psi = 0.1, c_L \in [0.25, 0.5]$

In the example illustrated by Figure 1, $\bar{s}$ is relatively high such that consumers with the maximal switching cost $s = \bar{s}$ would not purchase either product directly at any positive price. A high level of $\bar{s}$ is not necessary for *PF* to dominate *PC*, but it simplifies exposition in the following way.[4] S never optimally covers the market only through direct sales, even if it earns zero margin in intermediated sales. Further, as shown in Panels (a) and (b) of Figure 1, M never finds it optimal to lower its fee below what is needed to make S indifferent about selling M's targeted intermediated product through M. Under *PF*, M either chooses a high fee level $\bar{\tau}$ to extract all surplus in intermediated sales or the lower fee level $\tilde{\tau}$ when $\frac{c_H}{v_H} > \frac{c_L}{v_L}$ to just induce S to make intermediated sales of H. Under *PC*, M either chooses a high feel level $\bar{\tau}$ to extract all surplus from intermediated sales of L when $\frac{c_H}{v_H} > \frac{c_L}{v_L}$ or the lower fee level τ^* to just induce S to make intermediated sales of H.

Recall that M must set $\tau \leq \tilde{\tau}$ to induce S to sell H through M under *PF*, and M must set $\tau \leq \tau^*$ to induce S to sell H through M under *PC*. When $\frac{c_H}{v_H} > \frac{c_L}{v_L}$, ad valorem fees are relatively more costly to S's sale of H than they are to its sale of L. In addition to this, for low levels of c_L, S's margin is similar for direct sales of L and H in this example. Thus for low levels of c_L, M must set τ very low to induce S to sell H through M under either pricing policy ($\tilde{\tau}$ and τ^* are low for low c_L). Instead, M optimally sets $\tau^{PF} = \tau^{PC} = \bar{\tau} = \frac{v_L - c_L}{v_L}$ for low levels of c_L to extract all surplus from intermediated sales of L rather than a small share of surplus from intermediated sales of H. M prefers *PC* over *PF* for small c_L because *PC* increases the cost for M to induce leakage through direct sales of H due to additional search costs ψs.

As $\frac{c_L}{v_L}$ increases to $\frac{c_H}{v_H}$, $\bar{\tau} = \frac{v_L - c_L}{v_L}$ decreases so that M earns less per-transaction revenue by inducing intermediated sale of L, meanwhile $\tilde{\tau}$ and τ^* increase so that more per-transaction revenue may be earned by inducing intermediated sale of H. Eventually, as $\frac{c_L}{v_L}$ increases but remains below $\frac{c_H}{v_H}$, S switches to the lower fees $\tau^{PF} = \tilde{\tau}$ and $\tau^{PC} = \tau^*$ in order to induce sales of H rather than L through M. This switch occurs sooner under *PF* because it is more costly for M to induce this switch under *PC* ($\tau^* < \tilde{\tau}$) for any given $c_L > 0$. This is because S must forgo direct sales of H when it sells H through M under *PC* but not under *PF*. M thus achieves increasing profits by switching to a lower fee level under *PF* before it does so under *PC*, and *PF* dominates *PC* for some values of c_L for which M sets $\tau^{PF} = \tilde{\tau}$ (increasing in c_L) and $\tau^{PC} = \bar{\tau}$ (decreasing in c_L).

Once M switches to the lower fee level under both pricing policies, it faces the following tradeoff. On one hand, $\tau^{PC} < \tau^{PF}$ so that M earns a higher per-transaction revenue under *PF*. On the other hand, more transactions occur through M under *PC* because $\tau^{PC} < \tau^{PF}$ and S retains a less attractive direct sales option of L rather than H under *PC*. The former effect dominates the latter for intermediate values of c_L because S's direct sales option remains sufficiently profitable to induce significant leakage under *PC*. *PF* dominates *PC* for intermediate levels of c_L. Once c_L is high enough so that $\frac{c_L}{v_L} = \frac{c_H}{v_H}$, M sets $\tau^{PF} = \bar{\tau} = \frac{v_H - c_H}{v_H}$ to extract all surplus from intermediated transactions of H under *PF*. Any further increase in c_L has no effect on M's problem under *PF* because S sells H both through M and directly. However, further increase in c_L continues to decrease

[4] For instance, *PF* also dominates *PC* for some c_L in the example with each $\bar{s} \in \{0.25, 0.50, 0.75\}$ rather than $\bar{s} = 1$, as shown in Appendix B.

S's direct sales margin under PC and increases the volume of intermediated transactions of H under PC. Although τ^{PC} remains below τ^{PF} for high c_L, the loss in per-transaction revenue relative to PF is offset by the increase in the number of intermediated transactions. M prefers PC over PF for high c_L.

A mismatch in M's and S's incentives plays a central role in why PF may dominate PC. While M is concerned with both the number of intermediated sales and the per-intermediated-sale revenue it earns from each intermediated sale, S is mainly concerned with the transaction-weighted average margin it earns between intermediated and direct sales because it always makes sales to every consumer. PF only changes the margin S earns through intermediated sales, but PC restricts the margin S earns through both intermediated and direct sales when S makes intermediated sales of H. M must compensate S for this difference in order to tax H in intermediated sales. This compensation may be suboptimal if S retains a sufficiently profitable outside sales option and induces a significant number of direct sales.

5 Conclusion

In this paper, I argue that existence of a multiproduct seller on a platform introduces two strategic mechanisms that a firm and a platform can use to interact in a typical platform market: strategic assortment and availability coherence clauses. A seller may make strategic assortment decisions by varying its menu of available products across selling channels, and a platform may restrict this behavior by enforcing an availability coherence clause. I show that strategic assortment plays a significant role in seller-platform relationships that lessens the power of platforms in many situations. While a price coherence clause allows a platform to fully monetize the access it provides between a seller and consumers in a single-product firm setting, a multiproduct firm's ability to gain market access by partial presence on a platform weakens and, in some cases, reverses this result. A platform can recover its ability to fully monetize access by pairing a price coherence clause with an availability coherence clause, but this may not be feasible from an implementation or regulation standpoint, as it effectively eliminates any off-platform sales option available to a participating seller. As platforms continue to carry out fundamental capacities in many buyer-seller relationships across industries, the strategic roles introduced by varying product scope provided by sellers should be considered in study and further regulation evaluations.

In this paper, I focus on the relationship between the presence of a multiproduct seller on a platform and platform coherence policies. A critical assumption in the analysis is that sellers may gain market awareness by partial presence on a platform. Considerable attention has recently been drawn to algorithmic steering on platforms, where platforms may punish certain seller behaviors by hiding their products from consumer view. Even without price and availability coherence clauses, if platforms steer based on product availability, then strategic assortment may be less effective for sellers than it is in this setting. Platforms have also drawn attention for acting dually as intermediaries and sellers, using data collected by third party sellers to inform their own market entry and product design decisions. This may present another important component of strategic assortment. Optimal assortment strategies may change if a platform is fundamental to seller discovery but also increases competition in product markets present on the platform. This paper is one of the first to consider the role that multiproduct sellers play in platform markets, and it would be interesting to investigate their role in these and other aspects of platform markets in future work.

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Appendix A: Omitted Proofs

Proof of Lemma 1: The statement follows from the argument in the main text and the following algebraic equivalences:

$$\frac{c_L}{v_L} \leq \frac{c_H}{v_H} \Leftrightarrow \frac{v_H - c_H}{v_H} \leq \frac{v_L - c_L}{v_L}$$
$$\Leftrightarrow \tilde{\tau} \leq \frac{v_H - c_H}{v_H}. \blacksquare$$

Proof of Lemma 2: From the proof of Lemma 1, intermediated sales of H at price v_H are more profitable than those of L at price v_L if and only if $\tau \in \left[0, \min\left\{\frac{v_H - c_H}{v_H}, \tilde{\tau}\right\}\right]$. Suppose S makes intermediated sales of L when $\tau \in \left[0, \min\left\{\frac{v_H - c_H}{v_H}, \tilde{\tau}\right\}\right]$. Then any consumer who purchases L through M earns a surplus of $v_L - p_L^m$. Any consumer who purchases H through M must earn the same surplus, otherwise all consumers would have the same strict preference for either L or H in intermediated sales. Then by setting the intermediated price of H to $p_H^m = p_L^m + (v_H - v_L)$ and slightly raising the intermediated price of L, S makes consumers strictly prefer purchasing H through M to purchasing L through M without changing their surplus earned through intermediated purchase. Thus, this action produces no profitable deviation for any consumer who purchases directly but yields S a higher profit from intermediated sales:

$$(1-\tau)p_H^m - c_H = (1-\tau)[p_L^m + (v_H - v_L)] - c_H \geq (1-\tau)p_L^m - c_L \Leftrightarrow \tau \leq \tilde{\tau}.$$

A similar argument shows that S will not make intermediated sales of H when $\tau \in \left[\min\left\{\frac{v_H - c_H}{v_H}, \tilde{\tau}\right\}, \bar{\tau}\right]$.

To show that intermediated sales are priced at consumer valuations, consider again the case when $\tau \in \left[0, \min\left\{\frac{v_H - c_H}{v_H}, \tilde{\tau}\right\}\right]$, so that only intermediated sales of H are made. If $p_H^m > v_A$, then S makes no intermediated sales of H. Given $\tau \leq \frac{v_H - c_H}{v_H}$, so that an intermediated sale of H is profitable, S can attract any consumers with high switching costs who do not purchase directly (if any) by setting $p_H^m = v_H$ to weakly increase profit. Any consumers who purchase through M at this price earn zero surplus, so no demand is drawn away from direct sales by this action. It is immediate that S only makes direct sales of H since it has a higher margin on that product. Then if instead, $p_H^m < v_H$, S earns

$$[(1-\tau)p_H^m - c_H][1 - G(p_H^m - p_H^d)] + (p_H^d - c_H)G(p_H^m - p_H^d).$$

S can increase both p_H^m and p_H^d by a small amount to increase its margin on sales from both channels without changing demand through either channel. Thus, $p_H^m = v_H$. A similar argument shows that when S makes sales of L through M, it sets $p_L^m = v_L$. This completes the proof of (i) and (ii). To see $p_H^d < v_H$ and verify (iii), note that if $p_H^d \geq v_H$, then S makes no direct sales of H. Making a small decrease to the direct price from v_H makes a discontinuous increase of τv_H in the margin on direct sales from those with low switching costs without changing overall demand. ■

Proof of Lemma 3: Write S's respective profits from listing only L or only H through M as

$$\Pi_S^{LPC}(\tau) \equiv \max_{p_H^d} [(1-\tau)v_L - c_L]\left[1 - G\left(\frac{v_H - p_H^d}{1+\psi}\right)\right] + (p_H^d - c_H)G\left(\frac{v_H - p_H^d}{1+\psi}\right),$$
$$\Pi_S^{HPC}(\tau) \equiv \max_{p_L^d} [(1-\tau)v_H - c_H]\left[1 - G\left(\frac{v_L - p_L^d}{1+\psi}\right)\right] + (p_L^d - c_L)G\left(\frac{v_L - p_L^d}{1+\psi}\right).$$

It is immediate that $\Pi_S^{HPC}(0) \geq \Pi_S^{LPC}(0)$ and $\Pi_S^{LPC}(\bar{\tau}) \geq \Pi_S^{HPC}(\bar{\tau})$ and that $\Pi_S^{LPC}(\tau) \geq \Pi_S^{HPC}(\tau)$ for all $\tau \geq \tilde{\tau}$ since intermediated profits are larger for L than H for such τ. The first two inequalities hold strictly when $v_H - c_H > v_L - c_L$. Then since $\Pi_S^{LPC}(\tau)$ and $\Pi_S^{HPC}(\tau)$ are continuous over $[0, \bar{\tau}]$, by showing $\frac{d\Pi_S^{LPC}(\tau)}{d\tau} \geq \frac{d\Pi_S^{HPC}(\tau)}{d\tau}$ for all $\tau \in [0, \min\{\tilde{\tau}, \bar{\tau}\}]$, we may conclude that $\Pi_S^{LPC}(\tau)$ and $\Pi_S^{HPC}(\tau)$ intersect at some unique fee level $\tau^* \in (0, \bar{\tau})$. Using the Envelope theorem, compute

$$\frac{d\Pi_S^{LPC}(\tau)}{d\tau} = -v_L\left[1 - G\left(\frac{v_H - p_{H,PC}^d(\tau)}{1+\psi}\right)\right],$$
$$\frac{d\Pi_S^{HPC}(\tau)}{d\tau} = -v_H\left[1 - G\left(\frac{v_L - p_{L,PC}^d(\tau)}{1+\psi}\right)\right].$$

Notice that $\frac{d\Pi_S^{LPC}(\tau)}{d\tau} \geq \frac{d\Pi_S^{HPC}(\tau)}{d\tau}$ if more leakage is induced when L is listed through M than when H is listed through M at any τ, or when $v_H - p^d_{H,PC}(\tau) \geq v_L - p^d_{L,PC}(\tau)$. The first order conditions for $p^d_{L,PC}(\tau)$ and $p^d_{H,PC}(\tau)$ can be rewritten as

$$-[v_L - p^d_{L,PC}(\tau)] = (1-\tau)v_H - v_L - (c_H - c_L) + (1+\psi)\frac{G\left(\dfrac{v_L - p^d_{L,PC}(\tau)}{1+\psi}\right)}{g\left(\dfrac{v_L - p^d_{L,PC}(\tau)}{1+\psi}\right)},$$

$$-[v_H - p^d_{H,PC}(\tau)] = (1-\tau)v_L - v_H + (c_H - c_L) + (1+\psi)\frac{G\left(\dfrac{v_H - p^d_{H,PC}(\tau)}{1+\psi}\right)}{g\left(\dfrac{v_H - p^d_{H,PC}(\tau)}{1+\psi}\right)}.$$

Now $\tau \leq \tilde{\tau}$ implies

$$(1-\tau)v_L - v_H + (c_H - c_L) \leq (1-\tau)v_H - v_L - (c_H - c_L),$$

so that the rewritten first order condition for $p^d_{H,PC}(\tau)$ implies

$$-[v_H - p^d_{H,PC}(\tau)] \leq (1-\tau)v_H - v_L - (c_H - c_L) + (1+\psi)\frac{G\left(\dfrac{v_H - p^d_{H,PC}(\tau)}{1+\psi}\right)}{g\left(\dfrac{v_H - p^d_{H,PC}(\tau)}{1+\psi}\right)}.$$

Then by the rewritten first order condition for $p^d_{L,PC}(\tau)$ and since $\frac{G(x)}{g(x)}$ is increasing, we must have $v_H - p^d_{H,PC}(\tau) \geq v_L - p^d_{L,PC}(\tau)$. ■

Proof of Lemma 4: (ii) Let $\tau \in (\tau^*, \tilde{\tau})$ be given. S only sells L through M under PC, and S only sells H through M under PF. S induces more leakage under PF than it does under PC if and only if

$$\frac{v_H - p^d_{H,PC}(\tau)}{1+\psi} \geq v_H - p^d_{HH,PF}(\tau).$$

We can rewrite the first order condition for $p^d_{H,PC}(\tau)$ and $p^d_{HH,PF}(\tau)$ as

$$-\left[\frac{v_H - p^d_{H,PC}(\tau)}{1+\psi}\right] = \frac{1}{1+\psi}[(1-\tau)v_L - v_H + (c_H - c_L)] + \frac{G\left(\dfrac{v_H - p^d_{H,PC}(\tau)}{1+\psi}\right)}{g\left(\dfrac{v_H - p^d_{H,PC}(\tau)}{1+\psi}\right)},$$

$$-[v_H - p^d_{HH,PF}(\tau)] = -\tau v_H + \frac{G\left(v_H - p^d_{HH,PF}(\tau)\right)}{g\left(v_H - p^d_{HH,PF}(\tau)\right)}.$$

Since $\tau \leq \tilde{\tau}$, $(1-\tau)v_H - c_H \geq (1-\tau)v_L - c_L$, which along with $\frac{G(x)}{g(x)}$ increasing implies from the rewritten first order condition for $p^d_{H,PC}(\tau)$ that

$$-\left[\frac{v_H - p^d_{H,PC}(\tau)}{1+\psi}\right] \leq -\tau v_H + \frac{G\left(\frac{v_H - p^d_{H,PC}(\tau)}{1+\psi}\right)}{g\left(\frac{v_H - p^d_{H,PC}(\tau)}{1+\psi}\right)}$$

only for ψ sufficiently small. From the first order condition for $p^d_{HH,PF}(\tau)$, this expression implies

$$\frac{v_H - p^d_{H,PC}(\tau)}{1+\psi} \geq v_H - p^d_{HH,PF}(\tau).$$

Thus, there exists $\psi^*(\tau)$ satisfying the stated criteria. Since $p^d_{H,PC}(\tau)$ decreases in τ, $\psi^*(\tau)$ increases in τ. This completes the proof of (ii). A similar argument confirms that S always induces more leakage under *PF* than it does under *PC* for $\tau \leq \tau^*$. If $\tau \geq \tilde{\tau}$, then S sells L through M and H directly under both *PF* and *PC*, but it is more costly to induce leakage under *PC* due to the additional costs ψs. Thus S induces more leakage under *PF* than *PC* for $\tau \geq \tilde{\tau}$ as well, which completes the proof of (i). ■

Appendix B: Robustness of the Numerical Example

Section 4.4.3 demonstrates how *PC* need not dominate *PF*. Here I demonstrate the robustness of this result to differing values of the fixed parameters in that example. As in Section 4.4.3, I numerically solve the model with uniform switching costs. I normalize $v_H = 1$ and consider various values for ψ and $\bar{s}$. For each choice of ψ and $\bar{s}$, I allow (v_L, c_H) to uniformly vary over a discretized set $[0,1] \times [0,1]$. For each specification of $(\psi, \bar{s}, v_L, c_H)$, I solve for M's optimal profits under *PF* and *PC* for all c_L over a discretized interval $[c_L^{\min}, c_L^{\max}]$, where $c_L^{\min} \equiv \min\{0, v_L - (v_H - c_H)\}$ and $c_L^{\max} \equiv \min\{v_L, c_H\}$. Thus, for each ψ and $\bar{s}$, I consider all permissible values of (v_L, c_H, c_L) in the model such that $c_L \leq c_H$. For each specification $(\psi, \bar{s}, v_L, c_H)$, I document the fraction of costs c_L over $[c_L^{\min}, c_L^{\max}]$ for which *PF* dominates *PC*.[5] Figure B1 records the results of this exercise.

It is clear from Figure B1 that for all choice of ψ and $\bar{s}$ considered, *PC* is more likely to dominate *PF* for randomly chosen values of (v_L, c_H, c_L). *PF* is relatively more likely to dominate *PC* for moderately high values of v_L. This is because direct sale of L must be sufficiently profitable relative

[5] To account for any small numerical errors, I only record *PF* as dominating *PC* if $\Pi_M^{PF} > \Pi_M^{PC} + 0.001$.

to the sale of H in order to induce significant leakage for PF to dominate PC. Next, PF is relatively more likely to dominate PC for lower values of ψ because high values of ψ make it more costly for S to induce leakage under PC. Finally, PF is relatively more likely to dominate PC for higher values of $\bar{s}$ considered. Recall that M's main tradeoff between PC and PF is between per-intermediated-transaction revenue and leakage. If $\bar{s}$ is low, then leakage is easily induced by S and may be more costly than a loss in per-transaction revenue for M. Overall, Figure B1 verifies that while PC is more likely to dominate PF overall, Proposition 2(ii) is relevant in many circumstances in which PF may dominate PC.

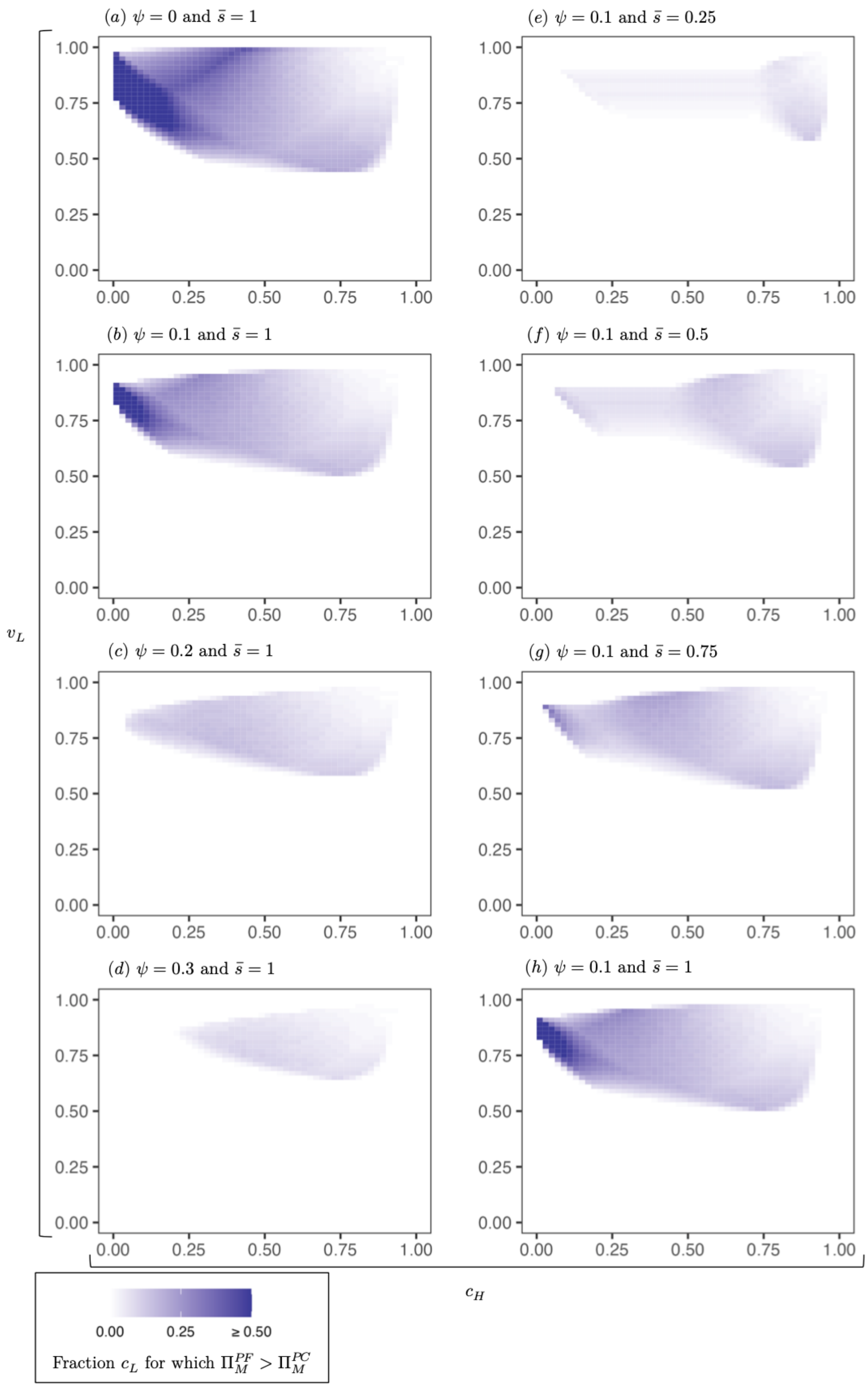

Figure B1

Notes: Figure B1 shows the fraction of costs $c_L \in [c_L^{\min}, c_L^{\max}]$ for which *PF* dominates *PC* at various other parameter levels. Switching costs are distributed uniformly over $[0, \bar{s}]$. The high valuation v_H is normalized to one.

Appendix C: Heterogenous Consumer Valuations

Assume that a fraction α of consumers (called type 1) have valuation v_L for both L and H, and the remaining fraction $1-\alpha$ of consumers (called type 2) have valuation v_L for L and v_H for H. Type 1 consumers have no taste for quality beyond that provided by L, and type 2 consumers are sensitive to improvement in quality beyond that provided by L. As S acts after M acts in the game, assume that consumers choose to purchase the product that maximizes S's profit when indifferent between purchasing L and H. Finally, assume that consumers' quality preference types and their switching costs are independently realized in stage three of the game. Note that the main model is the special case of this extension when $\alpha = 0$. Below I establish S's assortment options and pricing problems under *PAC*, *PF*, and *PC* given an arbitrary fee $\tau \leq \bar{\tau}$. A second source of consumer heterogeneity introduces significant complexities in the analysis, so upon solving for S's assortment and pricing problems under each policy, I proceed to demonstrate the robustness of the main results by numerically solving this extended model with uniform switching costs.

PAC. Under *PAC*, S faces an all-or-nothing listing decision and all transactions are facilitated through M. S will list both products through M provided $\tau \leq \bar{\tau}$. S will sell L to type 1 consumers if $\tau \leq \frac{v_L}{v_L - c_L}$; otherwise, it will not sell to type 1 consumers. S will sell H to type 2 consumers if $\tau \leq \min\{\tilde{\tau}, \bar{\tau}\}$; it will sell L to type 2 consumers if $\tau \in [\tilde{\tau}, \bar{\tau}]$. In all cases, S prices at valuation for each product it makes sales of so that all consumers earn zero surplus.

PF. By arguments analogous to those in the proof of Lemma 2, S will minimize the surplus it offers to consumers in sales through M. S will only make sales of a product through M if it is profitable to do so, and it will make sales of the more profitable product through M whenever possible.

Suppose H is more cost-intensive than L and $\tau \leq \tilde{\tau}$. S can make direct sales only of L, only of H, or of both L and H. These strategies earn respective profits of

$$\begin{aligned}
&\max_{p_L^d} \alpha[(1-\tau)v_L - c_L][1 - G(v_L - p_L^d)] + (1-\alpha)[(1-\tau)v_H - c_H][1 - G(v_L - p_L^d)] \\
&\qquad + (p_L^d - c_L)G(v_L - p_L^d), \\
&\max_{p_H^d} \alpha[(1-\tau)v_L - c_L][1 - G(v_L - p_H^d)] + (1-\alpha)[(1-\tau)v_H - c_H][1 - G(v_H - p_H^d)] \\
&\qquad + \alpha(p_H^d - c_H)G(v_L - p_H^d) + (1-\alpha)(p_H^d - c_H)G(v_H - p_H^d), \\
&\max_{p_L^d, p_H^d} \alpha[(1-\tau)v_L - c_L][1 - G(v_L - p_L^d)] + (1-\alpha)[(1-\tau)v_H - c_H][1 - G(v_H - p_H^d)] \\
&\qquad + \alpha(p_L^d - c_L)G(v_L - p_L^d) + (1-\alpha)(p_H^d - c_H)G(v_H - p_H^d),
\end{aligned}$$

where the third problem is solved subject to the type 2 incentive compatibility constraint $p_H^d - p_L^d \le v_H - v_L$. If H is more cost-intensive than L and $\tau \in (\tilde{\tau}, \bar{\tau}]$, then S's three strategies yield respective profits

$$\begin{aligned}
&\max_{p_L^d}[(1-\tau)v_L - c_L][1-G(v_L - p_L^d)] + (p_L^d - c_L)G(v_L - p_L^d),\\
&\max_{p_H^d}\alpha[(1-\tau)v_L - c_L][1-G(v_L - p_H^d)] + (1-\alpha)[(1-\tau)v_L - c_L][1-G(v_H - p_H^d)]\\
&\qquad\qquad + \alpha(p_H^d - c_H)G(v_L - p_H^d) + (1-\alpha)(p_H^d - c_H)G(v_H - p_H^d),\\
&\max_{p_L^d, p_H^d}\alpha[(1-\tau)v_L - c_L][1-G(v_L - p_L^d)] + (1-\alpha)[(1-\tau)v_L - c_L][1-G(v_H - p_H^d)]\\
&\qquad\qquad + \alpha(p_L^d - c_L)G(v_L - p_L^d) + (1-\alpha)(p_H^d - c_H)G(v_H - p_H^d),
\end{aligned}$$

where again the third problem is solved subject to the type 2 incentive compatibility constraint $p_H^d - p_L^d \le v_H - v_L$.

Now suppose L is more cost-intensive than H. S can again directly sell only L, only H, or both L and H. If $\tau \le \frac{v_L - c_L}{v_L}$, then these strategies yield respective profits

$$\begin{aligned}
&\max_{p_L^d}\alpha[(1-\tau)v_L - c_L][1-G(v_L - p_L^d)] + (1-\alpha)[(1-\tau)v_H - c_H][1-G(v_L - p_L^d)]\\
&\qquad\qquad + (p_L^d - c_L)G(v_L - p_L^d),\\
&\max_{p_H^d}\alpha[(1-\tau)v_L - c_L][1-G(v_L - p_H^d)] + (1-\alpha)[(1-\tau)v_H - c_H][1-G(v_H - p_H^d)]\\
&\qquad\qquad + \alpha(p_H^d - c_H)G(v_L - p_H^d) + (1-\alpha)(p_H^d - c_H)G(v_H - p_H^d),\\
&\max_{p_L^d, p_H^d}\alpha[(1-\tau)v_L - c_L][1-G(v_L - p_L^d)] + (1-\alpha)[(1-\tau)v_H - c_H][1-G(v_H - p_H^d)]\\
&\qquad\qquad + \alpha(p_L^d - c_L)G(v_L - p_L^d) + (1-\alpha)(p_H^d - c_H)G(v_H - p_H^d),
\end{aligned}$$

subject to $p_H^d - p_L^d \le v_H - v_L$ in the third problem. If $\tau \in \left(\frac{v_L - c_L}{v_L}, \bar{\tau}\right]$, then S's three strategies yield respective profits

$$\begin{aligned}
&\max_{p_L^d}(1-\alpha)[(1-\tau)v_H - c_H][1-G(v_L - p_L^d)] + (p_L^d - c_L)G(v_L - p_L^d),\\
&\max_{p_H^d}(1-\alpha)[(1-\tau)v_H - c_H][1-G(v_H - p_H^d)] + \alpha(p_H^d - c_H)G(v_L - p_H^d)\\
&\qquad\qquad + (1-\alpha)(p_H^d - c_H)G(v_H - p_H^d),\\
&\max_{p_L^d, p_H^d}(1-\alpha)[(1-\tau)v_H - c_H][1-G(v_H - p_H^d)] + \alpha(p_L^d - c_L)G(v_L - p_L^d)\\
&\qquad\qquad + (1-\alpha)(p_H^d - c_H)G(v_H - p_H^d)
\end{aligned}$$

subject to $p_H^d - p_L^d \le v_H - v_L$ in the third problem.

PC. S can list only L through M, only H through M, or both L and H through M. Since sales of both products may be made through the same channel, listing both products through M is no longer immediately strictly dominated. If only one product is listed through

M, then leakage may be induced only by the other product due to *PC*, and it is expensive due to the extra location costs ψs incurred by consumers. If S lists only L through M, then it sets $p_L = v_L$ and earns

$$\max_{p_H^d} 1_{\tau \in \left[0, \frac{v_L - c_L}{v_L}\right]} \cdot [(1-\tau)v_L - c_L] \left\{ \alpha \left[1 - G\left(\frac{v_L - p_H^d}{1+\psi}\right)\right] + (1-\alpha)\left[1 - G\left(\frac{v_H - p_H^d}{1+\psi}\right)\right]\right\} + (p_H^d - c_H)\left[\alpha G\left(\frac{v_L - p_H^d}{1+\psi}\right) + (1-\alpha) G\left(\frac{v_H - p_H^d}{1+\psi}\right)\right]$$

If S lists only H through M, then it sets either $p_H = v_L$ or $p_H = v_H$. These two strategies yield respective profits

$$\begin{aligned} \max_{p_L^d} 1_{\tau \in \left[0, \frac{v_L - c_H}{v_L}\right]} & \\ & \cdot [(1-\tau)v_L - c_H] \left\{ \alpha \left[1 - G\left(\frac{v_L - p_L^d}{1+\psi}\right)\right] \right. \\ & \left. + (1-\alpha)\left[1 - G\left(\frac{v_L - p_L^d - v_H + v_L}{1+\psi}\right)\right]\right\} \\ & + (p_L^d - c_L)\left[\alpha G\left(\frac{v_L - p_L^d}{1+\psi}\right) + (1-\alpha) G\left(\frac{v_L - p_L^d - v_H + v_L}{1+\psi}\right)\right], \end{aligned}$$

$$\max_{p_L^d} 1_{\tau \in \left[0, \frac{v_H - c_H}{v_H}\right]} \cdot [(1-\tau)v_H - c_H](1-\alpha)\left[1 - G\left(\frac{v_L - p_L^d}{1+\psi}\right)\right] + (p_L^d - c_L) G\left(\frac{v_L - p_L^d}{1+\psi}\right).$$

Finally, suppose S lists both products through M. Suppose H is more cost-intensive than L. If $\tau \in [0, \tilde{\tau}]$, then S earns

$$\alpha[(1-\tau)v_L - c_L] + (1-\alpha)[(1-\tau)v_H - c_H].$$

If $\tau \in (\tilde{\tau}, \bar{\tau}]$, then S earns $(1-\tau)v_L - c_L$. Now suppose H is less cost-intensive than L. If $\tau \in \left[0, \frac{v_L - c_L}{v_L}\right]$, then S earns

$$\alpha[(1-\tau)v_L - c_L] + (1-\alpha)[(1-\tau)v_H - c_H].$$

If $\tau \in \left(\frac{v_L - c_L}{v_L}, \bar{\tau}\right]$, then S earns $(1-\alpha)[(1-\tau)v_H - c_H]$.

Given S's assortment options and pricing problems, M's profit equation can easily be written as a function of $(\mathcal{P}, \mathcal{A}, \tau)$. It is immediate that Proposition 1 holds in this extended model with heterogenous consumer valuations in that *PAC* remains M's optimal policy. A viable direct sales channel constrains M's per-intermediated-transaction revenue at a fixed number of intermediated transactions beyond profitability of S. PAC eliminates any viable direct sales channel such that M can maximize its per-intermediated-transaction revenue subject to S's profitability and without any effect on the number of intermediated transactions.

To demonstrate the robustness of the tradeoff between PF and PC to heterogenous consumer preferences for quality, I numerically solve the model with uniform switching costs as in Figure 1. I consider the same fixed parameters used in Figure 1 ($s \sim U[0, \bar{s} = 1], v_H = 1, v_L = 0.75, c_H = 0.5, \psi = 0.1, c_L \in [0.25, 0.5]$). I allow the heterogenous taste parameter α to vary uniformly over $[0, 1]$ and find that PF dominates PC for a positive fraction of costs $c_L \in [0.25, 0.5]$ for all $\alpha \in [0, 1)$. This fraction decreases to zero as $\alpha \to 1$. Over all possible $\alpha \in [0, 1]$, PF dominates PC for an average of 12.5 percent of the cost levels $c_L \in [0.25, 0.5]$.

Figure C1 demonstrates that the underlying mechanism for these results is the same with both homogenous and heterogenous valuations by illustrating the case of maximal consumer heterogeneity ($\alpha = 0.5$). Again, it is more costly under PC for M to induce S to sell its targeted product set through M because S loses its ability to sell those products directly if they are sold through M. As a consequence of this, M lowers τ^{PF} below $\frac{v_H - c_H}{v_H}$ to induce intermediated sales of H and to achieve increasing profits for lower values of c_L than when it lowers τ^{PC} below $\frac{v_H - c_H}{v_H}$ to induce intermediated sales of H and to achieve increasing profits. Once M induces sale of both products through M, all leakage is eliminated under PC but some leakage remains under PF. The tradeoff between lower per-intermediated-transaction revenue and lower levels of leakage identified in the main analysis persists. Note that the right end behavior in Figure C1 differs from that in Figure 1 because M's "targeted" intermediated product set differs between environments for high values of c_L. When $\alpha = 0$ (Figure 1), M targets only H under both PF and PC, and there is no intermediated sale of L for high c_L. Thus further increases in c_L have nondecreasing effects on Π_M^{PC} and Π_M^{PF}. When $\alpha = 0.5$ (Figure C1), however, M targets both L and H under both PF and PC for high c_L. Thus further increases in c_L have decreasing effects on Π_M^{PC} and Π_M^{PF}. Overall, for different values of $\alpha \notin \{0, 0.5\}$, M's targeted intermediated product set may change for fixed levels of c_L, but the underlying mechanism remains in that PC still makes it costly to induce the targeted product set's intermediated sale compared to PF because of the restriction PC places on direct sales and consequently direct sales margins.

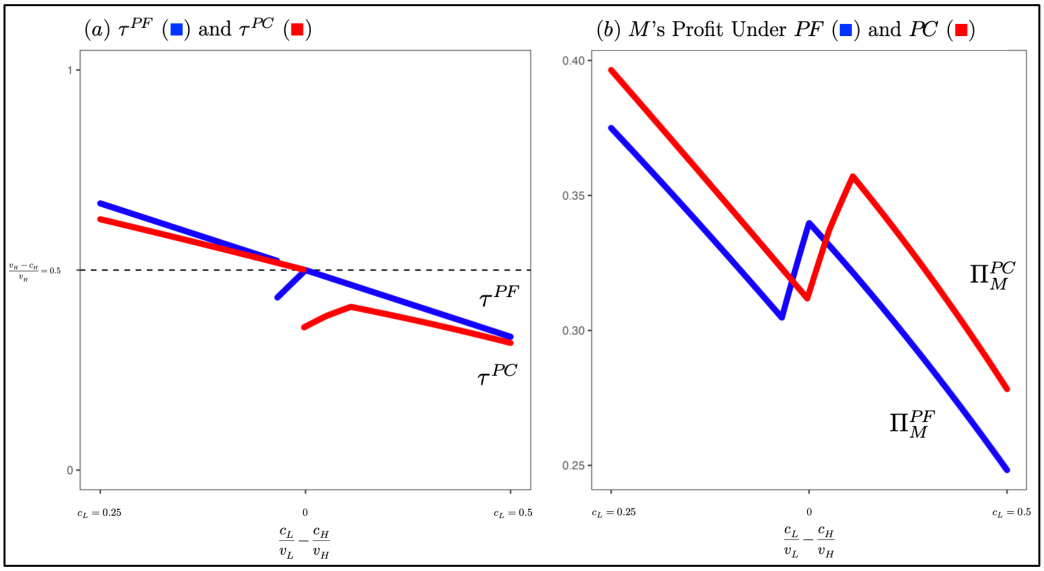

Figure C1

Parameters: $\alpha = 0.5, s \sim U[0, \bar{s} = 1], v_H = 1, v_L = 0.75, c_H = 0.5, \psi = 0.1, c_L \in [0.25, 0.5]$
Equilibrium assortment decisions: S lists both L and H through both channels for all c_L under PF. When $\frac{c_L}{v_L} \leq \frac{c_H}{v_H}$, S lists only L through M under PC. When $\frac{c_L}{v_L} > \frac{c_H}{v_H}$, S lists both L and H through M.