Optional Intermediaries and Pricing Restraints*

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March 31, 2021

Abstract

When a platform is an *optional intermediary*, should it require sellers to charge the same price to the platform's users as they charge their direct customers? If the platform does this, how will it affect consumers' and overall welfare? In a model leveraging insight from the study of third-degree price discrimination, we show that an interesting markup-versus-volume tradeoff governs the platform's choice. Moreover, a *drawing-in* effect, geared towards low-valuation platform users, makes such a policy surprisingly appealing for consumers.

Keywords: Platform governance, price coherence, price discrimination, digital payments

*We thank Yongmin Chen, Simon Cowan and Germain Gaudin for helpful comments. We are also grateful to Zhiming Feng, Baiyun Jing, and Yuyang Jiang for excellent research assistance.

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1 Introduction

As platforms' place in the economy grows increasingly important, a notable phenomenon is their frequent role as *optional intermediaries*. That is, there are many situations where consumers, wishing to purchase something from a particular seller, may do so directly, but they may, instead, choose to include the platform as part of the transaction. For example, to order a meal, a takeout diner can call the restaurant directly or place the order on an app such as DoorDash; a grocery shopper may go to the supermarket or order via Instacart; a consumer of myriad products may order directly from sellers' websites or they can purchase them using Amazon; customers at physical stores may pay with cash or they may use a payment card.

Although platforms might, in many cases, prefer to be the exclusive channel through which consumers can access a seller, staking out such a position is not always feasible. For both legal and practical reasons, platforms often must operate under the possibility that consumers and/or sellers can choose to "disintermediate" (Gu and Zhu, 2021), i.e., to circumvent the platform and transact directly. The model that we consider in this paper focuses on such situations. Specifically, cases within our scope have the following two features. First, the platform must attract a seller to participate, and, even after the latter chooses to do so, it retains a direct sales channel. Second, the direct sales channel is available, at the time of any transaction, to *all* consumers, including both users of the platform and other unaffiliated "non-users."

In addition to the examples mentioned above, other types of platforms that, broadly speaking, fit this description include software and travel intermediaries. For example, in the former category, Google Play, which offers Android-based mobile software, and the Mac App Store, which offers software for Apple computers, both also allow developers to sell the same apps directly via their websites. Similarly, in the latter category, Booking.com and Expedia both offer plane tickets, hotel rooms and car rentals that can also be booked directly with providers.[1]

When a platform is an optional intermediary, in order to be successful, it must provide its users with enough incentive to actually make their purchases *using it*, rather than to bypass

[1]Not all platforms in these categories fall within our scope, however. For example, the iOS App Store, for iPhone/iPad apps, is, for all practical purposes, the exclusive channel for developers to put their software on iPhones.

it and transact directly with sellers. This can be accomplished, partly, by providing complementary benefits to users, such as those mentioned above (e.g., convenience, delivery, service, etc.). Beyond offering benefits, an additional kind of tool is a restraint on sellers' pricing. If, when making purchases, users can obtain the aforementioned kinds of benefits without paying a surcharge, this provides further incentive to transact via the platform. Thus, optional intermediaries potentially benefit from requiring *price coherence* (Edelman and Wright, 2015b), i.e., prohibiting sellers from offering lower prices via their direct channels than they do via the platform. However, imposing such a policy is not without its costs, as it tends to make the platform less appealing for sellers.

One main objective of this paper is to clarify what tradeoffs an optional intermediary faces when it decides whether or not to adopt such a price restraint. In doing so, the paper helps to distinguish between circumstances in which a platform should require price coherence and those in which it is better off giving merchants *price flexibility*, i.e., the ability to price differently across channels. A second main objective of the paper is to analyze the consequences of this decision that a platform makes on other interested parties, such as consumers and sellers. Addressing these questions is significant both for the purpose of understanding how such platforms can best perform within their given environments and for analyzing a set of relevant policy questions.[2]

In the model, a monopoly platform must decide on the terms that it offers a seller facing two different sorts of customers: (a) some who value the convenience offered by the platform and prefer to make their purchases using this channel, and (b) others who have no particular preference for the platform and may not even know about it or have access to it. One option for the platform is to grant the seller price flexibility. This corresponds, for instance, to the case where a shopping app allows a supermarket to post different prices on the app from those that it charges in-store. The other option for the platform's is to impose price coherence. Think, for example, of a store that has committed to charge the same price, regardless of whether buyers pay by card or cash.

[2]As Edelman and Wright (2015a) show, platforms in numerous different categories impose some form of price coherence. On the policy front, in 2018, the United States Supreme Court ruled in favor of American Express and against the US Department of Justice, allowing the former to continue its practice of imposing price coherence.

Regarding the platform's choice between the two regimes, there is a clear upside to the platform of preventing the seller from discounting its direct sales. Nevertheless, we find that, sometimes, offering price flexibility is more profitable. This is because, in choosing between the two regimes, the platform faces a tradeoff. On the one hand, for the intuitive reason mentioned above, imposing price coherence boosts the volume of transactions that the platform mediates. On the other hand, imposing price coherence forces the platform to charge the seller a lower per-transaction fee. This is because, under price coherence, when the seller passes along this per-transaction fee to its customers, it must do so to *all* of them, not just platform users, as is feasible under price flexibility. Consequently, the maximum per-transaction fee that the seller is willing to accept is lower under price coherence.

We find that, when demand for the good and, thus, the seller's profit function are sufficiently concave, this disparity in the seller's willingness-to-pay (of transaction fees) across the two regimes grows. As the disparity grows larger, from the platform's perspective, the additional transaction volume offered by price coherence is not enough to compensate for the reduced fees.

Regarding the welfare consequences of the platform's decision, we find, surprisingly, that both consumer surplus and total surplus tend to be greater under price coherence. A switch from price flexibility to price coherence is certain to help some consumers and harm others. That is, if imposing price coherence leads to a single price that lies below the prior *mediated price* (charged via the platform) and above the prior *direct price*, then such a policy benefits platform users but harms direct buyers. The crucial step is to compare these two offsetting effects.

We do so by incorporating, into a platform model, a style of analysis typically found in the literature on third-degree price discrimination (especially Chen and Schwartz, 2015; Chen, Li, and Schwartz, Forthcoming), and we show why, in dollar terms, the positive effect is likely to outweigh the negative one. In particular, we identify a so-called *undershooting* condition. In a standard model of third-degree price discrimination, this condition is not enough to make uniform pricing across two markets better for consumers, overall, than separate prices in each market. However, in our setting, there is a *drawing-in* effect, whereby the platform attracts to the seller, users with relatively low valuations for the good. This effect makes the undershooting condition sufficient to ensure that, in aggregate, consumers are better off under price coherence.

We first show this with exogenous platform fees, in Section 4. Endogenizing the platform's fees, as we do in Section 5, further reinforces the argument in favor of price coherence. This is because, as explained above, under price coherence, the platform charges a lower per-transaction fee than it does under price flexibility. As a result, it is as though, under the former regime, the seller has a lower unit cost when transacting with platform users than it does under the latter.

In Section 6, we also endogenize buyers' decision of whether or not to join the platform. Here, we reveal another tradeoff, between *transaction surplus* and *joining costs*. For the reasons described above, price coherence tends to lead to greater consumer (and total) surplus from the sale of the good. However, as Edelman and Wright (2015b) show, by eliminating the possibility for cash discounts, price coherence spurs more users to join the platform and thus raises aggregate joining costs. The question thus arises of whether the gains from transactions outweigh the costs of excessive joining. We show that they can. Nevertheless, it is important to take the latter effect into account, because it could be the dominant force when users' demand for joining the platform is sufficiently elastic.

2 Related literature

The literature on multi-sided platforms, to which this paper contributes, was pioneered by articles such as Anderson and Coate (2005), Armstrong (2006), Caillaud and Jullien (2003), Evans (2003), Hagiu (2006), Parker and Van Alstyne (2005), Rochet and Tirole (2003) and Rysman (2004). Within this broad category, there is a particularly relevant literature studying payment intermediaries and the rules governing them, which includes Gans and King (2003), Wright (2003), Wright (2004), Rochet and Tirole (2008), Rochet and Tirole (2011).

More specifically, our model is closest to Edelman and Wright (2015b) and Schwartz and Vincent (2006), both of which also consider the comparison between price coherence and flexibility. A crucial step that we take, beyond Edelman and Wright (2015b), is to allow for general demand curves for the good, which leads to variable total sales. This opens up a new avenue of analysis that we show to be significant. Our focus on platforms as *optional* intermediaries is an important point of contrast with Schwartz and Vincent (2006). In their setting, since users' only available channel for purchasing the good is the platform, the incentives facing both the platform and the seller are quite different. Importantly, compared to their setup, ours is more predisposed to favor price flexibility, yet we still find potential advantages of price coherence from the perspectives of both the platform and users.

Another pair of recent papers that focus on similar issues are Gomes and Tirole (2018) and Bourguignon, Gomes, and Tirole (2019). Their approach is quite different from ours, in that they assume users do not learn about their costs/benefits of paying via the platform until the time of a given sale. Interestingly, their findings that platform-imposed restrictions on surcharging (or cash discounting) may be efficient appear, broadly speaking, to align with ours. An appealing aspect of our approach is that it draws a clear connection to the classic comparison between uniform versus differential pricing across different markets. In making this connection, we focus most directly on the framework of Chen and Schwartz (2015), but also see Aguirre, Cowan, and Vickers (2010), Cowan (2012), Cowan (2016), Chen, Li, and Schwartz (Forthcoming).

A somewhat less related strand of literature is the one on "Most Favored Nation" (MFN) clauses, i.e., restraints that platforms sometimes impose on sellers from offering lower prices elsewhere. This literature, which includes Boik and Corts (2016) and Johnson (2017) largely focuses on the way in which such restraints might dampen competition between platforms, which is outside the scope of this paper.

Finally, in studying circumstances where users and sellers, both of which participate on a platform, may still endogenously meet or transact with one another "off-platform," this paper relates to work that considers (a) such parties incentives to "disintermediate" and (b) the way that platforms may respond, given the presence of such incentives. Gu and Zhu (2021) is a recent empirical contribution documenting the importance of such phenomena. Such circumstances are considered from different theoretical perspectives by works such as Bakos and Halaburda (2020), Halaburda, Jan Piskorski, and Yıldırım (2018), Hagiu and Jullien (2011), Hagiu, Jullien, and Wright (2020), Hagiu and Spulber (2013) and White (2013).

3 The model

Consider the following model in which an intermediary ("the platform") mediates transactions between some, but not all, buyers and a merchant. Each member of the unit mass of buyers has a valuation for the merchant's good, v, drawn from a twice continuously differentiable distribution, g, with strictly positive support on $(0, \overline{v})$, where $0 < \overline{v} \leq \infty$. A fraction, $\lambda \in (0, 1)$, of buyers have not joined the platform and, thus, if they purchase the good, may only do so directly. If they do, they receive payoff $v - p$, where p denotes the price of the good.

The remaining $1 - \lambda$ buyers are "users" that have joined the platform. When deciding whether or not to purchase the good, they may also choose whether to make the purchase via the platform or directly. If a user pays via the platform, she receives a benefit, $b > 0$, which can represent added convenience from using the platform, such as free delivery of the good, simpler sign-in via an app, or better access to customer service and returns. Users who pay via the platform receive a payoff of $v + b - p$. If users choose to pay directly or to not purchase at all, they receive the same payoffs as non-users. When users face the option to pay via the platform at price p, we refer to $p - b$ as their *net price*.[3]

Note that, here, buyers' decisions whether or not to be users of the platform is exogenously given. We relax this assumption in Section 6. Also, the distribution of buyers' valuations for the good is the same, independently of whether or not they are users.

We are interested in comparing two types of contractual arrangement between the platform and the merchant, which, following Edelman and Wright (2015b), we label *price flexibility* (F) and *price coherence* (C). In both arrangements, the platform collects a transaction fee, f, from the merchant, for each sale made via the platform.[4] Under price flexibility, the merchant is allowed to charge two different prices – one, p_m, for "mediated" purchases made via the platform and another, p_d, for direct purchases. In contrast, under price coherence, the merchant must charge

[3]An alternative interpretation of this section's model is that all consumers are users, but that purchasing via the platform brings benefit b to only $1 - \lambda$ of them, while it brings zero benefit to the remaining λ-share.

[4]One might argue that in reality, intermediaries often charge *ad valorem* rather than unit transaction fees. We show in Appendix B that all our results and intuitions extend to (and are, broadly speaking, strengthened in) an environment with *ad valorem* transaction fees. In the main text, we focus on unit transaction fees to make the analysis cleaner.

the same price, $\hat{p}$, to all buyers, regardless of their method of purchase.

The merchant produces the good at zero marginal cost. Under price flexibility, assuming all users who purchase prefer to pay via the platform (which, we will show, holds at equilibrium), the merchant faces demand from non-users equal to the λ-share of $Q(p_d) = \int_{p_d}^{\infty} g(x)\,dx$. Demand from users is the $(1-\lambda)$-share of $Q(p_m - b) = \int_{p_m - b}^{\infty} g(x)\,dx$. Thus, the merchant's total profits are

$$\lambda Q(p_d)\, p_d + (1-\lambda)\, Q(p_m - b)(p_m - f)\,. \tag{1}$$

Under price coherence, the demands facing the merchant are analogous, but it can choose only one price, $\hat{p}$, giving rise to profits of

$$\lambda Q(\hat{p})\, \hat{p} + (1-\lambda)\, Q(\hat{p} - b)(\hat{p} - f)\,. \tag{2}$$

The platform has zero costs, and it receives f for each purchase that its users make. Therefore, under price flexibility, it earns profits of $(1-\lambda)\, Q(p_m - b)\, f$, and, under price coherence, it earns profits of $(1-\lambda)\, Q(\hat{p} - b)\, f$.

The timing is as follows.

1. The platform sets the transaction fee, f, and it chooses which arrangement to use, price flexibility or price coherence.

2. The merchant chooses whether or not to allow its good to be sold via the platform. If it participates, then, under price flexibility, it sets p_d and p_m, whereas, under price coherence, it sets $\hat{p}$.

3. Buyers choose whether or not to purchase the good. In so doing, users can choose whether to make their purchase via the platform or directly.

Our solution concept is subgame-perfect equilibrium.

4 Analysis of the main mechanism

This section studies a simplified version of the model in which the platform's fee stays constant across the two regimes. In doing so, it isolates the crucial mechanism behind our results. In particular, it identifies a key *undershooting* condition on prices, and it shows how, in our platform setting, this condition guarantees that the gains users enjoy under price coherence outweigh the losses that non-users incur under this regime. It contrasts this finding with non-platform, third-degree price discrimination settings in which undershooting does not have such implications.

4.1 Price flexibility

In the final stage, non-users purchase the good if and only if $v \geq p_d$. Regarding the choices facing users, first, they prefer to make a purchase via the platform rather than directly if and only if $p_m - b \leq p_d$. Second, if this inequality is satisfied, they purchase the good if and only if $v + b \geq p_m$.

Next, consider the merchant's price-setting problem in stage 2. Lemma 1 says when the merchant chooses to participate on the platform.

Lemma 1. *Under price flexibility, the merchant participates on the platform if and only if $f \leq b$.*

To set prices, the merchant maximizes equation (1) with respect to p_d and p_m, yielding

$$p_d^* = \frac{Q\left(p_d^*\right)}{-Q'\left(p_d^*\right)}, \qquad p_m^* = f + \frac{Q\left(p_m^* - b\right)}{-Q'\left(p_m^* - b\right)}. \tag{3}$$

Since $f \leq b$, users' net price, $p_m^* - b \leq p_d^*$, ensuring that users who buy the good choose to do so via the platform. Note that this implies that the marginal user's valuation for the good is weakly less than the marginal non-user's valuation.

4.2 Price coherence

In the final stage, assuming the merchant participates, non-users purchase the good if and only if $v \geq \hat{p}$. Users purchase if and only if $v + b \geq \hat{p}$. If the merchant participates, to set its price, it maximizes (2) with respect to $\hat{p}$, giving first-order condition

$$\lambda\left(Q\left(\hat{p}^*\right)+\hat{p}^* Q'\left(\hat{p}^*\right)\right)+(1-\lambda)\left(Q\left(\hat{p}^*-b\right)+\left(\hat{p}^*-f\right)Q'\left(\hat{p}^*-b\right)\right)=0. \tag{4}$$

If it does not participate, the merchant sets a direct price equal to p_d^* in (3). Lemma 2 states the condition under which the merchant chooses to participate.

Lemma 2. *Under price coherence, the merchant participates on the platform if and only if $f \leq \overline{f}$, where $\overline{f} \in (0, b)$.*

4.3 Ranking of prices under the two regimes

We now establish the ranking among a set of relevant prices arising from the two regimes. In order to do this, we impose the following assumption throughout.

Assumption 1. *The demand function, $Q(\cdot)$, is globally strictly log-concave.*

This assumption not only guarantees the merchant's second-order condition is satisfied, but also it restricts the *pass-through rate* of the demand function, which we denote by $\delta(p)$, to be strictly less than one.[5] Furthermore, in order to restrict attention to cases in which, under both regimes, the merchant optimally chooses to participate, we assume that $f \in \left[0, \overline{f}\right]$.[6] We now state Lemma 3.

Lemma 3. *Given any transaction fee that leads the merchant to participate under either price flexibility or price coherence, the following ranking holds:*

$$\hat{p}^* - b < p_m^* - b < p_d^* < \hat{p}^* < p_m^*. \tag{5}$$

[5]The pass-through rate says how fast a monopolist facing a given demand curve optimally increases its price in response to an increase in marginal cost. It can be derived by totally differentiating the standard monopoly pricing formula, $p^* = mc + \frac{Q(p^*)}{-Q'(p^*)}$, with respect to mc, yielding $dp^*/dmc = 1/\left(2 - \frac{Q''}{Q'} \middle/ \frac{Q'}{Q}\right) \equiv \delta(p)$. For details, see Bulow and Pfleiderer (1983) and Weyl and Fabinger (2013).

[6]In Sections 5 and 6, in which the platform endogenously sets a regime-specific f, the appropriate maximal value will also be regime-specific. For the purposes of this section, it is conservative to impose a stricter-than-necessary upper bound, $\overline{f}$, under price flexibility.

To understand this lemma, first consider the ordering $p_m^* - b < p_d^* < p_m^*$. This says that, under price flexibility, the nominal price paid by users is greater than the direct price; however, the direct price exceeds users' net price. Note that $p_d^* < p_m^*$ depends on Assumption 1, which effectively limits the merchant's incentive to discount users' net price by too much, compared to the direct price. The fact that $\hat{p}^*$ lies between p_d^* and p_m^* follows standard logic from third-degree price discrimination that, when a monopolist is constrained to set a uniform price in two markets, this price must be between the optimal price in each of the respective markets (see, e.g., Schmalensee (1981)).

4.4 Consumer surplus under the two regimes

Now we compare consumer surplus under price flexibility and price coherence. We first give a result that applies to an exogenous set of prices that follows the ranking established in Lemma 3. Then we move on to the case of endogenous prices.

For three prices, p_d, p_m and $\hat{p}$, we will refer to the following condition.

Condition 1 (Undershooting). $\hat{p} \leq \lambda p_d + (1-\lambda) p_m$. *In words, this condition holds when, under price coherence, the merchant's nominal price (weakly)* undershoots *the population-weighted average of the direct and mediated prices it charges under the flexible regime.*

Denote consumer surplus associated with demand function $Q(\cdot)$ by $S(p) \equiv \int_p^\infty Q(x)\,dx$. Note that for all $p \in (0, \overline{v})$, $S'(p) = -Q(p) < 0$, $S''(p) = -Q'(p) > 0$. Under the respective regimes, consumer surplus is thus $S^F(p_d, p_m) \equiv \lambda S(p_d) + (1-\lambda) S(p_m - b)$ and $S^C(\hat{p}) \equiv \lambda S(\hat{p}) + (1-\lambda) S(\hat{p} - b)$. In Proposition 1, we make use of this convexity of $S(\cdot)$ to compare consumer surplus under the two regimes.

Proposition 1. *For any set of prices and net prices ranked as in equation* (5)*, if Condition 1 is satisfied, then consumer surplus is greater under price coherence than under price flexibility, i.e.,* $S^C(\hat{p}) > S^F(p_d, p_m)$.

To understand Proposition 1, imagine a shift from a regime with direct price p_d and mediated price p_m to a regime with a single price $\hat{p}$. As non-users now face a higher price and users now face a lower price, the former group is made worse off by this shift, and the latter group is made better off. When the undershooting condition holds, the latter effect dominates.

To see why this is true, consider Figure 1, which assumes that there are equal shares of users and non-users ($\lambda = 1/2$). Area A represents non-users' loss in a standard way. Users' gain, however, includes not only area B but also area C. This is because, among users, new buyers are those with valuations *for the good* that lie in between the *net* prices $p_m - b$ and $\hat{p} - b$, rather than the nominal prices, p_m and $\hat{p}$. On the one hand, the undershooting condition implies that $(p_m - b) - (\hat{p} - b) \geq \hat{p} - p_d$, i.e., the width of area B+C weakly exceeds that of area A. On the other hand, since demand is strictly downward-sloping, the minimum height of area B+C strictly exceeds the maximum height of area A. Thus, when the undershooting condition is satisfied, the shift from price flexibility to price coherence gives more new surplus to users than it takes away from non-users.

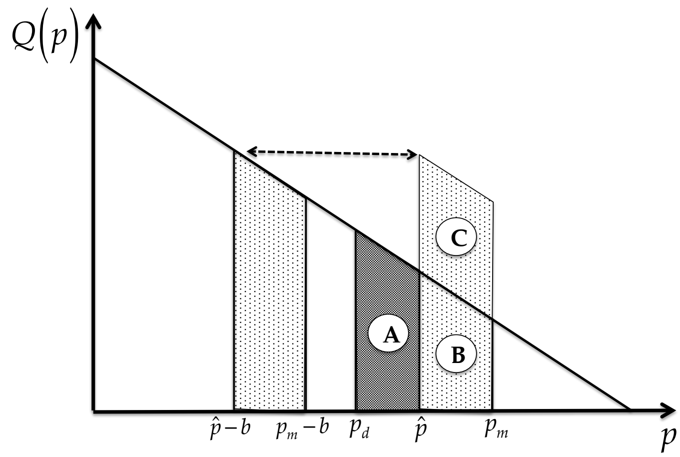

Figure 1: *Change in consumer surplus following a shift in pricing regime, when $\lambda = 1/2$. Area A represents non-users' loss and areas B and C, together, represent users' gain, when nominal prices shift from p_d and p_m to a single price $\hat{p}$.*

Contrast this with a standard, non-platform-oriented model comparing consumer surplus under differential and uniform pricing.[7] In such an example, under differential pricing, the "low market" features price p_d, the "high market" features price p_m, and the uniform price is $\hat{p}$. Here, following a shift from differential to uniform pricing, the exiting buyers in the "low market" still have valuations between p_d and $\hat{p}$, but the new buyers in the "high market" have valuations

[7]See, for instance, Section 3 of Chen and Schwartz (2015).

between $\hat{p}$ and p_m. Thus, the gain in consumer surplus in the high market includes only area B. In such an exercise with exogenous prices, the conditions under which consumers could, on net, gain from a switch from differential to uniform pricing are more restrictive than in our setting. This is because the average height of area B is strictly lower than the average height of area A, and so, for the analogous result to obtain, area B's height disadvantage must be made up for in width.

Two interesting points arise from the comparison made in Figure 1. First, switching from price flexibility to price coherence has a *drawing-in* effect, in the following sense. The users who purchase the good under price coherence only ($v \in [\hat{p} - b, p_m - b]$) all have lower valuations *for the good* than the non-users who purchase under price flexibility only ($v \in [p_d, \hat{p}]$). This stems from the fact that users incorporate the benefit, b, that the platform provides, into their purchase decision, whereas this factor is irrelevant for non-users. Thus, our model urges caution against the possible intuition that a price coherence regime simply benefits wealthy consumers, i.e., those with high willingness-to-pay for goods, at the expense of poorer ones.

Second, despite the apparent contrast, described above, between Proposition 1 and the findings that obtain in a standard, non-platform model, there is a deeper, unifying aspect. This is that, in both examples, consumer surplus is greater in the regime with a larger divergence between the valuations, for the good, of the two types of marginal buyers. On the one hand, in our model, a shift from price flexibility to price coherence increases this difference from $p_d - (p_m - b)$ to $\hat{p} - (\hat{p} - b)$. On the other hand, in the standard example, a shift *to* price flexibility *from* price coherence increases this difference from 0 to $p_m - p_d$.

As we show in the proof of Proposition 1, all of these insights extend to the case where the shares of users and non-users are unequal (i.e., arbitrary $\lambda \in (0, 1)$).

Endogenous pricing. We now move to the case where the merchant optimally chooses p_d^*, p_m^* and $\hat{p}^*$. Here, to simplify the analysis, we focus on the following *constant pass-through* family of demand functions:

$$Q(p) = (1 - p/\overline{v})^{\gamma}, \quad \gamma > 0, \quad 0 \leq p \leq \overline{v}. \tag{6}$$

Note that in this specification, the pass-through rate satisfies $\delta(p) = \gamma/(1+\gamma)$, and $\gamma = 1$ corresponds to the special case of linear demand. This form of demand leads to a straightforward result, which we state in Proposition 2. In doing so, we assume that b is not so large as to incentivize the merchant to fully exclude non-users in the price coherence regime.

Proposition 2. *With demand in the constant pass-through family, the merchant chooses prices that satisfy Condition 1 if and only if $\gamma \leq 1$. Therefore, if $\gamma \leq 1$, price coherence gives rise to greater consumer surplus than price flexibility.*

To interpret Proposition 2, note the following implications.

- Under linear demand, consumer surplus is higher under price coherence than under price flexibility. This also holds for all demand in the constant pass-through family that is strictly concave.
- Linear demand tightly satisfies Condition 1, but this undershooting condition is stronger than necessary to guarantee that consumers are better off under price coherence.

Figure 2 illustrates these points. It shows which of the two regimes gives rise to greater consumer surplus, as a function of the platform benefit parameter, b, and the curvature parameter, γ. In it, the region with less convex demand to the left of the solid curve features higher consumer surplus under price coherence. The opposite holds in the region with more convex demand to the right of this curve. Note that, in a sizeable zone (including all values of $\gamma \in (1,2)$), the overshooting condition does not hold, yet price coherence still leads to greater consumer surplus.

Figure 3 is analogous to Figure 1, depicting a case of strictly convex demand. In particular, it shows why, even when the set of endogenous prices violate Condition 1, consumer surplus can still be greater under price coherence.[8] Here, since $\gamma > 1$, the merchant sets prices that violate the undershooting condition. Hence, the width of area A exceeds that of area B+C. Nevertheless, the taller height of the latter allows for consumer surplus to be greater under the price coherence regime.

[8]This corresponds, in Figure 2, to the area lying to the right of the dotted line and to the left of the solid curve.

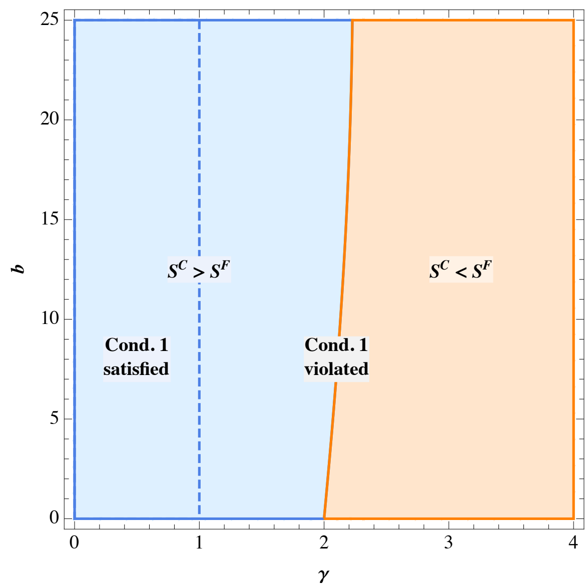

Figure 2: *Ranking of consumer surplus across the two regimes, under constant pass-through demand. Here, $f = \overline{f}(\gamma, b)$, $v = 100$, and $\lambda = 1/2$, but the basic pattern is not sensitive to these choices.*

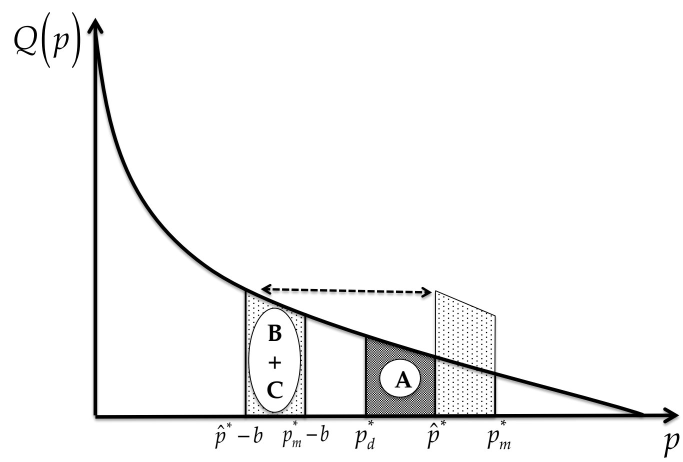

Figure 3: *Change in consumer surplus following a shift in pricing regime, with a convex demand function, when $\lambda = 1/2$. Here, unlike in Figure 1, Condition 1 fails to hold, yet area B + C may still exceed area A.*

Now, consider the comparison between Proposition 2 and the analogous result in a standard, non-platform model, as presented in Section 3 of Chen and Schwartz (2015). There, when the firm faces constant pass-through demand of the form defined in equation (6) and sets prices endogenously, Condition 1 always holds with equality (under any value of γ), but differential pricing leads to greater consumer surplus.

Another relevant comparison is the one between our model, with variable total demand, and a similar platform model in which merchants compete in a Vickrey-Salop "circular city," as studied by Edelman and Wright (2015b). In this latter setting, since total demand is fixed regardless of prices, performing analogous exercises to those in this section, one finds that Condition 1 always holds with equality. However, consumer surplus remains constant across the two regimes, because the price changes simply amount to transfers between non-users and users. In Section 6, we draw further comparisons between our model and that of Edelman and Wright.

5 Equilibrium when transaction fees are endogenous

Now we analyze the full game, as described in Section 3. Here, the platform chooses whether to impose price coherence or to allow the merchant price flexibility, and it sets the transaction fee, denoted by either f^C or f^F, depending on the regime. After stating a general result on the ranking of the platform's fees, we explore both (a) which regime the platform chooses, and (b) which one is better for consumers and in for total surplus. Interestingly, we find that consumers and society as a whole are better off under price coherence, but that, in some cases, the platform may, nevertheless, prefer to grant price flexibility to the merchant.

5.1 Platform transaction fees

We first compare the platform's optimal transaction fees under the two regimes, with general demand satisfying Assumption 1 of strict log-concavity. Recall that, under price flexibility, the direct price, $p_d^* \equiv \text{argmax}_p \; Q(p)\, p$, is simply the "standard" monopoly price, given the demand function $Q(\cdot)$ and zero marginal cost. Thus, in the absence of a platform, the merchant's marginal buyer has a valuation for the good equal to p_d^*. Also recall, Assumption 1 implies that, wherever the pass-through rate, $\delta(p)$, is defined, it is strictly less than one.

Condition 2 (Primacy of the good). $p_d^* \big/ \delta\left(p_d^*\right) \geq b$. *In words, the valuation for the good of the marginal buyer, in the absence of a platform, inflated by the (local) pass-through rate, exceeds the benefit that users perceive when purchasing via the platform versus buying directly.*

Roughly speaking, this condition holds so long as the good is of nontrivial value to buyers. It would be violated only when, for some reason, a substantial fraction of users who would purchase the good in the absence of the platform are, nevertheless, more interested in transacting via the platform for its own sake than they are in consuming the good. We now state Lemma 4, regarding the platform's optimal fee under price flexibility. Note that, starting in the proof of this result, we sometimes write the merchant's optimal prices under the respective regimes as functions of the platform's fee, denoting them by $p_m^*\left(f^F\right)$ and $\hat{p}^*\left(f^C\right)$.

Lemma 4. *$f^F = b$ if and only if Condition 2 holds. Otherwise, $f^F < b$.*

Lemma 4 says that, whenever the primacy condition holds, under price flexibility, the platform charges the maximum transaction fee that the merchant is willing to accept. This result leads naturally to the following proposition.

Proposition 3. *If Condition 2 holds, then $f^C < f^F$. That is, when the primacy condition is satisfied, the platform sets a strictly lower transaction fee in the price coherence subgame than it does in the price flexibility subgame.*

This result follows from the fact that the maximum transaction fee the merchant is willing to accept is higher under price flexibility than it is under price coherence. (See Lemmas 1 and 2.) Thus, provided that, under price flexibility, the platform charges the maximal fee, b, the fee it charges under price coherence must be lower, because it is upper-bounded by $\overline{f} < b$.

Proposition 3, therefore, reinforces the findings of the previous section (see Proposition 2 and Figure 2) showing the potential for price coherence to yield greater consumer surplus than price flexibility. This is because, when, in that setting, f was held fixed across regimes, it was harder for undershooting to occur than if, upon switching from price flexibility to coherence, f decreases. We now focus on linear and constant pass-through demands to explore this effect further.

5.2 Linear demand

The case of linear demand ($\gamma = 1$) can be solved analytically. Proposition 4 highlights the important properties of equilibrium, which the proof fully characterizes. Hereafter, we assume that Condition 2 holds.

Proposition 4. *Under linear demand, the following statements hold.*

(a) The transaction fee that the platform sets under price coherence is strictly lower than the transaction fee that it sets under price flexibility.

(b) Consumer surplus is greater under price coherence than under flexibility.

(c) In the unique subgame-perfect equilibrium of the game, the platform chooses to impose price coherence. Moreover, total surplus is greater under price coherence.

Note, first, that part (a) is a simple application of Proposition 3.[9] Part (b), meanwhile, follows in a straightforward manner from Proposition 2. Recall, that result implies that, when demand is linear and $f^F = f^C \leq \overline{f}$, the undershooting condition holds with equality. Thus, when $f^C = \overline{f} < f^F$, there is strict undershooting.

Part (c) is subtler, because it is not immediately clear why the platform should prefer price coherence to price flexibility. On the one hand, because $f^F > f^C$, the platform earns less per transaction under price coherence. On the other hand, however, the good is cheaper for users under price coherence than it is under price flexibility: $\hat{p}^*\left(f^F\right) < p_m^*\left(f^C\right)$. Thus, price coherence leads to a larger volume of transactions mediated by the platform. Under linear demand, the latter effect dominates, leading the platform to prefer coherence. Since consumer surplus and platform profits are each greater under price coherence, and the binding transaction fees equalize the merchant's payoff across the two regimes, total surplus is greater under price coherence.

[9]Here, following Lemma 4, $f^F = b$, and it also holds that $f^C = \overline{f}$.

5.3 Constant pass-through demand

We now generalize to the case of constant pass-through demand, as defined in equation (6). This environment does not typically admit a closed-form solution for $\overline{f}$, the maximum transaction fee that the platform may charge under price coherence, so we solve the game numerically. Throughout the range of parameters we explore, the platform indeed finds it optimal, under price coherence, to set $f^C = \overline{f}$ (as well as $f^F = b$, since Condition 2 holds).

The following two features stand out. First, no matter how large the convexity measure γ, both consumer surplus and total surplus are always greater under price coherence. Second, however, as demand becomes sufficiently concave (i.e., γ becomes small), even though consumers would be better off under price coherence, the platform chooses price flexibility at equilibrium. This is because, as demand becomes more concave, the merchant's profits from direct and mediated sales of the good also each become more concave. With more concave profit functions arising from each group, the cost that the merchant incurs from not being allowed to charge separate, optimal prices to each group becomes larger. Thus, the maximum fee that the merchant is willing to pay under price coherence decreases. Consequently, from the standpoint of the platform, a low value of γ makes it relatively appealing to sacrifice the higher transaction volume that price coherence offers, in favor of the high transaction fees that price flexibility allows.

Figure 4 illustrates these features. In it, the solid curve separates the left-hand region, in which the platform allows for price flexibility, from the right-hand region, in which it imposes price coherence. To the left of the dotted line, the vector of fully endogenous prices satisfies the undershooting condition,[10] while, to the right of the dotted line, it does not.

In summary, in this environment, there are two possibilities. On the one hand, the platform's preference between the two regimes may be aligned with the interests of both consumer and total surplus maximization. In this case, at equilibrium, we would observe price coherence. On the other hand, the platform's preference may run counter to these objectives, in which case, at equilibrium, we would observe price flexibility, even though a switch to price coherence would

[10]That is, $\hat{p}^*\left(f^C\right) < \lambda p_d^* + (1-\lambda)p_m^*\left(f^F\right)$.

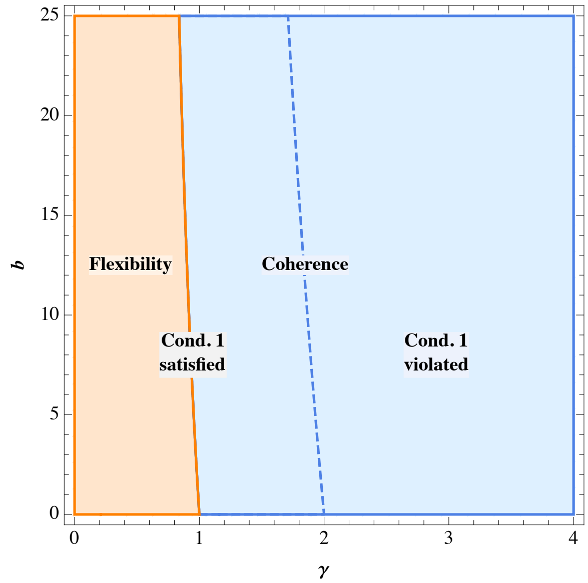

Figure 4: *The platform's equilibrium choice of regime. Here,* $\lambda = 1/2$ *and* $v = 100$*, but the basic pattern is not sensitive to these choices.*

lead to an increase in both of these measures of welfare.

6 Endogenous user participation on the platform

In this section, we endogenize buyers' decision of whether or not to join the platform to begin with. Here, we find that price coherence continues to bring about greater consumer and total surplus, from sales of the good, than price flexibility. However, price coherence also leads more users to join the platform, which generates higher aggregate joining costs. We explore the tradeoff created by these opposing forces. We find that price coherence still delivers greater total surplus, but that overall consumer surplus may be greater under price flexibility if users' are elastic enough in their demand for joining the platform.

6.1 Setup

We assume that each member of the unit mass of buyers incurs a joining cost, c, if she chooses to sign up for the platform, and that these costs are distributed according to distribution H. The new timing is as follows.

1. The platform sets the transaction fee, f, and it chooses which arrangement to use, price flexibility or price coherence.

2. Each buyer observes her value of c and decides whether to join the platform. Simultaneously, the merchant chooses whether or not to allow its good to be sold via the platform. If it participates, then, under price flexibility, it sets p_d and p_m, whereas, under price coherence, it sets $\hat{p}$.

3. Each buyer learns her value of v and chooses whether or not to purchase the good. In so doing, if the merchant has chosen to participate, users can choose whether to make their purchase via the platform or directly.

The only difference here, compared to the preceding sections, is the feature that, in stage 2, not only the merchant, but also buyers choose whether or not to join the platform.[11]

We solve the model numerically, adopting the following specifications. The distribution of joining costs for potential users, H, embeds the earlier, exogenous setup as a special case. Intuitively, this distribution can be described as follows. A share, $\xi \in [0, 1)$, of consumers have joining cost of zero, while the complementary share, $1 - \xi$, have (strictly) positive joining costs. Among those with positive joining costs, one share, $\phi \in [0, 1]$, have costs that are uniformly distributed over the interval $(0, \bar{c})$, where $\bar{c}$ is large enough to be make joining prohibitively costly. The complementary share, $1 - \phi$, among this group, all have a prohibitively high joining cost, $\bar{c}$.[12]

Figure 5 plots this distribution. Note that, when $\phi = 0$, this is equivalent to the setup studied above, in that $1 - \xi = \lambda$ always choose to be non-users, and $\xi = 1 - \lambda$ always choose to join. Meanwhile, when $\phi = 1$ and $\xi = 0$, we have a simple uniform distribution over $(0, \bar{c})$.

Beyond merely embedding these two canonical cases, this specification has a natural in-

[11] Note that this timing matches that of Edelman and Wright (2015b).

[12] Formally, this distribution takes the form

$$H(c) = \begin{cases} \xi, & c = 0, \\ \xi + (1 - \xi)\,\phi \cdot c/\bar{c}, & 0 < c < \bar{c}, \\ 1, & c = \bar{c}. \end{cases}$$

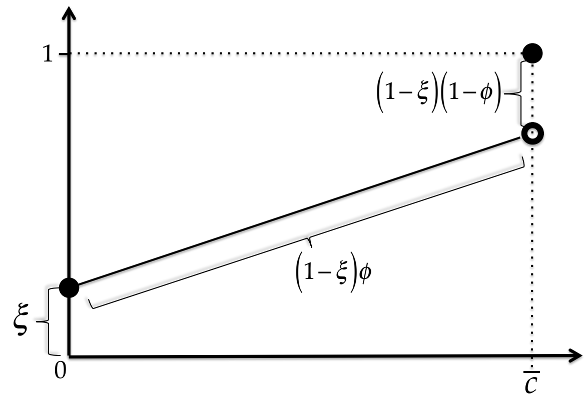

Figure 5: *Cumulative distribution, H, on buyers' joining costs. It has has point mass ξ at $c = 0$, point mass $(1 - \xi)\left(1 - \phi\right)$ at $c = \overline{c}$, and the rest is uniformly distributed over $(0, \overline{c})$.*

terpretation. The share, ξ, of buyers with zero joining costs may be enrolled in the platform automatically for various reasons. For instance, they may sign up for a travel or shopping platform by simply not un-checking a box during some previous online purchase. Similarly, they may sign up for a payment platform, without making any concerted effort to do so, by virtue of of holding a bank account. Meanwhile the share, $(1 - \xi)(1 - \phi)$, of buyers with prohibitively high joining costs may include groups such as those with foreign billing addresses or insufficient documentation who are ineligible to sign up for the platform.[13]

As in Subsection 5.2, we focus on the case of linear demand for the good; i,e., the distribution, G, of valuations for the good is uniform over the interval $[0, \overline{v}]$. We further assume that buyers joining costs and valuations for the good are independently distributed.

In the second stage, given transaction fee f and the selected regime, each buyer joins the platform if and only if her joining cost, c, is below some threshold, $\tilde{c}$. Thus, under the respective regimes, the total mass of buyers that join is $1 - \lambda^F = H\left(\tilde{c}^F\right)$ and $1 - \lambda^C = H\left(\tilde{c}^C\right)$, and aggregate joining costs are given by $L^F \equiv \int_{x \leq \tilde{c}^F} x\, dH(x)$ and $L^C \equiv \int_{x \leq \tilde{c}^C} x\, dH(x)$. We maintain the definitions $S^F \equiv \lambda^F S(p_d) + \left(1 - \lambda^F\right) S(p_m - b)$ and $S^C \equiv \lambda^C S(\hat{p}) + \left(1 - \lambda^C\right) S(\hat{p} - b)$, which now denote consumer surplus derived from purchasing the good. Define *inclusive* consumer surplus (taking into account joining costs) as $W^F \equiv S^F - L^F$ and $W^C \equiv S^C - L^C$. Let T^F and T^C denote total surplus

[13]Note, however, that the size, ξ, of the former group with zero joining cost is more meaningful than the size, $(1 - \xi)(1 - \phi)$, of the latter group with joining cost $\overline{c}$, because increases in ϕ can be offset by increases in $\overline{c}$, so as to hold fixed the total mass of consumers with joining costs above any particular threshold.

under the two regimes, defined as the sum of inclusive consumer surplus, merchant profits and platform profits.

6.2 Equilibrium

Example 1 characterizes the equilibrium of this model under specific numerical values for parameters $\overline{v}$, b, and $\overline{c}$. However, the outcomes we describe hold much more generally in the environment with uniform, independently distributed joining costs, c and valuations, v. We have explored many other parameter values, beyond those reported here and have always found qualitatively similar results, so long as (i) b is not so large that the merchant is incentivized to fully exclude non-users in the price coherence regime, and (ii) $\overline{c} > b$, so that some buyers always choose not to join the platform.

Example 1. *Let* $\overline{v} = 100$ *and* $b = 5$*, and let* $\overline{c} = 10$*. The following points hold.*

(a) For all values of $\left(\xi, \phi\right) \in (0,1)^2$ *,*

- *at equilibrium, the platform chooses to impose price coherence. It sets its transaction fee equal to the maximum level that the merchant is willing to accept,* $\overline{f}$*.*
- *more buyers join the platform under price coherence than under flexibility (*$\tilde{c}^F < \tilde{c}^C$*),*
- *consumer surplus derived from purchasing the good and total surplus are greater under price coherence than under flexibility (*$S^C > S^F, T^C > T^S$*).*

(b) When the mass of buyers with zero joining costs is sufficiently large, relative to the mass buyers that are potentially marginal, then inclusive consumer surplus is greater under price coherence ($W^C > W^F$*). Otherwise, the reverse is true.*

Figures 6 and 7 further illustrate this example.

These results raise the following three points. First, in this setting where consumers endogenously decide whether or not to join the platform, the main theme discussed in previous sections continues to hold. That is, the surplus that consumers derive from *transactions* (i.e., including their valuations for the good, v, and their benefit from purchasing via the platform, b) tend to

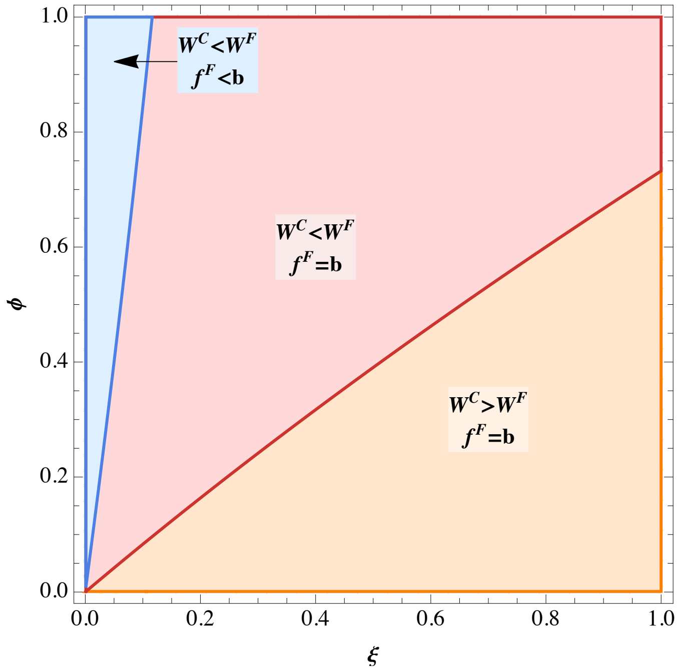

Figure 6: *Comparisons, under the two regimes, of inclusive consumer surplus, W, and the platform's optimal transaction fee under price flexibility,* f^F.

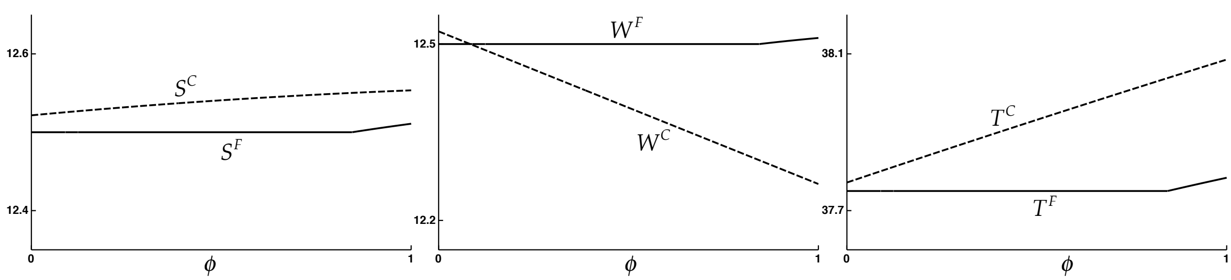

Figure 7: *Here,* ξ*=0.1; these plot comparisons under the two regimes of, from left to right, consumer surplus derived from purchasing the good, S, inclusive consumer surplus, W, and total surplus, T.*

be greater under price coherence than under flexibility. Specifically, here, we study the case of linear demand for the good and find this to hold.

Second, *inclusive consumer surplus* may be greater under either regime. On the one hand, so long as there are *some* consumers "on the margin" between joining the card or not, aggregate joining costs are greater under price coherence. To see why, note that, under coherence, the equilibrium price of the good is lower than under flexibility, and, therefore, the joining cost of the marginal consumer must be higher. Consequently, the crucial factor determining whether price coherence helps consumers, overall, is whether increased surplus from transactions exceeds the higher joining costs. Figures 6 and 7 show circumstances in which each of these outcomes prevail. In particular, Figure 6 shows that when the relative mass of potentially undecided consumers is low, compared to those who could be swayed either way, then price coherence gives rise to higher inclusive consumer surplus.

On the other hand, when the set of potentially undecided consumers becomes significant enough, the opposite holds. Consumers are worse off at equilibrium, featuring price coherence, than they would be if the platform were required to allow price flexibility but could still set its merchant fee optimally. At one level, our results under such parameter values mirror the findings of Edelman and Wright (2015b), who also find price flexibility to be better for consumers. However, the crucial difference is that, in their setting with Vickrey-Salop competition among merchants, consumer surplus from transactions is the same under the two regimes, and thus the sole driving force is the higher joining costs under price coherence. In our setting with a variable volume of total transactions, there is a potentially more interesting tradeoff.

For example, consider the following stylized description of a potential policymaking scenario. Suppose that, at the *status quo*, a competition authority observes a platform imposing price coherence. Using the lens of our model, if the authority had the ability to forbid the platform from imposing price coherence, should it do so?

If the authority's objective is to maximize total surplus, then our model suggests that it should allow price coherence. If the goal is to maximize consumer surplus, then the answer is not clear-cut, but an interesting point arises regarding the level of penetration that the platform has already attained. If a large share of the potential consumers of the good have already joined the platform, and their joining costs are sunk, a prohibition on price coherence has the potential to further harm them by leading to a less desirable pricing regime for the good.

7 Conclusion

This paper considers platforms that act as optional intermediaries, i.e., that mediate transactions for which users may also choose to bypass the platform and purchase directly from the seller. We focus on a potential pricing restraint that platforms sometimes impose on sellers, namely, to charge the same price for direct purchases as for mediated transactions. We examine the forces that influence whether the platform should prefer to impose such price coherence or whether it is better off allowing the seller to have price flexibility. Also, we study the effect that this choice has on consumers and on total surplus.

Regarding the platform's choice, imposing price coherence drives up the volume of sales that are transacted via the platform. However, price flexibility allows the merchant to extract from users a greater share of the benefit they enjoy from using the platform. Due to this tradeoff, either arrangement may be preferable, and the choice depends on the shape of the seller's demand. When the seller incurs steep dropoffs in profits from charging sub-optimal prices, the platform is better off allowing price flexibility. Otherwise, the platform earns greater profits under price coherence.

Notably, we find that consumer surplus and total surplus are often greater under price coherence. This finding stems from a novel *drawing-in effect*. Here, the benefit that the platform provides attracts, to the seller, a set of consumers with relatively low valuations who would, in the platform's absence, be uninterested. This effect operates under price coherence but not under price flexibility, because the latter arrangement allows the merchant to cleanly extract the aforementioned benefit.

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Appendices

A Proofs

Proof of Lemma 1. Let $\tilde{p} \equiv p_m - b$ and rewrite equation (1) as

$$\lambda Q(p_d)\,p_d + (1-\lambda)\,Q(\tilde{p})\,(\tilde{p} - (f-b)). \tag{7}$$

If $f > b$, then the effective marginal cost of selling via the platform is positive. Therefore, it is more profitable for the merchant not to participate on the platform (or, equivalently, to participate and set p_m to an arbitrarily high level that induces no sales via the platform). If $f \leq b$, even if the merchant were to set $\tilde{p} = p_d$, it would make (weakly) greater profits than if it didn't participate and charged that same price. When $f < b$, by separately setting prices optimally for each group, it makes strictly greater profits. $\square$

Proof of Lemma 2. We show that, if $f = 0$, participating makes the merchant strictly better off, and, if $f = b$, doing so makes it strictly worse off. Note, first, that if the merchant refuses to participate, its maximal profits are $Q\left(p_d^*\right)p_d^*$. Now, suppose $f = 0$. If the merchant participates and sets $\hat{p} = p_d^*$, it earns $\lambda Q\left(p_d^*\right)p_d^* + (1-\lambda)\,Q\left(p_d^* - b\right)p_d^* > Q\left(p_d^*\right)p_d^*$. Next, suppose $f = b$. Lemma 1 shows that, in this case, under price flexibility, the merchant is indifferent whether or not to participate. That is, $Q\left(p_d^*\right)p_d^* = \lambda Q\left(p_d^*\right)p_d^* + (1-\lambda)\,Q\,(p_m^* - b)\,(p_m^* - b)$, which implies that $p_d^* = p_m^* - b$. Since this profit level requires the merchant to charge the two groups different prices, it is not feasible under price coherence. $\square$

Proof of Lemma 3. First we show that $p_m^* - b < p_d^*$. Lemma 2 implies that the merchant participates under price coherence only if $f \leq \overline{f} < b$, so the term $f - b$ in equation (7) is strictly negative. Thus, the optimal prices for each group satisfy $p_d^* > \tilde{p}^* = p_m^* - b$.

Next we show that $p_d^* < p_m^*$. For any $f, b > 0$, denote by $p^*(f,b)$ the solution to

$$p = f + \frac{Q(p-b)}{-Q'(p-b)}.$$

We have $p_d^* = p^*(0,0)$ and $p_m^* = p^*(f,b)$. Implicit function theorem implies that

$$\frac{\partial p^*}{\partial f} = -\frac{-1}{1 + \frac{(Q')^2 - QQ''}{(Q')^2}} = \frac{1}{2 - \frac{Q''}{Q'}\Big/\frac{Q'}{Q}} > 0,$$

$$\frac{\partial p^*}{\partial b} = -\frac{-\frac{(Q')^2 - QQ''}{(Q')^2}}{1 + \frac{(Q')^2 - QQ''}{(Q')^2}} = \frac{1 - \frac{Q''}{Q'}\Big/\frac{Q'}{Q}}{2 - \frac{Q''}{Q'}\Big/\frac{Q'}{Q}} > 0,$$

since the log-concavity of $Q(\cdot)$ from Assumption 1 indicates that $\frac{Q''}{Q'}\Big/\frac{Q'}{Q} < 1$ globally. Thus, $p_d^* = p^*(0,0) < p^*(f,b) = p_m^*$.

Finally, because the profit functions for each group are single-peaked, it follows that $p_d^* < \hat{p}^* < p_m^*$, with $Q(\hat{p}^*) + \hat{p}^* Q'(\hat{p}^*) < 0$ and $Q(\hat{p}^* - b) + (\hat{p}^* - f) Q'(\hat{p}^* - b) > 0$. This implies that $\hat{p}^* - b < p_m^* - b$. □

Proof of Proposition 1. By assumption, $\hat{p} - b < p_m - b < p_d < \hat{p} < p_m$. Hence, Lagrange's mean value theorem implies that

$$\begin{aligned} S^C(\hat{p}) > S^F(p_d, p_m) &\Leftrightarrow \lambda S(\hat{p}) + (1-\lambda) S(\hat{p} - b) > \lambda S(p_d) + (1-\lambda) S(p_m - b) \\ &\Leftrightarrow (1-\lambda)(S(\hat{p} - b) - S(p_m - b)) > \lambda (S(p_d) - S(\hat{p})) \\ &\Leftrightarrow (1-\lambda) \cdot ((p_m - b) - (\hat{p} - b)) \cdot (-S'(\xi_1)) > \lambda \cdot (\hat{p} - p_d) \cdot (-S'(\xi_2)), \end{aligned}$$

where $\hat{p} - b < \xi_1 < p_m - b < p_d < \xi_2 < \hat{p}$. Since $S(\cdot)$ is convex, $-S'(\xi_1) > -S'(\xi_2)$. Thus, it suffices to have $(1-\lambda)(p_m - \hat{p}) \geq \lambda(\hat{p} - p_d)$, which is equivalent to Condition 1. □

Proof of Proposition 2. From optimality condition (3), we have

$$p_d^* = \frac{\overline{v}}{1+\gamma}, \quad p_m^* = \frac{\overline{v} + b + \gamma f}{1+\gamma},$$

so

$$p_\lambda \equiv \lambda p_d^* + (1-\lambda) p_m^* = \frac{\overline{v} + (1-\lambda)(b + \gamma f)}{1+\gamma},$$

and Condition 1 is equivalent to $\hat{p}^* \leq p_\lambda$. Since $\hat{p}^*$ satisfies the first-order condition (4),

$$\lambda (Q(\hat{p}^*) + \hat{p}^* Q'(\hat{p}^*)) + (1-\lambda)(Q(\hat{p}^* - b) + (\hat{p}^* - f) Q'(\hat{p}^* - b)) = 0,$$

$\hat{p}^* \leq p_\lambda$ if and only if the left-hand side of equation (4) is weakly negative when evaluated at p_λ, i.e.,

$$\lambda (Q(p_\lambda) + p_\lambda Q'(p_\lambda)) + (1-\lambda)(Q(p_\lambda - b) + (p_\lambda - f) Q'(p_\lambda - b)) \leq 0,$$

which is equivalent to

$$\lambda (1-\lambda)(b + \gamma f)\left((\overline{v} + b - p_\lambda)^{\gamma - 1} - (\overline{v} - p_\lambda)^{\gamma - 1}\right) \leq 0 \quad \Leftrightarrow \quad \gamma \leq 1.$$

This completes the proof. □

Proof of Lemma 4. Under price flexibility, the platform finds it optimal to set

$$f^F \equiv \underset{f \leq b}{\operatorname{argmax}} \; Q(p_m^*(f) - b) f.$$

Ignoring the $f \leq b$ constraint, the first-order derivative of platform profits with respect to f is

$$Q\left(p_m^*(f) - b\right) + f \cdot Q'\left(p_m^*(f) - b\right) \cdot \frac{dp_m^*}{df} = Q\left(p_m^*(f) - b\right) + f \cdot Q'\left(p_m^*(f) - b\right) \cdot \delta\left(p_m^*(f) - b\right). \quad (8)$$

Thus, the constraint is binding if and only if the expression in (8) is positive at $f = b$. Note that when $f = b$, it holds that $p_m^*(f) - b = p_d^*$. From the merchant's optimality condition, (3), we have $Q\left(p_d^*\right) = -Q'\left(p_d^*\right) p_d^*$. Thus, evaluated at $f = b$, the right-hand side of expression (8) can be rewritten as

$$Q\left(p_d^*\right) + b \cdot Q'\left(p_d^*\right) \cdot \delta\left(p_d^*\right) = -Q'\left(p_d^*\right)\left(p_d^* - \delta\left(p_d^*\right) b\right),$$

which is nonnegative if and only if $p_d^* - \delta\left(p_d^*\right) b \geq 0 \Leftrightarrow p_d^* \big/ \delta\left(p_d^*\right) \geq b$. This completes the proof. □

Proof of Proposition 3. From Lemma 4, $f^F = b$ if Condition 2 holds. Together with Lemma 2, we have $f^C \leq \overline{f} < b = f^F$. This completes the proof. □

Proof of Proposition 4. Under linear demand, $Q(p) = 1 - p/\overline{v}$. Thus,

$$S(p) = \int_p^{\overline{v}} Q(x)\, dx = \frac{(\overline{v} - p)^2}{2\overline{v}}.$$

Condition 2 becomes $b \leq \overline{v}/2$. From optimality conditions (3) and (4), we obtain

$$p_m^*(f) = \frac{\overline{v} + b + f}{2}, \quad p_d^* = \frac{\overline{v}}{2}, \quad \hat{p}^*(f) = \frac{\overline{v} + (1 - \lambda)(b + f)}{2}.$$

By definition, $\overline{f}$ solves

$$(1 - \lambda)\, Q\left(\hat{p}^*\left(\overline{f}\right) - b\right) \cdot \left(\hat{p}^*\left(\overline{f}\right) - \overline{f}\right) + \lambda Q\left(\hat{p}^*\left(\overline{f}\right)\right) \hat{p}^*\left(\overline{f}\right) = Q\left(p_d^*\right) p_d^*,$$

which yields

$$\overline{f} = \frac{2\overline{v} + (1 - \lambda)\, b}{\overline{v} + (1 + \lambda)\, b + \sqrt{\overline{v}^2 + 4\lambda \overline{v} b + 4\lambda b^2}}\, b \in (0, b).$$

Now consider the platform's optimal transaction fees under the two regimes, f^F and f^C:

$$f^F = \underset{f \leq b}{\operatorname{argmax}} \;\; Q\left(p_m^*(f) - b\right) f, \quad f^C = \underset{f \leq \overline{f}}{\operatorname{argmax}} \;\; Q\left(\hat{p}^*(f) - b\right) f.$$

First consider price flexibility. The first-order derivative of the platform's profits evaluated at $f = b$ is

$$Q\left(p_m^*(b) - b\right) + b \cdot Q'\left(p_m^*(b) - b\right) \cdot \left.\frac{dp_m^*}{df}\right|_{f=b} = \frac{1}{2} + b \cdot (-1/\overline{v}) \cdot \frac{1}{2} = \frac{1 - b/\overline{v}}{2} > 0,$$

so it would profit from a marginal increase in f when $f = b$ if it could ignore the merchant's acceptance constraint. Hence, the constrained maximization leads to corner solution, which implies that $f^F = b$.

Next consider price coherence. Similarly, the first-order derivative of the platform's profits evaluated at $f = b$ is

$$Q\left(\hat{p}^*(b) - b\right) + b \cdot Q'\left(\hat{p}^*(b) - b\right) \cdot \left.\frac{d\hat{p}^*}{df}\right|_{f=b} = \frac{1}{2} + \lambda\left(b/\overline{v}\right) + b \cdot \left(-1/\overline{v}\right) \cdot \frac{1-\lambda}{2} = \frac{1-(1-3\lambda)\,b/\overline{v}}{2} > 0,$$

so, similarly, the constrained maximization leads to corner solution, which implies that $f^C = \overline{f} < b = f^F$, i.e., the transaction fee that the platform sets under price coherence is strictly lower than the transaction fee that it would set if it chose to allow price flexibility.

Note that the difference in platform profits across regimes,

$$\begin{aligned} & Q\left(\hat{p}^*\left(f^C\right) - b\right) f^C - Q\left(p_m^*\left(f^F\right) - b\right) f^F \\ = & \frac{2\lambda(1-\lambda)b^3\left(\overline{v}+b\right)}{\overline{v}\left(\overline{v}^2 + (1+3\lambda)\,\overline{v}b + 4\lambda b^2 + \left(\overline{v} + (1+\lambda)b\right)\sqrt{\overline{v}^2 + 4\lambda\overline{v}b + 4\lambda b^2}\right)} > 0, \end{aligned}$$

so the platform chooses to impose price coherence at equilibrium.

It remains to compare surplus. Proposition 2 implies that if the transaction fee is set at an exogenously level $f = \overline{f}$, price coherence gives rise to greater consumer surplus than price flexibility. Now that price flexibility would lead to a strictly higher transaction fee, the consumers would be hurt even more. Therefore, consumer surplus is greater under price coherence than under flexibility. It follows immediately that total surplus is greater under price coherence, because this regime favors both consumers and the platform, while the merchant is indifferent between the two regimes (it would earn $Q\left(p_d^*\right) p_d^*$ under both). This completes the proof. □

B *Ad valorem* transaction fees

B.1 The model

Here, we retain the same structure of the model in Section 3, except that in both arrangements, the platform collects an *ad valorem* "transaction fee", a share a, from the merchant, of the total sale made via the platform. In addition, here it is no longer without loss of generality to normalize marginal cost for the merchant to be zero, so we assume that the merchant produces the good at constant marginal cost $\kappa > 0$. Thus, under price flexibility, assuming all users who purchase prefer to pay via the platform (which, we will show, holds at equilibrium), the merchant's total profits are

$$\lambda Q\left(p_d\right)\left(p_d-\kappa\right)+(1-\lambda) Q\left(p_m-b\right)\left((1-a) p_m-\kappa\right). \tag{B.1}$$

Under price coherence, the merchant's total profits are

$$\lambda Q(\hat{p})(\hat{p}-\kappa)+(1-\lambda) Q(\hat{p}-b)((1-a) \hat{p}-\kappa). \tag{B.2}$$

Under price flexibility, the platform earns profits of $(1-\lambda) Q\left(p_m-b\right) a p_m$, and, under price coherence, it earns $(1-\lambda) Q(\hat{p}-b) a \hat{p}$.

B.2 Exogenous transaction fees

B.2.1 Price flexibility

Assume that the merchant participates on the platform. To set prices, the merchant maximizes equation (B.1) with respect to p_d and p_m, yielding

$$p_d^*=\kappa+\frac{Q\left(p_d^*\right)}{-Q'\left(p_d^*\right)}, \qquad p_m^*=\frac{\kappa}{1-a}+\frac{Q\left(p_m^*-b\right)}{-Q'\left(p_m^*-b\right)}. \tag{B.3}$$

Lemma B.1 says when the merchant chooses to participate.

Lemma B.1. *Under price flexibility, the merchant participates on the platform if and only if $a \leq \bar{a}^F$, where $\bar{a}^F \in\left(\frac{b}{p_d^*+b}, \frac{b}{\kappa+b}\right)$*

Proof of Lemma B.1. Let $\tilde{p} \equiv p_m-b$ and rewrite equation (B.1) as

$$\lambda Q\left(p_d\right) p_d+(1-\lambda)(1-a) Q(\tilde{p})\left(\tilde{p}-\left(\frac{\kappa}{1-a}-b\right)\right). \tag{B.4}$$

If $a \geq \frac{b}{\kappa+b}$, then the effective marginal cost of selling via the platform $\frac{\kappa}{1-a}-b \geq \kappa$. Moreover, $1-a<1$. Therefore, it is more profitable for the merchant not to participate (or, equivalently, to participate and set p_m to an arbitrarily high level that induces no sales via the platform).

If $a \leq \frac{b}{p_d^*+b}$, even if the merchant were to set $\tilde{p}=p_d$, it would make (weakly) greater profits than if it didn't participate and charged that same price. By separately setting prices optimally for each group, it makes strictly greater profits. □

Since $\frac{\kappa}{1-a}-b<\kappa$, users' net price, $p_m^*-b<p_d^*$, ensuring that users who buy choose to pay pay via the platform.

B.2.2 Price coherence

If the merchant participates on the platform, to set its price, it maximizes (B.2) with respect to $\hat{p}$, giving rise to the first-order condition

$$\lambda \left(Q\left(\hat{p}^*\right) + \left(\hat{p}^* - \kappa\right) Q'\left(\hat{p}^*\right)\right) + (1-\lambda)\left((1-a)\, Q\left(\hat{p}^* - b\right) + \left((1-a)\,\hat{p}^* - \kappa\right) Q'\left(\hat{p}^* - b\right)\right) = 0. \tag{B.5}$$

If it does not participate, the merchant sets a direct price equal to p_d^* in (B.3). Lemma B.2 states the condition under which the merchant chooses to participate.

Lemma B.2. *Under price coherence, the merchant participates on the platform if and only if $a \leq \overline{a}^C$, where $\overline{a}^C \in \left(0, \overline{a}^F\right)$.*

B.2.3 Ranking of prices under the two regimes

We now establish the ranking among a set of relevant prices arising from the two regimes. Here Assumption 1 on the demand function $Q(\cdot)$ is maintained. It turns out that we can establish the ranking of equilibrium prices in exactly the same manner as in Lemma 3:

Lemma B.3. *Given any* ad valorem *transaction fee that leads the merchant to participate on the platform under either price flexibility or price coherence, the following ranking holds:*

$$\hat{p}^* - b < p_m^* - b < p_d^* < \hat{p}^* < p_m^*. \tag{B.6}$$

B.2.4 Consumer surplus under the two regimes

Now we compare consumer surplus under price flexibility and price coherence. Note that the change in fee structure does not have any impact on the formulae for consumer surplus. Under the respective regimes, consumer surplus is still $S^F(p_d, p_m) = \lambda S(p_d) + (1-\lambda) S(p_m - b)$ and $S^C(\hat{p}) = \lambda S(\hat{p}) + (1-\lambda) S(\hat{p} - b)$. So Proposition 1 applies here, and Condition 1 is still the relevant sufficient condition for consumer surplus to be greater under price coherence than under price flexibility.

We now move to the case where the merchant optimally chooses p_d^*, p_m^* and $\hat{p}^*$. We focus on constant pass-through demand (as defined in equation (6)) for simplicity. The assumption is retained that b is not so large as to incentivize the merchant to fully exclude non-users in the price coherence regime .

Proposition B.1. *Given any* ad valorem *transaction fee, a, that leads the merchant to participate on the platform under either price flexibility or price coherence, with demand in the constant pass-through family, the merchant chooses prices that satisfy Condition 1 if and only if $\gamma \leq \overline{\gamma}(a)$, where $\overline{\gamma}(0) = 1$ and $\overline{\gamma}(\cdot)$ is strictly increasing in a. Therefore, if $\gamma \leq \overline{\gamma}(a)$, price coherence gives rise to greater consumer surplus than price flexibility.*

Proof of Proposition B.1. From optimality condition (B.3), we have

$$p_d^* = \frac{\overline{v} + \gamma\kappa}{1+\gamma}, \ \ p_m^* = \frac{\overline{v} + b + \gamma\frac{\kappa}{1-a}}{1+\gamma},$$

so

$$p_\lambda \equiv \lambda p_d^* + (1-\lambda)\, p_m^* = \frac{\overline{v} + (1-\lambda)\, b + \left(\lambda + \frac{1-\lambda}{1-a}\right)\gamma\kappa}{1+\gamma},$$

and Condition 1 is equivalent to $\hat{p}^* \leq p_\lambda$. Since $\hat{p}^*$ satisfies FOC (B.5)

$$\lambda \left(Q\left(\hat{p}^*\right) + \left(\hat{p}^* - \kappa\right) Q'\left(\hat{p}^*\right)\right) + (1-\lambda)\left((1-a)\, Q\left(\hat{p}^* - b\right) + \left((1-a)\,\hat{p}^* - \kappa\right) Q'\left(\hat{p}^* - b\right)\right) = 0,$$

$\hat{p}^* \leq p_\lambda$ if and only if the left-hand side of equation (B.5) is weakly negative when evaluated at p_λ, i.e.,

$$\lambda \left(Q\left(p_\lambda\right) + \left(p_\lambda - \kappa\right) Q'\left(p_\lambda\right)\right) + (1-\lambda)\left((1-a)\, Q\left(p_\lambda - b\right) + \left((1-a)\, p_\lambda - \kappa\right) Q'\left(p_\lambda - b\right)\right) \leq 0,$$

which is equivalent to

$$\lambda\,(1-\lambda)\left((1-a)\, b + a\gamma\kappa\right)\left(\left(\overline{v} + b - p_\lambda\right)^{\gamma-1} - \frac{1}{1-a}\left(\overline{v} - p_\lambda\right)^{\gamma-1}\right) \leq 0.$$

Note that when $a = 0$, the above inequality is equivalent to $\gamma \leq 1$. For $a > 0$, it is a strict equality when $\gamma = 1$. This gives rises to the result in Proposition B.1. □

Figure B.1 is analogous to Figure 2, but here the platform charges an *ad valorem* fee. In it, the region with less convex demand to the left of the solid curve features higher consumer surplus under price coherence. The opposite holds in the region with more convex demand to the right of this curve. Note that, in a sizeable zone (including all values of $\gamma \in (2, 6)$), the overshooting condition does not hold, yet price coherence still leads to greater consumer surplus.

B.3 Equilibrium when transaction fees are endogenous

We now analyze the subgame-perfect equilibrium of the full game, including the first stage, in which the platform chooses both whether to impose price coherence or to allow for price flexibility and the level of the *ad valorem* transaction fee, a.

We still consider constant pass-through demand. This environment does not typically admit a closed-form solution for $\overline{a}^F$ and $\overline{a}^C$, so we solve the game numerically. Throughout the range of parameters we explore, the platform indeed finds it optimal to set $a^F = \overline{a}^F$ and $a^C = \overline{a}^C$. It then follows from Lemma B.2 that the platform sets a strictly lower transaction fee in the price coherence subgame than it does in the price flexibility subgame. This reinforces the findings of the previous section (see Figure B.1) showing the potential for price coherence to yield greater

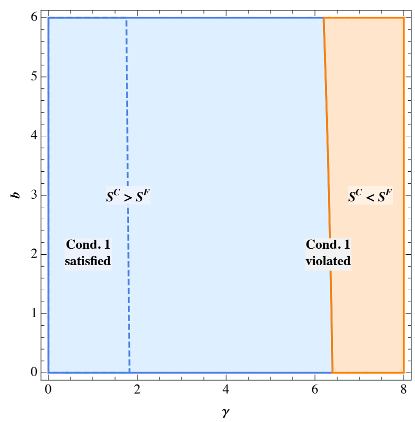

__Figure B.1:__ Ranking of consumer surplus across the two regimes, under constant pass-through demand. Here, $a = \overline{a}^C(\gamma, b)$, $v = 100$, $\kappa = 30$, and $\lambda = 1/2$, but the basic pattern is not sensitive to these choices.

consumer surplus than price flexibility.

The following two features stand out from our computations. First, no matter how large the convexity measure γ, both consumer surplus and total surplus are always greater under price coherence. Second, however, as demand becomes sufficiently concave (i.e., γ becomes small), even though consumers would be better off under price coherence, the platform chooses price flexibility at equilibrium.

Figure B.2 is analogous to Figure 4, illustrating these features. In it, the solid curve separates the left-hand region, in which the platform allows for price flexibility, from the right-hand region, in which it imposes price coherence. To the left of the dotted line, the vector of fully endogenous prices satisfies the undershooting condition,[14] while, to the right of the dotted line, it does not.

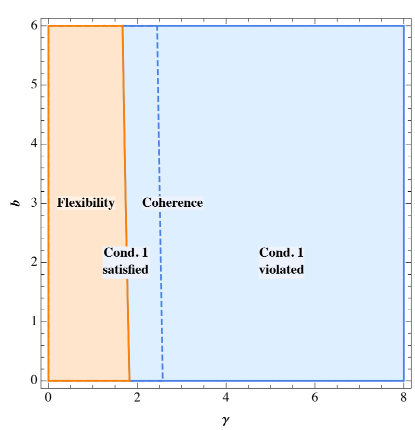

__Figure B.2:__ The platform's equilibrium choice of regime. Here, $\lambda = 1/2$, $v = 100$, and $\kappa = 30$, but the basic pattern is not sensitive to these choices.

[14]That is, $\hat{p}^*\left(a^C\right) < \lambda p_d^* + (1-\lambda)p_m^*(a^F)$.