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Deceptive Features on Platforms

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Deceptive Features on Platforms

Abstract

Many products sold on online platforms have additional features. Platforms can deliberately shroud these features from consumers, e.g. by revealing them only late in the purchase process. For example, platforms often reveal shipping- and handling fees, or upgrades like luggage or hotel services only late in the purchase process. We study when a two-sided platform discloses (a.k.a unshrouds) additional fees when some buyers naively ignore shrouded fees. We uncover a novel mechanism to explain why platforms shroud: platforms shroud or unshroud to manipulate cross-group externalities between buyers and sellers. Exploring this mechanism, we highlight two results suggesting online marketplaces lead to more shrouded features. First, we ask when a platform shrouds seller fees on its marketplace. Driven by cross-group network externalities to attract buyers and appear cheap, the platform has stronger incentives to shroud seller fees than sellers themselves. Second, we investigate when the platform shrouds its own additional fees and uncover a perverse effect of seller competition: fiercer competition between sellers encourages the platform to shroud its own fees. Both results hold even though the platform earns no commission to shroud seller fees and does not sell its own brands, so banning these practices will not induce a transparent marketplace. We discuss further policy implications and connect to common practices like drip pricing, steering, and rebate design.

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Deceptive Features on Platforms[*]

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Abstract

Many products sold on online platforms have additional features like fees for shipping, luggage, upgrades etc. We study when a two-sided platform uses dark patterns to shroud additional features towards potentially-naive buyers. We explore a novel mechanism according to which platforms shroud to manipulate network externalities between buyers and sellers. Exploring this mechanism, we argue the advent of online marketplaces led to less-transparent markets. First, platforms have stronger incentives to shroud seller fees than sellers themselves. Second, when sellers on the platform compete more fiercely, platforms—somewhat perversely—shroud more. We connect these results to the current debate on regulating online platforms.

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1   Introduction

Policymakers have started to more-actively regulate online marketplaces that obfuscate fees. The EU pressured AirBnB to include service fees and cleaning charges of hosts in upfront prices.[1] UK authorities forced the ticket marketplace Viagogo 'to make its exorbitant fees and delivery charges clear'.[2] The US Department of Transport ruled that online travel agents must display total ticket prices more prominently than price components.[3] More generally, the FTC is concerned with what it calls 'dark patterns' on platforms, which includes obfuscated additional fees and features.[4] Despite the growing concerns of regulators worldwide and reports in the popular press,[5] the economic literature has not yet studied the incentives of two-sided platforms to hide additional fees on their marketplaces.[6] In particular, as in some examples above, why do platforms hide fees they do not even earn themselves? Can regulators rely on platforms to design a transparent marketplace, and if not, how should regulators intervene?

In Section 2, we introduce our baseline model. We build on the framework by Armstrong (2006) and assume positive cross-group externalities between buyers and sellers on the platform: buyers benefit from more sellers to buy products from and vice versa. The profit-maximizing platform can charge membership fees to buyers and sellers who join the marketplace. But in line with our applications, we focus on settings where the platform gives free access to buyers.

We enrich the standard setting and explicitly model the buyer-seller interaction on the platform based on Gabaix and Laibson (2006). In each product category on the platform, sellers charge a base price f and a potentially-shrouded additional fee $a \leq \overline{a}$. There are naive and sophisticated buyers. When naive buyers chose a product, they wrongly ignore shrouded additional fees and end up paying more than they anticipated. Sophisticated buyers take shrouded fees into account and

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[1] See https://www.euronews.com/2018/09/20/airbnb-complies-with-eu-consumer-regulation-demands. Accessed 6 December 2019.

[2] Source: https://www.theguardian.com/money/2018/aug/01/viagogo-ticket-prices-fees-delivery-costs. Accessed 6 December 2019. Also, the OFT (2012) worries about intransparent payment surcharges of online retailers, and the UKRN (2016) worries about unanticipated additional fees of sellers on price-comparison websites

[3] See https://www.transportation.gov/individuals/aviation-consumer-protection/buying-ticket. Accessed 6 December 2019.

[4] See https://www.ftc.gov/news-events/events/2021/04/bringing-dark-patterns-light-ftc-workshop, accessed 7 July 2022.

[5] For example, see the report in 'Last Week Tonight' on obfuscated fees of online ticket platforms. Available at https://www.youtube.com/watch?v=-_Y7uqqEFnY&t=545s. Accessed 6 July 2022.

[6] Two recent reports targeted at economic practitioners, i.e. Scott Morton et al. (2019) and De Streel et al. (2018), stress the need to study non-transparent pricing and consumer biases as a source of harm on platform markets.

can avoid them at a cost $e < \bar{a}$. This captures that sophisticated buyers are more suspicious and therefore more inclined to adjust their behavior to respond to shrouding on a platform.

The critical novel feature is that the platform can shroud or unshroud additional fees that sellers charge. Unshrouding reveals additional fees to buyers when they choose a product and turns (some) naive buyers into sophisticated ones, thereby making buyers more sensitive to additional fees. Thus, platforms face a choice between helping sellers shroud their additional fees or unshrouding fees to design a transparent marketplace. For example, flight-comparison websites like Skyscanner, Google Flights, or Kayak could disclose luggage fees, include them in list prices, or prioritize airlines with transparent fees in their search algorithm. Instead, they could shroud additional fees and display them late in the purchase process, a practice known as 'drip pricing'. Drip pricing induces some naive buyers to underestimate fees for luggage or upgrades. More-sophisticated travelers anticipate hefty fees and might reduce their luggage or give up on an upgrade to avoid fees.

In Section 3, we discuss this and other applications. Compelling evidence shows that drip-pricing boosts sales. For example, studying a leading US event-ticket platform, Blake et al. (2021) find that—fixing prices and fees—drip pricing 15% of fees boosts sales, and revenues by 21%. Marketplaces and price-comparison websites (PCWs) widely use drip pricing for express-shipping fees, resort fees, product upgrades or insurance, and the huge effects drip pricing has on demand shows that it is a first-order issue. Other examples for shrouding on platforms include product steering (Ellison and Ellison, 2009, Heidhues et al., 2020), and rebate design (Rodemeier, 2021).

In Section 4, we analyse our baseline model. The novel mechanism underlying our results is that the platform shrouds or unshrouds additional fees of sellers to manipulate cross-group externalities. Shrouding impacts the average perceived buyer surplus per interaction on the platform (henceforth 'buyer surplus'): a larger buyer surplus attracts more buyers to the platform, and due to cross-group externalities, more buyers make the platform more attractive for sellers.

Shrouding seller fees has two opposing effects on buyer surplus. When the platform shrouds, sellers know that buyers cannot observe additional fees when choosing a product and charge large additional fees $\bar{a}$. First, naive buyers ignore shrouded additional fees and wrongly believe products are cheap, increasing perceived buyer surplus. Second, sophisticated buyers anticipate and avoid large shrouded fees, and the avoidance cost e reduces buyer surplus. The platform trades off these effects to increase buyer surplus and attract more buyers, because more buyers—via cross-group

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externalities—increase the willingness of sellers to join the platform. Thus, the platform shrouds seller fees to make products look cheap if and only if there are sufficiently many naive buyers. This mechanism is closely in line with the evidence mentioned above by Blake et al. (2021). We will discuss other examples, like the response of online-travel-agents (OTAs) to hotels' resort fees, that also suggest drip pricing encourages activity on the platform by making products appear cheaper.

To better evaluate the platform's incentive to shroud seller fees, we compare it to a laissez-faire benchmark where sellers can shroud their own additional fees. This leads to our first main insight: even though the platform neither earns the shrouded fees nor commissions for shrouding, it has stronger incentives to shroud seller fees than sellers themselves. Intuitively, under laissez-faire a shrouding equilibrium exists where all sellers shroud to earn large additional fees $\bar{a}$ from naive buyers. But a seller might gain a competitive edge by unshrouding and reducing additional fees, thereby showing sophisticated buyers that she is cheaper. By competing through unshrouding, however, sellers also reveal to naive buyers that products are more expensive than anticipated, which can induce some buyers to leave the marketplace. To prevent unshrouding sellers from inducing buyers to leave the marketplace, the platform prefers to coordinate shrouding for all sellers. Unlike in the laissez-faire case, the platform might even shroud when it harms sophisticated buyers.

Our laissez-faire benchmark shows that cross-group externalities drive the platform to shroud more. Sellers—neglecting cross-group externalities—ignore that their unshrouding induces buyers to leave the platform, which reduces demand for other sellers. Because the platform internalizes cross-group externalities, it shrouds seller fees more often to keep more buyers on the platform.

Section 5 extends our basic model and we explore when the platform charges and shrouds its own additional fees. For example, event-ticket platforms or OTAs charge service fees, or offer complementary products like travel insurance. What drives the platform to shroud its own additional fees? On the one hand, buyers attract many sellers, so when it unshrouds, the platform sets all its fees to zero to attract buyers. As a result, shrouded platform fees cannot make the platform look cheaper; but since sophisticated buyers avoid shrouded fees at a cost, *shrouded platform fees reduce the total number of buyers* and—via cross-group externalities—revenues from sellers. On the other hand, shrouded platform fees allow the platform to *raise revenues from naive buyers*.

Trading off these two effects, more buyers incite the platform to raise revenues from buyers by shrouding its own additional fees. This leads to our second main result: when sellers on the platform

compete more fiercely, the platform attracts more buyers and—to cash-in on these buyers—benefits more from shrouding platform fees. This result uncovers a perverse effect of seller competition: when the platform facilitates comparison and encourages competition between sellers, it also has stronger incentives to shroud its own fees.

In Section 6, we discuss policies. Existing work on intermediaries suggests they may bias their advice to earn commissions for certain products (Inderst and Ottaviani, 2012, Murooka, 2015), or to promote their own brands (Anderson and Bedre-Defolie, 2021, De Corniere and Taylor, 2019). Our results imply that banning these practices does not solve the problem: even without commissions or self-preferencing, cross-group externalities drive platforms to appear cheap and shroud more than sellers themselves.

We also study policies that limit shrouded fees, like all-inclusive upfront prices, and fee regulation. First, policies that limit shrouded seller fees can lead to waterbed effects and raise base prices. Larger base prices make products appear more expensive and cause buyers to leave the marketplace. Policymakers who are concerned about insufficient participation on platforms might therefore hesitate to target seller fees on platforms. Indeed, Competition and Markets Authority (2017) voices concerns that many consumers do not yet use digital comparison tools. Second, network effects limit waterbed effects so that buyers' membership fees stay zero after unshrouding. This is why policies that target shrouded platform fees do not have the same adverse effect on buyer participation and more unambiguously increase actual total consumer surplus.

Our model helps explain several empirical facts: the prevalence of drip pricing on platforms, that drip pricing increases demand, the popularity of rebate promotions, that OTAs shroud resort fees even though they allow hotels to avoid commissions, that eBay sellers should optimally charge either large shipping fees or transparent and free shipping (Einav et al., 2015, Tran, 2019), and why platforms with free access for buyers still charge rather shrouded service fees.

Our results nuance the common argument by researchers and policymakers that online marketplaces facilitate product comparison and encourage competition. We suggest two reasons why online marketplaces may have lead to less-transparent markets. First, cross-group externalities incite platforms to shroud seller fees to make products look cheap. Second, platforms have stronger incentives to shroud their own fees exactly when sellers compete more fiercely on their marketplaces.

Evidence suggests that platforms indeed have strong incentives to shroud. First, we predict

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that OTAs may shroud more than airlines themselves. Indeed, four years after the EU forced all-inclusive upfront pricing for air tickets, Steer Davies Gleave (2012) find 13% of airlines did not fully comply with the rule compared to 24% of online platforms. Second, Blake et al. (2021) report a wide range of online platforms using drip pricing, and a large empirical literature[7] shows drip pricing raises demand on platforms, suggesting this arguably deceptive practice is quite common.

We contribute to the ongoing policy debate on online marketplaces. The EU Commissioner Margrethe Vestager describes platforms as private rule-makers who design a marketplace and set rules sellers must follow.[8] Our framework suggests platforms as private rule-makers can have strong incentives to shroud features, and regulators should not rely on platforms to initiate reliable consumer-protection rules on their marketplaces. Indeed, the examples we provide in the initial paragraph suggest that policymakers are increasingly active against obfuscation on platforms. Also the EU's recent Digital Services Act (DSA) proposal would mandate online platforms to design marketplaces that enable sellers to comply with existing price transparency rules.[9]

We combine two disjoint literatures, namely those on shrouded fees and two-sided platforms. First, existing work on shrouded features following Gabaix and Laibson (2006) does not explain why two-sided platforms would help sellers hide their fees. Second, our approach offers a fundamentally novel perspective on the role of platforms for consumer protection. In practice, many online platforms are eager to attract consumers and offer them free access. In models with rational consumers (e.g. Caillaud and Jullien (2003), Rochet and Tirole (2003), and Armstrong (2006)), such a platform needs to offer buyers more value, giving platforms strong incentives to protect rational consumers. Thus, from the perspective of these papers, it is a puzzle why platforms give free access to buyers, but obfuscate fees at the same time. We show that platforms can also attract consumers by reinforcing biases to appear more valuable. In this way, adding consumer biases to the picture fundamentally changes the perspective on whether interventions are needed to protect consumers, and what the consequences of interventions are.

Section 7 discusses extensions, e.g. we show results are robust when platforms compete. Section

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[7] See Blake et al. (2021), Brown et al. (2010), Einav et al. (2015), Hossain and Morgan (2006), Smith and Brynjolfsson (2001), Tran (2019). For surveys on evidence from Marketing, and Consumer Psychology, see Ahmetoglu et al. (2014) and Greenleaf et al. (2016).

[8] See https://ec.europa.eu/commission/commissioners/2019-2024/vestager/announcements/speech-forum-europe-conference-digital-services-act_en, accessed 10 December 2020.

[9] See p.29. point (50) of https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020PC0825&from=en, accessed 11 May 2021.

8 the related literature and Section 9 concludes.

2 Model

We now introduce our baseline model of a two-sided market with three types of players: sellers, buyers, and a platform. Buyers and sellers interact exclusively on the platform.

The monopoly platform has zero marginal costs for serving a buyer or seller, and sets membership fees M_S for sellers and $M_B \geq 0$ for buyers.[10] Additionally, the platform can influence the transparency of fees on the marketplace and can shroud or unshroud additional fees of sellers.

There are infinitely many buyers and sellers who might join the platform. The value of buyers and sellers from joining the platform are

$$v_B = n_S u - M_B \quad \text{and} \quad v_S = n_B \pi - M_S,$$

where n_B and n_S denote the mass of buyers and sellers who join the platform, respectively. These valuations capture some common assumptions. First, each seller (buyer) interacts with all n_B buyers (n_S sellers) on the platform and enjoys the expected perceived benefit π (u) per buyer (seller) on the platform. Thus, buyers benefit from more sellers and vice versa—the platform features positive cross-group externalities (a.k.a. indirect network effects). Second, each additional interaction has the same marginal value.

Buyers and sellers choose to join the platform or not. There is a mass one of potential buyers whose outside option is uniformly distributed on the interval $[0, 1]$. There is a mass one of sellers. For tractability, we assume the sellers' outside option is homogeneous and normalized to zero.[11]

Importantly—and in contrast to the existing literature—the platform can manipulate the cross-group externalities π and u by shrouding sellers' fees. We therefore model the interaction on the platform between buyers and sellers explicitly, based on Gabaix and Laibson (2006).

Each seller potentially offers a single product in one product category on the platform. We assume all product categories are identical and independent. Each product category on the platform

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[10] Main results are robust when sellers do not pay a membership fee but a royalty of their revenue on the platform. We assume zero marginal costs to simplify exposition, but they seem indeed negligible for online platforms. Negative membership fees may attract unprofitable arbitrageurs who do not actually use the platform.

[11] Homogeneous outside options of sellers imply more buyers increase benefits of sellers without attracting more sellers in equilibrium. This limits—without eliminating—cross-group externalities and simplifies the demand system. Heterogeneous outside options would reinforce Propositions 1 and 2.

has two potential sellers.[12] In each product category the two potential sellers have marginal cost c and are located at opposite ends of a Hotelling line of length one. Each seller $s \in \{1, 2\}$ charges a base price f_s and an additional fee $a_s \in [0, \bar{a}]$.[13] For simplicity we assume that charging a_s comes at no additional cost to sellers. In the flight-ticket example, flights from Brussels to Budapest on a given day can be a product category, f_s is the ticket price, and a_s a fee for add-ons and upgrades like extra luggage, seat selection, or travel insurance.

In each product category the position of each buyer is uniformly distributed on the Hotelling line.[14] Buyers have linear transportation costs t, and a value v for the products. We assume v is large enough such that when both sellers in a product category join the platform, the market is covered. All buyers are aware of the base price f_s, but they differ by whether they take additional fees into account. At each location on the Hotelling line, buyers are naive with probability α. When the platform shrouds additional fees a_s, naifs ignore additional fees and wrongly believe they are zero. With probability $1 - \alpha$ buyers are sophisticated. These buyers also do not observe shrouded additional fees when choosing a product, but understand the sellers' incentives and have correct Bayesian posteriors about shrouded fees, denoted $\mathbb{E}[a_s]$. When they anticipate large additional fees, sophisticated buyers can engage a precautionary avoidance cost e (with $0 < e < \bar{a}$) to avoid paying the additional price. Because avoiding additional fees costs e but sellers can charge them without additional costs, avoiding additional fees is inefficient.

In general e captures that when facing shrouded features, more-suspicious consumers, i.e. sophisticates, are more inclined to adjust their behavior. For example, faced with shrouded luggage fees on a comparison website, more-suspicious consumers take precautions, make an effort to find out how much luggage is actually included and pack accordingly.

The platform shrouds or unshrouds additional fees, and it does so for all transactions on the platform. Unshrouding allows buyers to observe additional fees and turns naifs into sophisticates.[15]

The timing is as follows:

- **Stage 1:** The platform shrouds or unshrouds additional fees, and charges membership fees.

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[12] The mass 1 of sellers and each seller having one potential rival implies there is a mass $1/2$ of product categories.

[13] See Gabaix and Laibson (2006) or Heidhues and Kőszegi (2018) for different interpretations of $\bar{a}$: a naive consumer's unanticipated willingness-to-pay for an add-on with shrouded fees, a regulatory price cap, a price above which consumers register a complaint, or the cost of a last-minute intervention to avoid an add-on.

[14] Results extend to continuous, symmetric, and unimodal distributions.

[15] To simplify exposition we assume unshrouding turns all naifs into sophisticates, but we prove our main results for a more general setting where unshrouding turns the share $\lambda \in (0, 1]$ of naifs into sophisticates, see Section 7.

- **Stage 2:** Buyers and sellers decide whether to join the platform.

- **Stage 3:** Sellers choose f_s and a_s.

- **Stage 4:** In each product category, buyers who joined the platform learn their position on the Hotelling line and whether they are naive or sophisticated. Buyers observe f_s and decide which seller to buy from. With shrouded additional fees naive buyers consider only f_s, and sophisticated buyers form Bayesian posteriors on a_s. With unshrouded additional fees, all buyers are sophisticated and observe f_s and a_s. Buyers can initiate costly behavior e that allows them to substitute away from paying a_s.

- **Stage 5:** Buyers observe the additional fee (if they have not observed it already). Buyers who engaged in substitution in stage 4 do not pay a_s. All others pay a_s.

Stages 1 and 2 capture the monopolist's *platform design*, while stages 3 - 5 model *competition on the platform*. Buyers are ex-ante identical in the platform-design stages and uncertainty about their sophistication and position on the Hoteling line is only revealed after they join the platform. We discuss in Section 7 that our results are robust to this and other simplifying assumptions.

We look for perfect Bayesian equilibria.[16] As common with multi-sided platforms, there can be equilibria with zero probability of interactions on the platform. To rule out these economically uninteresting cases, we focus on equilibria with a strictly positive mass of buyers and sellers.

We make the following two selection assumptions throughout the main text:

Assumption 1. $\pi \geq u$.

$\pi \geq u$ means that buyers exert a large cross-group externality on sellers. This implies the platform has strong incentives to attract buyers and optimally sets the lowest possible membership fee for buyers, $M_B = 0$. In the vast majority of our applications buyers can access platforms for free, and, thus, we think of this as an arguably weak condition.[17]

Assumption 2. In each product category, total profit and perceived buyer surplus are larger with duopoly sellers than a monopoly seller.[18]

[16] As in Eliaz and Spiegler (2006, 2008), naive buyers and firms agree to disagree on the model. Alternatively, we could follow Heidhues and Kőszegi (2017) and study subgame-perfect Nash equilibria in the model between firms.

[17] Our results about shrouding seller fees, i.e. Propositions 1 and 2, hold more generally under $\pi < u$ as well.

[18] Formally, we need that the Hotelling line with monopoly seller is not covered, i.e. $v - c + \max\{\alpha\bar{a} + (1-\alpha)e, 2e\} \leq 2t$, and that buyer surplus increases with duopoly, which follows from $\frac{7}{4}t \leq v - c + \min\{\alpha\bar{a} - (1-\alpha)e, e\}$.

Assumption 2 focuses the main analysis on cases with some competition on the platform, i.e. where the platform prefers to have duopoly sellers in the product categories.[19]

3   Key Premises and Applications

Our baseline model makes many simplifying assumptions but our results are robust to a wide range of extensions. We now highlight our key premises and connect to some applications. First, following the growing literature on Behavioral Industrial Organization,[20] some consumers can make systematic mistakes and underestimate the total expenses for a product they buy on a platform. Second, more-suspicious consumers—the sophisticated ones—anticipate shrouded fees before it is too late, i.e. while they can still adjust their behavior. We discuss examples of this adjustment cost e below. Finally, platforms can raise awareness of additional fees: they can require sellers to clearly display prices, use all-inclusive upfront prices, or favor transparent sellers in their search algorithm. This captures the notion expressed by EU Commissioner Margrethe Vestager that platforms are private rule-makers who design a marketplace and set rules sellers have to follow.

We illustrate how platforms can shroud fees with three widely-used practices. Our first example for shrouding is **rebate design**. In field experiments with an online retailer, Rodemeier (2021) shows that claimable rebates increase sales substantially even though almost half the consumers do not claim them. As with our avoidance effort e, claiming rebates is a costly hassle, and consistent with our hidden fee, consumers underestimate this cost by 20€, leading them to underestimate prices. Platforms could unshroud and avoid consumer mistakes by applying rebates automatically.

Second, many platforms and price-comparison websites (PCWs) like eBay or Amazon use **drip pricing**: they reveal some fees like shipping- or service fees, VATs, resort fees, or prices for add-ons and upgrades only later during the purchase process. Extensive evidence shows drip pricing induces at least some consumers to underestimate the total costs of products: consumers are less sensitive to dripped prices than to upfront prices, inducing them to purchase more often or buy an expensive upgrade.[21] To help consumers avoid these mistakes, platforms could use more upfront pricing, or

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[19] Assumption 2 is based on Karle et al. (2019). Intuitively, with duopoly more consumers buy and get products closer to their taste, so that duopolists earn more profits and the platform prefers to have duopoly sellers.

[20] See Heidhues and Kőszegi (2018) for a survey.

[21] Overwhelming field evidence finds drip pricing increases demand (Blake et al., 2021, Brown et al., 2010, Chetty et al., 2009, Einav et al., 2015, Hossain and Morgan, 2006, Morwitz et al., 1998, Smith and Brynjolfsson, 2001, Tran, 2019). No study finds a negative effect of drip pricing on demand, and one study (Dertwinkel-Kalt et al., 2020) finds

adapt their search algorithm to favor sellers with lower dripped prices.[22]

A third example is **steering** consumers towards expensive upgrades. Ellison and Ellison (2009) discuss the case of a PCW. They find extremely price-sensitive demand for basic products. But—in line with our perspective—they argue many buyers who inspect basic products are then steered towards expensive and obfuscated upgrades. In their setting, the merchants seem to do the steering, but platforms could still unshroud by favoring sellers who steer less in their search algorithm, or encourage consumers to choose a product version before they compare prices.

Rebate design, steering, and drip pricing are widely applied by online marketplaces, but the latter two require that products have add-ons or upgrades. We now give some examples of such products, starting with **avoidable add-ons or product upgrades**. The evidence on drip pricing suggests consumers underestimate fees for common avoidable add-ons in online marketplaces like express shipping, or upgrades and complementary products like insurance. Avoiding these expenses can involve a cost for consumers like effort, slower delivery, or foregone utility, which we capture with the avoidance cost e.

The example in Section 2 of flight-comparison websites like Skyscanner, Bravofly or Google Flights fits into this category, and so do event-ticket platforms like StubHub, Ticketmaster, or Viagogo. Another closely related application are hotel-booking platforms. They usually show basic room prices, but might not disclose resort fees and prices for add-ons like breakfast, gym access, wifi, etc. Naive consumers might underestimate their demand for add-ons or their prices. Sophisticated consumers are more suspicious about the hotels' pricing incentives; they take precautions and use restaurants, sports facilities, and wifi elsewhere to avoid expensive add-ons.

Previously-studied examples of deceptive products also fall in this category like credit cards (Ausubel, 1991, Heidhues and Kőszegi, 2010, 2017, Schoar and Ru, 2016, Stango and Zinman, 2009, 2014, 2015), bank accounts (Alan et al., 2018), printers and cartridges (Hall, 1997), or cell-phone contracts (Grubb, 2009, Grubb and Osborne, 2014). They are frequently traded on two-sided online platforms, but existing work does not explore if platforms want to unshroud deceptive features.

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a null effect, as one might expect with rational buyers. See also Santana et al. (2020) and Huck and Wallace (2015) for experimental studies. The work by Dertwinkel-Kalt et al. (2022) suggests that concentration bias can explain these patterns: subjects under-appreciate costs when they are spread out over multiple smaller cost components.

[22] As an illustrative example, Google users outside the US, Canada, and Israel will see hotel rates with taxes and fees included, while users in the US and Canada only see the base rate upfront. See `https://www.sabrehospitality.com/blog/importance-of-transparency-for-hotel-taxes-and-fees/`. Accessed 3 September 2020.

Our model also applies to **unavoidable fees** like service fees, fees for standard shipping, VATs, or taxes. Also with unavoidable fees, mistakes make naive consumers more profitable for sellers. Naive and sophisticated consumers pay the same total price. But naifs underestimate the total price and therefore generate more revenue via their larger demand (Heidhues and Kőszegi, 2018).[23] The adjustment cost e captures different features. First, an inefficient option to bypass the platform, like interacting directly with an airline, hotel, or merchant.[24] Second, inefficient cancellation of another add-on: realizing products are expensive, sophisticated consumers might give up insurance for their new smartphone, get a cheaper rental car, forgo fast shipping, or buy a more-basic version. Third, following Heidhues and Kőszegi (2018), e can stand for a participation distortion: sophisticated buyers anticipate large fees *before they purchase*, so they might give up the purchase even though their valuation is above marginal costs. Fourth, following Gamp et al. (2018) e captures additional search costs of sophisticated buyers: because sophisticated buyers can identify deceptive products, shrouding induces them to search more until they find a better product.

4   Shrouding Seller Fees

We now analyse our baseline model from Section 2. First, we explore competition on the platform (stages 3-5) and then look at the platform's design choices (stages 1 and 2).

4.1   Seller Competition on Platforms

In stage 3, the platform's membership fees are sunk and only the platform's choice to shroud or unshroud influences demand of sellers. We therefore distinguish these two cases. We suppose for now there are two sellers in each product category and show below that this holds in equilibrium.

Seller competition with unshrouding.   We start with subgames after the platform unshrouds additional fees. Unshrouding turns all buyers into sophisticated ones who observe additional fees when they choose a base product. Seller s with a rival r faces demand

$$d_s(f_s, f_r; unshrouding) = \frac{1}{2} + \frac{f_r - f_s}{2t} + \frac{\min\{a_r, e\} - \min\{a_s, e\}}{2t}.$$

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[23] Note that in these cases, it does not matter whether sellers or someone else earns the unavoidable fee.

[24] In this context, e could also capture that sophisticates use the direct channel to learn about the product and how to avoid potential tricks and traps.

The first two terms are classic Hotelling demand. The third term captures that buyers avoid unshrouded additional fees $a_s > e$. To simplify, observe that each seller s optimally charges unshrouded additional fees $a_s \leq e$. Otherwise, if seller s charged $a_s > e$ she could reduce a_s below e and increase f_s by the same amount to strictly increase margins without affecting demand. Thus, sellers compete in unshrouded additional fees to help buyers avoid the inefficient cost e.[25]

Using that $a_s, a_r \leq e$, the profits of seller s simplify to $(f_s + a_s - c) \left(\frac{1}{2} + \frac{(f_r + a_r) - (f_s + a_s)}{2t} \right)$. Only total prices $f_s + a_s$ determine profits of sellers, resulting in classic Hotelling prices, profits, and buyer surplus. Applying the superscript 'un' for 'unshrouding', the equilibria of the subgame satisfy $f^{un} + a^{un} = c + t$, where $a^{un} \leq e$. The ex-ante in period 2 expected profit per buyer on the platform is $\pi^{un} = t/2$, and the ex-ante expected buyer surplus per seller on the platform is

$$u^{un} = \frac{1}{2} \left[v - \frac{5}{4}t - c \right]. \tag{1}$$

Seller competition with shrouding. In stage 3—after the platform shrouds—a seller s with a rival r faces demand

$$d_s(f_s, f_r; shrouding) = \frac{1}{2} + \frac{f_r - f_s}{2t} + (1 - \alpha) \frac{\min\{\mathbb{E}[a_r], e\} - \min\{\mathbb{E}[a_s], e\}}{2t}.$$

All consumers take base prices into account. Naive buyers ignore shrouded additional fees, while sophisticated ones have Bayesian posteriors and avoid additional fees they expect to exceed e.

To simplify demand, note that sellers optimally charge $\bar{a}$. In stage 4 buyers cannot condition their purchase decision on shrouded additional fees and for any given $\mathbb{E}[a_s]$ each seller s optimally charges $a_s = \bar{a}$. In equilibrium, sophisticated buyers correctly suspect $a_s = \bar{a}$ and pay e to avoid shrouded additional fees. Only naive buyers pay $\bar{a}$, but wrongly ignore it when they choose a seller in stage 4. This simplifies the demand of seller s to $\frac{1}{2} + \frac{f_r - f_s}{2t}$. Because a seller's average margin per buyer is $\alpha(f_s + \bar{a} - c) + (1 - \alpha)(f_s - c)$, the profit of seller s simplifies to $(f_s + \alpha \bar{a} - c) \left(\frac{1}{2} + \frac{f_r - f_s}{2t} \right)$. Applying the superscript 'shr' for 'shrouding', this leads to equilibrium base prices $f^{shr} = c + t - \alpha \bar{a}$, ex-ante expected profits per buyer $\pi^{shr} = t/2$, and ex-ante *perceived* expected buyer surplus per seller on the platform

$$u^{shr} = \underbrace{\frac{1}{2} \alpha \left[v - \frac{5}{4}t - c + \alpha \bar{a} \right]}_{\text{perceived utility of naifs}} + \underbrace{\frac{1}{2}(1 - \alpha) \left[v - \frac{5}{4}t - c + \alpha \bar{a} - e \right]}_{\text{perceived utility of sophisticates}} = u^{un} + \frac{1}{2} \left[\alpha \bar{a} - (1 - \alpha)e \right]. \tag{2}$$

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[25] Note that $a_s \leq e$ is not pinned down only in the extreme case where $\lambda = 1$. For all λ close to one, it is strictly better to charge $a_s = e$ to maximize benefits from the remaining naifs. For details, see Lemma 4 in the Appendix.

The outcome resembles earlier results on shrouded attributes (Armstrong and Vickers, 2012, Gabaix and Laibson, 2006, Heidhues and Kőszegi, 2018). Sellers earn the same profits with shrouding and unshrouding ($\pi^{shr} = \pi^{un}$): sophisticated buyers avoid large shrouded fees, and sellers earn $\alpha \bar{a}$ in shrouded fees from naifs. But sellers compete away this revenue and reduce base prices by $\alpha \bar{a}$. Effectively, naive buyers do not increase sellers' profit but cross-subsidize sophisticated buyers.

To develop intuition, it will be important to understand how shrouding affects perceived buyer surplus. To do so, we first show how it affects the buyers' perceived cost of purchase (gross of transport cost). Because of shrouding, naive buyers only take base prices into account and perceive the costs $f^{shr} = c + t - \alpha \bar{a}$. Sophisticated buyers avoid $\bar{a}$ at cost e and have costs $f^{shr} + e = c + t - \alpha \bar{a} + e$. With unshrouding, the cost of purchase is $f^{un} + a^{un} = c + t$ for all buyers. Thus, shrouding makes products look cheaper to naifs, but because sophisticated buyers bear avoidance costs, shrouding increases their cost of purchase if $e > \alpha \bar{a}$.

The effect of shrouding on perceived buyer surplus u^{shr} captures these two effects. Because shrouding makes products look cheaper, buyer surplus increases in $\alpha \bar{a}$. All buyers believe to pay $\alpha \bar{a}$ less to sellers. Naifs because they wrongly ignore additional prices $\bar{a}$; sophisticates because they avoid $\bar{a}$ and are effectively cross-subsidized by naifs. But avoiding $\bar{a}$ costs e to sophisticates, reducing perceived buyer surplus by $(1 - \alpha)e$. Thus, shrouding makes products look cheap, but induces inefficient effort of sophisticated buyers. The former effect dominates if and only if $\alpha \geq \underline{\alpha} \equiv \frac{e}{\bar{a}+e}$, i.e. the share of naifs on the platform is sufficiently large. Lemma 1 summarizes these results.

Lemma 1.

1. $\pi^{un} = \pi^{shr} = t/2 \equiv \pi$.
2. $u^{shr} \geq u^{un}$ if and only if $\alpha \geq \underline{\alpha}$.

4.2 Platform Design

We now explore when the platform shrouds fees of sellers on the marketplace. We solve the platform's problem for generic benefits per interaction of π and u and later apply the (equilibrium) benefits per interaction from Lemma 1. Recall that buyers are ex-ante identical in stage 2 and expect the same perceived surplus u per seller on the platform.

To start, we derive demand of buyers and sellers for joining the platform in stage 2. Because buyers' outside option is uniformly distributed on the interval $[0, 1]$, free entry leads to $n_B^* = v_B =$

$n_S^* u - M_B$, i.e. the number of buyers increases linearly in their valuation for the platform. Because sellers' outside option is homogeneous and normalized to zero, the monopoly platform chooses $M_S = n_B \pi$ to extract all profit from sellers, and all sellers join the platform ($n_S^* = 1$).

Next, we explore how shrouding impacts demand. By Lemma 1, $\pi = t/2$ for shrouded and unshrouded additional fees, but shrouding does impact the number of buyers via u. Thus, because the platform earns no direct revenues from shrouded seller fees, the platform shrouds or unshrouds fees of sellers only to manipulate cross-group externalities. We can therefore write the platform's problem as if it chooses u directly:

$$\max_{M_S, M_B, u} n_S^* M_S + n_B^* M_B = \max_{M_B, u} (u - M_B)(\pi + M_B),$$

where we plug in n_S^*, n_B^*, and $M_S = n_B^* \pi$ from above. The next Lemma characterizes the solution.

Lemma 2. *In the unique equilibrium, the monopoly platform attracts two sellers per product category, sets membership fees $M_B = 0$ and $M_S = u\pi$, and earns profits $\Pi = \pi u$. The platform shrouds or unshrouds to maximize u.*

The key observation is that the platform shrouds or unshrouds seller fees a_s to increase buyer surplus u and attract more buyers. A larger u attracts more buyers to the platform, and more buyers—via cross-group externalities—increase the willingness-to-pay of sellers. Even though $M_B = 0$, the platform prefers a larger u to extract a higher membership fee from sellers.

Using this insight, we can now describe when the platform shrouds seller fees. To do so we combine the results from Lemmas 1 and 2.

Proposition 1. *The platform shrouds sellers' additional fees if and only if $\alpha \geq \underline{\alpha} = \frac{e}{e + \bar{a}}$, inducing sellers to charge large additional fees $\bar{a}$. Otherwise the platform unshrouds sellers' additional fees and sellers charge additional fees weakly below e.*

We saw in Lemma 1 that shrouding has two effects. First, shrouding seller fees makes products on the platform look cheap. They look cheap to naive buyers and are indeed cheaper for sophisticated buyers who are suspicious and avoid additional fees. Second, the avoidance behavior of sophisticated buyers is costly. By Lemma 2, the platform balances these effects to maximize the number of buyers on the marketplace. Thus, the platform shrouds seller fees to appear cheap if the first effect dominates, i.e. if it has enough naive buyers $\alpha \geq \underline{\alpha}$.

The cutoff $\underline{\alpha}$ captures unshrouding incentives. It increases in e and decreases in $\bar{a}$. When $\bar{a}$ increases, shrouding hides more fees and makes products look even cheaper, attracting more buyers. When e increases, shrouding creates more hassle for sophisticated buyers and attracts fewer buyers.

Our results help connect recent evidence on online platforms. First, that platforms shroud fees to increase demand is in line with evidence by Blake et al. (2021) on the event-ticket platform StubHub. StubHub used upfront prices that included most fees, but changed to drip pricing of fees like shipping and handling. Using a randomized control trial, they show that, everything else equal, drip pricing fees of 15% raises revenue by 21%. Just like shrouding in our model, drip pricing boosts demand for tickets and upgrades to more expensive tickets. Also the extensive evidence we discuss in Section 3 confirm that drip pricing of platforms massively increases demand.

Second, for eBay Germany, Tran (2019) finds demand under-responds to marginal changes in shipping fees, but also a discontinuous positive effect of free shipping on demand. Based on similar observations on eBay US, Einav et al. (2015) argue sellers who charge relatively small shipping fees below 10\$ can increase revenue by either increasing shipping fees, or by offering free shipping. Because free shipping on eBay is transparent and prevents consumers from underestimating shipping fees just like unshrouding, these findings are in line with our result that sellers either charge large shrouded fees, or transparent and low fees.

Third, our results connect to the debate on hotel resort fees (a.k.a. amenity/destination/facility fee) that guests pay on top of basic room rates. In 2018 hotels earned around \$2.9 billion in resort fees. Hotels usually do not pay commissions to OTAs on their resort fees, so one might expect that OTAs favor hotels without them. But they do not: in 2019, ten major OTAs, including Expedia and booking.com, showed initial room rates without including even mandatory resort fees. After increased reporting in 2019, some OTAs like booking.com and Expedia announced to take action against resort fees.[26] But booking.com took action by applying commissions also on resort fees, which arguably does not induce transparency but gives booking.com a cut of the pie. Expedia announced it would lower priority in their search algorithm for hotels charging resort fee, but hotels can pay to accelerate their listing, so also this measure appears like a tool to extract revenue rather than to induce transparency.[27] Indeed, still in 2022, CNN and Forbes report that Expedia—while

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[26] See https://www.consumerreports.org/fees-billing/the-sneaky-ways-hotels-are-hiding-their-resort-fees/, and https://nypost.com/2019/05/24/booking-com-is-cracking-down-on-hotel-resort-fees/, accessed 6 July 2022.

[27] See https://skift.com/2019/11/14/expedia-tells-hotels-adding-resort-fees-will-lower-your-listings-on-its-pages

announcing search results include taxes and fees—does not include resort fees.[28] One might argue that OTAs cannot do more because they do not have the tools to pressure hotels further. But OTAs enforced most-favored-nation clauses that force hotels to charge their cheapest rates on OTAs, so this argument is not fully convincing.[29] Our mechanism, however, can explain the OTAs' lack of action against resort fees: they shroud these fees and might even accept to forgo commissions to generate activity on their platforms.[30]

4.3 Benchmark with a Laissez-Faire Platform

To evaluate shrouding incentives more carefully, we now ask if the platform has stronger incentives to shroud seller fees than sellers themselves. To do so, we explore a laissez-faire platform where each seller decides if she wants to shroud or unshroud her additional fee.

The setting resembles Gabaix and Laibson (2006). Consider a product category with two sellers. Each seller can decide to shroud or unshroud additional fees at the same time as they set prices.[31] If a seller unshrouds, naive buyers become sophisticated and all consumers observe the seller's additional fee in stage 4.

Lemma 3. *(Benchmark: Proposition 1 of Gabaix and Laibson (2006)). On a laissez-faire platform, an equilibrium with shrouded additional fees $\overline{a}$ exists if $\alpha \geq \hat{\alpha} \equiv e/\overline{a}$. Otherwise sellers unshroud additional fees and set them weakly below e.*

Shrouding sellers face the following tradeoff. If both sellers shroud they charge $a_s = \overline{a}$ and earn $\alpha\overline{a}$ in shrouded fees from their naive customers. But a seller might deviate to *gain a competitive edge by unshrouding* and reducing additional fees to e: the deviating seller shows to sophisticated buyers that her additional fee is only e. Thus, sophisticated buyers no longer need to avoid additional fees, and the deviating seller earns smaller additional fees e from *all* its customers.

The next Proposition compares the laissez-faire platform with Proposition 1 where the platform shrouds sellers' fees. The result follows directly from comparing the respective cutoffs $\underline{\alpha}$ and $\hat{\alpha}$. Figure 1 illustrates this graphically. It is our first main result.

Proposition 2. *The platform has stronger incentives to shroud than sellers, i.e. $\underline{\alpha} < \hat{\alpha}$.*

The platform has stronger incentives to shroud sellers' fees than sellers' themselves. Indeed, for $\alpha \in (\underline{\alpha}, \hat{\alpha})$, sellers would like to unshroud to gain a competitive edge over their shrouding rivals, but unshrouding reduces the number of buyers on the marketplace and the platform prefers to prevent sellers from unshrouding. More precisely, for $\alpha \notin (\underline{\alpha}, \hat{\alpha})$ the platform and sellers have the same shrouding incentives. But for $\alpha \in (\underline{\alpha}, \hat{\alpha})$, Lemma 3 shows that sellers unshroud to gain a competitive edge over their shrouding rivals. In the resulting unshrouding equilibrium, sophisticates no longer incur the hassle cost e, but products also appear more expensive to formerly naive buyers. Since $\alpha > \underline{\alpha}$, the latter effect dominates and unshrouding reduces the number of buyers on the platform. To prevent buyers from leaving, the platform prefers to coordinate shrouding for all sellers, eliminating the possibility for individual sellers to unshroud to gain a competitive edge.

The benchmark reveals that cross-group externalities drive the platform to shroud more. Because sellers ignore cross-group externalities, they neglect that their unshrouding can reduce the number of buyers and therefore demand on the platform. The platform, however, internalizes cross-group externalities and shrouds more to keep more buyers on the marketplace.

Cross-group externalities have implications for the impact of shrouding on actual buyer surplus. For $\alpha \in (\underline{\alpha}, \hat{\alpha})$, platforms shroud seller fees even though in each product category, shrouding makes naive *and* sophisticated buyers worse off. This contrasts with previous work on deceptive products (Gabaix and Laibson (2006), Heidhues et al. (2016a), Heidhues et al. (2016b)), where shrouding tends to harm naive consumers and benefits sophisticated ones through the cross-subsidy.

There is suggestive evidence that platforms have indeed strong incentives to shroud. First, in a report for the European Commission, Steer Davies Gleave (2012) find that four years after the EU forced all-inclusive upfront prices for air tickets, only 13% of airlines did not comply with the rule, compared to 24% of online platforms. Second, Blake et al. (2018) show in their Table 9 that a wide range of two-sided online platforms like AirBnB, eBay, Hotels.com or TaskRabbit use some form of drip pricing. Third, a large empirical literature (Ahmetoglu et al., 2014, Blake et al., 2021, Brown et al., 2010, Ellison and Ellison, 2009, Einav et al., 2015, Greenleaf et al., 2016, Hossain and

Figure 1: Unshrouding incentives of a monopoly platform, and sellers without platforms.
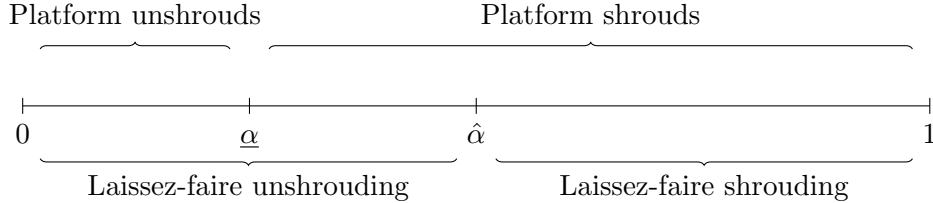
Morgan, 2006, Smith and Brynjolfsson, 2001, Tran, 2019) studies drip pricing on online platforms and shows it raises demand, suggesting that this arguably deceptive practice is quite common.

5   Shrouding Platform Fees

So far we studied when a platform shrouds fees of third-party sellers on its marketplace. In practice platforms might charge their own additional fees like service- and admin fees, or fees for complementary products like travel insurance. Platforms can also shroud their own additional fees using, for example, drip pricing. We now explore when the platform shrouds its own additional fees.

We change the setting from Section 2 to allow platforms to charge additional fees. In stage 1, the platform now also chooses its own additional fee $A \in [0, \bar{A}]$ paid by buyers per transaction with a seller, and whether to shroud or unshroud this fee.[32] Naive buyers wrongly believe that shrouded platform fees A are zero, while sophisticated ones have Bayesian posteriors about A. Unshrouding turns all naive buyers into sophisticated ones who observe A in stage 2. In stage 4, buyers who suspect large shrouded platform fees A can avoid them by initiating the costly behavior $E\,(< \bar{A})$.[33]

We start with competition in product categories in stages 3 to 5. As before we assume v is sufficiently large such that the market in each product category is covered. Because A applies equally to all sellers, it does not affect competition between sellers. Thus, the perceived surpluses per interaction gross of platform-related interaction costs—π and u—are unaffected by E and A.

We move on to characterize demand for the platform in stage 2, starting with demand of sellers. As in Section 2, sellers have an outside option normalized to zero, implying the platform optimally

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[32] Results are qualitatively unaffected when the platform sets royalties instead, i.e. a share of the sellers' basic fees.

[33] For tractability we assume unshrouding A does not affect naiveté about seller fees a and vice versa. A positive direct spillover of unshrouding could even reinforce our results.

charges $M_S = n_B \pi$ and all sellers join the platform. Next, we look at the demand of buyers. Because the outside option of buyers is uniformly distributed on $[0, 1]$, participation of buyers is determined by $n_B = v_B$. This leads to the following demand of buyers for joining the platform under shrouding and unshrouding, respectively:

$$
\begin{aligned}
n_B^{shr} &= n_S \left[u - \frac{1}{2}(1 - \alpha) \min\{\mathbb{E}[A], E\} \right] - M_B, \\
n_B^{un} &= n_S \left[u - \frac{1}{2} \min\{A, E\} \right] - M_B.
\end{aligned}
\tag{3}
$$

The expressions in squared brackets are the perceived buyer surpluses per seller net of platform-related interaction costs E and A.[34] As before u is the perceived buyer surplus per seller gross of the platform-related interaction costs, and M_B are membership fees of buyers. With shrouded platform fees naifs ignore additional fees A; the second term captures that sophisticated buyers have rational expectations about shrouded platform fees and avoid them when optimal. Unshrouding turns naive- into sophisticated buyers who can observe additional fees.

We can now analyze the platform's design choices in stage 1. By Assumption 1, buyers exert a strong externality on sellers, which is why the platform wants to attract buyers, sets $M_B = 0$, and wants to appear cheap about its own additional fees. To appear cheap, the platform either unshrouds and sets low platform fees $A = 0$, or shrouds and charges large platform fees $\bar{A}$. Because naive buyers are less sensitive to shrouded fees than to membership fees, shrouding its additional fees allows the platform to earn $\bar{A}$ from naive buyers despite their large cross-group externality. Thus, the platform charges large additional fees if and only if it shrouds. This matches the casual observation that platforms rarely charge buyers for access, but use drip-priced and rather shrouded admin- and service fees.

These observations simplify the platform's profits to $n_S M_S + n_B^{shr} M_B + \frac{1}{2} n_B^{shr} n_S \alpha \bar{A} = n_B^{shr}(\pi + M_B + \frac{1}{2}\alpha\bar{A})$ and $n_B^{un}(\pi + M_B)$ under shrouding and unshrouding, respectively. The next Proposition summarizes the equilibrium and characterizes when the platform shrouds fees.

Proposition 3. *The platform charges $M_B = 0$. When shrouding platform fees it charges $A = \bar{A}$, and when unshrouding platform fees $A = 0$. The platform shrouds A if and only if $\alpha \geq \alpha'$, for a unique $\alpha' \in (0, 1)$. α' is strictly decreasing in u and strictly increasing in π.*

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[34] A and E are weighted by $1/2$, because in each product category each buyer interacts with one of the two sellers.

As in the previous setting in Proposition 1, the platform shrouds or unshrouds seller fees a to attract more buyers and benefit from the externalities they exert on sellers.

Concerning its own additional fees A, the platform trades off two sources of revenue: shroud to extract revenues from buyers directly, or unshroud to attract more buyers and benefit from their externality on sellers. We already saw that the shrouding platform charges additional fees $\bar{A}$ to earn direct revenue from naive buyers. To see that shrouding A reduces the number of buyers on the marketplace, note first that shrouding A does not affect the perceived value of naive buyers: shrouding does not change membership fees because access is free ($M_B = 0$) under shrouding and unshrouding, and unshrouded additional fees A are zero just like the wrongly-perceived shrouded fees. But sophisticated buyers anticipate and avoid large shrouded additional fees at cost E. Thus, shrouding A reduces the average buyers' perceived value from joining the marketplace and reduces the number of buyers. Because fewer buyers lower the willingness-to-pay of sellers, the shrouding platform reduces the membership fee M_S for sellers. To sum up, the platform trades off to shroud A and earn direct revenues from buyers with unshrouding A to increase revenue from sellers.

The platform's incentive to unshroud its own fees, i.e. α', depends on the size of the cross-group externalities π and u in an intuitive way. Suppose π increases and sellers benefit more from interacting with buyers. This encourages the platform to unshroud A to attract more buyers and further increase the willingness-to-pay of sellers ($n_B\pi$). A larger u, however, attracts more buyers and incites the platform to shroud and cash-in $\bar{A}$ from naive buyers. Thus, the incentives to unshroud platform fees decrease in u and increase in π.

We highlight two important implications of this result. First, our findings nuances one of the classic results on pricing users of platforms, i.e. that platforms subsidize the side with the larger externality on the other (Armstrong, 2006, Rochet and Tirole, 2003). We find that, despite pressure from network externalities to attract buyers, platforms may charge large shrouded fees to buyers.

Second, the result links shrouding incentives to other platform-design features that affect cross-group externalities like competition on platforms. In our model, a decrease in t captures fiercer competition between sellers. Fiercer competition reduces profits per buyer (lower π), and attracts buyers (larger u). Using these insights, Proposition 3 implies that competition has a perverse effect on platform design: fiercer competition between sellers attracts buyers and thereby incites the platform to cash-in on buyers by charging its own shrouded additional fees.

Corollary 1 (Perverse Effect of Seller Competition). *A lower transportation cost t increases the platform's incentives to shroud its own additional fee.*

Recent empirical work emphasizes that platform design influences competition on platforms (Fradkin, 2015, Chen and Yao, 2017, Dinerstein et al., 2018, Ghose et al., 2014). Our result suggests that more competition on platforms—exactly because it attracts buyers— encourages platforms to shroud their fees. Fiercer competition between sellers can even reduce actual total consumer surplus.[35]

Together with our result from Proposition 2 that platforms have stronger incentives to shroud sellers' fees than sellers themselves, this suggests that the increasing relevance of platforms in recent years could have lead to more shrouding of additional fees. This perspective nuances the common argument by policymakers and academics that online marketplaces facilitate product comparison and encourage competition.[36] Instead, our results suggest that platforms can have large incentives to shroud fees exactly because they induce a competitive marketplace.

6   Policy Implications

The EU Commissioner Margrethe Vestager describes platforms as private rule-makers who design a marketplace and set rules sellers have to follow.[37] Our framework suggests that regulators should not rely on platforms to set rules that initiate reliable consumer protection on their marketplaces.

Indeed, the examples we provide in the introduction suggest that policymakers become increasingly active against obfuscation on platform. Also the EU's recent DSA and DMA are steps toward stricter regulation of large online platforms.

We now discuss implications of our results for some specific policies.

Bans on commissions and hybrid platforms. Existing research on intermediaries suggests

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[35] Throughout, 'total consumer surplus' denotes actual surplus that includes shrouded and unshrouded fees. To see how a more competitive platform design can reduce total consumer surplus, take two search algorithms 1 and 2 where 1 is more competitive and by Proposition 3 we have $\alpha_1' < \alpha_2' \equiv \alpha_1' + \epsilon$, where $\epsilon > 0$. But then for $\alpha \in (\alpha_1', \alpha_2')$, the platform only shrouds under the more competitive search algorithm. For $\epsilon > 0$ sufficiently small, the less competitive algorithm would increase the number of buyers, prevent inefficient effort E, and increase total consumer surplus.

[36] For example, Competition and Markets Authority (2017) write on p.6 that digital comparison tools 'save time and effort for people by making searching around and comparing easier and more appealing', and 'they make suppliers compete harder'. See also Brynjolfsson and Smith (2000), Dinerstein et al. (2018), Ellison and Ellison (2018).

[37] See `https://ec.europa.eu/commission/commissioners/2019-2024/vestager/announcements/speech-forum-europe-conference-digital-services-act_en`, accessed 10 December 2020.

they might give biased advice to earn commissions (Inderst and Ottaviani, 2012, Murooka, 2015), for example from merchants who pay a PCW to push a certain product, or to favor their own brands (Anderson and Bedre-Defolie, 2021, De Corniere and Taylor, 2019). So one might think that bans on commissions, or hybrid platforms and self-preferencing might solve problems related to biased intermadieries. Indeed, banning marketplaces from selling their own brands and limiting self-preferencing are frequently discussed in the context of Amazon.[38] Our results suggest that such bans, while potentially beneficial for the reasons outlined in previous work, do not solve the problem: in our setting platforms do not earn commissions, nor sell their own brands, but shroud seller fees more than sellers themselves. Indeed, even in a version of our model where the platform charges commissions in the form of a royalty on all prices of sellers, a binding cap on the royalty does not affect the platform's incentive to shroud seller fees.

Transparency-inducing policies. Policymakers can prevent drip pricing of some fees and insist that prices are revealed upfront. For example, the EU pushed AirBnB and OTAs to reveal fees upfront.

Our model captures such transparency policies as forcing platforms to unshroud fees. This leads to the following implications. First, more-transparent seller fees can cause buyers to leave the marketplace and reduce actual, i.e. corrected for mistakes, total consumer surplus. Unshrouding seller fees (a) induces sellers to lower these fees below the avoidance cost e, leading to less inefficient avoidance behavior and larger actual buyer surplus for a *given* number of interactions on the marketplace. But forced unshrouding of seller fees makes naive buyers aware of previously shrouded fees, and can lead to a waterbed effect and larger base prices. Both effects cause buyers to leave the marketplace. Thus, the policy increases actual buyer surplus per interaction but reduces interactions on the marketplace, and the effect on actual total consumer surplus is ambiguous.[39]

Second, policies that unshroud platform fees (A) increase actual total consumer surplus more unambiguously. By Proposition 3, cross-group externalities drive the platform to reduce its unshrouded fees to zero, without increasing buyers' membership fees. Cross-group externalities induce low fees and prevent the waterbed effect that induces the adverse effects of unshrouded seller fees.

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[38] See https://www.theguardian.com/commentisfree/2020/nov/14/when-it-comes-to-amazon-breaking-up-is-hard-to-do, accessed 12 March 2021.

[39] Note that reducing buyer demand can increase efficiency when buyers consume too much. For example, before EU regulation on all-inclusive upfront pricing for air tickets (Steer Davies Gleave, 2012), some flight tickets were priced below cost. Similarly, for the US credit-card market, Heidhues and Kőszegi (2015) argue there is overconsumption.

This attracts more buyers to the platform and increase actual total consumer surplus.

Regulating additional fees. Policymakers could impose caps on additional fees. Our model captures these caps as reductions in $\bar{a}$ and $\bar{A}$. We see from the cutoffs $\underline{\alpha}$ and α' in Propositions 1 and 3 that sufficiently low caps encourage the platform to unshroud, leading to the same qualitative effects as the aforementioned transparency policies.

A cap that reduces seller fees $\bar{a}$ only a little could backfire: the platform continues to shroud, but sellers—as in the previous waterbed effect—increase base prices f^{shr}. On the one hand, actual total prices decrease for naifs and the cap shifts surplus per interaction from sophisticated buyers to naifs. But products get more expensive for sophisticated buyers and appear more expensive to naive ones, so the cap causes buyers to leave the marketplace and reduces total consumer surplus. Since caps on $\bar{A}$ do not affect buyers' membership fees, they do not cause buyers to leave the platform. Thus, also small caps on platform fees more unambiguously increase total consumer surplus.

To summarize, policies that limit shrouded seller fees, by forced unshrouding or by caps on $\bar{a}$, can lead to waterbed effects and raise base prices. Larger base prices make products appear more expensive and cause buyers to leave the marketplace. Policymakers who are concerned about insufficient participation on platforms might therefore hesitate to target seller fees on platforms. Indeed, Competition and Markets Authority (2017) voices concerns that many consumers do not yet use digital comparison tools. Network effects, however, limit waterbed effects and buyers' membership fees are zero with and without shrouding. This is why policies that target shrouded platform fees (A) do not have the same adverse effect on buyer participation and more unambiguously increase actual total consumer surplus.

7 Extensions and Robustness Checks

In this section we summarize extensions that provide new insight, and list further robustness checks.

Rational benchmark. Naiveté plays a key role in explaining why platforms shroud fees. For a simple benchmark, consider Propositions 1 and 3 with $\alpha = 0$: without naive buyers, the platform unshrouds to prevent inefficient avoidance behavior of sophisticated buyers. We obtain the same result when some sophisticated buyers pay additional fees even when they are expensive. See Appendix A.3 for the details. This mirrors classic results on the pricing of add-ons and upgrades

(Ellison, 2005, Gabaix and Laibson, 2006), where sellers always disclose add-on prices when doing so is cheap and all consumers are sophisticated. Thus, naiveté is indeed crucial to explain why platforms shroud to increase activity on their marketplaces. Along these lines, we argue in Section 8 that transaction- or search cost cannot explain evidence that drip pricing increases demand.

Ex-ante heterogeneous buyers. To simplify exposition, the baseline model assumes buyers are ex-ante identical when they join the platform. Relaxing this assumption—such that consumers are already naive or sophisticated when they choose to join the platform—only reinforces our results. The reason is a selection effect: since naive buyers ignore some fees, they have a larger perceived benefit from joining the platform than sophisticated ones, implying that the share of naive buyers on the platform is larger than in the population. The higher share of naive buyers makes shrouding even more profitable for the platform. See Appendix A.4 for details.

Price discrimination. In the baseline model all consumers face the same membership fee. But some of our applications feature second-degree price discrimination. For example, while standard Amazon has a zero membership fee, Amazon Prime costs a fixed monthly fee but offers advantages like free express delivery.[40] We can translate this to our model with a basic membership $M_B = 0$, and a prime membership that costs $M'_B > 0$ in exchange for automatic avoidance of additional fees, e.g. free express shipping. Sophisticated buyers see the value of reduced avoidance effort and self-select into prime, but naive ones underestimate this benefit and select a basic membership. An immediate implication is that the platform no longer faces a trade-off between shrouding and unshrouding and always shrouds its additional fees for basic users. Thus, the possibility to price discriminate makes shrouding even more profitable for platforms, strengthening our results.

Competition. Our basic insight is robust to competition between platforms who decide about shrouding and membership fees in stage 1. We illustrate this in Appendix A.2. Intuitively, the monopolist in our main model shrouds to attract buyers who would otherwise not buy. Similarly, a competitive platform shrouds to appear cheaper and poach buyers from its rivals. Thus, competition might not suffice to induce a more-transparent marketplace.

Imperfect Unshrouding. In practice, sellers and platforms likely differ in how effectively they unshroud fees. We show that our results in Propositions 1 and 2 are qualitatively robust and platforms have stronger incentives to shroud than sellers themselves also when the platform is

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[40] See https://www.amazon.com/amazonprime Accessed 10 September 2020.

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more or less effective at unshrouding than sellers. Details are in Appendix A.1.

Other Robustness Checks. In the Web Appendix we establish that our findings are robust to (i) general non-linear demand of buyers, (ii) heterogeneous product categories with $n > 2$ sellers and different transportation costs, and (iii) exogenous additional fees.[41]

8   Related Literature

We identify a novel mechanism that explains why two-sided intermediaries might design intransparent platforms: they shroud fees to manipulate cross-group externalities between their users.

Literature on the regulation of online platforms. There are growing concerns about—and an increasing regulatory scrutiny into—harmful commercial practices of large online platforms (a.k.a tech giants).[42]   Such practices include Amazon and Google favoring their own products versus third-party sellers on their marketplaces (Hagiu et al., 2020); killer acquisitions (Hemphill, 2020, Cunningham et al., 2021); predatory pricing (Khan, 2016); booking.com putting pressure on consumers by misleading sales tactics (Teubner and Graul, 2020). The growing number of cases we discuss and reports we listed in the introduction show that also hidden fees on platforms are a major policy concern. We contribute to this ongoing debate by providing the first framework to explores the incentives of two-sided platforms to hide fees.

Our approach offers a fundamentally novel perspective on the role of platforms for consumer protection. In practice, many online platforms are eager to attract consumers and offer them free access. In classic models with rational consumers (e.g. Caillaud and Jullien (2003), Rochet and Tirole (2003), and Armstrong (2006)), a platform that wants to attract more buyers needs to offer them more value, giving platforms strong incentives to protect rational consumers. From the perspective of these papers, it is a puzzle why platforms give free access to buyers, but obfuscate fees. We show that platforms can also attract more consumers by reinforcing their biases to appear more valuable. In this way, adding consumer biases to the picture fundamentally changes the perspective on whether interventions are needed to protect consumers, and what the consequences of interventions are.

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[41] The Web Appendix is available on `https://sites.google.com/site/johannesjohneneconomist/research` .

[42] `https://www.nytimes.com/2020/07/30/technology/europe-new-phase-tech-amazon-apple-facebook-google.html` Accessed 10 August 2020.

Literature on shrouded attributes. A growing literature studies incentives of firms to shroud fees to naive consumers who underestimate total expenses (Dahremöller, 2013, Gabaix and Laibson, 2006, Gomes and Tirole, 2018, Heidhues et al., 2016a,b, Johnen, 2020, Kosfeld and Schüwer, 2017, Murooka, 2015). But these papers do not consider two-sided intermediaries and cannot explain why they shroud fees they do not earn themselves and without receiving a commission for shrouding.

Literature on advice from intermediaries. Some articles study advice from intermediaries when all consumers are sophisticated. Intermediaries give biased advice due to commissions (Inderst and Ottaviani, 2012), or because they sell their own version of a product (De Corniere and Taylor, 2019). Closest to our work, Murooka (2015) investigates when intermediaries like financial advisers recommend products with shrouded attributes. Intermediaries may recommend deceptive products because firms who sell deceptively can offer more generous commissions than non-deceptive rivals. In contrast, our intermediary shrouds seller fees but earns no commissions for shrouding and does not sell its own products.

Literature on intermediaries and consumer search. Recent articles study platforms and consumer search (Armstrong and Zhou, 2011, Eliaz and Spiegler, 2011, Hagiu and Jullien, 2011, Heresi, 2018, Mamadehussene, 2020, Ronayne, 2019, Wang and Wright, 2020). In Heresi (2018) platforms might increase consumer search costs and accept to weaken their user experience in order to raise sellers' profits. But in these settings, larger search costs tend to reduce consumer participation on platforms, and therefore cannot explain evidence cited in Section 3 that drip pricing increases demand.[43] In our perspective, platforms drip price to make products on the marketplace look cheap to attract buyers and increase seller profits.

Only few articles explicitly model add-on fees on two-sided platforms. Gomes and Tirole (2018) study a two-sided credit-card network who charges fees to merchants, and merchants can charge buyers extra for card payments. Concerned about missed sales, merchants will not pass the network's fees on to buyers, effectively subsidizing card payments. We have a different focus and study add-ons as deceptive features that platforms might shroud.

Other articles model competition on platforms explicitly. Belleflamme and Peitz (2019), Karle et al. (2019) analyze how the platforms' membership fees impact the number of sellers and thereby the

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[43] An exception is Armstrong and Zhou (2011) that finds larger search costs can reduce prices when only the cheapest product is prominent on a platform, because firms compete fiercely in prices to become prominent. But also this model cannot explain evidence by Blake et al. (2021), that drip pricing increases demand *for given prices*.

degree of competition on the platform. Edelman and Wright (2015) and Hunold et al. (2018) study intermediaries who restrict sellers from charging lower prices outside the platform. In contrast, we explore the platforms' non-price design choices like shrouding of sellers' additional fees.

9   Conclusion

We explore when two-sided platforms design a transparent marketplace or shroud fees towards buyers. First, driven by cross-group externalities, we find that platforms have stronger incentives to shroud sellers' fees than sellers themselves. Second, fiercer competition in the marketplace encourages platforms to shroud their own fees. Third, we highlight a range of policy implications.

Naive consumers who figure out they were exploited might blame the platform. Such reputation effects, however, might be minor in practice. First, exploitation might be worth the loss in reputation. Murooka (2015) shows that intermediaries simply require more generous payments from sellers to compensate for lost reputation; Chiles (2020) finds that shrouding resort fees reduces a hotel's ratings on online-travel agents, but also illustrates that the losses in revenues from lower ratings are smaller than the additional revenues from shrouding. Second, buyers might not blame the platform but sellers or themselves for their own mistakes. Third, buyers might not learn about their mistakes. Drip pricing is widely used, and the evidence we cite throughout spans more than 20 years, so there were ample learning opportunities. But even recent articles find that drip pricing has a substantial impact on demand, suggesting consumers do to learn much from experience.

One might argue that sellers themselves can do more unshrouding. For example, hosts on AirBnB could announce 'NO CLEANING FEES' in their headlines. But since platforms literally choose what their users do and do not see, they ultimately have the last word on whether such attempts of sellers to unshroud will actually reach consumers.

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A Online Appendix: Extensions and Robustness

A.1 Imperfect Unshrouding

First we generalize results from Section 4.1 to all $\lambda \in (0,1]$, where λ is the share of naive buyers that become sophisticated by unshrouding. Consider subgames after the platform unshrouds additional fees. Only $(1-\lambda)\alpha$ of buyers remain naive. All others are sophisticated and observe additional fees. Demand is

$$d_s(f_s, f_r; unshrouding) = \frac{1}{2} + \frac{f_r - f_s}{2t} + (1-(1-\lambda)\alpha)\frac{\min\{a_r, e\} - \min\{a_s, e\}}{2t}.$$

The remaining $(1-\lambda)\alpha$ naifs continue to ignore additional fees. All other buyers are sophisticated and can now observe the unshrouded additional fees. Thus, a seller s can either charge large additional fees $a_s > e$ that sophisticates avoid, or small $a_s \leq e$ that sophisticates pay. The following Lemma characterizes the optimal choice of unshrouded additional fees.

Lemma 4. *Suppose $\lambda \in (0,1)$ and let $\bar{\alpha} \equiv \frac{e}{(1-\lambda)\bar{a}}$. With unshrouded additional fees, each seller s charges low fees $a_s = e$ if and only if $\alpha < \bar{\alpha}$, and large fees $a_s = \bar{a}$ otherwise. If $\lambda = 1$, sellers charge $a_s \leq e$.*

The intuition has two steps. First, both sellers set either e or $\bar{a}$. To see this, suppose a seller s charges (f_s, a_s) with $a_s < e$. Naifs and sophisticates who buy from s pay this price. Increasing a_s and reducing f_s by the same amount does not affect total prices, but the product appears cheaper for the remaining naifs and increases demand. Now consider fees $a_s \in (e, \bar{a})$. Only naifs pay these fees but ignore them, so increasing a_s to $\bar{a}$ increases profits. Second, for a given f_s the choice of additional fees $\bar{a}$ or e does not affect demand. Take again a seller s who charges e or $\bar{a}$. Naifs ignore additional fees and choose a seller only based on base prices. Sophisticates either pay cost e to avoid $\bar{a}$ or pay an additional fee e. In either case their costs of purchasing from s are $f_s + e$. Thus, sellers either charge $\bar{a}$ and earn $(1-\lambda)\alpha\bar{a}$ from their naive customers, or e from all their customers.

Using the superscript 'un' for 'unshrouding', if both sellers charge $a_s = \bar{a}$, they maximize $(f_s + (1-\lambda)\alpha\bar{a} - c)\left(\frac{1}{2} + \frac{f_r - f_s}{2t}\right)$, leading to $f^{un;\bar{a}} = c - (1-\lambda)\alpha\bar{a} + t$, profits $\pi^{un;\bar{a}} = t/2$, and

$$u^{un;\bar{a}} = \frac{1}{2}\left[v - \frac{5}{4}t - c + (1-\lambda)\alpha\bar{a} - (1-(1-\lambda)\alpha)e\right]. \tag{A.1}$$

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This expression follows the same intuition as u^{shr} in the main text with the only difference that unshrouding reduces the share of naifs to $(1 - \lambda)\alpha$.

If both sellers charge $a_s = e$, seller s maximizes $(f_s + e - c)\left(\frac{1}{2} + \frac{f_r - f_s}{2t}\right)$, leading to $f^{un;e} = c - e + t$. Profits are $\pi^{un;e} = t/2$, and average perceived buyer surplus per seller

$$u^{un;e} = \frac{1}{2}\left[v - \frac{5}{4}t - c + (1 - \lambda)\alpha e\right]. \tag{A.2}$$

Intuitively, no consumer pays e anymore, but the share $(1 - \lambda)\alpha$ of naifs still ignores additional fees and believes the reduction in base prices e is a good deal.

The following Lemma generalizes Lemma 1 and summarizes the relation between buyer and seller surplus under the different scenarios.

Lemma 5. *Let* $\underline{\alpha}_\lambda \equiv \frac{e}{\bar{a} + \lambda e}$.
1. $\pi^{un;\bar{a}} = \pi^{un;e} = \pi^{shr} = t/2 \equiv \pi$.
2. $u^{shr} \geq u^{un;e}$ *if and only if* $\alpha \geq \underline{\alpha}_\lambda$.
3. $u^{un;\bar{a}} \geq u^{un;e}$ *if and only if* $\alpha \geq \bar{\alpha}$.
4. $u^{shr} \geq u^{un;\bar{a}}$.

As in the main text, sellers earn expected profits $\pi = t/2$ per buyer, whether the platform shrouds or unshrouds. As seller profits are the same in both scenarios, the inefficiencies in the model — arising from inefficient avoidance e — will show up in buyer surplus. Also note that $u^{shr} \geq u^{un;\bar{a}}$. Unshrouding without lower fees increases the share of sophisticates. More buyers pay avoidance cost and fewer naifs wrongly believe to get a good deal.

As a direct consequence of Lemma 5, when the monopolist platform aims to maximize perceived buyer surplus per interaction, shrouding is optimal for $\alpha \geq \underline{\alpha}_\lambda$, whereas unshrouding is optimal for $\alpha < \underline{\alpha}_\lambda$ as it induces sellers to choose low additional fees e by Lemma 4.

Finally, note that $\underline{\alpha}_\lambda < \hat{\alpha}$ for all $\lambda \in (0, 1]$ and $\hat{\lambda} \in (0, 1]$, where $\hat{\lambda}$ denotes how effectively sellers unshroud their own additional fees. Therefore our main results about shrouding seller fees (i.e. Propositions 1 and 2) generalize to the case of imperfect unshrouding.

To simplify the analysis in the remaining extensions, we replace Assumption 2 and assume from now on that the platform prefers duopoly sellers in each product category.

A.2 Competing Platforms

We established in Proposition 1 and 3 that platforms can have strong incentives to shroud sellers' fees. One might hope that competition between platforms drives them to design a more transparent marketplace with unshrouded additional fees. We show in this Section, however, that competition might not change platforms' incentives to shroud sellers' fees.

We study a setting with flexible unshrouding where platforms choose membership fees and whether to shroud simultaneously in stage 1. This captures quick fixes that raise awareness of exploitative features like pop-up windows on websites to remind consumers about airlines' luggage surcharges.[44]

Two-sided singlehoming. We first analyze competition between two platforms with two-sided single-homing. Two-sided single-homing captures that all buyers and sellers can join at most one of the platforms. Following Armstrong (2006), we assume that the number of agents joining platform $i \in \{1, 2\}$ in each group is given by the following Hotelling specification:

$$n_B^i = \frac{1}{2} + \frac{v_B^i - v_B^j}{2\tau_B} \quad \text{and} \quad n_S^i = \frac{1}{2} + \frac{v_S^i - v_S^j}{2\tau_S}, \tag{A.3}$$

where τ_B and τ_S are transportation costs incurred by buyers and sellers, respectively. Buyer and seller surpluses from joining platform i are similar to Section 2:

$$v_B^i = n_S^i u^i - M_B^i + k \quad \text{and} \quad v_S^i = n_B^i \pi - M_S^i + k. \tag{A.4}$$

k captures the platforms stand-alone benefit, i.e. the benefit that buyers get from joining a platform even when the platform attracts no buyers. We assume that k is large enough to have both the buyers' and the sellers' market covered.[45] Average buyer surplus u^i can differ between platforms to allow for asymmetric scenarios where one platform shrouds and the other one unshrouds.

To simplify the demand system, we make the following assumption, to replace Assumption 1:

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[44] Flexible unshrouding does not capture some forms of unshrouding. For example, changing an online platform from drip-pricing to list prices that include all unavoidable fees upfront may require major changes to the website's interface and takes more time than changing membership fees. We study this more rigid (un)shrouding in a previous working paper version, i.e. Johnen and Somogyi (2019). Following Dahremöller (2013), rigid shrouding also captures that naive buyers who observe unshrouded attributes remain aware of these attributes for future purchases. When regular consumers stay sophisticated after unshrouding, platforms will take the effect of unshrouding on future price competition into account. Thus, rigid unshrouding better describes platforms with frequently returning buyers, while flexible unshrouding captures platforms with more occasional buyers.

[45] In particular, $k > \max\{2\tau_B; \ 3\tau_S - \pi/2 - \pi u/\tau_B\}$ is a sufficient condition.

Assumption 3. $M_B^i = M_B^j = 0$.

Using this assumption, we can derive the demand of buyers and sellers for platform i.

Lemma 6. *Suppose Assumption 3 holds. Then demand of sellers and buyers is*

$$n_S^i = \frac{\tau_B \tau_S - \pi u_j + \tau_B (M_S^j - M_S^i)}{2\tau_B \tau_S - \pi(u_i + u_j)} \ and \ n_B^i = \frac{1}{2} + \frac{(M_S^j - M_S^i)(u_i + u_j) + \tau_S(u_i - u_j)}{4\tau_B \tau_S - 2\pi(u_i + u_j)}. \quad (A.5)$$

Buyer surplus u_i has a positive direct effect on the demand of sellers. Because of the virtuous circle, a larger u_i attracts more sellers, which in turn attracts more buyers etc.

We assume that the cost of serving an additional agent is vanishingly small for most digital platforms. We can now analyze the maximization problem of platform i

$$\max_{M_S^i, u_i} M_S^i \cdot n_S^i(M_S^i, M_S^j, u_i, u_j). \quad (A.6)$$

With flexible unshrouding, i chooses M_S^i, and whether to (un)shroud sellers' fees, i.e. u_i, simultaneously. We are mainly interested in whether platform i's profit increases as a result of shrouding sellers' fees, as summarized by the next Proposition.

Proposition 4. *Suppose Assumption 3 holds. Then the profit of platform i increases in u_i, for all $i \in \{1, 2\}$ and all u_j with $j \neq i$. Under platform competition with flexible shrouding, the platforms' shrouding incentives coincide with the monopoly platform's shrouding incentives.*

Competition with flexible shrouding induces the same shrouding incentives as of monopoly platforms. In both cases, platforms maximize profits by maximizing buyers' perceived surplus per interaction. Because platforms set prices and (un)shroud simultaneously, they only consider the direct positive effect of (un)shrouding via u_i on sellers' demand: a larger perceived surplus attracts more buyers, which in turn attracts more sellers. Thus, the shrouding conditions in Proposition 1 apply to this competitive case as well. More importantly, the results from Proposition 2 extend and with flexible shrouding platforms have stronger incentives to shroud than sellers without platforms.

Multihoming. Next, we work out under which conditions the results on shrouding incentives with flexible unshrouding are robust to the presence of multihoming sellers. To do so, we extend the previous model. We first focus on situations where platforms compete for singlehoming sellers, i.e. not exclusively for multihomers, and subsequently derive a sufficient condition for this to hold.

We model buyers as above. The share $\gamma \in (0, 1)$ of sellers multihome. They join a platform i if and only if $v_S^i = n_B^i \pi - M_s^i \geq 0$. Thus, we assume that mulihomers have zero opportunity cost of entering a platform, in contrast to singlehomers who have positive opportunity cost and only join a single platform. This captures the idea that multihomers are more likely to be professional businesses who enter a platform whenever it is profitable. $v_S^i \geq 0$ also implies that whenever singlehomers enter, multihomers do as well. The remaining $1 - \gamma$ sellers singlehome and are as above in this section. We assume that competition *on the platform* is unaffected by multihomers. Thus, supposing singlehomers enter, the number of sellers is now given by

$$n_S^i = \gamma + (1 - \gamma) \left[\frac{1}{2} + \frac{v_S^i - v_S^j}{2\tau_S} \right].$$

Intuitively, multihomers enter whenever $v_S^i \geq 0$, and singlehomers choose between the two platforms as above. As before, the number of buyers is $n_B^i = \frac{1}{2\tau_B} \left[\tau_B + v_B^i - v_B^j \right]$, and $v_B^i = n_S^i u_i$, where we use Assumption 3 again. We can follow the same steps as in Lemma 6 to derive sellers' demand for platform i, taking into account that now $n_S^i + n_S^j = 1 + \gamma$:

$$n_S^i = \frac{(1 + \gamma)\tau_B \tau_S - (1 - \gamma^2)\pi u_j + (1 - \gamma)\tau_B(M_S^j - M_S^i)}{2\tau_B \tau_S - (1 - \gamma)\pi(u_i + u_j)}$$

and demand of buyers for platform i

$$n_B^i = \frac{\tau_B - (1 + \gamma)u_j + n_S^i(u_i + u_j)}{2\tau_B}.$$

We see that both demand functions increase in u_i. This immediately implies that results from two-sided singlehoming are robust in this setting: with flexible unshrouding firms unshroud seller fees to maximize perceived buyer surplus and shrouding incentives for seller fees coincide with the monopolies' incentives.

Since the main results of monopoly platforms carry over to competition with flexible shrouding, competition on its own is not enough to induce unshrouding and a more transparent marketplace.

A.3   Rational Benchmark with Heterogeneous Consumers

The rational benchmarks in the main text assume for simplicity that all sophisticated consumers are identical and avoid additional fees if they expect them to be large. We show now that the

benchmark results also hold when some sophisticated consumers—just like naifs in the main text—pay additional fees also when they are expensive, but—unlike naifs in the main text—correctly anticipate large additional fees.

The share $1 - \gamma$ of consumers is sophisticated as in the main text. These consumers can avoid additional fees if they believe or observe that they are above e, their cost of avoiding additional fees. The remaining consumers γ do not avoid additional fees even when they are expensive and cost $\bar{a}$. These consumers have a willingness to pay $\bar{a}$ for an additional service. They are like naifs in the main text with the key difference that they correctly anticipate to pay additional fees, whether platforms shroud or unshroud them.

Unshrouding seller fees. We start with the platforms incentives to unshroud sellers' fees analoguous to Section 4.2 and proceed in two steps. First we investigate average buyer surplus u from interacting with sellers on the platform. Afterwards we can determine the optimal shrouding decisions of platforms.

When sellers charge large additional fees $a = \bar{a}$, avoiding consumers avoid additional fees, and the large additional fees extract the entire willingness to pay $\bar{a}$ of non-avoiding buyers. Thus, firms extract all surplus from non-avoiding buyers, and they have the same perceived utility than naive ones. This implies that $u^{un;\bar{a}} = u^{shr} = v - \frac{t}{4} - c - t + \gamma\bar{a} - (1 - \gamma)e$, with $f^{shr} = f^{un;\bar{a}} = c - \gamma\bar{a} + t$ and additional fees $\bar{a}$.

The implications, however, change for lower unshrouded additional fees $a = e$. As before, we get $f^{un;e} = c - e$ and $a = e$.[46] But buyer surplus now is

$$u^{un;e} = \gamma\left[v + \bar{a} - f^{un;e} - a\right] + (1 - \gamma)\left[v - f^{un;e} - a\right] = c + \gamma\bar{a} - c - t - \frac{t}{4}.$$

In contrast to naive consumers in the main text, sophisticated consumers actually have a large willingness to pay $\bar{a}$ for the additional service. Thus, average buyer surplus is larger in this case than with naive consumers. Since consumers have correct expectations, this means that also when additional fees are regulated at e but shrouded, we have $u^{shr;e} = u^{un;e}$.

Do sellers have an incentive to charge a above e when additional fees are unshrouded? While this might be optimal with naive consumers, it is never optimal with sophisticated consumers. The reason is that sophisticated non-avoiding consumers respond to increases in unshrouded additional

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[46] In fact any total price $f + a = c + t$ with $a \leq e$ is an equilibrium.

prices with decreased demand. More formally, suppose $f = c - e + t$ and $a = e$. An increase in a above e with unshrouded additional fees changes profits from non-avoiding sophisticates by

$$\gamma \left[\frac{1}{2} + \frac{e - a}{2t} \right] - \frac{\gamma}{2t} \left[c - e + t + a - c \right] = -\frac{\gamma}{t}(a - e) \leq 0.$$

Clearly, increasing a above e reduces profits from avoiding consumers, so the overall effect on profits is negative.

Similarly, reducing additional fees from $\bar{a}$ downwards such that $a > e$ increases profits by $\frac{\gamma}{t}(\bar{a} - a) \geq 0$. We conclude that firms never charge large additional fees $a = \bar{a}$ when additional fees are unshrouded.

The following Lemma summarizes these results.

Lemma 7. *Sellers always charge additional fees below e when platforms unshroud fees. $u^{shr;e} = u^{un;e} > u^{shr}$.*

Thus, even when sophisticated buyers have a large willingnes-to-pay $\bar{a}$ for unshrouded fees, the platform always prefers to unshroud sellers' fees when there are no naive buyers.

Unshrouding platform fees. We now follow Section 5 and show that if we replace naive buyers with sophisticates who have a willingness to pay $\bar{A}$ for additional services, the platform always unshrouds its additional fees.

To do so, we assume now that non-avoiding sophisticates also have a willingness-to-pay $\bar{A}$ for the service associated with the platform's additional fee.

First, suppose the platform shrouds its own fees. Then demand becomes

$$n_B^{shr} = n_S \left[u + \frac{1}{2}\gamma \left(\bar{A} - \mathbb{E}[A] \right) - \frac{1}{2}(1 - \gamma) \min\{\mathbb{E}[A], E\} \right] - M_B.$$

Buying the add-on increases utility of non-avoiding sophisticates by $\bar{A}$, and they have correct expectations about the price $\mathbb{E}[A]$. As in the proof of Proposition 3, this demand does not depend on A, implying the monopolist optimally sets $A = \bar{A}$. Using this, and that all consumers have correct Bayesian posteriors, we simplify demand to

$$n_B^{shr} = n_S \left[u - \frac{1}{2}(1 - \gamma)E \right] - M_B.$$

Substituting γ for α, this is the same demand as with shrouding in the proof of Proposition 3. Thus, profits under shrouding are $\Pi^{shr} = (u - \frac{1}{2}(1 - \gamma)E)(\pi + \frac{1}{2}\gamma\bar{A})$.

Second, suppose the platform unshrouds its additional fees. Then demand becomes

$$n_B^{un} = n_S \left[u + \frac{1}{2}\gamma \left(\bar{A} - A \right) - \frac{1}{2}(1-\gamma)\min\{A, E\} \right] - M_B.$$

Akin to assuming $\pi > u$ in proof of Proposition 3, $\pi > u + \frac{1}{2}\gamma\bar{A}$ implies the platform optimally sets $M_B = A = 0$, leading to profits $\Pi^{un} = \pi(u + \frac{1}{2}\gamma\bar{A})$. Note that if $u < \pi \le u + \frac{1}{2}\gamma\bar{A}$, Π^{un} is a lower bound for platform profits under unshrouding.

Finally, comparing Π^{un} and Π^{shr} shows the platform strictly prefers to unshroud for all $\gamma \in [0, 1)$.

We conclude that the results discussed in Section 7 translate to this more general rational benchmark where also some sophisticated consumers have a large willingness-to-pay for additional services.

A.4   Ex-ante Heterogeneous Buyers

In the main text we assume for simplicity that all buyers are ex-ante identical and learn whether they are naive or sophisticated only after joining the platform. In this extension we investigate how ex-ante buyer heterogeneity affects our main results. In particular, we first show that ex-ante heterogeneity reinforces our result in Proposition 2. Next, we show the results in Proposition 3 generalize under fairly weak conditions.

Shrouding seller fees.   First we analyze the model without the platform charging own additional fees in order to show robustness of Proposition 2. Recall from Section 4.1 that $u^{un} = \frac{1}{2}\left[v - \frac{5}{4}t - c \right]$, and we can reformulate naifs' and sophisticates' perceived utility under shrouding as $u^{naif} = u^{un} + \frac{\alpha(M_B)\bar{a}}{2}$ and $u^{soph} = u^{un} + \frac{\alpha(M_B)\bar{a}-e}{2}$, respectively, where $\alpha(M_B)$ is the share of naifs *on the platform*. As it will become clear in (A.8), the share of naifs is a function of M_B in this setting.

Let β denote the share of naifs *in the population*. From the linear valuation assumption the mass of naifs and sophisticates who join the platform is $\beta(u^{naif} - M_B)$ and $(1-\beta)(u^{soph} - M_B)$, respectively. We will assume in the following that some sophisticates join the platform, i.e.

$$u^{un} + \frac{\alpha(M_B)\bar{a} - e}{2} > M_B. \tag{A.7}$$

Then the share of naifs on the platform as a function of their share in the population is given by $\frac{\beta(u^{naif}-M_B)}{\beta(u^{naif}-M_B)+(1-\beta)(u^{soph}-M_B)}$, i.e.

$$\alpha(M_B) = \frac{\beta(u^{un} + \alpha(M_B)\overline{a}/2 - M_B)}{u^{un} - M_B + \alpha(M_B)\overline{a}/2 - (1-\beta)e/2} \tag{A.8}$$

Notice that $\alpha(M_B) > \beta$ for all M_B follows directly from $u^{naif} > u^{soph}$. The reason is that the perceived utility of joining the platform is higher for naifs than for sophisticates, thus a larger share of naifs join it. In the proof in Appendix B, we show that this share is well-defined: there is a unique $\alpha(M_B)$, between 0 and 1, for any M_B.

Let $u(M_B)$ denote the average perceived utility weighted by the share of buyers in the entire population, i.e. $u(M_B) = \beta u^{naif} + (1-\beta)u^{soph}$. The total number of buyers on the platform, n_B is then given by $u(M_B) - M_B$. As before, $M_S = n_B\pi$ and $n_S = 1$. The platform now solves

$$\max_{M_B} \ M_S + n_B M_B = n_B(\pi + M_B) = (u(M_B) - M_B)(\pi + M_B) \quad \text{s.t.} \quad M_B \geq 0.$$

In the proof in Appendix B we show that $\pi > \frac{u(M_B)}{1 - u'(M_B)}$ is a sufficient condition to have $M_B = 0$ as the optimal choice. This condition replaces the condition of $\pi > u$ we have in the baseline model.

Proposition 5. *Assume that buyers are ex-ante heterogeneous, some sophisticates join the platform, i.e. $u^{un} + \frac{\alpha(M_B)\overline{a} - e}{2} > M_B$, and $\pi > \frac{u(M_B)}{1 - u'(M_B)}$. Then the optimal membership fees are $M_B = 0$, $M_S = u\pi$, and the platform's profit equals $u\pi$. The platform shrouds seller fees if and only if $\alpha(M_B)\overline{a} > (1-\beta)e$, thus it has stronger incentives to shroud than sellers on a laissez-faire platform.*

The equivalent of the shrouding condition in the baseline model is $\beta\overline{a} > (1-\beta)e$ as there we assume that the share of naifs on the platform equals their share in the entire population, β. With ex-ante buyer heterogeneity, there are more naifs on the platform than in the population $(\alpha(M_B) > \beta)$, thus the condition in Proposition 5 is less stringent than its equivalent in the baseline model. In other words, with ex-ante heterogeneous buyers the unshrouding incentive (i.e. the cutoff value for the share of naifs making it worth shrouding) is lower than its equivalent in the baseline model, which is already lower than in the laissez-faire benchmark. Therefore ex-ante heterogeneity reinforces the result in Proposition 2, namely that a platform has stronger incentives to shroud seller fees than sellers themselves in a laissez-faire situation.

Shrouding platform fees. Now we analyze the model where the platform has the possibility to charge own additional fees. There are four cases depending on whether the platform shrouds or unshrouds seller fees and its own additional fees.

We proceed in two steps. First, we show that under some conditions, the platform's shrouding incentives of seller fees are stronger than sellers' on a laissez-faire platform, despite its ability to also charge platform fees. In other words, we generalize both Proposition 2 and Proposition 5. Second, we partially generalize all the statements in Proposition 3 about unshrouding platform fees. In particular, for this statement, we make the simplifying assumption that buyers are only ex-ante heterogeneous in their perception of platform fees but not seller fees. We derive conditions under which there exists a unique cutoff value of unshrouding incentive for platform fees such that the platform unshrouds their own fees if and only if the share of naifs is lower than this cutoff. Moreover, this cutoff value is increasing in sellers' profit and decreasing in the perceived average utility of buyers.

We will make the following assumption:

$$\pi > \max\{u^{un}; \ u^{un} + \frac{\alpha\bar{a}}{2} - (1-\beta)\frac{e}{2}\} > (1-\beta)\frac{E}{2}. \tag{A.9}$$

The first inequality replaces the assumption $\pi > u$ in the baseline model. The second inequality is reminiscent to the assumption A.7, it guarantees that some sophisticates join the platform in each of the four possible shrouding scenarios. The next proposition establishes the first result about potentially shrouded platform fees.

Proposition 6. *Assume* $\pi > \max\{u^{un}; \ u^{un} + \frac{\alpha\bar{a}}{2} - (1-\beta)\frac{e}{2}\} > (1-\beta)\frac{E}{2}$. *Then the platform has stronger incentives to shroud seller fees than sellers on a laissez-faire platform, both when it shrouds and when it unshrouds its own fees.*

The proof, relegated to Appendix B, is constructive. It consists in deriving the platform's profit in each of the four shrouding scenarios and comparing the profit under shrouded and unshrouded platform fees. Intuitively, positive cross-group externalities are present under ex-ante buyer heterogeneity as well, thus increasing the perceived utility of buyers increases participation of buyers on the platform, which in turn allows it to extract higher surplus from sellers.

We can now compare the profit of the platform when it shrouds its own fees to the scenario when it does not, both under shrouded and unshrouded seller fees. The following proposition

generalizes Proposition 3 to the case of ex-ante buyer heterogeneity with respect to platform fees, while assuming homogeneity with respect to seller fees.

Proposition 7. *Assume that buyers are ex-ante heterogeneous in their perception of platform fees but homogeneous with respect to seller fees. Assume $\pi > \max\{u^{un};\ u^{un} + \frac{\alpha\bar{a}}{2} - (1-\beta)\frac{e}{2}\}$ and $u^{un} > (1-\beta)\frac{e+E}{2}$. Under both shrouded and unshrouded seller fees, there exists a threshold value for the incentive to unshroud platform fees in (0,1). These threshold values are strictly increasing in seller surplus π and strictly decreasing in perceived average buyer surplus $u(M_B)$.*

The proof is relegated to Appendix B. The intuition is that ex-ante buyer heterogeneity with respect to platform fees increases the share of naifs present on the platform compared to the baseline model, but leaves the main mechanisms otherwise unchanged. Thus, unshrouding the platform still trades off larger margins from sellers with lower margins from buyers. Therefore, everything else equal, the platform finds it more profitable to unshroud whenever seller surplus π is large and perceived buyer surplus $u(M_B)$ is small.

B Proofs (Intended for Online Appendix)

Proof of Lemma 1. The Lemma follows immediately from comparing u^{shr}, and u^{un} in the main text. We now proof a more general version that allows for imperfect unshrouding and holds for all $\lambda \in (0,1]$. λ captures the share of naive buyers that unshrouding turns into sophisticated buyers. We prove the more general statement in two steps.

We start with Lemma 4 to pin down additional fees, and then proof Lemma 5, which generalizes Lemma 1. Both Lemmas are stated in the Appendix in Section A.1 where we summarize results in imperfect unshrouding.

Proof of Lemma 4. We first consider the case where $a_s \leq e$. Seller s has the following profits:

$$(1-\lambda)\alpha\left(\frac{1}{2} + \frac{f_r - f_s}{2t}\right)(f_s + a_s - c) + (1 - (1-\lambda)\alpha))\left(\frac{1}{2} + \frac{f_r + \min\{a_r, e\} - f_s - a_s}{2t}\right)(f_s + a_s - c).$$

Seller s chooses f_s and a_s. Clearly, profits from sophisticates only depend on the total price $f_s + a_s$, but demand from naifs is independent of a_s. Therefore, an increase in a_s is more profitable than an equal increase in f_s, and s optimally sets $a_s = e$. To see this, note that a combination (f_s, a_s) with $a_s < e$ cannot be optimal. Seller s can increase profits by charging (f_s', e) such that

$f'_s + e = f_s + a_s$. This keeps profits from sophisticates and margins from naifs unaffected while increasing demand from naifs. Note that for special case $\lambda = 1$, all $a_s \leq e$ are also optimal.

Similarly, $a_s > e$ sophisticates avoid additional fees and naifs do not observe increases of a_s. Thus, each seller s chooses either $a_s = e$ or $a_s = \bar{a}$.

When s charges $a_s = e$, it earns

$$(f_s + e - c)\left(\frac{1}{2} + \frac{f_r + \min\{a_r, e\} - f_s - e}{2t}\right) = (f_s + e - c)\left(\frac{1}{2} + \frac{f_r - f_s}{2t}\right).$$

Since rival r either charges $a_r = e$ or $a_r = \bar{a}$, we know that $\min\{a_r, e\}$. Alternatively, s could charge $a_s = \bar{a}$ and earn

$$(f_s + (1 - \lambda)\alpha\bar{a} - c)\left(\frac{1}{2} + \frac{f_r + e - f_s - \min\{\bar{a}, e\}}{2t}\right) = (f_s + (1 - \lambda)\alpha\bar{a} - c)\left(\frac{1}{2} + \frac{f_r - f_s}{2t}\right).$$

Notice that the larger additional fee does not reduce demand for firm s as sophisticates avoid it by paying e, and naifs do not take it into account. This is also why s's profits from $\bar{a}$ or e do not depend on whether r charges $\bar{a}$ or e. Thus, with unshrouded additional fees sellers prefer to charge low fees $a_s = e$ if and only if $(1 - \lambda)\alpha\bar{a} < e$. For $\lambda = 1$, all $a_s \leq e$ are optimal. □

Proof of Lemma 5. Using Lemma 4, we prove Lemma 5 in the text in Appendix A.1. □

This concludes the proof of Lemma 1.

□

Proof of Lemma 2.

We proceed in three steps. In the first step, we show that the claims in the Lemma hold if there are two sellers per product category. In the second step, we show that it is indeed optimal for the platform to have two sellers per product category whenever Assumption 2 holds. In the third step, we show the existence and uniqueness of the equilibrium described in the Lemma.

Step 1: Membership fees with two sellers per product category. Assume there are two sellers per category. As the platform induces full participation from the seller side ($n_S = 1$) the demand of buyers is $n_B = u - M_B$. Therefore the optimal membership fee M_S extracts all the surplus from sellers and writes as $M_S = (u - M_B)\pi$. Using these observations, the maximization problem of the monopoly platform boils down to

$$\max_{M_B, u} M_S + n_B M_B = (u - M_B)(\pi + M_B) \quad \text{s.t.} \quad M_B \geq 0. \tag{B.1}$$

The optimal membership fee for buyers is $M_B = \max\{\frac{u-\pi}{2}; 0\}$. By Assumption 1, $u - \pi < 0$, so $M_B = 0$, thus $M_S = u\pi$, and the platform's profit is $u\pi$ as well. This optimal profit is strictly increasing in u. This concludes the first step of the proof.

Step 2: Platform prefers duopoly sellers. We show that the platform indeed prefers to have duopoly sellers over monopoly sellers in each product category. We show this for the more general case with imperfect unshrouding where $\lambda \in (0, 1]$ captures the share of naive buyers that unshrouding turns into sophisticated ones. The results displayed in the main text obtain for the special case with $\lambda = 1$. Note that for $\lambda \in (0, 1]$, Assumption 2 becomes $\frac{7}{4}t \leq v - c + \min\{\alpha\bar{a} - (1-\alpha)e, (1 - (1-\lambda)\alpha)e\}$, and $v - c + \max\{\alpha\bar{a} + (1-\alpha)e, (2 - (1-\lambda)\alpha)e\} \leq 2t$. For $\lambda = 1$, this becomes $\frac{7}{4}t \leq v - c + \min\{\alpha\bar{a} - (1-\alpha)e, e\}$, and $v - c + \max\{\alpha\bar{a} + (1-\alpha)e, 2e\} \leq 2t$.

Step 2/a: Unshrouded seller fees. First we look at the case of unshrouded additional fees. To start, we show that when the platform unshrouds, monopoly sellers charge $a_s \leq e$. Towards a contradiction, suppose the opposite. Given monopoly sellers charge $a_s > e$, they optimally charge $a_s = \bar{a}$. Given $a_s > e$, sophisticated buyers avoid additional fees in equilibrium, and a larger a_s increases margins from naive buyers without reducing demand from any buyer. Thus, monopoly sellers charge $a_s = \bar{a}$. We show now that given the platform unshrouds and monopoly sellers charge $a_s = \bar{a}$, the platform prefers to shroud instead and sell to monopoly sellers. Note first that under shrouding, buyers cannot condition their purchase decision on a_s, and monopoly sellers also charge additional fees $\bar{a}$. Shrouding increases the share of naive consumers who pay $\bar{a}$, benefiting monopoly sellers. Also perceived buyer surplus increases with shrouding because more naive buyers falsely ignore $\bar{a}$, and fewer sophisticated buyers pay avoidance cost e, both effects increase perceived buyer surplus. Thus, deviating to shrouding increases buyer and seller surplus per interaction, which attracts more buyers, raises seller profits, and therefore allows the platform to raise profits, a contradiction. We conclude that when the platform unshrouds, monopoly sellers charge $a_s \leq e$.

We now characterize profits and perceived buyer surplus given the platform unshrouds. To start, we show that when the platform unshrouds, monopoly sellers charge $a_s = e$. We know that monopoly sellers charge $a_s \leq e$. We now show that with unshrouding, monopolists charge additional fees $a_s = e$. Suppose otherwise, then they could raise a_s and reduce f_s by the same amount to raise demand from naive buyers without affecting demand or margins from sophisticated ones. Thus, when the platform unshrouds, monopoly sellers charge $a_s = e$.

Using these steps, we can write down the profits of the monopoly seller as

$$\frac{v - f_s - (1 - (1 - \lambda)\alpha)e}{t} \cdot (f_s + e - c).$$

The profits are maximized at

$$f_M^{un} = \frac{1}{2}(v + c - (2 - (1 - \lambda)\alpha)e).$$

Assumption 2 requires that the monopolist seller's maximization problem have an internal solution for both buyer types. For the case of unshrouding, this condition writes as $v - c + (2 - (1 - \lambda)\alpha)e \leq 2t$.

It is then straightforward to derive the profit of a monopolist seller who charges $a_s = e$ and the ensuing buyer surplus per seller:

$$\pi_M^{un} = \frac{(v - c + (1 - \lambda)\alpha e)^2}{4t}$$

and $\quad u_M^{un} = (1 - \lambda)\alpha \frac{(v - c + (2 - (1 - \lambda)\alpha)e)^2}{8t} + (1 - (1 - \lambda)\alpha)\frac{(v - c - (1 - \lambda)\alpha e)^2}{8t}.$

To calculate u_M^{un}, note that

$$u_M^{un} = (1 - \lambda)\alpha \int_0^{\frac{v - f_M^{un}}{t}} v - xt - f_M^{un} dx + (1 - (1 - \lambda)\alpha) \int_0^{\frac{v - f_M^{un} - e}{t}} v - xt - f_M^{un} - e dx.$$

We now compare profits and perceived buyer surplus under unshrouding in a product category for a monopoly seller and duopoly sellers. Comparing the monopolist seller's profit to the total profit of the two sellers in a category in the baseline model, we find that the monopolist has a lower profit if and only if

$$\pi_M^{un} \leq 2\pi \iff \frac{(v - c + (1 - \lambda)\alpha e)^2}{4t} < t \iff v - c + (1 - \lambda)\alpha e \leq 2t,$$

which is true by Assumption 2, i.e. since $v - c + (2 - (1 - \lambda)\alpha)e \leq 2t$. We conclude that with monopoly sellers in the product categories, total profits decrease in each product category.

We now compare perceived buyer surplus under unshrouding in a product category. Perceived buyer surplus in a product category decreases with a monopoly seller if

$$u_M^{un} \leq 2u^{un;e} \iff$$

$$(1 - \lambda)\alpha \frac{(v - c + (2 - (1 - \lambda)\alpha)e)^2}{8t} + (1 - (1 - \lambda)\alpha)\frac{(v - c - (1 - \lambda)\alpha e)^2}{8t} \leq v - c + (1 - (1 - \lambda)\alpha)e - \frac{5}{4}t.$$

We defined $u^{un;e}$ in Appendix A.1 as perceived average buyer surplus per buyer when the platform unshrouds and the duopoly sellers sellers charge e. Note that $u^{un;\bar{a}}$ can be larger than $u^{un;e}$ by Lemma 5, in which case the above is a sufficient condition. Since there are twox sellers per product category, we need to multiply $u^{un;e}$ by 2 to properly compare buyer surplus in a product category. As $v - c + (2 - (1 - \lambda)\alpha)e) > v - c - (1 - \lambda)\alpha e$, a sufficient condition for $u_M^{un} \leq 2u^{un;e}$ is

$$\frac{(v - c + (2 - (1 - \lambda)\alpha)e)^2}{8t} \leq v - c + (1 - (1 - \lambda)\alpha)e - \frac{5}{4}t.$$

Using $v - c + (2 - (1 - \lambda)\alpha)e \leq 2t$, this condition is implied by

$$v - c + (1 - (1 - \lambda)\alpha)e \geq \frac{7}{4}t,$$

We conclude that perceived buyer surplus under unshrouding is larger in a product category with duopoly sellers. Thus, if $\frac{7}{4}t \leq v - c + (1 - (1 - \lambda)\alpha)e$, and $v - c + (2 - (1 - \lambda)\alpha)e \leq 2t$ hold, with duopoly sellers the platform attracts more buyers for given membership fees to buyers, and sellers earn more profit per buyer in each product category, implying that the platform can charge larger membership fees to sellers per product category. Thus, the platform can earn larger fees and we conclude that the platform prefers unshrouding with duopolists in each product category over unshrouding with monopolists in each product category.

Step 2/b: Shrouded seller fees. Next, we investigate the case of shrouded additional fees. Suppose for now an interior solution for both buyer types. The profits of a monopoly seller under shrouding are

$$(1 - \alpha)\frac{v - f - e}{t}(f - c) + \alpha\frac{v - f}{t}(f + \bar{a} - c) = \frac{v - f - (1 - \alpha)e}{t}(f + \alpha\bar{a} - c) + \frac{\alpha(1 - \alpha)\bar{a}e}{t}.$$

Optimizing leads to $f_M^{shr} = \frac{v + c - \alpha\bar{a} - (1 - \alpha)e}{2}$, and profit of a monopolist seller and the ensuing buyer surplus per interaction:

$$\pi_M^{shr} = \frac{(v - c + \alpha\bar{a} + (1 - \alpha)e)^2}{4t} - \frac{(1 - \alpha)(v - c)e}{t}$$

$$\text{and} \quad u_M^{shr} = \frac{(v - c + \alpha\bar{a} + (1 - \alpha)e)^2}{8t} - \frac{(1 - \alpha)e}{2t}(v - c + \alpha(\bar{a} - e)).$$

To calculate u_M^{shr}, note that

$$u_M^{shr} = \alpha\int_0^{\frac{v - f_M^{shr}}{t}} v - xt - f_M^{shr}dx + (1 - \alpha)\int_0^{\frac{v - f_M^{shr} - e}{t}} v - xt - f_M^{shr} - edx.$$

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Assumption 2 requires that monopoly sellers do not sell to all consumers of both types, which holds if and only if $\frac{v - f_M^{shr}}{t} \leq 1 \iff v - c + \alpha\bar{a} + (1-\alpha)e \leq 2t$ holds.

We compare total profits and buyer surplus in a product category with a monopoly and duopoly sellers under shrouding. Starting with total profits, we get

$$\pi_M^{shr} < 2\pi = t \iff \frac{(v - c + \alpha\bar{a} + (1-\alpha)e)^2}{4t} - \frac{(1-\alpha)(v-c)e}{t} < t.$$

A sufficient condition is

$$\frac{(v - c + \alpha\bar{a} + (1-\alpha)e)^2}{4t} < t,$$

which is equivalent to $v - c + \alpha\bar{a} + (1-\alpha)e \leq 2t$ and holds for interior solutions.

Looking now at buyer surplus, we get that total perceived buyer surplus in a product category decreases with a monopoly seller if

$$u_M^{shr} \leq 2u^{shr} \iff \frac{(v - c + \alpha\bar{a} + (1-\alpha)e)^2}{8t} - \frac{(1-\alpha)e}{2t}(v - c + \alpha(\bar{a} - e)) \leq v - c + \alpha\bar{a} - (1-\alpha)e - \frac{5}{4}t.$$

A sufficient condition is

$$\frac{(v - c + \alpha\bar{a} + (1-\alpha)e)^2}{8t} \leq v - c + \alpha\bar{a} - (1-\alpha)e - \frac{5}{4}t.$$

Using $v - c + \alpha\bar{a} + (1-\alpha)e \leq 2t$, a sufficient condition is

$$\frac{7}{4}t \leq v - c + \alpha\bar{a} - (1-\alpha)e.$$

Thus, if this condition holds, the perceived buyer surplus and total profits under shrouding are larger in a product category with duopoly sellers. Thus, if $\frac{7}{4}t \leq v - c + \alpha\bar{a} - (1-\alpha)e$ and $v - c + \alpha\bar{a} + (1-\alpha)e \leq 2t$ hold, with duopoly sellers the platform attracts more buyers for given membership fees for buyers, and can earn larger membership fees from sellers per product category. We conclude that the platform prefers shrouding with duopolists in each product category over shrouding with monopolists in each product category.

Combining the results under shrouding and unshrouding, we conclude that if $\frac{7}{4}t \leq v - c + \min\{\alpha\bar{a} - (1-\alpha)e, (1 - (1-\lambda)\alpha)e\}$, and $v - c + \max\{\alpha\bar{a} + (1-\alpha)e, (2 - (1-\lambda)\alpha)e\} \leq 2t$ hold, it is never optimal for the platform to have monopoly sellers in the product categories. Additionally, by the first step in this proof, the platform can set $M_S = (u - M_B)\pi$ to attract two sellers in each product category. This concludes Step 2 of the proof.

Step 3: Existence and uniqueness of equilibrium. Next, we show that Assumptions 1, 2 and the covered market assumption under duopoly sellers on the platform can be jointly satisfied, i.e. the equilibrium exists. First, Assumption 1 writes as $v - c + \max\{\alpha\bar{a} - (1-\alpha)e, 0\} \leq \frac{9}{4}t$. Second, Assumption 2 requires $\frac{7}{4}t \leq v - c + \min\{\alpha\bar{a} - (1-\alpha)e, (1 - (1-\lambda)\alpha)e\}$ and $v - c + \max\{\alpha\bar{a} + (1-\alpha)e, (2 - (1-\lambda)\alpha)e\} \leq 2t$. Third, duopoly markets are covered for both buyer types if and only if $v - c + \max\{\alpha\bar{a} - e, 0\} \geq \frac{3}{2}t$. It is straightforward to verify that the four conditions are jointly satisfied when $e \to 0$ and $v - c + \alpha\bar{a} < 2t$ and $\frac{7}{4}t < v - c$.

Finally, the uniqueness of the equilibrium is guaranteed as the strategy described in Step 1 leads to the unique maximum of the platform's profit, since by Steps 2, Assumption 2 implies the platform always prefers duopoly sellers over monopoly sellers on the platform, and since we focus on equilibria with a strictly positive mass of buyers and sellers on the platform. This concludes the proof. □

Proof of Proposition 1. We show the more general version for all $\lambda \in (0, 1]$. This is why we refer to Lemma 5 instead of Lemma 1, because Lemma 5 is the more general case for all $\lambda \in (0, 1]$. Proposition 1 obtains for the special case $\lambda = 1$.

By Lemma 2, the monopoly platform chooses between shrouding and unshrouding based on what maximizes the cross-group externality u, i.e. perceived surplus of buyers of each interaction on the platform. Thus, the Proposition follows directly from Lemma 5. We proceed in three steps.

First, Lemma 5 states that sellers earn the same profits whether the platform shrouds or unshrouds. Thus, the platform chooses between shrouding and unshrouding based on what maximizes perceived buyer surplus.

Second, Lemma 5 shows that $u^{shr} \geq u^{un;\bar{a}}$, i.e. if sellers continue to charge large unshrouded additional fees, the platform prefers to shroud these fees. Additionally, $u^{shr} \geq u^{un;e}$ if and only if $\alpha \geq \underline{\alpha}_\lambda \equiv \frac{e}{\bar{a} + \lambda e}$. Thus, if $\alpha \geq \underline{\alpha}_\lambda$ the platform prefers to shroud additional fees.

Third, if $\alpha < \underline{\alpha}_\lambda$, we also have $\alpha < \bar{\alpha} = \frac{e}{(1-\lambda)\bar{a}}$ and Lemma 4 implies that sellers charge low additional fees e if the platform unshrouds. Since $u^{shr} < u^{un;e}$ if and only if $\alpha < \underline{\alpha}_\lambda$, the platform unshrouds if and only if $\alpha < \underline{\alpha}_\lambda$. Note that for the special case $\lambda = 1$, we define $\underline{\alpha} \equiv \underline{\alpha}_1 = \frac{e}{\bar{a} + e}$. This concludes the proof. □

Proof of Lemma 3.

A firm i that deviates from the shrouding equilibrium by unshrouding optimally sets $a_s = e$. With a larger a_s, unshrouding only reduces the share of profitable naive consumers and can never be optimal. With a smaller $a_s < e$, firm s could increase demand from consumers who remain naive by increasing a_s while keeping $f_s + a_s$ constant to keep demand from sophisticated consumers unaffected. Thus, deviating firms maximize

$$(1 - \hat{\lambda})\alpha \left(\frac{1}{2} + \frac{f^{shr} - f_s}{2t} \right) (f_s + e - c) + \left(1 - (1 - \hat{\lambda})\alpha \right) \left(\frac{1}{2} + \frac{f^{shr} + e - f_s - e}{2t} \right) (f_s + e - c),$$

which simplifies to

$$\left(\frac{1}{2} + \frac{f^{shr} - f_s}{2t} \right) (f_s + e - c).$$

Using $f^{shr} = c - \alpha\bar{a} + t$ from above, $f_s = c + t - \frac{1}{2}(\alpha\bar{a} + e)$ maximizes s's deviation profits, earning s a profit of $\pi^{dev} = \frac{1}{2t}\left(t + \frac{e - \alpha\bar{a}}{2}\right)^2$. Thus, this deviation from the shrouding equilibrium is unprofitable if $\pi = t/2 > \pi^{dev}$, that is $\alpha \geq \frac{e}{\bar{a}}$. We conclude that at least one firm unshrouds if $\alpha < \frac{e}{\bar{a}}$.

It remains to show that if $\alpha < \frac{e}{\bar{a}}$, both firms unshroud. To do so, suppose towards a contradiction that a firm s shrouds and her rival $u \neq s$ unshrouds. Again, consumers of firm s cannot condition the purchase decision on a_s, so firm s optimally sets $a_s = \bar{a}$. Profits are

$$\left(\frac{1}{2} + \frac{f_u - f_s}{2t} \right) \left(f_s + (1 - \hat{\lambda})\alpha\bar{a} - c \right).$$

By Lemma 4, firm u optimally sets $a_u = e$, earning

$$\left(\frac{1}{2} + \frac{f_s - f_u}{2t} \right) (f_u + e - c).$$

This leads to candidate equilibrium prices $f_s = c + t - \frac{2}{3}(1 - \hat{\lambda})\alpha\bar{a} - \frac{1}{3}e$ and $f_u = c + t - \frac{1}{3}(1 - \hat{\lambda})\alpha\bar{a} - \frac{2}{3}e$, and profits $\frac{1}{2t}\left(t + \frac{(1 - \hat{\lambda})\alpha\bar{a} - e}{3}\right)^2$ and $\frac{1}{2t}\left(t + \frac{e - (1 - \hat{\lambda})\alpha\bar{a}}{3}\right)^2$ for firms s and u respectively.

It is straightforward to show that firm s could deviate by unshrouding and charging $f_s = c + t - \frac{1}{6}(1 - \hat{\lambda})\alpha\bar{a} - \frac{5}{6}e$ and earn $\frac{1}{2t}\left(t + \frac{e - (1 - \hat{\lambda})\alpha\bar{a}}{6}\right)^2$. Since $(1 - \hat{\lambda})\alpha < \alpha < \frac{e}{\bar{a}}$, this deviation is strictly profitable. We conclude that if $\alpha < \frac{e}{\bar{a}}$, both firms must unshroud.

It remains to show that if $\alpha < \frac{e}{\bar{a}}$ and both firms unshroud, none has an incentive to deviate. As shown above, when both firms unshroud they charge $f^{un} = c + t - e$ and $a_s = e$ and earn $t/2$. Deviating and shrouding earns a firm $\frac{1}{2t}\left(t + \frac{1}{2}\left((1 - \hat{\lambda})\alpha\bar{a} - e\right)\right)^2$, which is not profitable if $\alpha < \frac{e}{\bar{a}}$. We conclude that if $\alpha < \frac{e}{\bar{a}}$ and both firms unshroud, none has an incentive to deviate. This concludes the proof. $\square$

Proof of Proposition 2. We show the more general version for all $\lambda \in (0, 1]$. Proposition 2 obtains for the special case $\lambda = 1$.

The Proposition follows immediately from the formulas in Lemma 5 and the assumption of $\lambda > 0$:

$$\underline{\alpha}_\lambda < \hat{\alpha} < \bar{\alpha} \Longleftrightarrow \frac{e}{\bar{a} + \lambda e} < \frac{e}{\bar{a}} < \frac{e}{\bar{a} - \lambda \bar{a}}.$$

$\square$

Proof of Proposition 3.

We prove the result in the more general setting where $\lambda \in (0, 1]$, i.e. where unshrouding only turns the share λ of naive buyers into sophisticated ones. We obtain Proposition 3 for the special case where $\lambda = 1$.

Lemma 8. *Suppose Assumptions 1 and 2 hold, and that either $(1 - \lambda)\alpha \leq \frac{\pi - u}{\pi}$ or $(1 - \lambda)\alpha > \frac{2u + 2\pi + \bar{A}}{2u\frac{\bar{A}}{E} + 2\pi + \bar{A}}$. The platform shrouds sellers' fees if and only if $\alpha \geq \underline{\alpha} = \frac{e}{\bar{a} + e}$. The platform charges $M_B = 0$. When shrouding platform fees it charges $A = \bar{A}$, and when unshrouding platform fees $A = 0$. The platform shrouds A if and only if $\alpha \geq \alpha'$, for a unique $\alpha' \in (0, 1)$. α' is strictly decreasing in u and strictly increasing in π.*

Proof of Lemma 8.

We proceed in three steps. First we suppose the platform shrouds A. Second, we suppose it unshrouds A. Third, we characterize when the platform prefers unshrouding.

Before we start the proof, note that by Lemma 2 we focus on settings with duopoly sellers in each product category.

We start with the first step and suppose the platform shrouds A. The platform optimally charges $M_S = n_B \pi$, inducing $n_s = 1$.

Under shrouding, buyers' valuation (3) depends on expectations about A, but not on A directly. Thus, a marginal increase in A increases margins of the platform without reducing demand, and the platform charges $A = \bar{A}$. Buyers' demand becomes

$$n_B = u - \frac{1}{2}(1 - \alpha)E - M_B.$$

Using these steps, we can simplify the platform's profits to

$$n_S M_S + \frac{1}{2} n_B n_S \alpha \bar{A} + n_B M_B = (u - \frac{1}{2}(1 - \alpha)E - M_B)(\pi + \frac{1}{2}\alpha\bar{A} + M_B).$$

It is straightforward to show that $M_B = 0$ is optimal if $\pi \geq u - \frac{1}{2}\alpha\bar{A} - \frac{1}{2}(1-\alpha)E$, which holds by Assumption 1. We conclude that Assumption 1 implies $M_B = 0$.

If $\pi \geq u$, profits under shrouding are $\Pi^{shr} = (u - \frac{1}{2}(1-\alpha)E)(\pi + \frac{1}{2}\alpha\bar{A})$. This increases in u.

We now move on to the second step and suppose the platform unshrouds A. The platform optimally sets $M_S = n_B\pi$. Larger prices reduce profits to zero, and smaller prices induce smaller profits without increasing demand. $M_S = n_B\pi$ implies that $n_S = 1$ in equilibrium.

Demand from buyers becomes

$$n_B = u - \frac{1}{2}(1 - (1-\lambda)\alpha)\min\{A, E\} - M_B = u - \frac{1}{2}(1 - (1-\lambda)\alpha)A - M_B.$$

The second equality uses that $n_S = 1$ and that after unshrouding, the share $(1 - (1-\lambda)\alpha)$ of consumers is sophisticated. The third equality uses that with unshrouding, $A \leq E$ is optimal. Unshrouding without reducing A below E only reduces demand (i.e. from naifs) and is never optimal. Thus, the platform's profits become

$$n_S M_S + n_B M_B + \frac{1}{2}n_S n_B A = n_B(\pi + M_B + \frac{1}{2}A) = (u - M_B - \frac{1}{2}(1 - (1-\lambda)\alpha)A)(\pi + M_B + \frac{1}{2}A).$$

It is straightforward to show that Assumption 1 implies that $M_B = 0$ is optimal. In addition, $A = 0$ is optimal if

$$(1-\lambda)\alpha \leq \frac{\pi - u}{\pi}. \tag{B.2}$$

We conclude that the candidate equilibrium profits under unshrouding are $\Pi^{un} = \pi u$, which increases in u.

We now show that $A = 0$ under unshrouding also if

$$(1-\lambda)\alpha \geq \frac{2u + 2\pi + \bar{A}}{2u\frac{\bar{A}}{E} + 2\pi + \bar{A}}. \tag{B.3}$$

To do so, we derive a sufficient condition for shrouding to be optimal over unshrouding. An upper bound for profits under unshrouding is $u(\pi + \frac{1}{2}E)$. In this case all consumers ignore unshrouded fees, but the platform still earns the margin E. Shrouding is more profitable if $\Pi^{shr} \geq u(\pi + \frac{1}{2}E)$, which we can simplify to

$$\frac{(1-\lambda)\alpha}{2}\bar{A}u - \frac{(1 - (1-\lambda)\alpha)}{2}E\pi - \frac{(1-\lambda)\alpha(1 - (1-\lambda)\alpha)}{4}\bar{A}E \geq \frac{1}{2}Eu.$$

A sufficient condition for this is

$$2(1-\lambda)\alpha\bar{A}u - 2(1-(1-\lambda)\alpha)E\pi - ((1-\lambda)\alpha)\bar{A}E \geq 2Eu,$$

which we can rearrange to obtain (B.3). Note that the right-hand-side in (B.3) is below $\frac{\pi-u}{\pi}$ if E is sufficiently small, implying that the platform either unshrouds and sets $A = 0$, or shrouds. We conclude that if either (B.2) or (B.3) hold, $A = 0$ under unshrouding and $\Pi^{un} = \pi u$.

Thus, under shrouding and unshrouding the platform profits increase in u, implying that incentives to shroud sellers' fees are unaffected and are the same as in Proposition 1.

We now proceed to the third step and ask when the platform prefers to unshroud its own fees, i.e. $\Pi^{un} \geq \Pi^{shr}$. This condition simplifies to

$$\alpha \leq \frac{E\pi}{\bar{A}u + E\pi - (1-\alpha)E\bar{A}/2}.$$

The left-hand side increases in α and the right-hand side decreases in α. At $\alpha = 0$, the l.h.s. is zero and since $u \geq E$, the r.h.s. is strictly positive. At $\alpha = 1$, the l.h.s. equals 1 and the r.h.s. is strictly less than 1. Thus, there is a unique $\alpha' \in (0,1)$ such that this equation holds, and for all $\alpha < \alpha'$, the platform strictly prefers to unshroud.

Applying the implicit function theorem to the equation at α' leads to

$$\frac{\partial \alpha'}{\partial u} = -\frac{\alpha'\bar{A}}{\bar{A}u + E\pi - (1-2\alpha')E\bar{A}/2} < 0,$$

and

$$\frac{\partial \alpha'}{\partial \pi} = \frac{(1-\alpha')E}{\bar{A}u + E\pi - (1-2\alpha')E\bar{A}/2} > 0,$$

where the inequalities follow from $u \geq E$.

Finally, since the r.h.s. decreases in α, a sufficient condition under which unshrouding is optimal is $\alpha \leq \frac{E\pi}{\bar{A}u+E\pi}$.

This concludes the proof. $\square$

Proof of Lemma 6. By plugging (A.4) into (A.3) and using $n_B^j = 1 - n_B^i$, one can express the number of agents joining the platforms as a function of the fees and n_B^i:

$$n_S^i = \frac{1}{2} + \frac{M_S^j - M_S^i + n_B^i\pi - (1-n_B^i)\pi}{2\tau_S} = \frac{1}{2} + \frac{M_S^j - M_S^i - \pi}{2\tau_S} + \frac{\pi}{\tau_S}n_B^i \qquad \text{(B.4)}$$

Using the same steps, we get the number of buyers on platform i:

$$n_B^i = \frac{1}{2} + \frac{v_B^i - v_B^j}{2\tau_B} = \frac{1}{2} + \frac{M_B^j - M_B^i - u_j}{2\tau_B} + \frac{u_i + u_j}{2\tau_B} n_S^i.$$

Plugging this expression back into equation (B.4), and rearranging terms reveals demand only as a function of membership fees and cross-group externalities, i.e.

$$n_S^i = \frac{2\tau_B\tau_S - 2u_j\pi + 2\pi(M_B^j - M_B^i) + 2\tau_B(M_S^j - M_S^i)}{4\tau_B\tau_S - 2\pi(u_i + u_j)}, \tag{B.5}$$

and similarly

$$n_B^i = \frac{2\tau_B\tau_S - \pi(u_i + u_j) + (M_S^j - M_S^i)(u_i + u_j) + 2\tau_S(M_B^j - M_B^i) + \tau_S(u_i - u_j)}{4\tau_B\tau_S - 2\pi(u_i + u_j)}. \tag{B.6}$$

Using Assumption 3 leads to (A.5). $\square$

Proof of Proposition 4. In the following we show that platform i's profit increases in perceived buyer surplus u_i. This implies that as in Section 4.2 shrouding is beneficial for the platforms whenever it increases average perceived buyer surplus.

First note that since firms choose M_S^i and whether to shroud or not simultaneously, we only need to consider the direct effect of u_i on (A.6).

For given membership fees, the change in platform i's profit as a result of an increase in perceived buyer surplus is given by

$$\frac{\partial\Pi^i}{\partial u_i} = M_S^i \frac{\partial n_S^i}{\partial u_i}.$$

It is straightforward to see from (A.5) that the number of sellers on the platform—n_S^i—increases in u_i. Thus the profit Π^i is also increasing in u_i.

We conclude that with flexible unshrouding, competing platforms decide between shrouding and unshrouding by what increases average perceived buyer surplus. $\square$

Proof of Lemma 7. In the text before the Lemma. $\square$

Proof of Proposition 5. First we show there is a unique $\alpha(M_B)$ for any M_B and $0 < \alpha(M_B) < 1$. For simplicity, we drop the argument of α in the proofs. The RHS of (A.8) must be in $(0, 1)$ for any value of α as long as some sophisticates join the platform, i.e. $u^{un} + \frac{\alpha\bar{a}-e}{2} - M_B > 0$. Moreover, the RHS is monotone and decreasing in α as its derivative equals

$$\frac{\beta\bar{a}/2[u^{un} - M_B + \alpha\bar{a}/2 - (1-\beta)e/2] - \bar{a}/2\beta[u^{un} + \alpha\bar{a}/2 - M_B]}{(u^{un} - M_B + \alpha\bar{a}/2 - (1-\beta)e/2)^2}$$

$$= \frac{-\beta(1-\beta)\bar{a}e/4}{(u^{un} - M_B + \alpha\bar{a}/2 - (1-\beta)e/2)^2},$$

which is always negative. The LHS is linearly increasing from 0 to 1 as α increases from 0 to 1, so α must be unique.

Next we show that α is increasing in M_B. Rearranging (A.8), we get

$$(\alpha - \beta)(u^{un} - M_B + \alpha\bar{a}/2) - (1-\beta)\alpha e/2 = 0$$

Applying the implicit function theorem,

$$\frac{\partial\alpha}{\partial M_B} = \frac{(\alpha - \beta)}{u^{un} - M_B + \alpha\bar{a} - \beta\bar{a}/2 - (1-\beta)e/2} > 0 \tag{B.7}$$

as $\alpha > \beta$ and the denominator is the sum of $(\alpha - \beta)\bar{a}/2 > 0$ and the term describing the utility of the sophisticates with the highest valuation, which we assume is positive. This also implies an inequality we will use later:

$$\frac{\partial\alpha}{\partial M_B} < \frac{(\alpha - \beta)}{(\alpha - \beta)\bar{a}/2} = \frac{2}{\bar{a}}. \tag{B.8}$$

Next, we derive the sufficient condition for the optimality of $M_B = 0$. The first-order condition for the platform's profit maximization is

$$(u'(M_B) - 1)(\pi + M_B) + u(M_B) - M_B.$$

where it is easy to derive that

$$0 < u'(M_B) = \frac{\bar{a}}{2}\frac{\partial\alpha}{\partial M_B} < 1,$$

and the inequalities follow from (B.7) and (B.8). Then the following holds for the profit's derivative:

$$(u'(M_B) - 1)(\pi + M_B) + u(M_B) - M_B < (u'(M_B) - 1)\pi + u(M_B) < 0$$

where the last inequality rewrites as $\pi > \frac{u(M_B)}{1-u'(M_B)}$ which is our new sufficient condition to have $M_B = 0$ as the optimal choice. It remains to show that the profit function is concave. The second-order condition is satisfied if

$$u''(M_B)(\pi + M_B) + 2(u'(M_B) - 1) \le 0,$$

which is true if $u'' = \frac{\bar{a}}{2}\frac{\partial^2 \alpha}{\partial M_B^2} \le 0$. Applying the implicit function theorem again on the equality in (B.7), one gets

$$\frac{\partial^2 \alpha}{\partial M_B^2} = \frac{\frac{\partial \alpha}{\partial M_B}}{\frac{\partial \alpha}{\partial M_B}\bar{a} - 1} = \frac{\alpha - \beta}{(\alpha - \beta)\bar{a} - (u^{un} - M_B + \alpha\bar{a} - \beta\bar{a}/2 - (1-\beta)e/2)} < 0,$$

where the inequality comes about as the denominator rewrites as $-[u^{un} - M_B + \beta\bar{a}/2 - (1-\beta)e/2]$, which is negative by Assumption (A.7). Therefore the second-order condition is satisfied and $M_B = 0$ is indeed optimal if the condition (A.7) and $\pi > \frac{u(M_B)}{1-u'(M_B)}$ hold. Thus the platform's profit simplifies to πu, therefore the platform shrouds if and only if it results in a larger u then unshrouding:

$$u^{un} < u^{shr} = u^{un} + \frac{\alpha\bar{a}}{2} - (1-\beta)\frac{e}{2} \iff \alpha\bar{a} > (1-\beta)e.$$

$\square$

Proof of Proposition 6. First we derive the profit of the platform in each of the four cases. Recall that $u(M_B)$ denotes buyers' average perceived utility per interaction, weighted by the share of naifs in the entire population, not including potential costs related to platform fees.

Case 1: Unshrouded platform fee, shrouded seller fees. In this case, we have

$$u(M_B) = u^{un} + \frac{\alpha(M_B)\bar{a}}{2} - (1-\beta)\frac{e}{2}.$$

As consumers observe the unshrouded value of A, the platform's profit writes as

$$(u(M_B) - \frac{1}{2}\min\{A, E\} - M_B)(\pi + M_B + \frac{1}{2}\min\{A, E\}).$$

It is straightforward to show that the profit is optimal under $M_B = A = 0$ given $\pi > u(M_B)$, which is implied by the assumption of the Proposition. Therefore the optimal profit of the monopoly simplifies to

$$\Pi_1 \equiv \left(u^{un} + \frac{\alpha_1(M_B)\overline{a}}{2} - (1-\beta)\frac{e}{2} \right)\pi, \quad \text{where}$$

$$\alpha_1(M_B) = \frac{\beta\left(u^{un} + \frac{\alpha_1(M_B)\overline{a}}{2} \right)}{\left(u^{un} + \frac{\alpha_1(M_B)\overline{a}}{2} - (1-\beta)\frac{e}{2} \right)}.$$

Case 2: Shrouded platform fee, shrouded seller fees. In this case, we have

$$u(M_B) = u^{un} + \frac{\alpha(M_B)\overline{a}}{2} - (1-\beta)\frac{e}{2}.$$

Following the line of arguments in the proof of Proposition 3, the platform chooses $A = \overline{A}$ and its profit writes as

$$(u(M_B) - (1-\beta)\frac{E}{2} - M_B)(\pi + M_B + \frac{1}{2}\alpha(M_B)\overline{A}).$$

Following the same line of arguments, $\pi > u(M_B)$ is a sufficient condition for $M_B = 0$ to be optimal. However, $\pi > u(M_B)$ is implied by the assumption of the Proposition. Then the share of naifs on the platform simplifies to

$$\alpha_2(M_B) = \frac{\beta u(M_B)}{u(M_B) - \frac{1-\beta}{2}E}$$

and the profit simplifies to

$$\Pi_2 \equiv \left(u^{un} + \frac{\alpha_2(M_B)\overline{a}}{2} - (1-\beta)\frac{e+E}{2} \right)\left(\pi + \frac{1}{2}\alpha_2(M_B)\overline{A} \right).$$

Case 3: Unshrouded platform fee, unshrouded seller fees. In this case, following the line of arguments in the proof of Lemma 1 and Proposition 3, when additional fees are unshrouded the sellers and the platform all choose them in such a way that avoids sophisticates avoiding them. Thus we have $a_s = e$ and $A = 0$, leading to $u(M_B) = u^{un}$. The platform's profit is then $(u(M_B) - M_B)(\pi + M_B)$ thus $M_B = 0$ is optimal under the usual condition of $\pi > u(M_B)$, implied by the assumption of the Proposition. The optimal profit is $\Pi_3 \equiv u^{un}\pi$.

Case 4: Shrouded platform fee, unshrouded seller fees. In this case we have $u(M_B) = u^{un}$. Following the line of arguments in Case 2, the platform's profit writes as

$$(u^{un} - (1-\beta)\frac{E}{2} - M_B)(\pi + M_B + \frac{1}{2}\alpha(M_B)\overline{A}).$$

It is straightforward to show that the profit is optimal under $M_B = 0$ assuming $\pi > u^{un} - (1-\beta)\frac{E}{2}$, which is implied by the assumption of the Proposition. Moreover, the share of naifs on the platform simplifies to

$$\alpha_4(M_B) = \frac{\beta u^{un}}{u^{un} - \frac{(1-\beta)E}{2}}.$$

Therefore the optimal profit of the monopoly simplifies to

$$\Pi_4 \equiv \left(u^{un} - (1-\beta)\frac{E}{2}\right)\left(\pi + \frac{1}{2}\alpha_4(M_B)\overline{A}\right).$$

We can now compare how the monopoly profit changes as a result of shrouding seller fees. Under unshrouded platform fees, comparing Π_1 and Π_3 directly shows that shrouding seller fees is beneficial if and only if $\alpha_1(M_B)\overline{a} > (1-\beta)e$.

Under shrouded platform fees, it is straightforward to show that

$$\alpha_2(M_B)\overline{a} > (1-\beta)e \iff \alpha_2(M_B) > \alpha_4(M_B) \iff \Pi_2 > \Pi_4.$$

We conclude that shrouding seller fees is profitable for the platform if and only if $\alpha_2(M_B)\overline{a} > (1-\beta)e$.

Finally, to see that under both shrouded and unshrouded platform fees the platform has stronger incentives to shroud seller fees than sellers without a platform, following the line of argument in the proof of Proposition 5, it suffices to notice that $\alpha_1(M_B) > \beta$ and $\alpha_4(M_B) > \beta$. $\qquad\square$

Proof of Proposition 7. Notice that the only assumption we use for deriving the four optimal profit values in the proof of Proposition 6 is $\pi > \max\{u^{un}; \ u^{un} + \frac{\alpha\overline{a}}{2} - (1-\beta)\frac{e}{2}\}$, also assumed in this Proposition. Moreover, the ex-ante homogeneity of buyers with respect to seller fees, which is the main difference compared to Proposition 6, only changes the profit in Case 1, i.e. when platform fees are unshrouded but seller fees are shrouded. Indeed, buyer heterogeneity with respect to seller fees does not matter when seller fees are unshrouded as all buyers have the same information

about seller fees in those cases (Cases 3 and 4). Under shrouded seller fees and shrouded platform fees, in Case 2, the profit is also unchanged as ex-ante heterogeneity with respect to platform fees still results in a larger share of naifs joining the platform than their share in the population $(\alpha_2(M_B) > \beta)$.

Under shrouded seller fees and unshrouded platform fees, in Case 1', thanks to the simplifying assumption of ex-ante homogeneity with respect to seller fees the share of naifs on the platform equals their share in the population, i.e. $\alpha_1 = \beta$. Using the same steps as in the proof of Proposition 6, the modified optimal profit value is

$$\Pi_1' \equiv \left(u^{un} + \frac{\beta \bar{a}}{2} - (1-\beta)\frac{e}{2} \right)\pi.$$

We can now compare the effect of unshrouding platform fees both under shrouded and unshrouded seller fees.

First, *under unshrouded seller fees*, the platform prefers shrouding its own fees as well if and only if

$$\Pi_4 \geq \Pi_3 \iff \left(u(M_B) - (1-\beta)\frac{E}{2} \right)\left(\pi + \frac{1}{2}\alpha_4(M_B)\overline{A} \right) \geq u^{un}\pi,$$

where $u(M_B) = u^{un} + \frac{\alpha_4(M_B)\bar{a}}{2} - (1-\beta)\frac{e}{2}$. Straightforward transformations reveal that this is equivalent to

$$\Gamma \equiv \left((\alpha_4(M_B) - \beta)\bar{a} - (1-\beta)E \right)\pi + \alpha_4(M_B)\overline{A}\left(u(M_B) - (1-\beta)\frac{E}{2} \right) \leq 0. \tag{B.9}$$

Next we show that there exists a unique value $\alpha_4 \in (0,1)$ for which $\Gamma = 0$ and the platform shrouds its own fees if and only if $\alpha \geq \alpha_4$. First note that for $\alpha_4(M_B) = \beta = 0$, $\Gamma = -E\pi < 0$. For $\alpha_4(M_B) = \beta = 1$, $\Gamma = \overline{A}u(M_B) > 0$. Moreover, Γ is clearly increasing in $\alpha_4(M_B)$, showing the existence and uniqueness of α_4.

Next, applying the implicit function theorem twice for (B.9) at $\alpha = \alpha_4$, we get

$$\frac{\partial \alpha_4}{\partial u(M_B)} = \frac{-\alpha_4(M_B)\overline{A}}{\bar{a}\pi + \overline{A}(u(M_B) - (1-\beta)E/2)} < 0, \quad \text{and}$$

$$\frac{\partial \alpha_4}{\partial \pi} = \frac{(1-\beta)E - (\alpha_4(M_B) - \beta)\bar{a}}{\bar{a}\pi + \overline{A}(u(M_B) - (1-\beta)E/2)}.$$

Thus $\frac{\partial \alpha_4}{\partial \pi}$ is positive if and only if $(1 - \beta)E - (\alpha_4(M_B) - \beta)\bar{a} > 0$. Further transformations reveal that $u^{un} > (1 - \beta)\frac{e + E}{2}$ is a sufficient condition for this, which we assume in this Proposition.

Second, *when seller fees are shrouded*, comparing the profit functions in Cases 1' and 2 and some additional transformations reveal that the platform unshrouds its own fees if and only if

$$\Pi'_1 \geq \Pi_2 \iff \Gamma \equiv \left((\alpha_2(M_B) - \beta)\bar{a} - (1 - \beta)E\right)\pi + \alpha_2(M_B)\overline{A}\left(u(M_B) - (1 - \beta)\frac{E}{2}\right) \leq 0, \quad \text{(B.10)}$$

where $u(M_B) = u^{un} + \frac{\alpha_2(M_B)\bar{a}}{2} - (1 - \beta)\frac{e}{2}$. Next we show that there exists a unique value $\alpha_2 \in (0, 1)$ for which $\Gamma = 0$ and the platform shrouds its own fees if and only if $\alpha \geq \alpha_2$. First note that for $\alpha_2(M_B) = \beta = 0$, $\Gamma = -E\pi < 0$. For $\alpha_2(M_B) = \beta = 1$, $\Gamma = \overline{A}u(M_B) > 0$. Moreover, Γ is clearly increasing in $\alpha_2(M_B)$, showing the existence and uniqueness of α_2.

Next, applying the implicit function theorem twice for (B.10) at α_2, we get

$$\frac{\partial \alpha_2}{\partial u(M_B)} = \frac{-\alpha_2(M_B)\overline{A}}{\bar{a}\pi + \overline{A}(u(M_B) - (1 - \beta)E/2)} < 0, \quad \text{and}$$

$$\frac{\partial \alpha_2}{\partial \pi} = \frac{(1 - \beta)E - (\alpha_2(M_B) - \beta)\bar{a}}{\bar{a}\pi + \overline{A}(u(M_B) - (1 - \beta)E/2)}.$$

Thus $\frac{\partial \alpha_2}{\partial \pi}$ is positive if and only if $(1 - \beta)E - (\alpha_2(M_B) - \beta)\bar{a} > 0$. Further transformations reveal that $u^{un} > (1 - \beta)\frac{e + E}{2}$ is a sufficient condition for this, which we assume in this Proposition. This concludes the generalization of Proposition 3 for the case of ex-ante buyer heterogeneity with respect to platform fees. $\qquad \square$