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"Platform Disintermediation with Repeated Transactions"

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Platform Disintermediation with Repeated Transactions*

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Abstract

We consider a setting in which a platform matches buyers and sellers, who then wish to transact with each other multiple times. The platform charges fees for hosting transactions, but also offers convenience benefits. We consider two scenarios. In one scenario, all transactions must occur on the platform; in the other scenario, buyers and sellers can disintermediate the platform after the first transaction, and do subsequent transactions offline. We find that the platform reacts to disintermediation by using a "front-loaded" pricing scheme, whereby it charges more for earlier transactions. We also show that sometimes the platform is better off when disintermediation is possible—because it can use disintermediation to screen users' private information about their convenience benefits. Buyers are not necessarily better off when they can disintermediate, due to the way in which the platform adjusts its fees.

Keywords: Platforms, disintermediation, convenience benefits, repeat transactions.

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1 Introduction

Online platforms help to connect buyers and sellers in a wide variety of product and service markets. These buyers and sellers often go on to transact with each other multiple times. For example, a holidaymaker may find a beach-side apartment on Airbnb, and choose to stay there again the following year; a local sports team may book a trainer on CoachUp to help prepare for a tournament, and use the same trainer for future competitions; a student might book a language tutor on Preply to help prepare for an exam, and continue lessons with the same tutor even after the exam. Most platforms take a commission for hosting transactions, making them vulnerable to disintermediation—after buyers and sellers have met and transacted once, they may be tempted to handle future transactions bilaterally outside the platform. At the same time, platforms typically offer convenience benefits to buyers and sellers who continue to transact there—such as insurance, dispute resolution, scheduling, and escrow payment services. Some platforms also offer more specialized convenience benefits—for example, Upwork offers AI-powered project management tools, Zeel offers 24/7 safety support, while on Preply students can use TalkNow to practice before lessons.[1]

The threat of platform disintermediation raises several important questions. For example, should a platform charge higher or lower commissions to buyers and sellers that have already transacted on it? To what extent does offering convenience benefits insulate a platform from disintermediation? Is disintermediation necessarily bad for a platform and good for buyers and sellers? In this paper we develop a theoretical model to address these and other related questions.

In our baseline model a platform connects a buyer with a seller, and also provides the buyer with a convenience benefit each time she transacts on the platform. The buyer wishes to transact either once or twice, and is privately informed about this, as well as about her convenience benefit. The platform charges the buyer a fee for each completed transaction. Since the platform is essential in matching the buyer and seller, the first transaction always occurs on the platform. We then consider two different scenarios for the second transaction. In one scenario disintermediation is impossible: if the buyer wishes to do a second transaction, she must do it on the platform. In the other scenario disintermediation is possible: if the buyer wishes to do a second transaction, she has the choice between doing it on or off the platform. The buyer therefore faces

[1] For further details see, respectively, https://shorturl.at/V6wQs, https://shorturl.at/51nfy, and https://shorturl.at/qU2tO.

a trade-off—if she disintermediates she no longer pays the platform a fee, but also loses out on the convenience benefit. Our baseline model makes several simplifying assumptions, so as to illustrate the main forces as cleanly as possible. However, later in the paper, we show our insights are robust to several generalizations: sellers obtain convenience benefits, sellers directly choose final prices, buyers wish to do an arbitrary number of transactions, and buyers and sellers jointly bargain over whether and how to disintermediate.

In this setting, we show that the platform reacts to the threat of disintermediation by using a "front-loaded" pricing scheme. Specifically, it tends to charge more for the first transaction, and less for the second transaction. Intuitively, the platform reduces the amount of disintermediation by pricing the second transaction more cheaply; this leaves rents to a buyer, which allows the platform to then charge a higher price for matching her with the seller and hosting the first transaction.

We then show that buyer heterogeneity crucially affects whether the platform is better or worse off when buyers can disintermediate. (i) When there is no buyer heterogeneity—meaning that all buyers wish to transact twice, and enjoy the same convenience benefit—disintermediation is *neutral* for the platform. The higher price on the first transaction exactly cancels the lower price on the second transaction. (ii) When buyers all enjoy the same convenience benefit, but some wish to transact once while others wish to transact twice, disintermediation is *harmful* for the platform. The reason is that buyers who only wish to transact once do not benefit from disintermediation, and so have a lower willingness-to-pay to meet the seller and do the first transaction. The platform must then choose between charging a low price for the first transaction, and giving up rents on buyers who wish to transact twice, or charging a high price for the first transaction, and giving up on hosting buyers who only wish to transact once. (iii) However, when buyers all wish to transact twice but have heterogeneous convenience benefits, disintermediation is *beneficial* for the platform. Intuitively, the platform uses disintermediation as a way to better screen buyers: buyers with a low convenience benefit use the platform once and then move offline, while buyers with a high convenience benefit use the platform for both transactions. (iv) Finally, disintermediation can either benefit or harm the platform when both types of buyer heterogeneity are present, depending on which one is relatively more important.

Our analysis also shows that buyers do not always gain from the ability to disintermediate. Depending on the type of buyer heterogeneity, some or even all buyers can be made worse off. This is intuitive, given that disintermediation potentially enables the platform to better screen buyers and thus extract more surplus from them. Nevertheless, it goes against some recent policies, such as the European Union's Digital Markets Act (DMA), which aim to make disintermediation easier.[2]

The rest of the paper proceeds as follows. We first discuss related literature, then introduce our baseline model in Section 2, and solve for a buyer's problem in Section 3 and the platform's problem in Section 4. Sections 5 and 6 provide various generalizations, while Section 7 discusses managerial implications. Section 8 concludes.

Related Literature Our paper is most closely related to Hagiu and Wright (2024), who consider a model of one-off transactions in which a buyer uses a platform to meet a seller, but can then transact off the platform by incurring a heterogeneous cost. The seller charges a lower price off the platform, so as to encourage disintermediation and thereby economize on platform fees. The platform responds by moderating its fee, thus reducing but not fully eradicating disintermediation. In this setting disintermediation is unambiguously harmful to the platform, so the authors analyze different ways the platform can minimize this harm. Sekar and Siddiq (2023) study a setting in which some buyers are risky and impose additional costs on sellers, and a platform observes a signal about this. The authors show that a platform may not wish to provide sellers with too precise information, because doing so would make it easy for sellers to cherry-pick safe buyers and transact with them off the platform. Casner (2025) studies a setting where sellers differ in their underlying quality. He shows that a platform may deliberately host some low-quality sellers (even though it can exclude them) and offer buyers a refund policy if they encounter a low-quality seller on the platform, because this makes it less attractive for buyers to disintermediate. In contrast to these papers, our model focuses on repeat rather than one-off transactions, and shows that a platform can sometimes use disintermediation to its advantage.

Our paper also relates to the literature on showrooming, where brick-and-mortar retailers face a form of disintermediation because they introduce buyers to products, which the buyers then purchase more cheaply elsewhere. One strand of this literature looks at how showrooming shapes price competition, finding that it can lead to either

[2]According to Articles 5(3) and 5(4) of the DMA, a platform cannot prevent sellers from offering their services at different prices on alternative sales channels, and sellers must be able to freely communicate these offers to buyers that they acquired on the platform. See https://shorturl.at/WseOI.

higher or lower prices depending on the setting considered. (See, e.g., Loginova, 2009; Balakrishnan, Sundaresan, and Zhang, 2014; Jing, 2018; Kuksov and Liao, 2018; Bar-Isaac and Shelegia, 2023.) Another strand of this literature looks at how traditional retailers can limit showrooming using price matching, or vertical restraints such as price parity clauses. (See, e.g., Mehra, Kumar, and Raju, 2018; Wang and Wright, 2020.) In contrast to these papers, we do not consider seller competition, focusing instead on how a platform should price repeat transactions when buyers can shift them offline.

Also related to our paper, therefore, is the (large) literature on pricing with repeat purchases. Some papers look at price dynamics when consumers face switching costs (e.g., Farrell and Klemperer, 2007) or learn their valuation for a good only after experiencing it (e.g., Villas-Boas, 2006). Other papers investigate whether or not firms should reward repeat customers with lower prices (e.g., Chen, 1997; Fudenberg and Tirole, 2000; Shin and Sudhir, 2010). In our paper the platform rewards repeat transactors with lower fees, but this is driven by buyers' ability to disintermediate, and so the mechanism is distinct from that in the above papers.

Finally, we note that there is a growing empirical literature that quantifies disintermediation and seeks to understand its causes. Some papers focus on services where repeat transactions are common. For instance, Zhou, Allen, Gretz, and Houston (2022) study an in-home healthcare platform in China, and find that disintermediation is more severe when clients and agents transact more often. Gu (2024) exploits the 2017 ban on Skype in China, which made off-platform communication more difficult, and shows that it leads to 18% less disintermediation on a U.S. outsourcing platform, with larger effects for repeated hires. Karacaoglu, Li, and Stamatopoulos (2022) consider a European cleaning platform, where the bulk of cleanings are for repeat customers, and estimate that the platform would host 24% more cleanings but for disintermediation. Gu and Zhu (2021) show that when a U.S. outsourcing platform displays past satisfaction scores for individual freelancers, the high-quality ones work 13% fewer hours, suggesting that disintermediation may be larger for repeat transactions. Other papers focus more on one-off transactions. Chintagunta, Huang, Miao, and Zhang (2023) find that communicating on WeChat increases buyer-led disintermediation by 21 percentage points on a Chinese outsourcing platform. Lin, Nian, and Foutz (2022) show that a policy which allows clients to book instantly on Airbnb (and so eliminates communication with hosts) reduces disintermediation by 9%. Xie and Zhu (2023) show that disintermediation on a Chinese cargo delivery platform is sensitive to new fees

2 Model

Consider a setting with one seller, one buyer, and a platform. The seller supplies a product at marginal cost c. With probability $\phi < 1$ the buyer wishes to buy the product once, and with probability $1 - \phi$ she wishes to buy the product twice.[3] The buyer and seller can only meet with the help of the platform. If a transaction subsequently takes place *off* the platform, the buyer has valuation v, where $v > c$. If instead a transaction takes place *on* the platform, the buyer has valuation $v + b$. We assume that b is distributed on $[\underline{b}, \bar{b}] \subseteq \mathbb{R}_+$ according to a (possibly degenerate) distribution function $F(b)$, with $\bar{b} > 0$; when b is non-degenerate, $1 - F$ is log-concave. Thus b captures convenience benefits of transacting on the platform. (See the Introduction for examples of these benefits.) We allow b to be heterogeneous, because different buyers may value convenience benefits differently. The buyer is privately informed about her benefit b, as well as whether she wants to buy the product once or twice.

The platform charges buyer fees $p_{B,1}$ and $p_{B,2}$. Specifically, the buyer needs to pay the platform $p_{B,1}$ to meet the seller and do the first transaction on the platform. Then, if the buyer wishes to transact a second time with the seller on the platform, she must pay the platform an additional $p_{B,2}$. To simplify the exposition we assume that the platform simply pays the seller c for each transaction completed on the platform (and argue later that this is without loss of generality).

We consider two scenarios. In the first scenario disintermediation is impossible, and so all transactions must take place on the platform. In the second scenario disintermediation is possible, meaning that (when relevant) the buyer chooses whether to do the second transaction on or off the platform. If the buyer decides to do the second transaction off the platform, she makes a take-it-or-leave-it offer to the seller. We impose the following tie-break rules: if the buyer is indifferent between buying or not, she buys, and if she is indifferent between buying on or off the platform, she buys on the platform. Also, if the seller is indifferent between transacting or not, she transacts.

The timing is as follows. First, the platform chooses $p_{B,1}$ and $p_{B,2}$. Second, the buyer decides whether to incur $p_{B,1}$ and meet the seller and do the first transaction on the platform. Third, if the buyer wishes to transact a second time, she chooses whether to incur $p_{B,2}$ and transact on the platform, or (when disintermediation is possible) transact off the platform and make the seller a take-it-or-leave it offer.

[3]The case $\phi = 1$, where for sure the buyer wants to transact only once, is examined in Section 5.

Discussion. Before solving the model, we briefly comment on our assumptions.

(i) Single buyer and seller. Our model can be reinterpreted as one with many buyers and sellers, where each buyer "matches" with only some sellers, and needs the platform to find them. When $\phi > 0$ buyers are heterogeneous in their purchase frequency, and when $\underline{b} < \overline{b}$ buyers are heterogeneous in their benefit from transacting on the platform. When we solve the platform's problem in Section 4 we adopt this alternative interpretation.

(ii) Seller pricing. We assume that the platform directly sets the prices paid by the buyer. This is a good fit with some real-world platforms such as Uber, Tutor.com, and Lawn Love.[4] Of course on other platforms it is the seller that sets prices. Therefore in Section 6.1 we show how our results extend to the case where the platform charges the seller a per-transaction fee, and the seller then sets the final purchase prices.

(iii) Buyer benefit. We assume that the buyer gets a benefit from transacting on the platform. In Section 6.2 we show that our results hold if the seller gets the benefit.

(iv) Frequency of purchase. We assume for simplicity that the buyer wants to transact once or twice. In Section 6.3 we allow for an arbitrary number of transactions.

(v) Buyer bargaining power. We assume that the buyer chooses whether the second transaction occurs on or off the platform and, in the latter case, has all the bargaining power in setting the price. In Section 6.4 we extend our results to the case where the buyer and seller bargain over where the second transaction occurs, and at what price.

3 Preliminary Analysis

We begin by solving a buyer's problem. We use the terms "one-time buyer" and "two-time buyer" to denote, respectively, a buyer who wishes to transact once or twice.

One-time buyer. The behavior of a one-time buyer is independent of whether or not disintermediation is possible. In both cases, the buyer completes her first (and only) transaction provided that

$$v + b \geq p_{B,1}. \tag{1}$$

Since the first transaction must occur on the platform, if the condition in (1) fails the buyer does not transact at all.

[4] See Zhou, Allen, Gretz, and Houston (2022) for further examples of platforms that directly set prices. In some cases, such as Airbnb, sellers set prices but the platform provides recommendations.

Two-time buyer. The behavior of a two-time buyer depends on whether or not disintermediation is possible.

Start with the case where disintermediation is impossible. Conditional on doing the first transaction, the buyer will also do the second transaction if and only if

$$v + b - p_{B,2} \geq 0. \tag{2}$$

Hence the buyer pays $p_{B,1}$ to meet the seller and do the first transaction if and only if the following "intertemporal" participation constraint holds:

$$v + b - p_{B,1} + \max\{v + b - p_{B,2}, 0\} \geq 0, \tag{3}$$

that is, provided the surplus from the first transaction $v + b - p_{B,1}$, combined with the surplus from the second transaction $\max\{v + b - p_{B,2}, 0\}$, is positive.

Now consider the case where disintermediation is possible. Conditional on doing the first transaction, the buyer can still do the second transaction on the platform and get $v + b - p_{B,2}$. Alternatively, she can now do the second transaction off the platform—in which case she foregoes the benefit b, but ends up with payoff $v-c$ because she can offer the seller c and get it accepted. Therefore, conditional on doing the first transaction, the buyer does the second transaction on the platform if and only if $v+b-p_{B,2} \geq v-c$. Equivalently, the buyer does the second transaction on the platform provided

$$b \geq p_{B,2} - c, \tag{4}$$

and otherwise does it off the platform. Hence, the second transaction occurs on the platform provided that the convenience benefit b that it provides outweighs the margin $p_{B,2} - c$ that it takes. Moreover, the buyer pays $p_{B,1}$ to meet the seller and do the first transaction if and only if the following intertemporal participation constraint holds:

$$v + b - p_{B,1} + \max\{v + b - p_{B,2}, v - c\} \geq 0, \tag{5}$$

that is, provided the combined surpluses from the two transactions are positive.

4 Solution

We now solve the platform's problem. We begin with the benchmark case where there is no heterogeneity in purchase frequency or platform benefit. We then introduce buyer heterogeneity and show how this changes the impact of disintermediation.

4.1 Benchmark Without Heterogeneity

In this subsection we assume that all buyers wish to transact twice (i.e., $\phi = 0$) and get the same benefit from transacting on the platform (i.e., F is degenerate at $\underline{b} = \overline{b} = b$).[5]

Note that, irrespective of whether disintermediation is possible or not, efficiency requires that both transactions occur on the platform, leading to a total surplus of $2(v + b - c)$. Our first result shows that the platform can always find prices such that it extracts this entire surplus. (All omitted proofs are available in the Appendix.)

Proposition 1. *Suppose there is no buyer heterogeneity. The platform earns* $2(v+b-c)$ *regardless of whether or not disintermediation is possible.*
(i) If disintermediation is not possible the platform chooses any prices that satisfy

$$p_{B,1} = 2(v + b) - p_{B,2} \quad \textit{and} \quad p_{B,2} \leq v + b. \tag{6}$$

(ii) If disintermediation is possible the platform chooses any prices that satisfy

$$p_{B,1} = 2(v + b) - p_{B,2} \quad \textit{and} \quad p_{B,2} \leq b + c. \tag{7}$$

In each case the buyer does both transactions on the platform.

The ability of buyers to disintermediate is *neutral* for platform profit. To understand why, start with the case where disintermediation is impossible. First, consider prices $p_{B,1} = p_{B,2} = v + b$. Note that the conditions in (2) and (3) are satisfied, and so the buyer does both transactions and pays a total amount $2(v + b)$ to the platform. After accounting for the payment to the seller, the platform earns $2(v+b-c)$ and so extracts the maximum possible surplus. Second, and more generally, any prices satisfying (6) induce the buyer to do both transactions and pay a total amount $2(v + b)$, and so also generate the same platform profit. Intuitively, if the platform charges a lower $p_{B,2} < v + b$ it leaves surplus to the buyer on the second transaction, which it fully extracts by charging a higher $p_{B,1} > v+b$ on the first transaction. These optimal prices are depicted by the solid red and dashed blue lines in Figure 1.

Next, suppose that disintermediation is possible. First, consider again prices $p_{B,1} = p_{B,2} = v + b$. Note that the condition in (5) holds, but the condition in (4) does not, and so the buyer would do the first transaction but then disintermediate the platform

[5]Equivalently, the buyer has no private information: the platform knows that the buyer wishes to transact twice, and also knows her convenience benefit. See discussion item (i) on page 7.

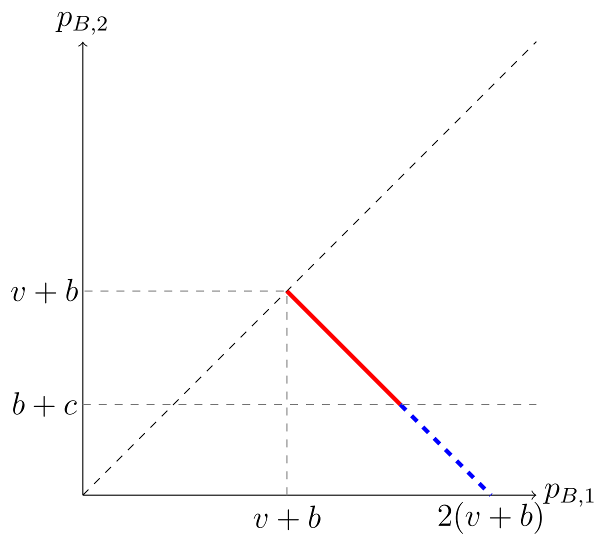

Figure 1: Optimal platform pricing when buyers are homogeneous.

on the second transaction, leading to a platform profit of only $v + b - c$. However, for any prices satisfying (7), the buyer optimally does both transactions on the platform and pays a total amount $2(v + b)$, such that the platform again extracts the maximum available surplus $2(v + b - c)$. Intuitively, the ability of the buyer to disintermediate forces the platform to take a low margin $p_{B,2} - c$ on the second transaction, but it can fully compensate for this by charging a higher $p_{B,1}$. These optimal prices are depicted by the dashed blue line in Figure 1. Note that they are a strict subset of the optimal prices charged when disintermediation is impossible.

In summary, when there is no buyer heterogeneity, the threat of disintermediation has no effect on platform profit. However, the platform may be forced to change its pricing strategy—by raising the price of the first transaction and reducing the price of the second transaction. This ensures that disintermediation never actually occurs.

Remark 1. *The case without buyer heterogeneity can also be reinterpreted as a setting where buyers have heterogeneous b, but the platform has data that allows it to observe each buyer's b and make personalized offers.*

Buyers are indifferent about whether disintermediation is possible or not, because in either case they get zero surplus (both when they are truly homogeneous, or when they have heterogeneous b but the platform can make personalized offers as in Remark 1).

4.2 Heterogeneous Purchase Frequency

In this subsection we continue to assume no heterogeneity in the benefit from transacting on the platform (i.e., F remains degenerate at $\underline{b} = \overline{b} = b > 0$). However we now assume that buyers differ in their purchase frequency—with probability $\phi \in (0, 1)$ a buyer wishes to transact once, and with probability $1 - \phi$ she wishes to transact twice.

Note that, irrespective of whether or not disintermediation is possible, efficiency again requires that all transactions occur on the platform, leading to total surplus $(2 - \phi)(v + b - c)$. We will now argue that the platform can extract this maximal surplus if and only if disintermediation is impossible—and therefore, in contrast to Proposition 1, disintermediation strictly reduces platform profit.

Start with the case where disintermediation is impossible. Note that if the platform *only* faced one-time buyers, it would charge $p_{B,1} = v + b$ and extract all their surplus; this is depicted by the green line in Figure 2. Similarly, recall from equation (6) that if the platform *only* faced two-time buyers, there is a continuum of optimal price pairs that extract all their surplus; these prices are depicted by the solid red and dashed blue lines in Figure 2. One such optimal price pair is $p_{B,1} = v + b$ and $p_{B,2} = v + b$. Since the platform actually faces a mixture of one- and two-time buyers, it has a unique optimum with $p_{B,1} = p_{B,2} = v + b$, which allows it to host all transactions and fully extract both buyer types; this is depicted by the diamond in Figure 2. After accounting for payments to sellers, platform profit is $(2 - \phi)(v + b - c)$; the platform extracts all of the maximum possible social surplus.

Now suppose that disintermediation is possible. The following observation will be useful in solving for the platform's optimum:

Lemma 1. *Suppose disintermediation is possible. The platform optimally chooses* $p_{B,2} \leq b + c$*; disintermediation does not arise in equilibrium.*

The platform's optimal pricing scheme ensures that disintermediation does not arise. To understand why, first note that one-time buyers are less likely to do the first transaction than two-time buyers; condition (1) is harder to satisfy than condition (5). (This is simply because doing the first transaction enables two-time buyers to then do the second transaction, which gives them positive surplus.) Hence the platform's optimal prices must ensure that (at least) two-time buyers do the first transaction—otherwise nobody would transact on the platform and it would earn zero profit. Next, suppose that, contrary to Lemma 1, the platform chooses $p_{B,2} > b + c$. Equation (4) implies

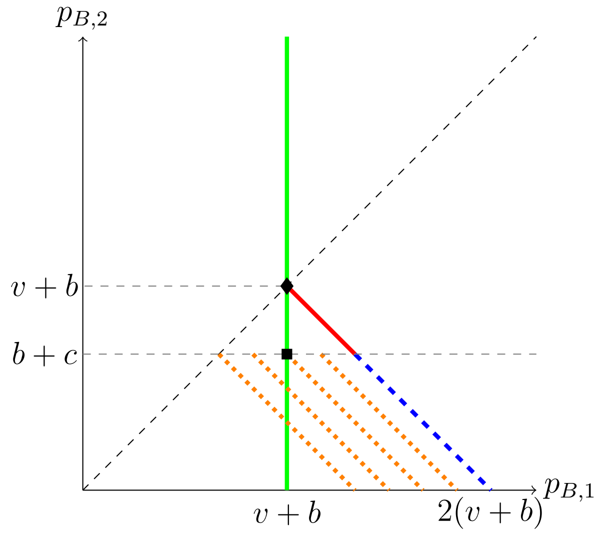

Figure 2: Optimal platform pricing when purchase frequency is heterogeneous.

that two-time buyers would do their second transaction off the platform. It is easy to see that the platform could do strictly better by deviating to $p'_{B,2} = b + c$; two-time buyers would still do the first transaction, because the left-hand side of (5) remains unchanged, but now they would also do the second transaction on the platform, giving the platform an additional profit $(1 - \phi)(p'_{B,2} - c) > 0$.[6]

Combining Lemma 1 with condition (5), a two-time buyer does the first transaction if and only if $p_{B,1} \leq 2(v + b) - p_{B,2}$. We now consider two separate cases, depending on whether the platform chooses a relatively high or a relatively low $p_{B,1}$.

First, consider $p_{B,1}$ that satisfy $v + b < p_{B,1} \leq 2(v + b) - p_{B,2}$. Using earlier work the platform only sells to two-time buyers, but it hosts both their transactions. Hence the platform wishes to

$$\max_{p_{B,1},p_{B,2}} (1 - \phi)(p_{B,1} + p_{B,2} - 2c) \quad \text{s.t.} \quad p_{B,1} \leq 2(v + b) - p_{B,2} \quad \text{and} \quad p_{B,2} \leq b + c.$$

The solution to this optimization problem is simple: the platform should make $p_{B,1}$ as high as possible, so as to fully extract two-time buyers, and therefore chooses the same prices as in equation (7) from earlier. The optimal price pairs are depicted by the blue dashed line in Figure 2. The platform earns profit $2(1 - \phi)(v + b - c)$.

Next, consider $p_{B,1}$ that satisfy $p_{B,1} \leq v + b$. Using earlier work the platform sells

[6] Recall that, by assumption, in this subsection we have $\underline{b} = \bar{b} = b > 0$ and hence $p'_{B,2} - c = b > 0$.

to all buyers and hosts all their transactions. Hence it wishes to

$$\max_{p_{B,1},p_{B,2}} \phi(p_{B,1}-c)+(1-\phi)(p_{B,1}+p_{B,2}-2c) \quad \text{s.t.} \quad p_{B,1}\leq v+b \quad \text{and} \quad p_{B,2}\leq b+c.$$

The solution to this optimization problem is also simple: the platform makes the two constraints bind, choosing $p_{B,1} = v + b$ and $p_{B,2} = b + c$. This price pair is depicted by the square in Figure 2. Specifically, the platform fully extracts one-time buyers by picking a price pair on the green vertical line in the figure. The platform then extracts as much surplus from two-time buyers as it can; the orange curves represent iso-profit curves from two-time buyers (i.e., price pairs with the same $p_{B,1}+p_{B,2}$), so the platform chooses prices which get it onto the highest iso-profit curve that intersects the green line. The platform earns profit $v - c + (2-\phi)b$.

Collecting the above results together, we then find that:

Proposition 2. *Suppose buyers have heterogeneous purchase frequency. If disintermediation is impossible the platform charges $p_{B,1} = p_{B,2} = v+b$ and earns $(2-\phi)(v+b-c)$. If disintermediation is possible, there exists a critical $\phi^* \in (0,1)$ such that:*
(i) If $\phi < \phi^*$ the platform charges any $p_{B,1}$ and $p_{B,2}$ satisfying (7), sells to two-time buyers only, and earns $2(1-\phi)(v+b-c)$.
(ii) If $\phi \geq \phi^*$ the platform charges $p_{B,1} = v + b$ and $p_{B,2} = b + c$, sells to all buyers, and earns $v - c + (2-\phi)b$.

The platform is strictly worse off when disintermediation is possible, because

$$\max\{2(1-\phi)(v+b-c), v-c+(2-\phi)b\} < (2-\phi)(v+b-c).$$

Intuitively, to prevent two-time buyers from disintermediating the second transaction, the platform reduces $p_{B,2}$ from $v+b$ down to (at most) $b+c$. We saw in Section 4.1 that if the platform only faced two-time buyers, it would then raise $p_{B,1}$ from $v + b$ up to $2(v+b)-p_{B,2} > v+b$ so as to fully extract them. However, when it faces both one- and two-time buyers, the platform faces a dilemma. One option is to still raise $p_{B,1}$ up to $2(v+b)-p_{B,2}$; the platform would fully extract two-time buyers, but would no longer sell to one-time buyers. Another option is to keep $p_{B,1}$ at $v+b$; the platform would continue selling to one-time buyers, but would be unable to fully extract two-time buyers. When ϕ is sufficiently small the platform pursues the first strategy, and otherwise it pursues the second strategy.[7] In either case the platform foregoes extracting full surplus from one type, and so is strictly worse off from a buyer's ability to disintermediate.[8]

Finally, buyers are (weakly) better off when they can disintermediate. The reason is simple. Recall that when disintermediation is impossible, the platform fully extracts every buyer, leaving them with zero surplus. However, when disintermediation is possible and $\phi \geq \phi^*$, the platform leaves strictly positive surplus to two-time buyers.

4.3 Heterogeneous Platform Benefit

Compared to the previous subsection, we now consider the opposite case where consumers all wish to transact twice (i.e., $\phi = 0$) but have heterogeneous benefits from doing so on the platform (i.e., $\underline{b} < \overline{b}$). Contrary to Propositions 1 and 2, we will show that disintermediation can strictly *benefit* the platform.

Start with the case where disintermediation is impossible. Platform profit equals

$$\pi^{ND} = \begin{cases} (p_{B,1} - c)[1 - F(p_{B,1} - v)] + (p_{B,2} - c)[1 - F(p_{B,2} - v)] & \text{if } p_{B,1} \leq p_{B,2}, \\ (p_{B,1} + p_{B,2} - 2c)\left[1 - F\left(\frac{p_{B,1}+p_{B,2}}{2} - v\right)\right] & \text{otherwise.} \end{cases} \tag{8}$$

This can be derived as follows. First consider prices that satisfy $p_{B,1} \leq p_{B,2}$. Using the participation constraints in (2) and (3), it is easy to see that buyers with $b < p_{B,1} - v$ do no transactions, buyers with $p_{B,1} - v \leq b < p_{B,2} - v$ do the first transaction only, and the remaining buyers do both transactions. Hence the platform hosts $1 - F(p_{B,1} - v)$ first transactions on which it earns margin $p_{B,1} - c$, and hosts $1 - F(p_{B,2} - v)$ second transactions on which it earns margin $p_{B,2} - c$. This gives the expression in the first line of π^{ND}. Next, consider prices that satisfy $p_{B,1} > p_{B,2}$. Using again the participation constraints in (2) and (3), it is easy to see that buyers with $b < \frac{p_{B,1}+p_{B,2}}{2} - v$ do no transactions, while all other buyers do both transactions and so generate a total margin $p_{B,1} + p_{B,2} - 2c$ for the platform. This gives the expression in the second line of π^{ND}.

Intuitively, if $p_{B,1} < p_{B,2}$, the first transaction is more attractive to buyers than the second transaction. Hence low-b buyers do no transaction, medium-b buyers do just the

[7]Note that as ϕ tends to zero we approach the outcome of the no-heterogeneity case studied in Section 4.1: the set of optimal prices under disintermediation is the same, and the loss in platform profit $\phi(v + b - c)$ due to disintermediation tends to zero.

[8]The inability of the platform to extract full surplus can also be seen in Figure 2. Fully extracting one-time buyers requires a price pair on the green line, while fully extracting two-time buyers requires a price pair on the dashed blue line. However these two lines do not intersect.

first transaction, and only high-b buyers do both transactions. If instead $p_{B,1} > p_{B,2}$, the first transaction is less attractive to buyers, so they do it only if they will also do the second one. As a result, only the *total* price for the two transactions $p_{B,1} + p_{B,2}$ (rather than individual prices) matters for consumer behavior and platform profit.

Using the profit expression π^{ND} we can solve for the platform's optimum:

Lemma 2. *Suppose buyers have heterogeneous platform benefit. If disintermediation is impossible the platform charges any* $\{p_{B,1}, p_{B,2}\}$ *that satisfy*

$$p_{B,1} + p_{B,2} = 2(v + b^{ND}) \quad \textit{and} \quad p_{B,2} \leq v + b^{ND}, \tag{9}$$

where (i) $b^{ND} = \underline{b}$ *if* $(v + \underline{b} - c)f(\underline{b}) \geq 1$, *and (ii) otherwise* $b^{ND} > \underline{b}$ *uniquely solves*

$$1 - F(b^{ND}) - f(b^{ND})(v + b^{ND} - c) = 0. \tag{10}$$

Buyers with $b < b^{ND}$ *do no transactions, while buyers with* $b \geq b^{ND}$ *do both transactions.*

The platform chooses a marginal buyer type b^{ND} and then prices in such a way that buyers with $b < b^{ND}$ do no transactions while buyers with $b \geq b^{ND}$ do both transactions.[9] Intuitively, since a buyer's willingness-to-pay for the first and second transactions is the same, it cannot be optimal to have some buyers do only the first transaction. The marginal buyer b^{ND} is then determined as follows. If $(v+\underline{b}-c)f(\underline{b}) \geq 1$, meaning that there are relatively many low-b buyers, and the surplus $v + \underline{b} - c$ that can be extracted from them is relatively large, the platform chooses $b^{ND} = \underline{b}$ and hosts all buyers. Otherwise the platform hosts only some buyers.

Now turn to the case where disintermediation is possible. Platform profit equals

$$\pi^D = \begin{cases} (p_{B,1} - c)[1 - F(p_{B,1} + c - 2v)] + (p_{B,2} - c)[1 - F(p_{B,2} - c)] & \text{if } p_{B,1} \leq p_{B,2} + 2(v - c), \\ (p_{B,1} + p_{B,2} - 2c)\left[1 - F\left(\frac{p_{B,1}+p_{B,2}}{2} - v\right)\right] & \text{otherwise.} \end{cases} \tag{11}$$

This can be derived as follows. First consider prices that satisfy $p_{B,1} \leq p_{B,2} + 2(v - c)$. Using the participation constraints in (4) and (5), one can verify that buyers with $b < p_{B,1} + c - 2v$ do no transactions, buyers with $p_{B,1} + c - 2v \leq b < p_{B,2} - c$ do the first transaction on the platform and disintermediate the second one, while the remaining buyers do both transactions on the platform. This explains the expression

[9] Notice that prices take the same form as those in Proposition 1(i) just with b replaced by b^{ND}.

in the first line of π^D. Next, consider prices that satisfy $p_{B,1} > p_{B,2} + 2(v - c)$. Using again the participation constraints in (4) and (5), it is easy to see that buyers with $b < \frac{p_{B,1}+p_{B,2}}{2} - v$ do no transactions, while all other buyers do both transactions on the platform. This explains the expression in the second line of π^D.

Intuitively, if $p_{B,1} \leq p_{B,2} + 2(v - c)$, doing the second transaction on the platform is relatively expensive. Hence low-b buyers do no transactions, medium-b buyers use the platform once, and only high-b buyers who value the platform's convenience benefits a lot use it for both transactions. If instead $p_{B,1} > p_{B,2} + 2(v - c)$, doing the second transaction on the platform is relatively cheap. Hence, conditional on doing the first transaction, a buyer does the second transaction on the platform as well. As a result, platform profit is exactly the same as in the second line of the π^{ND} expression, and again only depends on the total price $p_{B,1} + p_{B,2}$.

Using the profit expression π^D we can again solve the platform's optimization problem. It turns out that the solution depends qualitatively on whether $\underline{b}f(\underline{b})$ is greater or less than 1, so we deal with these two cases separately.

Lemma 3. *Suppose buyers have heterogeneous platform benefit. If disintermediation is possible and* $\underline{b}f(\underline{b}) \geq 1$*, the platform charges any* $\{p_{B,1}, p_{B,2}\}$ *that satisfy*

$$p_{B,1} + p_{B,2} = 2(v + \underline{b}) \quad \text{and} \quad p_{B,2} \leq \underline{b} + c. \tag{12}$$

All buyers do both transactions on the platform.

When $\underline{b}f(\underline{b}) \geq 1$ the platform optimally hosts both transactions for all buyers. It charges a total price $p_{B,1} + p_{B,2}$ to fully extract the willingness-to-pay of the marginal type with $b = \underline{b}$, and sets the price $p_{B,2}$ of the second transaction low enough that no buyer wishes to disintermediate. (Hence there is a continuum of optimal price pairs.) Intuitively, $\underline{b}f(\underline{b}) \geq 1$ implies that buyers are relatively homogeneous: even those with the lowest b are quite numerous, and value the platform's convenience benefits quite a lot. Hence the platform can charge relatively high prices and still host all transactions.

Next, consider the opposite case where $\underline{b}f(\underline{b}) < 1$:

Lemma 4. *Suppose buyers have heterogeneous platform benefit. If disintermediation is possible and* $\underline{b}f(\underline{b}) < 1$*, the platform charges*

$$p_{B,1} = b_1^D + 2v - c \quad \text{and} \quad p_{B,2} = b_2^D + c. \tag{13}$$

$b_1^D = \underline{b}$ *if* $[\underline{b} + 2(v - c)]f(\underline{b}) \geq 1$*, and otherwise* $b_1^D > \underline{b}$ *uniquely solves*

$$1 - F(b_1^D) - [b_1^D + 2(v - c)]f(b_1^D) = 0. \tag{14}$$

Also $b_1^D \le b^{ND}$, *with strict inequality if* $b^{ND} > \underline{b}$. *Moreover* $b_2^D > b^{ND}$ *uniquely solves*

$$1 - F(b_2^D) - b_2^D f(b_2^D) = 0. \tag{15}$$

Buyers do the first transaction if and only if $b \ge b_1^D$. *For the second transaction, buyers with* $b \in [b_1^D, b_2^D)$ *do it off the platform, while buyers with* $b \ge b_2^D$ *do it on the platform.*

When $\underline{b} f(\underline{b}) < 1$ the platform optimally segments buyers into groups.[10] In particular, the platform chooses two marginal buyers b_1^D and b_2^D. Buyers with $b < b_1^D$, who value platform benefits relatively little, do no transactions; buyers with $b_1^D \le b < b_2^D$, who value platform benefits moderately, do the first transaction on the platform and then disintermediate for the second transaction; buyers with $b \ge b_2^D$, who value platform benefits highly, do both transactions on the platform. Intuitively, $\underline{b} f(\underline{b}) < 1$ means that buyers are relatively heterogeneous: although some buyers have high b, there is a (small) pool of buyers with low b. Hence it is no longer optimal for the buyer to host all transactions, since the low price needed to achieve this is too costly.[11]

Lemma 4 also shows that $b_1^D \le b^{ND} < b_2^D$: the platform reacts to disintermediation by hosting weakly more first transactions, but strictly fewer second transactions. The reason is as follows. We argued earlier that, when disintermediation is possible, buyers can obtain $v - c$ by taking the second transaction off the platform. This raises their willingness-to-pay of doing only the first transaction on the platform from $v + b$ to $2v + b - c$, and reduces their willingness-to-pay of doing the second transaction on the platform from $v + b$ to $b + c$. The platform responds to higher demand for first transactions and lower demand for second transactions, by hosting more of the former and fewer of the latter.

Corollary 1. *Suppose buyers have heterogeneous platform benefit. The platform optimally charges more for first than second transactions:* $p_{B,1} > p_{B,2}$.

Consistent with earlier analysis, the platform charges a relatively high price for hosting the first transaction compared to the price it charges for hosting the second transaction.

[10] If $b_1^D = \underline{b}$ buyers are split into two groups, and otherwise they are split into three groups.

[11] Note that the lemma shows that the platform induces all buyers to do the first transaction if and only if $[\underline{b} + 2(v - c)] f(\underline{b}) \ge 1$. Intuitively, under this condition there are relatively many low-b buyers, and the surplus the platform can extract from them for hosting their first transaction (i.e., $v + \underline{b} - c$) and letting them disintermediate the second transaction (i.e., $v - c$) is relatively high.

Impact of disintermediation on platform profit We can now examine the impact of disintermediation on platform profit:

Proposition 3. *Suppose buyers have heterogeneous platform benefit. The platform weakly benefits from buyers' ability to disintermediate, and strictly so if* $\underline{b}f(\underline{b}) < 1$*.*

The proposition shows two things: first, disintermediation can *never harm* the platform, and second, under certain conditions it actually *benefits* the platform.

The reason why disintermediation never harms the platform is as follows. Recall from Lemma 2 that, when disintermediation is impossible, there is a critical buyer type b^{ND} such that buyers with $b < b^{ND}$ do no transactions, while all other buyers do both transactions. Moreover, the platform has a continuum of optimal price pairs, including $p_{B,1} = v + b^{ND}$ and $p_{B,2} = v + b^{ND}$. Now suppose disintermediation becomes possible. The platform could lower its price for the second transaction to $p_{B,2} = b^{ND} + c$, and from condition (4) a buyer with $b = b^{ND}$ would still be (just) willing to do the second transaction on the platform; the platform could then raise its price for the first transaction up to $p_{B,1} = b^{ND} + 2v - c$, such that from condition (5) a buyer with $b = b^{ND}$ would also still (just) be willing to do the first transaction. Hence by "rebalancing" prices in this way, the platform charges the same total price, and hosts the same transactions—and thus also earns the same profit—as it did when disintermediation was impossible. (Note that the same logic underpins our profit-neutrality result in Proposition 1 in the benchmark with no buyer heterogeneity.)

The reason why disintermediation strictly raises platform profit when $\underline{b}f(\underline{b}) < 1$ is as follows. We argued above that the platform can earn the same profit as when disintermediation is impossible, by charging $p_{B,1} = b^{ND} + 2v - c$ and $p_{B,2} = b^{ND} + c$. However Lemma 4 shows that when $\underline{b}f(\underline{b}) < 1$ the platform chooses *not* to do this: it (weakly) reduces $p_{B,1}$ below $b^{ND} + 2v - c$, and strictly raises $p_{B,2}$ above $b^{ND} + c$. Intuitively, starting from the no-disintermediation outcome, the marginal buyer is willing to pay relatively a lot for the first transaction (the surplus $v + b^{ND}$ from the first purchase, plus the surplus $v - c$ from disintermediating later on) but relatively little for the second transaction (only the extra surplus $b^{ND} + c$ from doing this transaction on rather than off the platform). Hence the platform raises $p_{B,2}$ to extract more surplus from high-b buyers who value using it a lot for the second transaction, and (weakly) lowers $p_{B,1}$ to sell to (weakly) more low-b buyers who value the chance to get matched with a seller with whom they can later transact elsewhere. As argued earlier, when $\underline{b}f(\underline{b}) < 1$ buyers are relatively heterogenenous: the platform therefore uses disintermediation to screen buyers and extract more surplus from them.

Example. Suppose b is uniformly distributed on $[0,1]$ and that $v=1$ and $c=1/4$. When disintermediation is impossible the platform charges $p_{B,1}+p_{B,2}=9/4$, which induces a marginal buyer $b^{ND}=1/8$, and generates platform profit $49/32\approx 1.53$. When disintermediation is possible the platform charges $p_{B,1}=7/4$ and $p_{B,2}=3/4$. This induces marginal buyers $b_1^D=0$ and $b_2^D=1/2$, and generates platform profit $7/4$ (which is roughly 14% higher than when disintermediation is impossible).

Impact of disintermediation on buyer surplus We now examine the impact of disintermediation on buyers. The case in which $\underline{b}f(\underline{b})\geq 1$ is simple: we know from Lemmas 2 and 3 that, regardless of whether disintermediation is possible, all buyers do both transactions on the platform at a total price of $2(v+\underline{b})$, and hence the ability to disintermediate has *zero* impact on each buyer's payoff.

In the remainder of this subsection we focus on the more interesting case $\underline{b}f(\underline{b})<1$. When disintermediation is impossible, we know from Lemma 2 that buyers with $b\leq b^{ND}$ don't transact, while those with $b>b^{ND}$ transact twice and pay a total price of $p_{B,1}+p_{B,2}=2(v+b^{ND})$. As a result, a buyer with platform benefit b gets surplus

$$U^{ND}(b)=2\max\{b-b^{ND},0\}.$$

When disintermediation is possible, we know from Lemma 4 that buyers with $b<b_1^D$ do zero transactions and get zero surplus; buyers with $b_1^D\leq b<b_2^D$ do the first transaction on the platform at price $p_{B,1}=b_1^D+2v-c$, and do the second transaction off the platform, thus obtaining surplus $2v+b-p_{B,1}-c=b-b_1^D$; buyers with $b\geq b_2^D$ do both transactions on the platform at a combined price of $p_{B,1}+p_{B,2}=2v+b_1^D+b_2^D$, thus obtaining surplus $2(v+b)-p_{B,1}-p_{B,2}=2b-b_1^D-b_2^D$. As a result, a buyer with platform benefit b gets surplus

$$U^D(b)=\max\{b-b_1^D,0\}+\max\{b-b_2^D,0\}.$$

We can then state the following:

Lemma 5. *Suppose buyers have heterogeneous platform benefit, and that* $\underline{b}f(\underline{b})<1$.
(i) If $b^{ND}=\underline{b}$ *then disintermediation strictly harms each buyer.*
(ii) If $b^{ND}>\underline{b}$ *and* $2b^{ND}<b_1^D+b_2^D$ *then there exists a* $\hat{b}$ *such that disintermediation*

(weakly) benefits each buyer with $b < \hat{b}$, and strictly harms each buyer with $b > \hat{b}$.
(iii) If $b^{ND} > \underline{b}$ and $2b^{ND} \geq b_1^D + b_2^D$ disintermediation (weakly) benefits each buyer.

The conventional wisdom is that disintermediation helps buyers, by giving them more choice over where to transact—but Lemma 5 shows this is not always true. Intuitively, recall that the impact of disintermediation on prices can be split into two parts. First, the platform "rebalances" prices to $p_{B,1} = b^{ND} + 2v - c$ and $p_{B,2} = b^{ND} + c$, such that it hosts the same transactions as before at the same total price. Second, the platform then (weakly) reduces $p_{B,1}$ so as to host (weakly) more transactions, and strictly raises $p_{B,2}$. Lemma 5 can then be understood as follows. In part (i) the platform already hosts all buyers absent disintermediation. Therefore, starting from the rebalanced prices, it keeps $p_{B,1}$ the same but strictly raises $p_{B,2}$, and so all buyers are worse off.[12] However, in parts (ii) and (iii) some low-b buyers do not transact when disintermediation is impossible. The platform therefore strictly reduces $p_{B,1}$ and strictly raises $p_{B,2}$ relative to the rebalanced prices. Low-b buyers, who do only the first transaction on the platform, gain from the lower $p_{B,1}$. High-b buyers, who do both transactions on the platform, gain if and only if the reduction in $p_{B,1}$ outweighs the increase in $p_{B,2}$—which happens if and only if $2b^{ND} \geq b_1^D + b_2^D$.

We now provide one primitive condition for each case in Lemma 5. These conditions depend on v and c as well as two properties of the distribution of platform benefits—namely $f(\underline{b})$, and the shape of the "inverse hazard rate" $[1 - F(b)]/f(b)$.[13]

Proposition 4. *Consider the different cases in Lemma 5.*
Part (i) arises when $\underline{b}f(\underline{b}) < 1 \leq (v + \underline{b} - c)f(\underline{b})$.
Part (ii) arises when, e.g., $[\underline{b} + 2(v - c)]f(\underline{b}) \leq 1$ and $[1 - F(b)]/f(b)$ is strictly convex.
Part (iii) arises when, e.g., $[\underline{b} + 2(v - c)]f(\underline{b}) \leq 1$ and $[1 - F(b)]/f(b)$ is weakly concave.

Figure 3 illustrates the impact of disintermediation on buyer surplus in three examples which correspond to the three parts of Proposition 4. In each panel the red solid curve

[12] More precisely, a buyer with $b = \underline{b}$ gets zero surplus irrespective of whether disintermediation is possible, but all other buyers are strictly worse off when disintermediation is possible.

[13] The inverse hazard rate is linear for distributions with constant curvature (e.g., uniform or exponential), convex for, e.g., the power distribution and many distributions with single-peaked densties (such as the truncated Normal), and concave for, e.g., $F(b) = 1 - [\gamma_0 - \gamma_1 \log p]/p$ with $\gamma_0, \gamma_1 > 0$, which is derived from the AIDS model (and which we use in the right panel of Figure 3). See Chen and Schwartz (2015) for more details.

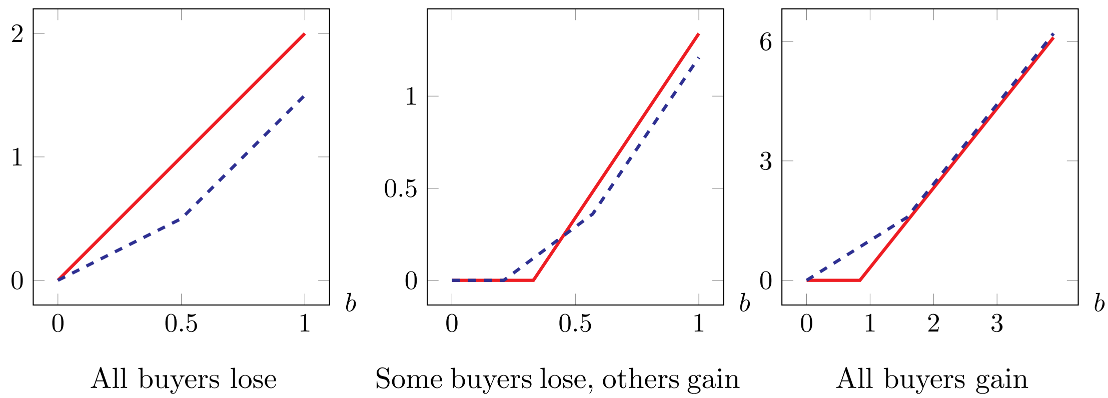

Figure 3: Buyer surplus when disintermediation is impossible (red solid curve) versus when it is possible (dashed blue curve).
(In each panel $v = 5/4$ and $c = 1/4$. In the left panel $F(b) = b$ on $[0, 1]$; in the middle panel $F(b) = b^2$ on $[0, 1]$; in the right panel $F(b) = 1 - \frac{6[1+2\ln 6-2\ln(b+6)]}{b+6}$ on $[0, 6(e^{1/2} - 1)]$.)

depicts a buyer's surplus when disintermediation is impossible, while the blue dashed curve depicts a buyer's surplus when disintermediation is possible. Disintermediation strictly harms every buyer in the left panel, and strictly benefits every buyer in the right panel (except for buyers with $b = \underline{b}$, who always get zero surplus). In the middle panel disintermediation (weakly) benefits all buyers below a threshold, but strictly harms all buyers above the threshold.

4.4 Heterogeneous Purchase Frequency and Platform Benefit

In this subsection buyers are heterogeneous in both purchase frequency and platform benefit (i.e., $\phi \in (0, 1)$ and $\underline{b} < \overline{b}$). We will show that disintermediation can either benefit or harm the platform, depending on which type of heterogeneity is more prevalent.

Using equation (1), one-time buyers do their first (and only) transaction provided $v + b \geq p_{B,1}$. Hence, when disintermediation is impossible, the platform will

$$\max_{p_{B,1}, p_{B,2}} \quad \phi(p_{B,1} - c)[1 - F(p_{B,1} - v)] + (1 - \phi)\pi^{ND}, \tag{16}$$

where π^{ND} is profit from two-time buyers, and was defined in equation (8). When instead disintermediation is possible, the platform will

$$\max_{p_{B,1}, p_{B,2}} \quad \phi(p_{B,1} - c)[1 - F(p_{B,1} - v] + (1 - \phi)\pi^{D}, \tag{17}$$

where π^D is profit from two-time buyers, and was defined in equation (11). Building on earlier results, we can prove the following:

Proposition 5. *Suppose buyers have heterogeneous purchase frequency and benefit b.*
(i) If $\underline{b}f(\underline{b}) \geq 1$ *then disintermediation strictly reduces platform payoff.*
(i) If $\underline{b}f(\underline{b}) < 1$ *then there exists a* $\hat{\phi} > 0$ *such that disintermediation strictly increases platform payoff if and only if* $\phi < \hat{\phi}$.

Intuitively, when disintermediation is impossible, there is a unique pair of prices $p_{B,1} = p_{B,2} = \arg\max(p - c)[1 - F(p - v)]$ that enable the platform to simultaneously maximize its profits from both one- and two-time buyers. (The logic is the same as that underpinning Proposition 2.) However, when disintermediation becomes possible the platform faces a dilemma. On the one hand, it would like to continue charging $p_{B,1} = \arg\max(p - c)[1 - F(p - v)]$ to maximize profit from one-time buyers. On the other hand, as we saw in the last subsection, it would like to raise $p_{B,1}$ and reduce $p_{B,2}$ to maximize profit from two-time buyers. In part (i) of the proposition buyers are relatively homogeneous, and we know from Lemma 3 that with disintermediation the platform can at best earn the same profit from two-time buyers as it did before. Since the optimal prices on one- and two-time buyers do not coincide, platform profit is strictly lower with disintermediation. However, in part (ii) of the proposition buyers are relatively heterogeneous. We know from Proposition 3 that with disintermediation the platform could potentially earn strictly more profit from two-time buyers than it did before. Hence, if ϕ is relatively small, the platform can price in such a way that the extra profit on two-time buyers outweighs the reduced profit from one-time buyers.

Figure 4 illustrates the above results in two numerical examples. In both panels the red solid curve depicts platform profit when disintermediation is impossible, and the blue dashed curve depicts platform profit when disintermediation is possible. In the left panel of the figure, part (i) of Proposition 5 applies, and so disintermediation strictly reduces platform profit at all $\phi \in (0, 1)$.[14] In the right panel part (ii) of the proposition applies, and disintermediation strictly benefits the platform provided the fraction of one-time buyers is below $\hat{\phi} \approx 0.35$.

Finally, consider buyer surplus. It is straightforward to show that disintermediation leads to a (weakly) higher $p_{B,1}$, and so unambiguously harms one-time buyers. For two-time buyers, as in the previous subsection a variety of outcomes are possible, depending on v, c, and the distribution of convenience benefits. Therefore, contrary to conventional wisdom, disintermediation can again be harmful to (at least some) buyers.

[14] Disintermediation has no effect on platform profit as ϕ approaches 0 and 1. The former follows from Proposition 3, while the latter is because at $\phi = 1$ the platform faces only one-time buyers.

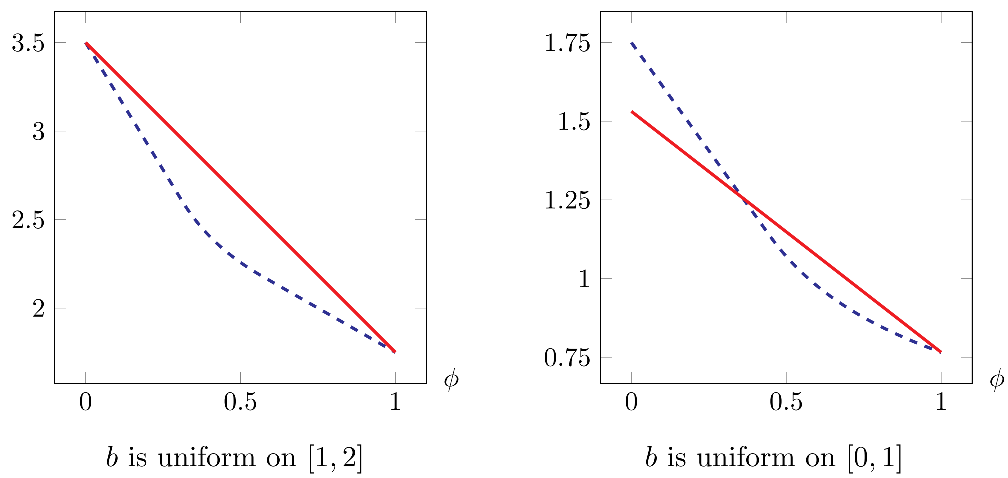

Figure 4: Platform profit with disintermediation (blue dashed curve) and without disintermediation (red solid curve) when buyers are heterogeneous in both purchase frequency and platform benefit. In both panels $v = 1$ and $c = 1/4$.

5 Discussion: One-Time Transactions

So far we have shown that, when buyers have heterogeneous platform benefits, the platform can benefit from disintermediation. We now show that this result can be extended even to the case where all buyers wish to transact only once.

As in our baseline model, assume that a buyer gets value v from buying the good off the platform, and $v + b$ from buying it on the platform. However, now suppose $\phi = 1$, such that *all* buyers wish to make a single transaction. Moreover, suppose that after the platform has introduced the buyer and seller, but before they have completed the transaction on the platform, the buyer can disintermediate.[15] In addition, suppose the platform can charge two fees—a referral fee r to introduce the buyer and seller, and a transaction fee t for hosting the transaction.[16]

We first solve for buyer participation constraints akin to those in equations (1) to (5). When disintermediation is impossible, the buyer has no choice but to transact on the platform, and therefore does so if and only if $v + b \geq r + t$. When disintermediation is possible, the buyer pays the referral fee if and only if $\max\{v+b-t, v-c\} \geq r$, and then

[15] If we instead assume, as in our baseline model, that disintermediation can only occur after the first transaction, then trivially disintermediation would have no effect given that $\phi = 1$.

[16] The ability to charge a referral fee is important for what follows: if the platform is forced to set $r = 0$ then it is easy to show that it is strictly harmed by disintermediation.

transacts on rather than off the platform provided $b \geq t - c$. (The logic is the usual one: after paying r and meeting the seller, the buyer gets $v + b - t$ from transacting on the platform, and $v - c$ if she transacts off the platform.)

Now turn to the platform's problem. When disintermediation is impossible it will

$$\max_{r,t} \quad (r + t - c)[1 - F(r + t - v)]. \tag{18}$$

The outcome of this maximization problem is a threshold b^{ND}, such that buyers transact if and only if $b \geq b^{ND}$. When instead disintermediation is possible, the platform's profit depends on the level of the referral fee r. If $r > v - c$ a buyer pays it only if she will also transact on the platform, and so the platform's profit is the same as in (18); this already establishes that the platform can do at least as well as before. However, if $r \leq v - c$ all buyers pay for the referral, and then those with $b \geq t - c$ also transact on the platform. Hence in this case the platform will

$$\max_{r,t} r + (t - c)[1 - F(t - c)]. \tag{19}$$

It is clear the platform optimally sets $r = v - c$, i.e., it extracts all the surplus that can be gained from taking the transaction offline. Then, just as in our baseline model, the platform uses the transaction fee t to screen buyers and extract more surplus from those with a strong preference for using its services. The next result then follows:

Proposition 6. *Suppose all buyers wish to do a single transaction but that they differ in their platform benefit. The ability of buyers to disintermediate weakly benefits the platform, and strictly so whenever* $\underline{b} f(\underline{b}) < 1$.

Even with one-off transactions, it is still the case that disintermediation can lead to higher platform profit. Nevertheless, the setting considered here is much less rich than our baseline model, where we have two types of heterogeneity, and where as a result disintermediation can either benefit or harm the platform, as in Proposition 5.

6 Robustness

We now show that our earlier insights on platform profit—specifically, that disintermediation can be good, bad, or neutral for the platform, depending on the exact nature of heterogeneity—are robust to several model extensions. (For brevity we relegate technical details of these extensions to the Online Appendix.)

6.1 Seller Pricing

In our baseline model the platform sets prices and the seller is passive. Here we assume the platform charges the seller per-transaction fees, and the seller sets final prices.

Consider our baseline model, but assume now that the platform charges the seller fees $\tau_{S,1}$ and $\tau_{S,2}$ to host the first and second transactions respectively. Observing these fees, the seller then chooses $p_{B,1}$ and $p_{B,2}$ which the buyer must pay to do the first and second transactions respectively on the platform. Assume, as in our earlier model, that the buyer and seller need to do the first transaction on the platform in order to meet. After this, if disintermediation is possible, the buyer can propose to do the second transaction off the platform and makes the seller a take-it-or-leave it offer.

The platform's optimal fees depend on the seller's pass-through rate, i.e., how much of any fee increase is passed through to final consumers. To ensure that pass-through is well-behaved, we impose a regularity condition: when $\underline{b} < \overline{b}$, define $I(b) \equiv \frac{1-F(b)}{f(b)} - b$ and assume $I''(b) \geq 0$.[17] We can then prove that:

Proposition 7. *Suppose the seller sets final prices on the platform. The ability of buyers to disintermediate: (i) is neutral for platform profit when buyers are homogeneous, (ii) strictly reduces platform profit when buyers are heterogeneous in how many times they wish to transact, and (iii) weakly benefits the platform when buyers are heterogeneous in their platform benefit (and strictly so when $1 - \underline{b}f(\underline{b}) > I'(\underline{b})$).*

When buyers are homogeneous, the platform reacts to the threat of disintermediation by rebalancing its fees—charging more for first-time transactions, and less for second-time transactions. This induces the seller to also rebalance its prices, enabling the platform to host the same transactions as before, and earn the same total fee on each transaction, and hence as in Proposition 1 earn the same profit as before. However, when buyers differ in their purchase frequency, adjusting fees in this way would lose transactions from one-time buyers, facing the platform with a dilemma as in Proposition 2. Finally though, when buyers differ in their convenience benefit, the platform can adjust its fees so as to take advantage of the higher demand for first-time transactions and the less elastic demand for second-time transactions, similar to in Proposition 3.

[17] As discussed in footnote 13 this assumption is satisfied by many common distributions.

6.2 Seller Benefits

In our baseline model the buyer receives a benefit from transacting on the platform and, when disintermediation is possible, chooses where to do the second transaction. Here we assume that the seller receives the platform benefit and decides where to transact.

Consider the following variant on our baseline model. The buyer wishes to buy twice, and each time her valuation for the product—irrespective of where the transaction occurs—is v. However, the seller's marginal cost now depends on where she transacts: her cost is c if she transacts off the platform, and $c - r$ if she transacts on the platform. Hence r is the reduction in cost (i.e., seller benefit) from using the platform. We assume that r has a distribution $G(r)$ with support $[\underline{r}, \overline{r}] \subseteq \mathbb{R}_+$, where $0 < \overline{r} < c$. Moreover, with probability $\phi < 1$ the seller can only serve the buyer once, and with probability $1 - \phi$ the seller can serve the buyer twice.[18] The seller is privately informed about her platform benefit r and whether she can serve the buyer once or twice. Mirroring our baseline analysis, the platform charges the buyer v for each transaction, and offers the seller $p_{S,1}$ and $p_{S,2}$ to complete, respectively, the first and second transactions on the platform. As usual, the buyer and seller can only meet with the help of the platform. However, after the first transaction, the seller can choose (when appropriate) whether to do the second transaction on or off the platform; if the second transaction occurs off the platform, the seller makes the buyer a take-it-or-leave-it offer.

Proposition 8. *Suppose the seller benefits from transacting on the platform. The ability of sellers to disintermediate: (i) is neutral for platform profit when sellers are homogeneous, (ii) strictly reduces platform profit when sellers are heterogeneous in how many times they can transact, and (iii) weakly benefits the platform when sellers are heterogeneous in their platform benefit r (and strictly so when $\underline{r}g(\underline{r}) < 1$).*

When buyers are homogeneous, the platform reacts to the threat of disintermediation by offering sellers a higher $p_{S,2}$ so as to prevent disintermediation, but a lower $p_{S,1}$ so as to reduce the overall compensation it pays out. As in Proposition 1, this rebalancing ensures the platform earns the same profit as when disintermediation was impossible. However, if sellers differ in how many times they can transact, the platform is worse off with disintermediation—because if it offers a lower $p_{S,1}$ to extract more

[18] We allow this dimension of heterogeneity for completeness, and to remain symmetric with respect to the baseline model, even though in practice it is more natural that the seller can always do both transactions if required (and hence r would be the only dimension of seller heterogeneity).

surplus from two-time sellers, it loses revenues from one-time sellers who are no longer willing to transact, similar to the trade-off it faced in Proposition 2. Finally, if instead sellers differ (enough) in their platform benefit r, the platform can use disintermediation to screen them and hence earn higher profit, just like in Proposition 3 where it used disintermediation to screen buyers.

6.3 General Number of Transactions

In our baseline analysis a buyer wishes to transact either once or twice. Here we allow for a general number of transactions.

Consider the same set-up as our baseline model, except that now a buyer wishes to transact $n = 1, \dots, N$ times. Let ϕ_k be the probability a buyer wishes to transact k times, where $\phi_1 < 1$ and $\sum_{k=1}^{N} \phi_k = 1$. The platform compensates the seller c for each transaction, and charges the buyer $p_{B,k}$ to complete a k^{th} transaction on the platform. As usual the buyer and seller can only meet with the help of the platform, but after the first transaction they can disintermediate. We break ties as follows: if a buyer is indifferent about whether to do an additional transaction she does it, and if she is indifferent about doing a transaction on or off the platform she does it on the platform.

Proposition 9. *Consider a general number of transactions. The ability of buyers to disintermediate: (i) is neutral for the platform when buyers are homogeneous, (ii) strictly reduces platform profit when buyers are heterogeneous in n, and (iii) weakly benefits the platform when buyers are heterogeneous in b (and strictly so if $\underline{b} f(\underline{b}) < 1$).*

When buyers all have the same b and n, the platform reacts to the threat of disintermediation by reducing $\{p_{B,2}, \dots, p_{B,n}\}$ so as to ensure the last $n-1$ transactions occur on the platform. This leaves surplus to buyers, which as in Proposition 1 the platform extracts by raising $p_{B,1}$, such that it earns the same profit as when disintermediation was impossible. However, when different buyers have different desired purchase frequencies, buyers with larger n would benefit more from the lower $\{p_{B,2}, \dots, p_{B,n}\}$, and so would need to be charged a higher $p_{B,1}$ to extract all their surplus. As in Proposition 2 the platform faces a dilemma: as it raises $p_{B,1}$ it extracts more surplus from high-n buyers, but forces low-n buyers off the platform completely, and so is always worse off compared to when disintermediation was impossible. Finally, if buyers differ only in their platform benefit b, the platform can use disintermediation to screen them and earn more profit, just like in Proposition 3.

6.4 Bargaining Between Buyers and Sellers

In our baseline analysis a buyer chooses where to transact and on what terms. Here we allow buyers and sellers to bargain over where to trade and at what price.

Consider our baseline model, but now suppose that the platform charges buyers and sellers $p_{B,1}$ and $p_{S,1}$ respectively to do the first transaction, and $p_{B,2}$ and $p_{S,2}$ respectively to do a second transaction. Buyers and sellers still need the platform to meet and perform the first transaction. However, after doing this first transaction, a buyer and seller can communicate and bargain with each other. To capture this in a simple way, suppose that with probability $\alpha \in [0, 1]$ the buyer chooses where a second transaction occurs, and at what price, and makes a take-it-or-leave-it offer to the seller; with probability $1-\alpha$ the seller chooses where a second transaction occurs, and at what price, and makes a take-it-or-leave-it offer to the buyer. (Hence a higher α means the buyer has more bargaining power.) For simplicity, we assume that the buyer and seller match only with each other, and hence have zero outside option if they fail to make an agreement; we also assume that if the seller is the one making the offer, she learns the buyer's on-platform b before making an offer.[19] In addition to the usual tie-break rules, we assume that if the seller has the bargaining power and is indifferent about where to do the second transaction, she does it on the platform.

The platform must now satisfy not only buyer participation constraints like those in equations (1) to (5), but also seller participation constraints. In the Online Appendix we show that when disintermediation is possible, a second transaction occurs on the platform if and only only if $p_{B,2} + p_{S,2} \leq b$, i.e., provided the total margin taken by the platform is less than the convenience benefit it brings. Hence only the total margin matters, not its individual components $p_{B,2}$ and $p_{S,2}$.[20] Because the seller may earn positive surplus from bargaining at the time of the second transaction, the platform may charge it a positive fee for the first transaction.

Proposition 10. *Suppose there is bargaining. The ability of agents to disintermediate: (i) is neutral for platform profit when buyers are homogeneous, (ii) weakly reduces*

[19] These assumptions avoid the well-known problems and technical complications associated with, respectively, multi-player bargaining, and bargaining under incomplete information.

[20] In the baseline model we assumed the platform compensates the seller c for each transaction, i.e., using our notation here, we set $p_{S,1} = p_{S,2} = -c$. As the above discussion shows, $p_{S,2} = -c$ is purely a normalization given that only $p_{B,2} + p_{S,2}$ matters. Moreover, since the seller has no bargaining power in the baseline model, one can show that it is indeed optimal for the platform to set $p_{S,1} = -c$.

platform profit when buyers are heterogeneous in how many times they wish to transact, and strictly so for $\alpha > 0$, and (iii) weakly benefits the platform when buyers are heterogeneous in b (and strictly so when $\underline{b}f(\underline{b}) < 1$ and α exceeds a threshold $\breve{\alpha} \in (0, 1)$).

When buyers are homogeneous, the platform reacts as usual to the threat of disintermediation by reducing its margin $p_{B,2} + p_{S,2}$ on the second transaction, so as to ensure that disintermediation does not occur. This leaves surplus to both buyers and sellers (depending on their bargaining powers), which the platform then extracts by raising $p_{B,1}$ and $p_{S,1}$. Just as in Proposition 1, this enables it to earn the same profit as when disintermediation was impossible. However, when buyers differ in their purchase frequency and $\alpha > 0$, the platform faces the usual dilemma from Proposition 2 between keeping $p_{B,1}$ low to host one-time buyers but give up surplus on two-time buyers, or raising $p_{B,1}$ to fully extract two-time buyers but lose one-time buyers. (The reason why this dilemma does not arise when $\alpha = 0$—and hence the platform is not harmed by disintermediation—is that in this case two-time buyers have no bargaining power over the second transaction, so their willingness-to-pay for the first transaction is the same as that of a one-time buyer.) Finally, if buyers differ in their convenience benefit b, the platform (weakly) benefits from disintermediation, and strictly so whenever $\underline{b}f(\underline{b}) < 1$ and α is sufficiently large. Intuitively, α must be relatively large because in that case buyers have a lot of bargaining power, and so buyers' payoffs are more sensitive to their b, implying more scope for the platform to screen them, just as in Proposition 3.

7 Managerial Implications

Contrary to existing literature, our paper shows that managers may be able to use disintermediation to increase their profits. However, in order for this to happen, buyers and sellers should obtain convenience benefits from transacting on the platform, and they should be relatively heterogeneous in how they value these benefits. Disintermediation is more of a threat to platforms that offer little or no convenience benefits, and that offer services where buyers and sellers differ greatly in terms of their intended use.

In order to maximize the benefit (or minimize the harm) from disintermediation, managers may need to qualitatively change their pricing strategy. Specifically, they should opt for a "front-loaded" pricing scheme, using a sliding scale whereby early transactions are relatively expensive and later transactions are relatively cheap. This helps to extract more of the value created by the platform, while also reducing the amount of disintermediation. Nevertheless, even if managers can entirely eliminate disintermediation, they should not necessarily do this. Indeed, when on-platform convenience benefits are sufficiently heterogeneous, the platform should actively encourage some disintermediation—because this enables it to extract more surplus from buyers and sellers who value platform services the most. To this end, platforms should emphasize the benefits that buyers and sellers can obtain by transacting there.

We note that some platforms have indeed adopted a front-loaded pricing scheme like the one suggested by our model. For example, CoachUp charges the client a one-off \$24.99 fee for their first booking, and charges the coach commissions on a sliding scale—starting at 43% for the first transaction with a new client, and gradually decreasing until reaching only 6% after the client has booked five or more sessions. Similarly, Preply charges a 100% commission on every trial lesson with a new student, while its commission on subsequent lessons decreases in the total number of hours taught on the platform. However, other platforms still take the same commission on each transaction. For example, Wyzant charges tutors a flat rate of 25%.[21] Our analysis suggests that managers of these platforms may benefit from taking less margin on repeat transactions.

Our model assumes that disintermediation can only occur after the first transaction; this enables the platform to extract more value at the start of a buyer-seller relationship, and potentially benefit from disintermediation. Managers should therefore renew efforts to limit early communication between buyers and sellers. Of course, for some services early communication is necessary (e.g., when personalization is important)—in which case managers should invest in better on-platform communication systems, and use AI tools which prevent sharing of email addresses and telephone numbers.

Lastly, although our main analysis focuses on services that are consumed repeatedly, we also showed that managers can benefit from disintermediation even with one-shot transactions. Nevertheless, in order to achieve this, the platform must use both a referral fee—to extract value from buyer-seller matches which will transact elsewhere, as well as a per-transaction fee—to extract value from participants who value the platform's convenience benefits highly. Our analysis does not, therefore, support a strategy which completely eschews transaction fees in favor of referral fees, like the one pursued by some platforms such as Thumbtack.[22]

[21] For the three examples in this paragraph, see respectively https://shorturl.at/MNY6p, https://shorturl.at/tgrzR, and https://shorturl.at/Gnjms.

[22] See https://shorturl.at/sahii for further details.

8 Conclusion

We have developed a model in which buyers and sellers meet on a platform and wish to transact repeatedly, but after the first transaction have the ability to disintermediate. The model allows for two forms of heterogeneity—frequency of transactions, and convenience benefits from transacting on the platform. We showed that, in equilibrium, disintermediation occurs whenever the margin taken by the platform exceeds the convenience benefit that it generates. We also showed that the platform optimally reacts to the threat of disintermediation by changing its pricing strategy, charging more for early transactions and less for later transactions. We provided conditions under which a platform can exploit disintermediation, and use it to earn higher profit. Moreover, we found that disintermediation does not necessarily benefit buyers—for example, sometimes it can harm all buyers, and other times it has distributional effects, benefiting some buyers but harming others. Our insights are robust to various extensions, including who sets final prices on the platform, who enjoys convenience benefits, and which side of the market initiates disintermediation.

We believe that our paper opens up several interesting avenues for future research. First, we have taken (the distribution of) convenience benefits as fixed. It would be worthwhile to endogenize them, and consider a platform's incentives to invest in these benefits, as well as how it changes with disintermediation. Second, we have considered a monopoly platform. It would be valuable to consider competition between platforms, especially given that buyers and sellers could meet on one platform and then disintermediate by moving to another platform where commissions are lower. Third, we have considered separately the cases where convenience benefits accrue to buyers (the main model) and to sellers (an extension). Although combining these would make the model much less tractable, it could allow us to consider broader platform design questions, such as how the platform might want to try and match different buyers and sellers, and how this interacts with disintermediation incentives. We leave these avenues for future work.

A Appendix: Omitted Proofs of the Main Results

Proof of Proposition 1. First, suppose disintermediation is not possible. To extract the maximum possible surplus the platform must ensure the second transaction occurs; hence $p_{B,2} \leq v + b$. The platform should then set $p_{B,1}$ as high as possible subject to the buyer taking the first transaction. This gives the prices in (6).

Next, suppose disintermediation is possible. To extract the maximum possible surplus the platform must ensure the second transaction occurs on the platform (since the surplus $v + b - c$ on the platform exceeds the surplus $v - c$ off the platform); hence $p_{B,2} \leq b + c$. The platform should then set $p_{B,1}$ as high as possible, giving (7).

One can check that in both cases the platform extracts the full surplus $2(v+b-c)$. □

Proof of Lemma 1. The proof follows arguments in the text and so is omitted. □

Proof of Proposition 2. In the case where disintermediation is impossible, the proof follows from arguments in the text and so is omitted.

Now consider the case where disintermediation is possible. Platform profit for $p_{B,1} \leq v + b$ and $v + b < p_{B,1} \leq 2(v + b) - p_{B,2}$ was derived in the text. Notice that if the platform chooses $p_{B,1} > 2(v + b) - p_{B,2}$ no buyer does even the first transaction, so the platform earns zero profit—meaning this range of $p_{B,1}$ is clearly dominated. Finally, we derive the threshold result on ϕ. Define $\Delta(\phi) = 2(1 - \phi)(v + b - c) - [v - c + (2 - \phi)b]$. Notice that $\Delta(0) > 0 > \Delta(1)$ and $\Delta'(\phi) < 0$. Hence there exists a unique ϕ^* such that $\Delta(\phi) = 0$, which after simple computations is $\phi^* = (v - c)/[2(v - c) + b]$. □

Proof of Lemma 2. We begin by maximizing the first line of π^{ND} in equation (8). The profit expression is separable and symmetric in $p_{B,1}$ and $p_{B,2}$, and also quasiconcave in each given the log-concavity of $1 - F$. It then follows that the optimal $p_{B,1}$ and $p_{B,2}$ are identical. Profit is strictly increasing in $p_{B,1} = p_{B,2} < v + \underline{b}$ so all prices here are dominated. The derivative of profit with respect to $p_{B,i} \geq v + \underline{b}$ for $i = 1, 2$ is

$$1 - F(p_{B,i} - v) - (p_{B,i} - c)f(p_{B,i} - v). \tag{20}$$

Given that log-concavity of $1 - F$ implies that $(1 - F)/f$ is decreasing, this crosses zero at most once in $p_{B,i}$, from positive to negative. Notice that (20) evaluated at $p_{B,i} = v + \underline{b}$ is weakly negative if and only if $(v + \underline{b} - c)f(\underline{b}) \geq 1$. Hence if $(v + \underline{b} - c)f(\underline{b}) \geq 1$ the solution is $p_{B,1} = p_{B,2} = v + \underline{b}$, and otherwise the solution is $p_{B,1} = p_{B,2} = v + b^{ND}$ where b^{ND} is the unique solution to equation (10).

Next, we maximize the second line of π^{ND} in equation (8). The profit expression is strictly increasing in $p_{B,1} + p_{B,2} < 2(v + \underline{b})$ so all prices here are dominated. The derivative of profit with respect to $p_{B,1} + p_{B,2} \geq 2(v + \underline{b})$ is

$$1 - F\left(\frac{p_{B,1} + p_{B,2}}{2} - v\right) - \left(\frac{p_{B,1} + p_{B,2}}{2} - c\right) f\left(\frac{p_{B,1} + p_{B,2}}{2} - v\right). \qquad (21)$$

Using the same arguments as in the first part of the proof, one can check that $p_{B,1} + p_{B,2} = 2(v + \underline{b})$ if $(v + \underline{b} - c)f(\underline{b}) \geq 1$, and otherwise $p_{B,1} + p_{B,2} = 2(v + b^{ND})$ where b^{ND} is the unique solution to equation (10). Given that $p_{B,1} > p_{B,2}$ in the second line of (8), we must have $p_{B,2} < v + b^{ND}$.

Putting together the optimal prices from the above two optimization problems gives the solution in the lemma. Finally, it is straightforward to check that buyers with $b < b^{ND}$ do no transactions and all other buyers do both transactions. □

Proof of Lemmas 3 and 4. We prove the two lemmas together. We start by maximizing the second line of π^D in equation (11). Since this expression is the same as the second line of π^{ND}, it follows from the proof of Lemma 2 that the platform charges $p_{B,1}+p_{B,2} = 2(v + \tilde{b})$, where $\tilde{b} = \underline{b}$ if $(v + \underline{b} - c)f(\underline{b}) \geq 1$ and otherwise $\tilde{b} > \underline{b}$ is the unique solution to $1 - F(\tilde{b}) - f(\tilde{b})(v + \tilde{b} - c) = 0$. This generates platform profit $2(v + \tilde{b} - c)[1 - F(\tilde{b})]$.

Next, consider the first line of π^D in equation (11). Notice that if the platform were to set $p_{B,1} = \tilde{b} + 2v - c$ and $p_{B,2} = \tilde{b} + c$, it would again earn $2(v + \tilde{b} - c)[1 - F(\tilde{b})]$. We now check under what conditions the platform can do strictly better than this. Notice that the first line of π^D is separable in $p_{B,1}$ and $p_{B,2}$, and quasiconcave in each given the log-concavity of $1 - F$. Using the same steps as in the proof of Lemma 2, and ignoring temporarily the constraint $p_{B,1} \leq p_{B,2} + 2(v - c)$, it is straightforward to show the following. The optimum has $p_{B,1} = b_1^D + 2v - c$ and $p_{B,2} = b_2^D + c$. Moreover, $b_1^D = \underline{b}$ if $[\underline{b} + 2(v - c)]f(\underline{b}) \geq 1$, and otherwise $b_1^D > \underline{b}$ uniquely solves

$$1 - F(b_1^D) - [b_1^D + 2(v - c)]f(b_1^D) = 0.$$

In addition, $b_2^D = \underline{b}$ if $\underline{b}f(\underline{b}) \geq 1$, and otherwise $b_2^D > \underline{b}$ uniquely solves

$$1 - F(b_2^D) - b_2^D f(b_2^D) = 0.$$

We now claim that the constraint $p_{B,1} \leq p_{B,2} + 2(v-c)$ is always satisfied, and so the above $\{p_{B,1}, p_{B,2}\}$ are also the solution to the constrained optimization. Note that the constraint reduces to $b_1^D \leq b_2^D$. Clearly this is satisfied if $[\underline{b} + 2(v-c)]f(\underline{b}) \geq 1$ because in this case $b_1^D = \underline{b} \leq b_2^D$. If instead $[\underline{b} + 2(v-c)]f(\underline{b}) < 1$ then $b_1^D, b_2^D \in (\underline{b}, \bar{b})$ satisfy

$$b_1^D + 2(v-c) = \frac{1 - F(b_1^D)}{f(b_1^D)} \quad \text{and} \quad b_2^D = \frac{1 - F(b_2^D)}{f(b_2^D)}.$$

Towards a contradiction, suppose that actually $b_1^D > b_2^D$. Then the left-hand side of the first equation strictly exceeds the left-hand side of the second equation. However, since $1 - F$ is log-concave, the right-hand side of the first equation is lower than the right-hand side of the second equation. But this is impossible. Hence $b_1^D \leq b_2^D$.

Next, we prove that $b_1^D \leq b^{ND}$, with strict inequality if $b^{ND} > \underline{b}$. (The proof that $b_2^D > b^{ND}$ is similar and so is omitted.) If $(v + \underline{b} - c)f(\underline{b}) \geq 1$ then from above and Lemma 2 we have $b_1^D = b^{ND} = \underline{b}$. If $(v + \underline{b} - c)f(\underline{b}) < 1 \leq [2(v-c) + \underline{b}]f(\underline{b})$ then from above and Lemma 2 we have $b_1^D = \underline{b} < b^{ND}$. If $[2(v-c) + \underline{b}]f(\underline{b}) < 1$ then from above and Lemma 2 we have $b^{ND} > \underline{b}$ and moreover

$$v + b^{ND} - c = \frac{1 - F(b^{ND})}{f(b^{ND})} \quad \text{and} \quad 2(v-c) + b_1^D = \frac{1 - F(b_1^D)}{f(b_1^D)}.$$

Towards a contradiction, suppose that $b_1^D \geq b_1^{ND}$. The left-hand side of the first equation is strictly lower than the left-hand side of the second equation. However, since $1 - F$ is log-concave, the right-hand side of the first equation is larger than the right-hand side of the second equation. But this is impossible, so $b_1^D \leq b^{ND}$.

For Lemma 3, note that $\underline{b}f(\underline{b}) \geq 1$ implies $b_1^D = b_2^D = \tilde{b} = \underline{b}$. Hence the first line of π^D is maximized at $p_{B,1} = \tilde{b} + 2v - c$ and $p_{B,2} = \tilde{b} + c$, leading to a profit $2(v + \tilde{b} - c)[1 - F(\tilde{b})]$. Since this is the same profit as can be achieved by maximizing the second line of π^D, there is a continuum of optimal prices that satisfy $p_{B,1} + p_{B,2} = 2(v + \underline{b})$ and $p_{B,2} \leq \underline{b} + c$. For Lemma 4, $\underline{b}f(\underline{b}) < 1$ implies $\{b_1^D, b_2^D\} \neq \{\tilde{b}, \tilde{b}\}$. Hence the first line of π^D is *not* maximized at $p_{B,1} = \tilde{b} + 2v - c$ and $p_{B,2} = \tilde{b} + c$. By revealed preference the platform earns strictly more than $2(v + \tilde{b} - c)[1 - F(\tilde{b})]$ and so the platform has a unique optimal price pair $\{p_{B,1}, p_{B,2}\}$, namely the one which maximizes the first line of π^D. □

Proof of Corollary 1. When $\underline{b}f(\underline{b}) < 1$, it suffices from equation (13) to prove that $b_1^D + 2(v-c) \geq b_2^D$. Using the previous proof, we know that

$$b_1^D + 2(v-c) \geq \frac{1 - F(b_1^D)}{f(b_1^D)} \quad \text{and} \quad b_2^D = \frac{1 - F(b_2^D)}{f(b_2^D)}.$$

where the weak inequality accounts for the possibility that $b_1^D = \underline{b}$. It is easy to see that $b_1^D + 2(v-c) \geq b_2^D$ because otherwise the above two conditions are inconsistent with each other. When $\underline{b}f(\underline{b}) \geq 1$, the claim follows from equation (12). $\square$

Proof of Proposition 3. First consider the case $\underline{b}f(\underline{b}) \geq 1$. Lemmas 2 and 3 show that regardless of whether disintermediation is possible, the platform hosts both transactions for all buyers and charges a total price $2(v + \underline{b})$, and so earns the same profit.

Next, consider the case $\underline{b}f(\underline{b}) < 1$. If disintermediation is impossible, we know from Lemma 2 that the platform hosts both transactions for all buyers with $b \geq b^{ND}$ and charges a total price $2(v + b^{ND})$, thus earning a profit $2(v + b^{ND} - c)[1 - F(b^{ND})]$. If instead disintermediation is possible, notice that the platform could charge $p_{B,1} = b^{ND} + 2v - c$ and $p_{B,2} = b^{ND} + c$, and from equation (11) it would again earn $2(v + b^{ND} - c)[1 - F(b^{ND})]$. However, the right-derivative of π^D in (11) with respect to $p_{B,2}$ evaluated at $p_{B,2} = b^{ND} + c$ is $1 - F(b^{ND}) - b^{ND}f(b^{ND})$. We claim that this is strictly positive, and so by raising $p_{B,2}$ the platform can earn strictly higher profit than it did when disintermediation was impossible. The claim is immediate if $b^{ND} = \underline{b}$ because by assumption $\underline{b}f(\underline{b}) < 1$; if instead $b^{ND} > \underline{b}$ then b^{ND} satisfies equation (10) and so $1 - F(b^{ND}) - b^{ND}f(b^{ND}) = f(b^{ND})(v - c) > 0$. $\square$

Proof of Lemma 5. For part (i), note from Lemma 4 that $b^{ND} = \underline{b}$ implies $b_1^D = b^{ND} < b_2^D$. Hence, for each $b > \underline{b}$, $U^{ND}(b) > U^D(b)$. For parts (ii) and (iii), note from Lemma 4 that $b^{ND} > \underline{b}$ implies $b_1^D < b^{ND} < b_2^D$. Hence, for each $b \leq b_1^D$, $U^{ND}(b) = U^D(b) = 0$. Also, for each $b \in (b_1^D, b^{ND}]$, $U^D(b) > 0 = U^{ND}(b)$. Moreover, for each $b \geq b_2^D$, $U^D(b) < U^{ND}(b)$ if and only if $2b^{ND} < b_1^D + b_2^D$. Finally, for $b \in (b^{ND}, b_2^D)$, $U^D(b) - U^{ND}(b)$ is decreasing in b so the existence of a cutoff in part (ii), and the fact that every buyer is better off under disintermediation in part (iii), follows immediately. $\square$

Proof of Proposition 4. Part (i) follows from Lemma 2.

Now consider parts (ii) and (iii). It is useful to introduce the notation $I(b) \equiv \frac{1-F(b)}{f(b)} - b$, and note that $1 - F$ log-concave implies $I'(b) < 0$ for all $b \in [\underline{b}, \overline{b}]$. We know from Lemmas 2 and 4 that $[\underline{b} + 2(v-c)]f(\underline{b}) \leq 1$ ensures that $\underline{b} \leq b_1^D < b^{ND}$, and that b_1^D satisfies (14) even in the edge case of $[\underline{b} + 2(v-c)]f(\underline{b}) = 1$. Moreover, equation (10) implies that $I(b^{ND}) = v - c$, while equations (14) and (15) imply respectively that $I(b_1^D) = 2(v-c)$ and $I(b_2^D) = 0$. Hence, for part (ii) we can write

$$I(b^{ND}) = \frac{I(b_1^D) + I(b_2^D)}{2} > I\left(\frac{b_1^D + b_2^D}{2}\right),$$

where the inequality uses strict convexity of $(1-F)/f$ and thus also of $I(b)$. Since $I'(b) < 0$ this implies that $2b^{ND} < b_1^D + b_2^D$. Meanwhile for part (iii) we can write

$$I(b^{ND}) = \frac{I(b_1^D) + I(b_2^D)}{2} \leq I\left(\frac{b_1^D + b_2^D}{2}\right),$$

where the inequality uses weak concavity of $(1-F)/f$ and thus also of $I(b)$. Since $I'(b) < 0$ this implies that $2b^{ND} \geq b_1^D + b_2^D$. □

Proof of Proposition 5. In this proof we denote the left-hand sides of (8) and (11) by respectively $\pi^{ND}(p_{B,1}, p_{B,2})$ and $\pi^D(p_{B,1}, p_{B,2})$, in order to make clear their dependence on $p_{B,1}$ and $p_{B,2}$. We also let $\pi^{OT}(p_{B,1}) \equiv (p_{B,1} - c)[1 - F(p_{B,1} - v]$ denote profit from a one-time buyer, and we let $\overline{\pi}^{OT} = \max_{p_{B,1}} \pi^{OT}(p_{B,1})$ denote its maximized value.

We first argue that if disintermediation is impossible the platform earns $(2-\phi)\overline{\pi}^{OT}$. Consider platform profit in equation (16). The first term is maximized at $p_{B,1} = \arg\max_p \pi^{OT}(p)$, and from the proof of Lemma 2 the second term is maximized by a a continuum of price pairs which include $p_{B,1} = p_{B,2} = \arg\max_p \pi^{OT}(p)$. Hence (16) has a unique maximizer, namely $p_{B,1} = p_{B,2} = \arg\max_p \pi^{OT}(p)$. After substituting this into (16) and simplifying, maximized platform profit equals $(2-\phi)\overline{\pi}^{OT}$.

We now prove part (i) of the proposition. Consider platform profit in equation (17). The first term is maximized at $p_{B,1} = \arg\max_p \pi^{OT}(p) = v + \underline{b}$, and its maximized value is $\phi\overline{\pi}^{OT}$. From the proof of Lemma 3 the second term reaches a maximum of $2(1-\phi)\overline{\pi}^{OT}$, but although there is a continuum of optimal price pairs they all have $p_{B,1} > v + \underline{b}$. Hence for any $\phi \in (0,1)$ it is impossible that both terms of (17) reach their maximum, and so maximized profit must be strictly below $(2-\phi)\overline{\pi}^{OT}$.

We now prove part (ii) of the proposition. To ease the exposition we introduce the following notation:

$$\{p_{B,1}(\phi), p_{B,2}(\phi)\} \equiv \arg \max_{\{p_{B,1}, p_{B,2}\}} \phi\pi^{OT}(p_{B,1}) + (1-\phi)\pi^D(p_{B,1}, p_{B,2}).$$

Let $\phi' \in (0,1)$ be a ϕ value where buyers' ability to disintermediate strictly raises platform profit. (Since disintermediation strictly raises platform profit when $\phi = 0$ by

Lemma 4, by continuity such a ϕ must exist.) Hence we have

$$\phi'\pi^{OT}(p_{B,1}(\phi')) + (1-\phi')\pi^{D}(p_{B,1}(\phi'), p_{B,2}(\phi')) > (2-\phi')\overline{\pi}^{OT}. \tag{22}$$

We claim that $\pi^D(p_{B,1}(\phi'), p_{B,2}(\phi')) > 2\overline{\pi}^{OT}$. On the way to a contradiction, suppose $\pi^D(p_{B,1}(\phi'), p_{B,2}(\phi')) \leq 2\overline{\pi}^{OT}$: since by definition $\pi^{OT}(p_{B,1}(\phi')) \leq \overline{\pi}^{OT}$, the left-hand side of (22) must be weakly below the right-hand side, but this is impossible. Hence $\pi^D(p_{B,1}(\phi'), p_{B,2}(\phi')) > 2\overline{\pi}^{OT}$. Next, notice that for $\phi'' \in (0, \phi')$ we have

$$\begin{aligned}
&\phi''\pi^{OT}(p_{B,1}(\phi'')) + (1-\phi'')\pi^{D}(p_{B,1}(\phi''), p_{B,2}(\phi'')) - (2-\phi'')\overline{\pi}^{OT} \\
&\geq \phi''\pi^{OT}(p_{B,1}(\phi')) + (1-\phi'')\pi^{D}(p_{B,1}(\phi'), p_{B,2}(\phi')) - (2-\phi'')\overline{\pi}^{OT} \\
&= \phi''\left[\pi^{OT}(p_{B,1}(\phi')) + \overline{\pi}^{OT} - \pi^{D}(p_{B,1}(\phi'), p_{B,2}(\phi'))\right] + \pi^{D}(p_{B,1}(\phi'), p_{B,2}(\phi')) - 2\overline{\pi}^{OT} \\
&> \phi'\left[\pi^{OT}(p_{B,1}(\phi')) + \overline{\pi}^{OT} - \pi^{D}(p_{B,1}(\phi'), p_{B,2}(\phi'))\right] + \pi^{D}(p_{B,1}(\phi'), p_{B,2}(\phi')) - 2\overline{\pi}^{OT} \\
&> 0,
\end{aligned}$$

where the first inequality uses the fact that (17) is maximized by $\{p_{B,1}(\phi''), p_{B,2}(\phi'')\}$ when $\phi = \phi''$, the second inequality uses $\phi'' < \phi'$, the result that $\pi^D(p_{B,1}(\phi'), p_{B,2}(\phi')) > 2\overline{\pi}^{OT}$, and the observation that $\overline{\pi}^{OT} \geq \pi^{OT}(p_{B,1}(\phi'))$, and the third inequality uses (22). However this string of inequalities implies that buyers' ability to disintermediate strictly raises platform profit when $\phi = \phi''$. The stated cutoff in the proposition then follows immediately. □

Proof of Proposition 6. First, suppose disintermediation is impossible. Log-concavity of $1-F$ implies that (18) is quasiconcave in $r+t$. Taking the first-order condition, the platform chooses a marginal buyer with $b = b^{ND}$ where $b^{ND} = \underline{b}$ if $1-(v+\underline{b}-c)f(\underline{b}) \leq 0$, and otherwise b^{ND} uniquely solves $1-F(b^{ND})-(v+b^{ND}-c)f(b^{ND}) = 0$. The platform then charges $r+t = v+b^{ND}$ and so earns $(v+b^{ND}-c)[1-F(b^{ND})]$.

Now suppose disintermediation is possible. Clearly (19) is maximized at $r = v-c$. Notice that if we set $t = b^{ND}+c$ the platform earns $(v-c)F(b^{ND}) + (v+b^{ND}-c)[1-F(b^{ND})]$; if $b^{ND} = \underline{b}$ this equals pre-disintermediation profit, and otherwise is strictly higher. Next, suppose $\underline{b}f(\underline{b}) < 1$, and note that the derivative of platform profit with respect to t evaluated at $t = b^{ND}+c$ is $1-F(b^{ND})-b^{ND}f(b^{ND})$. This is clearly strictly positive if $b^{ND} = \underline{b}$. It is also strictly positive if $b^{ND} > \underline{b}$, because from above we have in that case $1-F(b^{ND}) = (v+b^{ND}-c)f(b^{ND})$. Hence, when $\underline{b}f(\underline{b}) < 1$ the platform earns strictly more than it did absent disintermediation. □

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B Online Appendix: Not For Publication

Here we provide omitted proofs for each of the extensions in Section 6.

B.1 Seller Pricing

Proof of Proposition 7. As a preliminary step, note that the buyer participation constraints in equations (1) to (5) remain valid in this extension.

Now consider part (i). As usual it is efficient for both transactions to occur on the platform, generating total surplus of $2(v+b-c)$; this puts a bound on the total profit that can be earned by the platform and seller. Notice that if the platform sets $\tau_{S,1} = 2(v+b-c)$ and $\tau_{S,2} = 0$ then the seller can never make strictly positive profit. However, by charging, e.g., $p_{B,1} = 2(v+b)$ and $p_{B,2} = 0$, the seller can induce the buyer to do both transactions on the platform—irrespective of whether disintermediation is possible—and so generate zero profit. Since $\tau_{S,1} + \tau_{S,2} = 2(v+b-c)$ the platform extracts the full surplus regardless of whether disintermediation is possible.

Now consider part (ii). As usual it is efficient for all transactions to occur on the platform, generating total surplus of $(2-\phi)(v+b-c)$; this again puts a bound on the total profit that can be earned. Suppose disintermediation is impossible. Notice that if the platform sets $\tau_{S,1} = (2-\phi)(v+b-c)$ and $\tau_{S,2} = 0$ then the seller can never make strictly positive profit. However, by charging $p_{B,1} = p_{B,2} = v+b$, the seller can induce the buyer to do all desired transactions on the platform—earning the seller a zero profit, and allowing the platform to extract the maximum possible surplus. Next, suppose disintermediation is possible. Recall from Proposition 2 that the amount which can be extracted from the buyer is strictly less than $(2-\phi)(v+b-c)$, and so since the seller's profit cannot be negative, the platform must earn strictly less than $(2-\phi)(v+b-c)$.

Now consider part (iii). Recall the definition $I(b) = \frac{1-F(b)}{f(b)} - b$.

We first prove that, when disintermediation is impossible, the platform chooses a marginal buyer type b^{ND}, where $b^{ND} = \underline{b}$ if $I'(\underline{b}) - 1 + (v + \underline{b} - c) f(\underline{b}) \geq 0$, and otherwise $b^{ND} > \underline{b}$ is the unique solution to

$$I'(b^{ND}) \frac{1-F(b^{ND})}{f(b^{ND})} + v - c - I(b^{ND}) = 0. \tag{23}$$

The platform then charges fees satisfying $\tau_{S,1} \geq \tau_{S,2}$ and $\tau_{S,1} + \tau_{S,2} = 2[v - c - I(b^{ND})]$, such that the seller charges prices satisfying $p_{B,1} \geq p_{B,2}$ and $p_{B,1} + p_{B,2} = 2(v + b^{ND})$.

Given these seller prices, buyers with $b < b^{ND}$ do no transactions, and buyers with $b \geq b^{ND}$ do both transactions on the platform.

To prove the above result, first write the seller's profit as

$$\begin{cases} (p_{B,1} - c - \tau_{S,1})[1 - F(p_{B,1} - v)] + (p_{B,2} - c - \tau_{S,2})[1 - F(p_{B,2} - v)] & \text{if } p_{B,1} \leq p_{B,2}, \\ (p_{B,1} + p_{B,2} - 2c - \tau_{S,1} - \tau_{S,2}) \left[1 - F\left(\frac{p_{B,1}+p_{B,2}}{2} - v\right)\right] & \text{otherwise.} \end{cases} \tag{24}$$

Consider the first line of (24). Log-concavity of $1 - F$ implies that each term is quasi-concave in $p_{B,1}$ and $p_{B,2}$ respectively. The "unconstrained" optimum (i.e., ignoring the constraint $p_{B,1} \leq p_{B,2}$) is as follows: for $i = 1, 2$, $p_{B,i} = v + \underline{b}$ if $1 - (v + \underline{b} - c - \tau_{S,i}) f(\underline{b}) \leq 0$, and otherwise $p_{B,i}$ is the unique solution to $I(p_{B,i} - v) = v - c - \tau_{S,i}$. Next, consider the second line of (24). Let $\overline{p_B} \equiv (p_{B,1} + p_{B,2})/2$ and $\overline{\tau_S} \equiv (\tau_{S,1} + \tau_{S,2})/2$. Then $\overline{p_B} = v + \underline{b}$ if $1 - (v + \underline{b} - c - \overline{\tau_S}) f(\underline{b}) < 0$, and otherwise $\overline{p_B}$ is the unique solution to $I(\overline{p_B} - v) = v - c - \overline{\tau_S}$. Next, notice that any prices satisfying $p_{B,1} \geq p_{B,2}$ which have the same total price $p_{B,1} + p_{B,2}$ give the same seller profit. We can then conclude that if the unconstrained solution to the first line of (24) satisfies $p_{B,1} < p_{B,2}$ then it is the unique solution to the seller's optimization problem, and otherwise any $p_{B,1} \geq p_{B,2}$ that maximize the second line of (24) solve the seller's optimization problem.

Now consider the platform's optimization problem. We will argue that the platform optimally sets $\tau_{S,1} \geq \tau_{S,2}$. On the way to a contradiction, suppose the platform sets $\tau_{S,1} < \tau_{S,2}$. Define $\hat{\tau} \equiv v + \underline{b} - c - [1/f(\underline{b})]$ (a) One possibility is that $\tau_{S,1} < \tau_{S,2} \leq \hat{\tau}$. Earlier work implies that the unconstrained $p_{B,1}$ and $p_{B,2}$ that maximize the first line of (24) are equal. Hence the seller chooses total price $p_{B,1} + p_{B,2}$ (satisfying $p_{B,1} \geq p_{B,2}$) to maximize the second line of (24). However, since $\overline{\tau_S} < \hat{\tau}$, the platform can profitably deviate by raising $\tau_{S,1}$ slightly: the seller will not change its $p_{B,1} + p_{B,2}$ so the platform will host the same transactions but for a higher fee. Hence we cannot have $\tau_{S,1} < \tau_{S,2} \leq \hat{\tau}$. (b) Another possibility is that $\tau_{S,1} < \hat{\tau} < \tau_{S,2}$. Earlier work implies that the unconstrained seller prices satisfy $p_{B,1} < p_{B,2}$. Hence the seller chooses prices to maximize the first line of (24). However, since $\tau_{S,1} < \hat{\tau}$, the platform can profitably deviate by raising $\tau_{S,1}$ slightly: the seller will not change its prices, so the platform will host the same transactions but at higher fees. Hence we cannot have $\tau_{S,1} < \hat{\tau} < \tau_{S,2}$. (c) The final possibility is that $\hat{\tau} \leq \tau_{S,1} < \tau_{S,2}$. Earlier work again implies that the unconstrained seller prices satisfy $p_{B,1} < p_{B,2}$.[23] Hence the seller chooses prices to

[23] The reason is as follows. From earlier, in this case $p_{B,i}$ for $i = 1, 2$ satisfies $I(p_{B,i} - v) = v - c - \tau_{S,i}$.

maximize the first line of (24), and platform profit is $\tau_{S,1}[1 - F(p_{B,1} - v)] + \tau_{S,2}[1 - F(p_{B,2} - v)]$. Note that because (from earlier) $p_{B,i}$ satisfies $I(p_{B,i} - v) = v - c - \tau_{S,i}$ for $i = 1, 2$, we have that $dp_{B,i}/d\tau_{S,i} = -1/I'(p_{B,i} - v)$. The derivative of platform profit with respect to $\tau_{S,i}$ is therefore proportional to

$$\frac{1 - F(p_{B,i} - v)}{f(p_{B,i} - v)} + \frac{\tau_{S,i}}{I'(p_{B,i} - v)}.$$

This is strictly decreasing in $\tau_{S,i} \geq 0$ given that $I''(b) \geq 0$. Hence the platform will not choose $\tau_{S,1} < \tau_{S,2}$: it can move one fee closer to the other and strictly increase its profit.

We conclude from the above that the platform optimally chooses $\tau_{S,1} \geq \tau_{S,2}$. From earlier work, the unconstrained seller prices do not satisfy $p_{B,1} < p_{B,2}$ and so the seller chooses an average price to maximize the second line of (24). We can immediately rule out the platform choosing $\overline{\tau_S} < \hat{\tau}$ because it could slightly raise $\overline{\tau_S}$, the seller would continue to charge $\overline{p_B} = v + \underline{b}$, and the platform would earn higher profit. Hence, the platform sets $\overline{\tau_S} \geq \hat{\tau}$ and consequently, from earlier work, the seller sets an average price $\overline{p_B}$ which satisfies $I(\overline{p_B} - v) = v - c - \overline{\tau_S}$. Since the platform's profit is $2\overline{\tau_S}[1 - F(\overline{p_B} - v)]$, the derivative of its profit with respect to $\overline{\tau_S}$ is proportional to

$$\frac{1 - F(\overline{p_B} - v)}{f(\overline{p_B} - v)} + \frac{\overline{\tau_S}}{I'(\overline{p_B} - v)} = \frac{1}{I'(b^{ND})} \left[I'(b^{ND}) \frac{1 - F(b^{ND})}{f(b^{ND})} + v - c - I(b^{ND}) \right],$$

where in the second expression we have substituted in for $\overline{\tau_S}$ from the seller's first order condition $I(\overline{p_B} - v) = v - c - \overline{\tau_S}$, and substituted in $b^{ND} = \overline{p_B} - v$. Notice that the left-hand side is strictly decreasing in $\overline{\tau_S} \geq 0$ given our regularity condition $I''(b) \geq 0$, and hence platform profit is quasiconcave in $\overline{\tau_S}$. Notice also that the square-bracketed term on the right-hand side is strictly increasing in b^{ND} for the same reason. Therefore, following the usual logic, if the square-bracketed term is weakly positive when evaluated at $\underline{b}$ then the platform chooses $b^{ND} = \underline{b}$, and otherwise it chooses the unique b^{ND} which sets the square-bracketed term to zero. The claimed threshold, fees and prices described at the start of this part of the proof then follow. This generates platform profit $2[v - c - I(b^{ND})][1 - F(b^{ND})]$.

Now suppose that disintermediation is possible. First write out the seller's profit:

$$\begin{cases} (p_{B,1} - c - \tau_{S,1})[1 - F(p_{B,1} + c - 2v)] + (p_{B,2} - c - \tau_{S,2})[1 - F(p_{B,2} - c)] & \text{if } p_{B,1} \leq p_{B,2} + 2(v - c), \\ (p_{B,1} + p_{B,2} - 2c - \tau_{S,1} - \tau_{S,2}) \left[1 - F\left(\frac{p_{B,1} + p_{B,2}}{2} - v\right)\right] & \text{otherwise.} \end{cases} \tag{25}$$

Since $I'(b) < 0$ due to $1 - F$ being log-concave, $p_{B,i}$ is strictly increasing in $\tau_{S,i}$.

We begin by proving that the platform earns the same profit as it did when disintermediation was impossible, provided it chooses fees

$$\tilde{\tau}_{S,1} = 2(v-c) - I(b^{ND}) \quad \text{and} \quad \tilde{\tau}_{S,2} = -I(b^{ND}).$$

Notice that $(\tilde{\tau}_{S,1} + \tilde{\tau}_{S,2})/2$ equals the average fee chosen by the platform absent disintermediation. Consider the seller's pricing decision. Consider the first line of (25), and note that if we temporarily ignore the constraint $p_{B,1} \leq p_{B,2} + 2(v-c)$ on prices, the derivatives of seller profit with respect to $p_{B,1}$ and $p_{B,2}$ are, respectively

$$I(p_{B,1} + c - 2v) - I(b^{ND}) \quad \text{and} \quad I(p_{B,2} - c) - I(b^{ND}).$$

These equal zero if and only if the seller charges prices $\tilde{p}_{B,1} = b^{ND} + 2v - c$ and $\tilde{p}_{B,2} = b^{ND} + c$. These prices satisfy the pricing constraint, and moreover they ensure that buyers with $b < b^{ND}$ do no transaction, and buyers with $b \geq b^{ND}$ still do both transactions on the platform. Hence platform profit is exactly the same as before. (One can also verify the if the seller chooses prices to maximize the second line of (25), the same outcome arises.)

Finally, we prove that disintermediation enables the platform to earn strictly higher profit than before, provided that $1 - \underline{b}f(\underline{b}) > I'(\underline{b})$. Suppose the platform charges $\tau_{S,1} = \tilde{\tau}_{S,1}$ but slightly increases $\tau_{S,2}$ above $\tilde{\tau}_{S,2}$. The pricing constraint in the first line of (25) is satisfied strictly, from the seller's first order condition we have $I(p_{B,2} - c) = -\tau_{S,2}$, and platform profit equals

$$\tau_{S,1}[1 - F(p_{B,1} + c - 2v)] + \tau_{S,2}[1 - F(p_{B,2} - c)]. \tag{26}$$

The derivative of the platform's profit with respect to $\tau_{S,2}$ around $\tau_{S,2} = \tilde{\tau}_{S,2}$ is therefore proportional to

$$\frac{1 - F(b^{ND})}{f(b^{ND})} - \frac{I(b^{ND})}{I'(b^{ND})}.$$

One can check that if $b^{ND} = \underline{b}$ this is strictly positive since by assumption $1 - \underline{b}f(\underline{b}) > I'(\underline{b})$. One can check that it is also strictly positive if $b^{ND} > \underline{b}$, because in that case $\frac{1-F(b^{ND})}{f(b^{ND})} = -\frac{v-c-I(b^{ND})}{I'(b^{ND})}$. But this means that starting from $\tilde{\tau}_{S,2}$ and $\tilde{\tau}_{S,2}$, where the platform makes the same profit as it did absent disintermediation, it can do even better—and so earn strictly more than when disintermediation was impossible—by slightly raising $\tau_{S,2}$. □

B.2 Seller Benefits

We first derive a seller's participation constraints, which are the analogue of the buyers' participation constraints (1) to (5) from the baseline analysis. A "one-time seller" completes her first (and only) transaction provided

$$p_{S,1} \geq c - r. \tag{27}$$

When disintermediation is impossible, a "two-time seller" does the first transaction if and only if

$$p_{S,1} - (c - r) + \max\{p_{S,2} - (c - r), 0\} \geq 0, \tag{28}$$

and then conditional on doing the first transaction, does the second one if and only if

$$p_{S,2} \geq c - r. \tag{29}$$

When disintermediation is possible, she does the first transaction if and only if

$$p_{S,1} - (c - r) + \max\{p_{S,2} - (c - r), v - c\} \geq 0, \tag{30}$$

because this gives her the option to then either do the second transaction on the platform and get $p_{S,2} - (c - r)$, or do it off the platform and forego the platform benefit r but charge the buyer v and hence get $v - c$. Conditional on doing the first transaction, the seller therefore does the second transaction on the platform if and only if

$$p_{S,2} \geq v - r, \tag{31}$$

and otherwise does it off the platform. Using the above we can prove Proposition 8.

Proof of Proposition 8. Consider part (i). Notice that it is efficient for both transactions to occur on the platform, and that this generates total surplus of $2(v + r - c)$ (which is therefore the maximum possible profit the platform can achieve). Notice also that $p_{S,1} = 2c - r - v$ and $p_{S,2} = v - r$ satisfy (28) and (29), as well as (30) and (31), and hence induce the seller to do both transactions on the platform, and generate platform profit $2(v + r - c)$, irrespective of whether disintermediation is possible.

Now consider part (ii). First, suppose disintermediation is impossible. It is easy to see that by charging $p_{S,1} = p_{S,2} = c - r$ the platform hosts all $(2 - \phi)$ transactions, and extracts the maximum possible surplus $v + r - c$ on each one, giving a total platform profit of $(2 - \phi)(v + r - c)$. Since this is the maximal total surplus, the platform cannot do better. Next, suppose disintermediation is possible. Adapting the proof of Lemma 1, the optimum must have $p_{S,2} \geq v-r$ such that the platform hosts all second transactions. We can then proceed as in the proof of Proposition 2. (a) If $p_{S,1} < 2(c-r)-p_{S,2}$ no seller participates, and the platform earns zero profit. (b) If $2(c-r)-p_{S,2} \leq p_{S,1} < c-r$ then only sellers interested in transacting twice participate. Platform profit is then $(1-\phi)(2v-p_{S,1}-p_{s,2})$ which is maximized at $p_{S,1} = 2(c-r)-p_{S,2}$, for a total profit of $2(1-\phi)(v+r-c)$. (c) If $p_{S,1} \geq c-r$ then all sellers participate. Platform profit is then $v-p_{S,1}+(1-\phi)(v-p_{S,2})$ which is maximized at $p_{S,1} = c-r$ and $p_{S,2} = v-r$, for a total profit of $v+r-c+(1-\phi)r$. In all cases profit is strictly lower than $(2-\phi)(v+r-c)$.

Now consider part (iii). Using (28) and (29), platform profit when disintermediation is impossible is

$$\pi^{ND} = \begin{cases} (v-p_{S,1})[1-G(c-p_{S,1})] + (v-p_{S,2})[1-G(c-p_{S,2})] & \text{if } p_{S,1} \geq p_{S,2}, \\ (2v-p_{S,1}-p_{S,2})\left[1-G\left(c-\frac{p_{S,1}+p_{S,2}}{2}\right)\right] & \text{otherwise.} \end{cases}$$

Using (30) and (31), platform profit when disintermediation is possible is

$$\pi^{D} = \begin{cases} (v-p_{S,1})[1-G(2c-v-p_{S,1})] + (v-p_{S,2})[1-G(v-p_{S,2})] & \text{if } p_{S,1}+2(v-c) \geq p_{S,2}, \\ (2v-p_{S,1}-p_{S,2})\left[1-G\left(c-\frac{p_{S,1}+p_{S,2}}{2}\right)\right] & \text{otherwise.} \end{cases}$$

Using a change of variables $q_i = v+c-p_{S,i}$ for $i = 1,2$ we can rewrite these as

$$\pi^{ND} = \begin{cases} (q_1-c)[1-G(q_1-v)] + (q_2-c)[1-G(q_2-v)] & \text{if } q_1 \leq q_2, \\ (q_1+q_2-2c)\left[1-G\left(\frac{q_1+q_2}{2}-v\right)\right] & \text{otherwise.} \end{cases}$$

$$\pi^{D} = \begin{cases} (q_1-c)[1-G(q_1+c-2v)] + (q_2-c)[1-G(q_2-c)] & \text{if } q_1 \leq q_2+2(v-c), \\ (q_1+q_2-2c)\left[1-G\left(\frac{q_1+q_2}{2}-v\right)\right] & \text{otherwise.} \end{cases}$$

However, notice that if we replace q_i with $p_{B,i}$ for $i = 1,2$, and replace G with F, the last expressions for π^{ND} and π^{D} coincide with equations (8) and (11) from the baseline model. Hence the maximized profit earned by the platform with and without disintermediation is the same in this extension as in the baseline model; the profit comparison in the proposition then follows. □

B.3 General Number of Transactions

We first derive the optimal behavior of a buyer who wishes to transact n times in total. When disintermediation is impossible, let $V^{ND}(k)$ be the buyer's payoff from transacting

k times on the platform. Note that $V^{ND}(0) = 0$ and $V^{ND}(k) = \sum_{j=1}^{k}(v + b - p_{B,j})$ for $1 \leq k \leq n$. When disintermediation is possible, let $V^D(k)$ be the buyer's payoff from transacting k times on the platform and $n - k$ times off the platform. Note that $V^D(0) = n(v - c)$ and $V^D(k) = \sum_{j=1}^{k}(v + b - p_{B,j}) + (n - k)(v - c)$ for $1 \leq k \leq n$. Given our tie-break rule, the buyer chooses the largest $k \in \{0, 1, \ldots, n\}$ that maximizes $V^{ND}(k)$ or $V^D(k)$, depending on whether disintermediation is possible.

Proof of Proposition 9. Consider part (i). Let n be the (common) number of times that buyers wish to transact, and b be the (common) platform benefit. Notice that it is efficient for all n transactions to occur on the platform, and that this generates total surplus of $n(v+b-c)$ (which is therefore the maximum possible profit the platform can achieve). Notice also that prices $p_{B,1} = v+b+(n-1)(v-c)$ and $p_{B,2} = \cdots = p_{B,n} = b+c$ induce buyers to do all n transactions on the platform, and generate profit of $n(v+b-c)$, irrespective of whether disintermediation is possible.

Now consider part (ii). Let b be buyers' (common) platform benefit. First, suppose disintermediation is impossible. It is easy to see that by charging $p_{B,1} = \cdots = p_{B,N} = v + b$ a buyer who wishes to do $n = 1, \ldots, N$ total transactions does all n of them on the platform, and so the platform earns $\sum_{j=1}^{N}(\phi_j j)(v + b - c)$. Since this is the maximal total surplus, the platform cannot do better. Next, suppose disintermediation is possible. We argue that platform profit is strictly below $\sum_{j=1}^{N}(\phi_j j)(v + b - c)$. On the way to a contradiction, suppose the platform can earn $\sum_{j=1}^{N}(\phi_j j)(v + b - c)$. Since buyers have heterogeneous n, there must exist j' and $j'' > j'$ such that $\phi_{j'} > 0$ and $\phi_{j''} > 0$. Moreover buyers with $n = j'$ and $n = j''$ must do all their transactions on the platform, and in addition they must be fully extracted. The latter requires that

$$\sum_{i=1}^{j'} p_{B,i} = j'(v + b) \quad \text{and} \quad \sum_{i=1}^{j''} p_{B,i} = j''(v + b).$$

However, in that case a buyer with $n = j''$ will not do all j'' transactions on the platform: $V^D(j'') = 0 < (j''-j')(v-c) = V^D(j')$. This yields a contradiction, and hence platform profit is strictly less than $\sum_{j=1}^{N}(\phi_j j)(v + b - c)$.

Now consider part (iii). Let n be the (common) number of desired transactions.

First, suppose disintermediation is impossible. Notice that for given $(p_{B,1}, \ldots, p_{B,n})$, if a buyer with benefit b prefers to do j'' transactions rather than $j' < j''$ transactions, so do all buyers with benefit above b. Hence buyers follow a threshold rule. Introduce thresholds $b_1^{ND} \leq b_2^{ND} \leq \cdots \leq b_n^{ND}$ satisfying $b_1^{ND} \geq \underline{b}$ and $b_n^{ND} \leq \bar{b}$, such that a buyer transacts zero times if $b < b_1^{ND}$, transacts $k = 1, \ldots, n-1$ times if $b \in [b_k^{ND}, b_{k+1}^{ND})$, and transacts n times if $b \geq b_n^{ND}$. We claim that if $b_1^{ND} = \cdots = b_n^{ND} = \tilde{b}$ then prices satisfy

$$\sum_{i=1}^{n} p_{B,i} = n(v + \tilde{b}), \quad \text{and} \quad \sum_{i=j+1}^{n} p_{B,i} \leq (n-j)(v + \tilde{b}) \text{ for all } j = 1, \ldots, n-1. \tag{32}$$

The equality in (32) says that the marginal buyer type $\tilde{b}$ is fully extracted across the n transactions: we must have $\sum_{i=1}^{n} p_{B,i} \leq n(v + \tilde{b})$, otherwise a buyer with $b = \tilde{b}$ will not do all n transactions, but if the inequality is strict then either $\tilde{b} = \underline{b}$ and the platform could do better by raising some prices and still host all buyers, or $\tilde{b} > \underline{b}$ and types slightly below $\tilde{b}$ would also wish to do the n transactions which contradicts $\tilde{b}$ being the marginal type. The inequality in (32) says that having completed $j = 1, \ldots, n-1$ transactions, it is worthwhile for all buyers weakly above $\tilde{b}$ to do the remaining $n - j$ transactions. Hence if $b_1^{ND} = \cdots = b_n^{ND} = \tilde{b}$ platform profit equals

$$\left[\sum_{i=1}^{n} (p_{B,i} - c)\right] [1 - F(\tilde{b})] = \left(\sum_{i=1}^{n} p_{B,i} - nc\right) \left[1 - F\left(\frac{\sum_{i=1}^{n} p_{B,i}}{n} - v\right)\right],$$

and using the same approach as in the proof of Lemma 2, its maximized value is $n(v + b^{ND} - c)[1 - F(b^{ND})]$ where b^{ND} is the same as the one defined in Lemma 2. Next, we claim that the platform optimum must have $b_1^{ND} = \cdots = b_n^{ND}$. On the way to a contradiction, suppose not all the thresholds are identical. Then, we can partition them into $m \geq 2$ sets, $(\mathcal{B}_1, \ldots, \mathcal{B}_m)$, where all $i \in \mathcal{B}_j$ have the same threshold, but different partitions are associated with different thresholds. Using the same argument as above, in partition $\mathcal{B}_j$ we must have $\sum_{i \in \mathcal{B}_j} p_{B,i} = |\mathcal{B}_j|(v + b_{i \in \mathcal{B}_j})$ where $|\mathcal{B}_j|$ is the cardinality of that partition and $b_{i \in \mathcal{B}_j}$ is the value of the threshold in that partition. (Also, if the partition is not a singleton, prices associated with the thresholds in the partition must satisfy an inequality like the one in (32).) Hence we can write platform profit as

$$\sum_{j=1}^{m} \left[\sum_{i \in \mathcal{B}_j} (p_{B,i} - c)[1 - F(b_{i \in \mathcal{B}_j})]\right] = \sum_{j=1}^{m} |\mathcal{B}_j| \left[\left(\frac{\sum_{i \in \mathcal{B}_j} p_{B,i}}{|\mathcal{B}_j|} - c\right) \left[1 - F\left(\frac{\sum_{i \in \mathcal{B}_j} p_{B,i}}{|\mathcal{B}_j|} - v\right)\right]\right].$$

However, notice that each term in the (outer) summation takes the same form, namely $(X - c)[1 - F(X - v)]$. Hence the expression for platform profit is maximized when $\sum_{i \in \mathcal{B}_j} p_{B,i}/|\mathcal{B}_j|$ is the same for each j. But this means that $b_{i \in \mathcal{B}_j}$ is the same for each j, which is a contradiction. Hence the optimum must have $b_1^{ND} = \cdots = b_n^{ND}$.

Summing up, when disintermediation is impossible, the platform earns $n(v+b^{ND}-c)[1-F(b^{ND})]$ where b^{ND} is the same as the one defined in Lemma 2.

Next, suppose disintermediation is possible. To show that the platform earns (weakly) higher profit than above, it is sufficient to allow for two prices: $p_{B,1}$ for the first transaction and, abusing notation, the same $p_{B,>1}$ for each subsequent transaction. If $p_{B,1} \leq p_{B,>1} + n(v-c)$ then one can check that platform profit equals

$$(p_{B,1}-c)[1-F(p_{B,1}-nv+(n-1)c)] + (n-1)(p_{B,>1}-c)[1-F(p_{B,>1}-c)]. \quad (33)$$

Hence, if the platform charges $p_{B,1} = b^{ND} + nv - (n-1)c$ and $p_{B,>1} = b^{ND} + c$ it earns $n(v+b^{ND}-c)[1-F(b^{ND})]$, which is the same profit as it earned absent disintermediation. Hence the platform is not harmed by disintermediation. Moreover, the derivative of the above profit expression with respect to $p_{B,>1}$, evaluated at $p_{B,>1} = b^{ND} + c$, is $n-1$ multiplied by

$$1 - F(b^{ND}) - b^{ND} f(b^{ND}). \quad (34)$$

We claim this is strictly positive if $\underline{b} f(\underline{b}) < 1$. The claim is immediate if $b^{ND} = \underline{b}$. If instead $b^{ND} > \underline{b}$ then, using equation (10), the expression simplifies to $f(b^{ND})(v-c) > 0$. Hence, starting from prices $p_{B,1} = b^{ND} + nv - (n-1)c$ and $p_{B,>1} = b^{ND} + c$, if $\underline{b} f(\underline{b}) < 1$ the platform can earn strictly higher profit by raising $p_{B,>1}$. □

B.4 Bargaining Between Buyers and Sellers

We first derive buyer and seller participation decisions, starting with the buyers.

A one-time buyer completes her first (and only) transaction if and only if (1) holds. Now turn to a two-time buyer. Begin by considering the *second* transaction. If the buyer has the bargaining power, she can: propose no transaction, and obtain a zero payoff; propose to transact on the platform, drive the seller to her outside option by offering her $c + p_{S,2}$, and hence obtain $v + b - c - (p_{B,2} + p_{S,2})$; when disintermediation is possible, propose to transact off the platform, drive the seller to her outside option by offering her c, and hence obtain $v - c$. If the buyer does not have the bargaining power, the seller fully extracts her so she gets zero payoff on the second transaction, irrespective of whether disintermediation is possible. Therefore, when disintermediation is *not* possible, the buyer is willing to do the first transaction if and only if

$$U_B^{ND}(b) \equiv v + b - p_{B,1} + \alpha \max\{v + b - c - (p_{B,2} + p_{S,2}), 0\} \geq 0. \quad (35)$$

Conditional on the first transaction occurring, the second transaction occurs when the buyer has the bargaining power if and only if

$$p_{B,2} + p_{S,2} \leq v + b - c. \tag{36}$$

When disintermediation *is* possible, the buyer is willing to do the first transaction if and only if

$$U_B^D(b) \equiv v + b - p_{B,1} + \alpha \max\{v + b - c - (p_{B,2} + p_{S,2}), v - c\} \geq 0. \tag{37}$$

Conditional on the first transaction occurring, the second transaction occurs on the platform when the buyer has the bargaining power if

$$p_{B,2} + p_{S,2} \leq b, \tag{38}$$

and otherwise occurs off the platform.

Now consider the seller's participation decision. Recall that at the time of the first transaction the seller does not know whether the buyer is a one- or two-time buyer, nor does she know the buyer's b. Again begin by considering the second transaction (for a seller dealing with a two-time buyer). If the seller has the bargaining power, she can: propose no transaction, and obtain a zero payoff; propose to transact on the platform, drive the buyer to her outside option by charging her a price of $v + b - p_{B,2}$, and hence obtain $v+b-c-(p_{B,2}+p_{S,2})$; when disintermediation is possible, propose to transact off the platform, drive the buyer to her outside option by charging her v, and hence obtain $v - c$. If the seller does not have the bargaining power, the buyer fully extracts her so she gets zero payoff on the second transaction irrespective of whether disintermediation is possible. Therefore, when disintermediation is *not* possible, the seller is willing to do the first transaction if and only if

$$-p_{S,1} - c + (1 - \alpha)\mathbb{E}_b \left[\Pr(TT) \max\{v + b - c - (p_{B,2} + p_{S,2}), 0\}\right] \geq 0, \tag{39}$$

where $\Pr(TT)$ is the conditional probability (given platform prices) that a buyer who does the first transaction is a two-time buyer. (If no buyer does the first transaction, this seller constraint is moot so we can set $\Pr(TT) = 0$ without loss.) Conditional on the first transaction occurring, the second transaction occurs when the seller has the bargaining power if and only if (36) holds. When disintermediation *is* possible, the seller is willing to do the first transaction if and only if

$$-p_{S,1} - c + (1 - \alpha)\mathbb{E}_b \left[\Pr(TT) \max\{v + b - c - (p_{B,2} + p_{S,2}), v - c\}\right] \geq 0, \tag{40}$$

where again where $\Pr(TT)$ is the conditional probability of the seller encountering a two-time buyer. Conditional on the first transaction occurring, the second transaction occurs on the platform when the seller has the bargaining power if (38) holds, and otherwise occurs off the platform. We can now prove Proposition 10.

Proof of Proposition 10. Consider part (i). Notice that it is efficient for both transactions to occur on the platform, and that this generates total surplus of $2(v+b-c)$. Notice also that $p_{B,1} = v+b+\alpha(v-c)$, $p_{S,1} = (1-\alpha)v-(2-\alpha)c$, and $p_{B,2}+p_{S,2} = b$ satisfy (35) to (40), and hence induce the buyer and seller to do both transactions on the platform, and moreover generate platform profit $2(v+b-c)$, irrespective of whether disintermediation is possible.[24]

Now consider part (ii). It is socially efficient for all transactions to occur on the platform, leading to total surplus of $(2-\phi)(v+b-c)$. First, suppose disintermediation is impossible. It is easy to check that $p_{B,1} = v+b$, $p_{S,1} = -c$, and $p_{B,2}+p_{S,2} = v+b-c$ satisfy (1), (35), (36), and (39). Hence these prices induce the buyer and seller to do all transactions on the platform, and moreover they enable the platform to extract the maximal possible surplus $(2-\phi)(v+b-c)$. Next, suppose disintermediation is possible. Using the same argument as in Lemma 1, the optimum must have $p_{B,2}+p_{S,2} \leq b$: if not, (38) would be violated, so the platform would make zero profit from second transactions, whereas if it deviated and set $p_{B,2}+p_{S,2}$ equal to b the first-transaction participation constraints (37) and (40) would be unchanged, but the platform would host (and hence profit from) second transactions. We now derive platform profit for different values of $p_{B,1}$ and $p_{S,1}$. First, if $p_{B,1} > v+b+\alpha[v+b-c-(p_{B,2}+p_{S,2})]$ then no buyer does the first transaction and the platform therefore earns zero profit. Second, if $v+b < p_{B,1} \leq v+b+\alpha[v+b-c-(p_{B,2}+p_{S,2})]$ then two-time but not one-time buyers do the first transaction. If the platform does not satisfy the seller's participation constraint (40) it earns zero profit. Otherwise it seeks to

$$\begin{aligned}
&\max_{\{p_{B,1},p_{B,2},p_{S,1},p_{S,2}\}} (1-\phi)(p_{B,1}+p_{B,2}+p_{S,1}+p_{S,2}) \\
\text{s.t.}\quad &\text{(i)}\quad p_{S,1} \leq -c+(1-\alpha)[v+b-c-(p_{B,2}+p_{S,2})] \\
&\text{(ii)}\quad p_{B,2}+p_{S,2} \leq b \\
&\text{(iii)}\quad p_{B,1} \leq v+b+\alpha[v+b-c-(p_{B,2}+p_{S,2})].
\end{aligned}$$

[24]Note that if v and c are such that $p_{S,1} < 0$, the platform pays the seller to do the first transaction.

However, adding constraints (i) and (iii) together gives $p_{B,1} + p_{B,2} + p_{S,1} + p_{S,2} \leq 2(v+b-c)$ and so given any $p_{B,2}$ and $p_{S,2}$ that satisfy (ii), the platform sets $p_{S,1}$ and $p_{B,1}$ as high as possible to make (i) and (iii) bind, and consequently earns $2(1-\phi)(v+b-c)$. Third, if $p_{B,1} \leq v+b$ then all buyers do the first transaction. If the platform does not satisfy the seller's participation constraint (40) it again earns zero profit. Otherwise it seeks to

$$\begin{aligned} &\max_{\{p_{B,1}, p_{B,2}, p_{S,1}, p_{S,2}\}} p_{B,1} + p_{S,1} + (1-\phi)(p_{B,2} + p_{S,2}) \\ \text{s.t.} \quad &\text{(i)} \quad p_{S,1} \leq -c + (1-\alpha)(1-\phi)[v + b - c - (p_{B,2} + p_{S,2})] \\ &\text{(ii)} \quad p_{B,2} + p_{S,2} \leq b \\ &\text{(iii)} \quad p_{B,1} \leq v + b. \end{aligned}$$

Given any choice of $p_{B,2} + p_{S,2}$ constraints (i) and (iii) must bind for profit to be maximized; making them bind and substituting them, the platform's problem becomes

$$\max_{\{p_{B,2}, p_{S,2}\}} (v+b-c)[1 + (1-\alpha)(1-\phi)] + \alpha(1-\phi)(p_{B,2} + p_{S,2}) \quad \text{s.t.} \quad p_{B,2} + p_{S,2} \leq b.$$

Hence the platform sets $p_{B,2} + p_{S,2} = b$, for a total profit of $(2-\phi)(v+b-c) - \alpha(1-\phi)(v-c)$. Summing up, when disintermediation is possible platform profit is

$$\max\{2(1-\phi)(v+b-c), (2-\phi)(v+b-c) - \alpha(1-\phi)(v-c)\}$$

which is strictly less than the profit $(2-\phi)(v+b-c)$ earned when disintermediation is impossible, except at $\alpha = 0$ where the two are equal.

Now consider part (iii).

First, suppose disintermediation is impossible. Notice that given prices $p_{B,1}$ and $p_{B,2}$ buyers follow a threshold strategy. Therefore define thresholds b_1^{ND} and b_2^{ND} satisfying $b_1^{ND} \leq b_2^{ND}$ such that buyers do the first transaction if and only if $b \geq b_1^{ND}$ and do the second transaction if and only if $b \geq b_2^{ND}$. Then, assuming $b_1^{ND} < \bar{b}$, the seller's participation constraint (39) becomes

$$p_{S,1} \leq -c + (1-\alpha) \frac{\int_{b_2^{ND}}^{\bar{b}} [v + b - c - (p_{B,2} + p_{S,2})] dF(b)}{1 - F(b_1^{ND})}, \tag{41}$$

and conditional on this holding, platform profit is

$$(p_{B,1} + p_{S,1})[1 - F(b_1^{ND})] + (p_{B,2} + p_{S,2})[1 - F(b_2^{ND})]. \tag{42}$$

Since profit is increasing in $p_{S,1}$, the platform should make the seller's participation constraint bind by setting $p_{S,1}$ as high as possible. Hence platform profit equals

$$(p_{B,1}-c)[1-F(b_1^{ND})]+\int_{b_2^{ND}}^{\bar{b}}(1-\alpha)[v+b-c]dF(b)+\alpha(p_{B,2}+p_{S,2})[1-F(b_2^{ND})]. \quad (43)$$

There are then two subcases to consider. (a) Consider $p_{B,1}\leq p_{B,2}+p_{S,2}+c$. It is easy to see from (35) and (36) that $b_1^{ND}=p_{B,1}-v$ and $b_2^{ND}=p_{B,2}+p_{S,2}+c-v$. Hence we can rewrite platform profit as

$$\begin{aligned}&(p_{B,1}-c)[1-F(p_{B,1}-v)]+(1-\alpha)\int_{p_{B,2}+p_{S,2}+c-v}^{\bar{b}}[v+b-c]dF(b)\\&+\alpha(p_{B,2}+p_{S,2})[1-F(p_{B,2}+p_{S,2}+c-v)]. \quad (44)\end{aligned}$$

One can check that, if we ignore the constraint $p_{B,1}\leq p_{B,2}+p_{S,2}+c$, the above expression is quasiconcave in $p_{B,1}$ and in $p_{B,2}+p_{S,2}$ given the log-concavity of $1-F$, and that its derivative with respect to $p_{B,1}$ is weakly larger than its derivative with respect to $p_{B,2}+p_{S,2}$ when evaluated at $p_{B,1}=p_{B,2}+p_{S,2}+c$. However, this implies that the constraint must bind (and so $b_1^{ND}=b_2^{ND}$). Hence, substituting in $p_{B,1}=p_{B,2}+p_{S,2}+c$, we can write platform profit as

$$(1+\alpha)(p_{B,1}-c)[1-F(p_{B,1}-v)]+(1-\alpha)\int_{p_{B,1}-v}^{\bar{b}}[v+b-c]dF(b). \quad (45)$$

(b) Consider $p_{B,1}>p_{B,2}+p_{S,2}+c$. It is easy to see from (35) and (36) that $b_1^{ND}=b_2^{ND}=\frac{p_{B,1}+\alpha[p_{B,2}+p_{S,2}+c]}{1+\alpha}-v$. Hence we can rewrite platform profit as

$$\begin{aligned}&(1+\alpha)\left(\frac{p_{B,1}+\alpha[p_{B,2}+p_{S,2}+c]}{1+\alpha}-c\right)\left[1-F\left(\frac{p_{B,1}+\alpha[p_{B,2}+p_{S,2}+c]}{1+\alpha}-v\right)\right]\\&+(1-\alpha)\int_{\frac{p_{B,1}+\alpha[p_{B,2}+p_{S,2}+c]}{1+\alpha}-v}^{\bar{b}}[v+b-c]dF(b). \quad (46)\end{aligned}$$

However, notice that (45) and (46) take the same form. Hence, following the same approach as in the proof of Lemma 2, there is a continuum of optimal prices which lead to profit

$$(1+\alpha)(v+b^{ND}-c)[1-F(b^{ND})]+(1-\alpha)\int_{b^{ND}}^{\bar{b}}[v+b-c]dF(b), \quad (47)$$

where $b_1^{ND}=b_2^{ND}=b^{ND}$, and where $b^{ND}=\underline{b}$ if $1+\alpha-2f(\underline{b})(v+\underline{b}-c)\leq 0$ and otherwise b^{ND} is the unique solution to $[1-F(b^{ND})](1+\alpha)-2(v+b^{ND}-c)f(b^{ND})=0$.

Next, suppose disintermediation is possible. Again note that buyers follow a threshold strategy, and define b_1^D and b_2^D satisfying $b_1^D \leq b_2^D$ such that buyers do the first transaction if and only if $b \geq b_1^D$ and do the second transaction on the platform if and only if $b \geq b_2^D$. Then, assuming that $b_1^D < \bar{b}$, the seller's participation constraint (40) becomes

$$p_{S,1} \leq -c + (1-\alpha)\frac{(v-c)[F(b_2^D) - F(b_1^D)] + \int_{b_2^D}^{\bar{b}}[v+b-c-(p_{B,2}+p_{S,2})]dF(b)}{1-F(b_1^D)}. \quad (48)$$

Conditional on this holding, platform profit is still given by (42) after replacing b_1^{ND} and b_2^{ND} with b_1^D and b_2^D respectively. Since this is increasing in $p_{S,1}$ the platform should make the seller's participation constraint bind, which leads to platform profit

$$\begin{aligned}&(p_{B,1}-c)[1-F(b_1^D)] + (1-\alpha)(v-c)[F(b_2^D) - F(b_1^D)] \\ &+ \int_{b_2^D}^{\bar{b}}(1-\alpha)[v+b-c]dF(b) + \alpha(p_{B,2}+p_{S,2})[1-F(b_2^D)]. \quad (49)\end{aligned}$$

There are again two subcases to consider. (a) Consider $p_{B,1} > p_{B,2}+p_{S,2}+v+\alpha(v-c)$. It is easy to see from (37) and (38) that $b_1^D = b_2^D$ and that profit is exactly the same as (46). (b) Consider $p_{B,1} \leq p_{B,2}+p_{S,2}+v+\alpha(v-c)$. It is easy to see from (37) and (38) that $b_1^D = p_{B,1} - v - \alpha(v-c)$ and $b_2^D = p_{B,2}+p_{S,2}$ and hence platform profit is

$$\begin{aligned}&(p_{B,1}-c)[1-F(p_{B,1}-v-\alpha(v-c))] + (1-\alpha)(v-c)[F(p_{B,2}+p_{S,2}) - F(p_{B,1}-v-\alpha(v-c))] \\ &+ \int_{p_{B,2}+p_{S,2}}^{\bar{b}}(1-\alpha)[v+b-c]dF(b) + \alpha(p_{B,2}+p_{S,2})[1-F(p_{B,2}+p_{S,2})]. \quad (50)\end{aligned}$$

Notice that if the platform sets $p_{B,1} = v + b^{ND} + \alpha(v-c)$ and $p_{B,2}+p_{S,2} = b^{ND}$ it makes the pricing constraint just bind (i.e., $p_{B,1} = p_{B,2}+p_{S,2}+v+\alpha(v-c)$) and it earns the same profit (47) as it did when disintermedition was impossible. One can also check that, starting from these prices, the derivative of profit with respect to $p_{B,2}+p_{S,2}$ is $\alpha[1-F(b^{ND})] - b^{ND}f(b^{ND})$. If $\underline{b}f(\underline{b}) \geq 1$ this is negative for all α and all $b^{ND} \geq \underline{b}$ given log-concavity of $1-F$. If $\underline{b}f(\underline{b}) < 1$ and $\alpha = 1$, the derivative is strictly positive: for $b^{ND} = \underline{b}$ this is immediate, and for $b^{ND} > \underline{b}$ this follows from the equation which determines b^{ND}. By continuity, if $\underline{b}f(\underline{b}) < 1$ and α is above a threshold, the derivative remains strictly positive. (The threshold must be strictly positive, since the derivative is weakly negative at $\alpha = 0$.) But then the platform does strictly better than when disintermediation is impossible. □