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Leveraging Experienced Consumers to Attract New Consumers: An Equilibrium Analysis of Displaying Deal Sales by Daily Deal Websites

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Daily deal websites help small local merchants to attract new consumers. A strategy adopted by some websites is to continually track and display the number of deals sold by a merchant. We investigate the strategic implications of displaying deal sales and the website's incentive to implement this feature. We analyze a market in which a merchant offering an experience good is privately informed of its type. Whereas daily deals cannibalize a merchant's revenue from experienced consumers, we show that, by displaying deal sales, the website can transform this cannibalization into an advantage. Displaying deal sales can leverage discounted sales to experienced consumers to help a high-quality merchant signal its type and acquire new consumers at a higher margin. Signaling is supported through observational learning from displayed deal sales since it reveals how experienced consumers respond to the deal. Nevertheless, the website may not implement this feature if signaling entails too much distortion in the merchant's deal price. We also find that it can be optimal for the website to offer the merchant an up-front subsidy, but only if the website displays deal sales. Our analysis leads to managerial insights for daily deal websites.

Keywords: customer acquisition; daily deals; observational learning; online intermediaries; promotions; signaling; strongly undefeated perfect Bayesian equilibrium; two-sided market
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As customers, we like the counter because it indicates how popular deals are.

—Director of Communications, Groupon, as quoted in Julie M (2011)

We were concerned that the counter was having a negative impact on the consumers' perception of the deal.

—Vice President of Research, TroopSwap (Vasilaky 2012b)

1. Introduction

Daily deal websites, such as Groupon and LivingSocial, have emerged as a popular means of conducting online promotions for small local merchants. Daily deals are so called because new deals from different merchants are announced on the website every day. Each deal is available on the website for a specified period of time, ranging from a few days to a week or two. Most deals target consumers in a given city and are offered by merchants in that city, such as restaurants, spas, and gyms. In the United States alone, consumer spending on daily deals is estimated to have grown from $873 million in 2010 to $3.6 billion in 2012 and is expected to exceed $5 billion by 2015 (BIA/Kelsey 2011, 2012). Daily deal websites have also grown in their significance in many countries across the world. Thus, it is important to understand the strategies of daily deal websites.

One strategy adopted by some daily deal websites is to continually track and display the number of deals sold by a merchant through a "deal counter." However, not all websites have implemented this feature (e.g., AP Daily Deals, Restaurant.com, ValPak), and some websites that previously did no longer do (e.g., Dealsaver, KGB Deals, Tippr). As the opening comments indicate, while displaying deal sales can be useful to consumers, its impact on the website and the merchant are not immediately clear.[1] Thus, the rationale for this website strategy requires further investigation. In this paper, we examine the strategic implications of displaying deal sales and the website's incentive to do so.

Merchants use daily deal websites to attract new consumers. Although a merchant could offer an online promotion through its own website, it would have to incur significant costs of communication to drive new consumers to its website. A daily deal website,

[1] The quote by TroopSwap refers to deals with low sales and was made in the context of whether the website should display deal sales.

on the other hand, possesses economies of scale and scope in reaching a large and wide audience. Thus, it offers a more effective means to attract new consumers. For example, in a survey of small businesses, a majority identified daily deal websites as the most effective online tool to attract new consumers compared with other forms of digital marketing (Clancy 2013). Similarly, other small business surveys have shown that daily deals predominantly attract new consumers and that is the main reason merchants use daily deal websites (Dholakia 2011, 2012; Edison Research 2012).

Thus, at first glance, a daily deal website might appear to be simply an online counterpart to a traditional coupon mailer company that distributes coupons from local merchants to consumers by mail. Both forms of intermediaries increase awareness for a merchant among potential consumers and help the merchant attract new consumers. A closer look, however, brings forth important differences between the two. A coupon mailer company is not involved in the purchase transaction between the merchant and a consumer. To use a coupon, a consumer simply presents it to the merchant at the time of her purchase. By contrast, a daily deal website functions as a marketplace that also consummates the purchase transaction. This is made possible by the reduced cost of interactions on the Internet. To avail a daily deal, a consumer must purchase the deal up front through the website and redeem it later at the merchant.

As a result, unlike a coupon mailer company, a daily deal website is able to monitor consumer purchases linked to a deal with great ease. How can the website use this capability? As noted earlier, an interesting strategy used by some daily deal websites is to continually track and display deal sales. Who benefits from this? Can this be an equilibrium outcome? If this strategy is profitable to the website, are there ways to make it more effective? We seek to address these questions in this paper. We believe that these questions are of managerial interest. For instance, the management at Groupon and TroopSwap were concerned about how displaying deal sales influenced consumers and whether displaying deal sales hurt their business (Julie M 2011, Vasilaky 2012a).

A daily deal website also differs from a coupon mailer company in its business model. A daily deal website receives a share of the revenue from deal sales. Hence, the website is paid only if a sale occurs; i.e., it is paid for performance. Again, this is made possible by the website's ability to monitor transactions. By contrast, a coupon mailer company cannot easily monitor transactions and is, therefore, paid an up-front fixed fee. In this paper, we also analyze the equilibrium revenue-sharing contract between the website and the merchant.

To shed light on these issues, we develop a theoretical model that explicitly considers the strategic interaction between a daily deal website, merchant, and consumers. We analyze a market in which a merchant offering an experience good is privately informed about its type (probability of meeting consumer needs) and can reach new consumers by offering a deal through a daily deal website. Similar to other forms of discount promotion, a daily deal cannibalizes the merchant's regular sales, because the deal can be availed by experienced consumers who would have otherwise bought from the merchant at the regular price. We show, however, that displaying deal sales can help the merchant to leverage the discounted sales to experienced consumers for attracting new consumers. In particular, displaying deal sales may allow a high-type merchant to credibly signal its type to acquire new consumers at a higher margin. Signaling is supported through observational learning: new consumers can infer the merchant's type from displayed deal sales, which reflects how other (experienced) consumers responded to the deal. Thus, in contrast to a traditional coupon mailer company, a daily deal website can unlock the informational value of experienced consumers.

We find that displaying deal sales, however, is not always profitable for the website. In particular, the website implements this feature only if observational learning allows the merchant to signal without too much distortion in its deal price. It is important to note that the website has a role in determining whether the merchant can signal in equilibrium. Our model of a strategic website brings this out clearly. We also investigate the equilibrium contract between the website and the merchant. We find that it can be optimal for the website to offer the merchant an up-front subsidy but only if it displays sales. Our analysis leads to some managerial insights and recommendations for daily deal websites that we discuss in the conclusion.

1.1. Related Literature

To put our research in perspective, we briefly review several related streams of literature. We discuss in turn literature on the rationale for offering discounts to attract new consumers, displaying deal sales for daily deals; empirical research on how consumers may infer quality through observational learning; firm strategies in the presence of observational learning; signaling quality especially through price and additional instruments; and how firms can leverage social interactions to make marketing more effective.

Researchers have examined the use of price discounts to attract new consumers who are uncertain about their valuation of an experience good. Bergemann and Välimäki (2006) show that a monopolist adopts penetration pricing if the valuation of new consumers is below the optimal price to informed consumers and adopts price skimming otherwise. Villas-Boas and Villas-Boas (2008) show that if experienced consumers forget their preferences over time, then a monopolist offers periodic sales to induce uninformed consumers to learn their valuation, so that they will buy in the future at a higher (regular) price. Our focus is different. We show how a daily deal website, by displaying deal sales, can enable a merchant to attract new consumers at a higher deal price by leveraging its experienced consumers.

Early research on daily deals has focused on situations in which there is a minimum number of deals that must be sold before the deal is valid (Anand and Aron 2003, Jing and Xie 2011, Chen and Zhang 2015). Only Hu et al. (2013) have found a strategic role for displaying sales in the presence of minimum limits. They show that displaying deal sales informs consumers whether the minimum limit will be reached, thereby coordinating their buying decisions. They find that this always benefits the seller. We identify a different strategic role for displaying deal sales even in the absence of minimum limits. This is relevant because daily deal websites such as Groupon, LivingSocial, and Amazon Local display deal sales even though they do not use minimum limits.

Empirical research has shown that consumers may engage in observational learning by drawing quality inferences by observing others' choices. Zhang (2010) finds that in the U.S. kidney market, patients draw negative quality inferences from earlier refusals by other patients to accept a kidney that is available for transplant. Through counterfactual simulations, she shows that although observational learning improves patient decisions, patients would benefit further if the reasons for kidney refusals could be shared. There is also evidence that a website can facilitate observational learning and influence consumer decisions by displaying popularity information (Chen and Xie 2008, Tucker and Zhang 2011). In particular, Luo et al. (2014) find that deal sales information facilitates observational learning on a daily deal website. Zhang and Liu (2012) find evidence of observational learning on a crowdfunding website, wherein lenders infer the creditworthiness of the borrower from the funding level. The question remains whether providing consumers such information is beneficial for the website. We address this question using a theoretical framework.

Past research has studied firm strategies assuming consumers can infer product quality by observing past sales. Caminal and Vives (1996) show that firms may compete more aggressively for market share in order to signal-jam consumer inferences. Bose et al. (2006) show that the firm may distort its price to current buyers to facilitate information revelation to future buyers. Taylor (1999) shows that in housing markets an individual house seller may distort its price to minimize the negative inferences associated with her house remaining unsold. Miklós-Thal and Zhang (2013) show that a monopolist may visibly demarket its product to early adopters in order to improve the product's quality image among late adopters. We examine whether an intermediary, namely, the daily deal website, should enable consumers to observe deal sales. We show that displaying deal sales can allow the high-type merchant to credibly charge a higher deal price, which in turn leads to higher website profit under some conditions.

Starting with the seminal works of Nelson (1974), Kihlstrom and Riordan (1984), and Milgrom and Roberts (1986), past research has examined more broadly how a firm can signal its private information about quality to consumers. In our model, there is an intermediary, who is also strategic. We show that the website plays a crucial role in determining whether and how a merchant can convey private information to consumers. Indeed, we find that under some conditions the high-type merchant would prefer to signal its type but is unable to do so because it is not in the interest of the website. Chu and Chu (1994) show that if a manufacturer is unable to signal its product quality, then the retailer carrying its product may be able to signal on the manufacturer's behalf by making a nonsalvageable investment. In our setting, the website determines whether consumers can engage in observational learning and, thereby, whether the merchant can signal to consumers. In this manner, we add to the extant literature.

Turning specifically to the role of price in revealing private information, researchers have examined whether price alone can signal a firm's privately known quality.[2] Milgrom and Roberts (1986) show that price alone or price and noninformative advertising can signal a firm's quality in a setting with repeat purchases. Desai (2000) shows that a manufacturer may use a combination of wholesale price, slotting allowance, and advertising to signal demand for its product to a retailer. Moorthy and Srinivasan (1995) show that a combination of price and money-back guarantee may be necessary to signal product quality. Simester (1995) and Shin (2005) show that advertising prices of selected products can credibly signal the price image of a low-cost retailer. Our work has some similarity to Bagwell and Riordan (1991), who examine the role of informed consumers in enabling the high-quality firm to signal through price. We study situations in which only if the website displays deal sales do informed consumers play a role in enabling signaling, and that

[2] Researchers have also examined disclosure of verifiable quality information (e.g., Grossman 1981, Milgrom 1981, Guo and Zhao 2009, Kuksov and Lin 2010, Sun 2011). We study situations in which the merchant cannot disclose its type credibly and the website does not know the merchant's type.

role is an indirect one. Stock and Balachander (2005) also find that a firm may not be able to signal its privately known quality unless consumers are aware of its product's scarcity. We add to this literature by showing that for credible separation in deal price, consumers must both observe deal sales and engage in observational learning, thus requiring the website to implement a deal counter.

Our work is also broadly related to research on firm-level marketing strategies to leverage different forms of social interactions (e.g., Biyalogorsky et al. 2001, Amaldoss and Jain 2005, Godes et al. 2005, Mayzlin 2006, Chen and Xie 2008, Joshi et al. 2009, Kornish and Li 2010, Kuksov and Xie 2010, Jing 2011, Godes 2012). We study whether a daily deal website should allow a merchant to leverage one form of social influence, namely, observational learning, to attract new consumers. Finally, we should note that researchers have also examined a website's incentives in helping consumers make more informed decisions in various contexts. Wu et al. (2013) show that a matchmaking website may have an incentive to deliberately reduce the effectiveness of its matching technology. Dukes and Liu (2016) show that an online shopping intermediary may design a search environment that limits search by consumers. We show that a website may not display deal sales in order to suppress observational learning by consumers.

2. Model

Our model consists of three strategic players, namely, a daily deal website, a merchant, and consumers. The merchant offers a product (or service) that is an experience good, such as a restaurant, a spa, or a gym. The daily deal website enables the merchant to reach new consumers by offering a deal through its website. New consumers are uncertain about whether the merchant's product can meet their needs. The merchant has private information about the probability that its product meets their needs. Our main interest is in examining the website's strategic incentive to implement a certain website feature, namely, a *deal counter* that keeps track of, and displays, the number of deals sold. We model the following decisions. The website decides whether to display deal sales by implementing a deal counter. The merchant can choose whether or not to offer a deal. A deal is a price reduction relative to the merchant's regular price, which is how deals are usually presented both online and off-line. We refer to the price that the consumer must pay after the price reduction as the deal price. The merchant chooses the deal price. Consumers decide whether to buy the deal. Some consumers also decide when to buy the deal. Later, in §4, we also examine the website's optimal revenue-sharing contract. We start by describing the merchant.

The merchant can be one of two types, H or L. A type $t \in \{H, L\}$ merchant's product meets the needs of a proportion $\alpha_t \in (0, 1)$ of consumers, where $\alpha_H > \alpha_L$. A consumer derives a positive utility $r > 0$ if the product meets her need and zero utility otherwise. Thus, for a randomly chosen consumer, the product meets the need with probability α_t. Hence, we refer to α_t as the merchant's *probability of fit*, or simply, fit. A merchant's fit can be understood as how broadly its product will appeal to consumers and could be based on its ability to cater to the disparate needs of different consumers. For example, in the case of hair salons, consumers differ in their hair conditions and in their treatment preferences. A hair stylist that is more experienced (less experienced) in different hair conditions and treatment procedures would correspond to a high-fit (low-fit) merchant and can satisfy needs of a wide range (narrow range) of consumers. Or, in the case of restaurants, consumers differ in the dishes they prefer. A restaurant may not excel in all the dishes it offers. A restaurant that excels in many dishes (few dishes) would correspond to a high fit (low fit) merchant in our model and appeal to a broad group (niche group) of consumers.

The merchant faces a mix of *experienced consumers* and *new consumers* on the deal website. Experienced consumers have tried the merchant's product in the past. Hence, they are already aware of the merchant, know the merchant's type, and whether its product meets their needs. By contrast, new consumers become aware of the merchant only if it offers a deal through the website. Therefore, they neither know the merchant's type nor whether its product will meet their needs. Let N denote the size of new consumers. Without loss of generality, we normalize the size of experienced consumers to 1. Thus, N captures the relative proportion of new consumers.

The difference between experienced consumers and new consumers becomes clear if we evaluate their utility from buying the deal. We assume that a consumer may buy at most one unit of the product and derives zero utility if she does not buy. Let $d_t > 0$ denote the deal price at which a type t merchant offers the product. An experienced consumer's utility from buying the deal is

$$u_{EC} = i \cdot r - d_t, \tag{1}$$

where $i \in \{0, 1\}$ is an indicator variable that equals 1 if the product meets this consumer's need. An experienced consumer knows both i and t. We will refer to those experienced consumers for whom $i = 1$ as *matched consumers* because the product meets their need. Note that only matched consumers are willing to pay a positive price for the product. The number of matched consumers depends on the merchant's type and is equal to α_t.

Unlike experienced consumers, a new consumer is uncertain about the merchant's type and whether its product will meet her needs. Her expected utility from buying the deal is

$$u_{NC} = \theta r\alpha_H + (1-\theta) r\alpha_L - d_t, \tag{2}$$

where $\theta \in [0, 1]$ denotes her belief that the merchant's type is H, and $r\alpha_t$ is her expected utility from the product if the merchant is type t. We observe from Equation (2) that a new consumer's willingness to pay is increasing in her belief θ, and it ranges from $r\alpha_L$ (if $\theta = 0$) to $r\alpha_H$ (if $\theta = 1$). Her belief θ may, in general, depend on all observables including the deal price and, in particular, on deal sales information if it is displayed.

We assume that a deal lasts two periods, periods 1 and 2. Period 1 marks the start of the deal. If deal sales are displayed, then period 1 sales are displayed at the start of period 2. Some consumers visit the website in both periods, and we refer to them as *frequent visitors*. Frequent visitors can buy the deal in either period. Other consumers are not able to visit the website frequently. They visit the website either only in period 1 or only in period 2, and we refer to them as *early visitors* and *late visitors*, respectively. The frequency of visits is an exogenous feature of our model. We note that consumers typically do not know a priori whether or when a particular merchant will offer a deal. Therefore, we model the visits of early and late visitors as being random relative to the deal timing (period 1) and assume that there is an equal number of either of them.[3] Let $\beta \in [0, 1]$ denote the proportion of consumers who visit the website only once. Thus, a proportion $\frac{1}{2}\beta$ are early visitors, a proportion $\frac{1}{2}\beta$ are late visitors, and a proportion $1-\beta$ are frequent visitors. These proportions are assumed to be the same for experienced consumers and new consumers. Thus, each consumer can be characterized along two dimensions—experienced or new, and frequent, early, or late. For conciseness, we will say "early-new consumers" to refer to new consumers who are early visitors, and so on.

Each consumer segment in our model plays an important role in determining the effect of displaying deal sales. Experienced consumers' buying decisions can make the number of deals sold informative about the merchant's type. This is because the number of matched consumers, i.e., the experienced consumers willing to buy the product, depends on the merchant's type. Late- and frequent-new consumers' buying decisions can benefit from inferring the merchant's type from displayed deal sales. Thus, the interaction between consumer segments will determine the impact of displaying sales. Our goal is to determine whether and how the merchant and the website leverage this interaction.

We assume that experienced consumers can buy at the deal price either on the website or directly from the merchant at its regular price p, where $p \le r$. Because daily deals are of relatively short duration and offered infrequently (to attract new consumers rather than to promote to existing ones; see, for example, Dholakia 2011), we do not expect a daily deal promotion to affect the merchant's regular price. In other words, we assume that there are significant "menu costs" to changing the regular price. Therefore, we take p to be an exogenous parameter in our model. From Equation (2), new consumers' willingness to pay can range from $r\alpha_L$ to $r\alpha_H$. Since p is exogenous in our model, we keep the analysis straightforward by assuming that $p > r\alpha_H$, such that the regular price will not constrain the deal price at which the merchant can acquire new consumers. We discuss the implications if $p \le r\alpha_H$ in the conclusion (§5.2).

We next describe the revenue-sharing arrangement between the website and the merchant. Let R_t^D denote the deal revenue for a type t merchant if it offers a deal. Let Π^W denote the website's expected profit. Let $\lambda \in (0, 1)$ denote the merchant's share of deal revenue. Let R_t^O denote the revenue for a type t merchant from selling to experienced consumers at the regular price. We assume that the merchant has zero marginal costs. The revenue-sharing arrangement can be profitable for both the merchant and the website as long as offering the deal generates incremental revenue; i.e., $R_t^D > R_t^O$. To begin with, we assume that λ is exogenous and sufficiently high such that if a deal can generate incremental revenue, then it will also be profitable for the merchant to offer a deal. This approach allows us to bring out the essential effects of displaying deal sales and the website's incentives to do so. Having established these effects, we later let λ be endogenous and examine the website's optimal equilibrium contract in §4.

We should note that our assumption of zero marginal cost is not without loss of generality.[4] With nonzero marginal cost, the merchant's profit from deal sales will not equal its share of deal revenue λR_t^D. In particular, if the marginal cost is a high enough fraction of the deal price (higher than λ), then offering a deal can never be profitable. Nevertheless, as long as offering the deal generates incremental profit (accounting for the marginal cost), the revenue-sharing arrangement will be mutually profitable if λ is sufficiently high. Consequently, although a nonzero marginal cost imposes additional restrictions on λ, it does not qualitatively

[3] If some early visitors are able to return in period 2 for a specific deal, then this will be equivalent in our model to assuming that there are more frequent visitors.

[4] We thank the associate editor for pointing this out.

affect our main insights. Hence, for clarity of exposition, we assume zero marginal cost.

Having described the merchant and consumer decisions, we turn to the website's decision. The website can choose to either (i) display deal sales by implementing a deal counter or (ii) not display deal sales by not implementing a deal counter.[5] If the deal counter is implemented, then it displays zero at the start of period 1 and the number of deals sold in period 1 at the start of period 2. The website's decision to implement a deal counter is known to the merchant and to consumers.

It is important to note that we assume that it is too costly for the website to misreport sales. The implication of this assumption, and an essential condition in our analysis, is that consumers believe that the website will not deceive them by misreporting sales. Thus, we identify how displaying deal sales can benefit or hurt the website in this limiting case.[6] Misreporting sales can be costly for two reasons. First, laws against false or deceptive advertising can act as a constraint.[7] For example, the website would have engaged in deceptive advertising if misreporting sales caused consumers to buy a deal they otherwise would not have. Second, misreporting sales in our model can be detected by experienced consumers. Experienced consumers on one occasion (in one merchant or product category) can be new consumers on a future occasion. Consequently, misreporting sales can hurt the website in future interactions with the same consumers, as they would no longer believe that the website reports sales truthfully. In other words, it can be in the website's interest to report sales truthfully in order to maintain its reputation.[8] We also assume that it is not feasible for the merchant to significantly manipulate deal sales by buying its own deal. Daily deal websites typically do not allow bulk purchases, presumably to prevent reselling of deals.[9] Therefore, to significantly manipulate deal sales, a merchant would have to create several user accounts and use different credit cards. We assume that doing so is too cumbersome and, hence, not feasible.

Before we proceed to the analysis, it is useful to make clear the sequence of the game:

Stage 1 (*period* 0). The website decides whether or not to display deal sales by implementing a deal counter.

Stage 2 (*period* 0). The merchant decides whether or not to offer a deal and the deal price d_t if it will offer a deal.

Period 1 (*if deal is offered*). The deal counter, if implemented, displays 0. Early and frequent visitors visit the website and decide whether to buy the deal. Frequent visitors can also decide to wait till period 2.

Period 2 (*if deal is offered*). The deal counter, if implemented, displays number of deals sold in period 1. Frequent and late visitors visit the website and decide whether to buy the deal.

We assume that the model parameters are common knowledge. We assume that the merchant knows its type t and this is private information. The website and new consumers have a belief about the merchant's type and this is common knowledge. This belief can be conditioned on the regular price p and other information about the attributes of the merchant. Nevertheless, it will be useful to think of this belief as the initial or prior belief about the merchant's type. Denote this belief by $\bar{\theta} \in (0, 1)$. The prior belief $\bar{\theta}$ can be contrasted with the belief θ used in Equation (2), which is a new consumer's posterior belief at the time of making her buying decision. This posterior belief will depend on the merchant's decision to offer a deal, the deal price, and the deal sales information if it is displayed.

It is useful to think about the information that the website has about the merchant's type. Daily deal websites utilize a relatively low-skilled sales force to market their services to a large number of small merchants. As a result, qualifying the merchants is often impractical because it makes the selling process time consuming and effortful.[10] In particular, it would be especially difficult for a low-skilled sales person, without any specialized expertise about a merchant's product category, to determine the merchant's fit. In other words, it is too costly for the website to verify the merchant's type.

We assume that firms maximize their expected profits and consumers maximize their expected utility. We solve for a perfect Bayesian equilibrium (PBE). We restrict our attention to pure-strategy equilibria. It is well known that in games of incomplete information, multiple PBE can be supported by specifying sufficiently pessimistic off-equilibrium beliefs so as to make any deviation unattractive. In our context, this pertains to specifying pessimistic beliefs for new consumers (i.e., $\theta = 0$) at off-equilibrium deal prices, leading to multiple equilibria for merchant strategies. As in Miklós-Thal

[5] We remark that the common practice on websites such as Groupon, LivingSocial, and Amazon Local is to display the counter for all deals; i.e., it is a website feature and not specific to a deal.

[6] We thank an anonymous reviewer for suggesting this interpretation.

[7] In our discussion with website managers, we found that laws against false advertising do act as a constraint.

[8] See Chu and Chu (1994) for a formal development of how reputational concerns can prevent a firm from deceiving consumers in a signaling framework with repeated interactions. We thank an anonymous reviewer for this suggestion.

[9] For instance, most deals on Groupon have a limit of two purchases per person (including one as a gift).

[10] In our discussion with Groupon, we found that their sales team does not spend time qualifying merchants.

and Zhang (2013), because the *intuitive criterion* refinement (Cho and Kreps 1987) is not sufficiently strong to rule out unreasonable off-equilibrium beliefs in our model, we use the *strongly undefeated equilibrium* (SUE) refinement (Mailath et al. 1993, Spiegel and Spulber 1997, Taylor 1999, Mezzetti and Tsoulouhas 2000, Gomes 2000, Gill and Sgroi 2012) to obtain a unique equilibrium. As noted in Miklós-Thal and Zhang (2013), the SUE refinement is equivalent to selecting the PBE that yields the type H merchant the highest profit (among all PBEs). This property has intuitive appeal because it is the type L merchant that will have an incentive to mimic the type H merchant, and not vice versa. Said differently, in an SUE, the type H merchant follows its sequentially optimal strategy given that the type L merchant can mimic its strategy. It is important to note that, in our model, the SUE is also the unique PBE surviving the intuitive criterion that yields the highest profit for both merchant types. We provide a more formal description of the SUE refinement in the online appendix (available as supplemental material at https://doi.org/10.1287/mnsc.2015.2298). Without loss of generality, we normalize $r=1$ in the remainder of our analysis. Appendix A summarizes our model notation.

3. Strategic Implications of Displaying Deal Sales

There are two subgames following the website's decision in Stage 1—one in which deal sales are not displayed and another in which deal sales are displayed. In each subgame, there is asymmetric information about the merchant's type. To highlight the role of asymmetric information, we first examine a benchmark setting in which new consumers are assumed to know the merchant's type t. We refer to this as the *symmetric information benchmark*. Next, we solve for the equilibrium in each subgame under asymmetric information. Finally, we present the solution to the overall game to determine the conditions under which displaying deal sales is an equilibrium strategy.

Two observations help simplify our analysis. First, the merchant's profit from the deal is λR_t^D, where $\lambda \in (0,1)$. Therefore, the merchant's equilibrium deal price must be set to maximize the deal revenue R_t^D. Second, if no new consumers buy the deal, then the deal does not generate incremental revenue ($R_t^D \le R_t^O$) and, hence, cannot be mutually profitable for the merchant and the website. Therefore, at least some new consumers must buy the deal if it is offered in equilibrium. It follows that it is sufficient to focus on equilibrium deal price $d_t \in [\alpha_L, \alpha_H]$, since the reservation price of new consumers is in this price range.

3.1. Symmetric Information Benchmark

If new consumers know the merchant's type t, then they will be willing to pay α_t. For a profitable deal, the optimal deal price for a type t merchant is $d_t=\alpha_t$ because this is the maximum willingness to pay for new consumers. New consumers will therefore buy the deal. Matched consumers will also buy the deal since they obtain a positive surplus of $p-\alpha_t$ compared to buying at the regular price p. Hence, the deal revenue for a type t merchant is

$$R_t^D=\alpha_t(\alpha_t+N). \tag{3}$$

If the type t merchant does not offer a deal, then it sells to matched consumers at its regular price and obtains revenue of

$$R_t^O=p\alpha_t. \tag{4}$$

Offering the deal is profitable for the merchant if it generates incremental revenue, i.e., if $R_t^D>R_t^O$ so that $\lambda R_t^D>R_t^O$ for sufficiently high $\lambda\in(0,1)$. Hence, the type t merchant offers a deal iff

$$\alpha_t(\alpha_t+N)>p\alpha_t. \tag{5}$$

The foregoing inequality will hold if N is sufficiently large. In other words, offering a deal is profitable if there are sufficient numbers of new consumers on the website relative to the number of experienced consumers. To keep our analysis straightforward, we will assume that $N>1$, such that condition (5) holds for both merchant types. The website's expected profit is

$$\Pi_{\mathrm{SI}}^W=(1-\lambda)(\bar{\theta}\alpha_H(\alpha_H+N)+(1-\bar{\theta})\alpha_L(\alpha_L+N)). \tag{6}$$

Based on the symmetric information benchmark outcome, we can establish two results that are useful in our subsequent analysis. First, we show that the website's expected profit under symmetric information sets an upper bound for its expected equilibrium profit under asymmetric information. Second, the website can attain the upper bound under asymmetric information only in a separating equilibrium that replicates the benchmark outcome, i.e., in an equilibrium in which the type t merchant sets $d_t=\alpha_t$ and all matched consumers and new consumers buy the deal. We are able to establish these results without explicitly solving for the equilibrium under asymmetric information. The proofs of all lemmas are deferred to Appendix B unless otherwise stated.

Lemma 1. *The website's expected profit under symmetric information (Π_{SI}^W) is an upper bound for its expected equilibrium profit under asymmetric information. This upper bound can be attained under asymmetric information only in a separating equilibrium in which the deal price is $d_t=\alpha_t$ for $t\in\{H,L\}$, and all matched consumers and new consumers buy the deal.*

To see the intuition behind Lemma 1, consider a potential separating equilibrium in which the merchant types set different prices; i.e., $d_H\ne d_L$. We require $d_t\le\alpha_t$

in this equilibrium, such that new consumers buy the deal. Therefore, the equilibrium deal revenue cannot exceed that in the symmetric information benchmark for either merchant type. Consequently, the website's equilibrium expected profit cannot exceed Π^W_{SI} in any potential separating equilibrium.

Next, consider a potential pooling equilibrium in which the merchant types set the same deal price; i.e., $d_H = d_L$.[11] In this equilibrium, we require that the deal price does not exceed $\bar{\alpha} = \bar{\theta}\alpha_H + (1-\bar{\theta})\alpha_L$, which is the reservation price of new consumers based on their prior belief $\bar{\theta}$. Therefore, the deal price of $d_H = d_L = \bar{\alpha}$ provides an upper bound for website profit in a pooling equilibrium. We find that this upper bound is strictly lower than Π^W_{SI}. In particular, the website's expected profit from experienced consumers is strictly lower in a pooling equilibrium than in the benchmark. This is because the type H merchant, which has more matched consumers than the type L merchant, sets a lower price in the pooling equilibrium than in the benchmark; i.e., $\bar{\alpha} < \alpha_H$. Said differently, a pooling equilibrium results in higher cannibalization of revenue from experienced consumers. Moreover, the website's expected profit from new consumers in a pooling equilibrium cannot be higher than in the benchmark.

Thus, the website can attain the benchmark profit level only in a separating equilibrium that replicates the benchmark outcome. Under the benchmark outcome, the merchant's deal price reflects its fit, and a type H merchant acquires new consumers at a higher deal price than the type L merchant. Consequently, the benchmark outcome maximizes the expected revenue from new consumers while also minimizing the cannibalization of revenue from experienced consumers. We now examine the equilibrium under asymmetric information, first in the subgame with deal sales not displayed and next in the subgame with deal sales displayed.

3.2. Equilibrium in Subgame with Deal Sales Not Displayed

We consider the two possible equilibrium scenarios for both merchant types to offer a deal in this subgame: (i) a separating equilibrium in which the merchant types set different deal prices ($d_H \neq d_L$) and (ii) a pooling equilibrium in which both set the same deal price ($d_H = d_L$). We show that the separating equilibrium cannot occur (Lemma 2), and then we derive the pooling equilibrium (Lemma 3).

Lemma 2. *In the subgame with deal sales not displayed, there is no separating equilibrium in which both merchant types offer a deal at different prices.*

Lemma 2 shows that the type H merchant cannot credibly separate and set a higher deal price than the type L merchant. This is because the type L merchant will find it profitable to *mimic* the type H merchant by charging the same higher deal price as the type H merchant. New consumers cannot detect this mimicking and will buy from the type L merchant, believing (incorrectly) that the merchant is type H. Consequently, such a separating equilibrium cannot be sustained. Instead, we find that only a pooling equilibrium in which both merchant types set the deal price can occur. We derive this equilibrium in Lemma 3. Let $R^D_t|^{ND}_p$ denote the deal revenue for a type t merchant, and let $\Pi^W|^{ND}_p$ denote the website's expected profit in the pooling equilibrium.

Lemma 3. *In the subgame with deal sales not displayed, a pooling equilibrium in which both merchant types offer the deal at the same price occurs iff $\alpha_L \in (0, \alpha_1]$, $\bar{\theta} \in (\theta_1, 1)$, or $\alpha_L \in (\alpha_1, \alpha_H)$, where $\alpha_1 = p\alpha_H/(N+\alpha_H) < \alpha_H$, and $\theta_1 = (p\alpha_H - \alpha_L(N+\alpha_H))/((N+\alpha_H)(\alpha_H-\alpha_L)) \in (0,1)$. In this equilibrium, we have the following:*

(i) *Deal price is $d_H = d_L = \bar{\alpha}$.*

(ii) *Deal revenue is $R^D_t|^{ND}_p = \bar{\alpha}(\alpha_t + N)$ for $t \in \{H, L\}$.*

(iii) *Website's expected profit is $\Pi^W|^{ND}_p = (1-\lambda)\bar{\alpha}(\bar{\alpha}+N)$.*

In the pooling equilibrium, new consumers must maintain their prior belief $\bar{\theta}$ at the equilibrium deal price, and they will pay at most $\bar{\alpha}$. Therefore, both merchant types set a deal price $\bar{\alpha}$.[12] The deal is profitable for the type L merchant since it acquires new consumers at a higher deal price than in the symmetric information benchmark; i.e., $\bar{\alpha} > \alpha_L$. By contrast, because of mimicking by the type L merchant, the type H merchant is forced to set a lower deal price than in the symmetric information benchmark; i.e., $\bar{\alpha} < \alpha_H$. The pooling equilibrium occurs if it is profitable for the type H merchant to acquire new consumers at the deal price $\bar{\alpha}$. Lemma 3 provides the necessary and sufficient condition for this to be the case.

If the condition in Lemma 3 does not hold, then only the type L merchant offers a deal at the deal price α_L in equilibrium. In other words, the type H merchant is driven out of the market because of asymmetric information. In this equilibrium, new consumers must correctly believe that the merchant is type L and will buy the deal at the deal price α_L. All matched consumers also buy the deal. The website's expected profit in this case is $\Pi^W|^{ND}_l = (1-\lambda)(1-\bar{\theta})\alpha_L(\alpha_L+N)$. This equilibrium outcome will not be of substantive interest in this paper. We derive this equilibrium for the sake of completeness in Lemma 8 in Appendix B.

[11] By *pooling equilibrium*, we mean an equilibrium in which both merchant types follow the same equilibrium strategy. Consumers may still learn the merchant type in equilibrium through the deal counter.

[12] It is possible to construct pooling PBE in which the equilibrium deal price is lower than $\bar{\alpha}$ (by specifying pessimistic beliefs $\theta = 0$ at off-equilibrium deal prices). However, in Lemma 3, we show that such pooling PBE cannot survive the SUE refinement.

An immediate implication of Lemma 2 is that the website cannot attain the upper bound for its expected profit if deal sales are not displayed; i.e., $\Pi^W < \Pi^W_{\text{SI}}$, since there is no separating equilibrium. The following proposition formalizes this finding.

Proposition 1. *If deal sales are not displayed, then the website's expected profit is strictly lower than that under symmetric information.*

Proof. Follows from Lemmas 1 and 2. □

Thus, asymmetric information lowers website profit. Intuitively, mimicking by the type L merchant forces the type H merchant to either acquire new consumers at a lower deal price than under symmetric information or not offer a deal at all. The former leads to higher cannibalization of revenue from experienced consumers. The latter results in loss of deal revenue from the type H merchant altogether. In either case, the website's expected profit is lower than in the symmetric information benchmark.

3.3. Equilibrium in Subgame with Deal Sales Displayed

Displaying deal sales can enable observational learning by new consumers since it reveals how earlier consumers responded to the deal. That is to say, new consumers can infer their utility of buying the deal from the displayed deal sales. Period 1 sales can be informative because the number of experienced consumers willing to buy the deal (matched consumers) depends on the merchant's type. Consequently, late-new consumers in period 2 can update their belief about the merchant based on period 1 sales. Further, frequent-new consumers can wait till period 2 to observe period 1 sales before deciding whether to buy.

We now examine the equilibrium of the subgame with deal sales displayed. It will be useful to distinguish between a separating equilibrium that resembles the symmetric information benchmark and one that does not. We will say that there is "price distortion" in the latter case. More formally, we require that $d_L = \alpha_L$ and $d_H \in (\alpha_L, \alpha_H]$ in any separating equilibrium (as shown in the proof of Lemma 1). If $d_H = \alpha_H$ in the separating equilibrium, then there is no price distortion. If $d_H < \alpha_H$, then there is price distortion.

We thus consider, in turn, the three possible equilibrium scenarios for both merchant types to offer a deal in this subgame: (i) a distortionless separating equilibrium, (ii) a separating equilibrium with distortion, and (iii) a pooling equilibrium. To determine the equilibrium, we must examine these different scenarios simultaneously because of multiplicity of PBE. We invoke the SUE refinement to obtain the unique equilibrium, which is the PBE that leads to the highest profit for the type H merchant. For clarity of exposition and to keep the analysis straightforward, we first analyze the distortionless separating equilibrium, then the pooling equilibrium, and last the separating equilibrium with distortion; Lemmas 4, 5, and 6, respectively, characterize the conditions under which each outcome occurs. If none of the conditions in Lemmas 4–6 holds, then only the type L merchant offers a deal at the deal price α_L in equilibrium. The equilibrium revenue and website profit is the same as that in the corresponding equilibrium in the subgame with deal sales not displayed (see Lemma 8 in Appendix B).

3.3.1. Distortionless Separating Equilibrium.

In a distortionless separating equilibrium, we have $d_t = \alpha_t$ for $t \in \{H, L\}$. Whereas such an equilibrium does not occur if deal sales are not displayed, we find that it can occur if deal sales are displayed because of observational learning. In particular, frequent- and late-new consumers learn the merchant's type from period 1 sales, and so they condition their buying decisions on period 1 sales. They buy at the deal price α_H only if the merchant is type H and not otherwise. As a result, the type L merchant cannot sell to these consumers if it mimics the type H merchant. This loss in demand makes mimicking unattractive in equilibrium. Lemma 4 shows that this equilibrium occurs if α_L is large enough and describes the type t merchant's equilibrium deal revenue $R_t^D|^D_{s0}$ and the website's expected profit $\Pi^W|^D_{s0}$.

Lemma 4. *In the subgame with deal sales displayed, a separating equilibrium without price distortion ($d_H = \alpha_H$ and $d_L = \alpha_L$) occurs iff $\alpha_L \in [\alpha_2, \alpha_H)$, where $\alpha_2 = \frac{1}{2}[\sqrt{N^2 - 2N(1-\beta)\alpha_H + \alpha_H^2} - (N - \alpha_H)]$. In this equilibrium, we have the following:*

(i) *Frequent- and late-new consumers condition their buying decisions on period 1 sales. They buy the deal at the deal price α_H only if period 1 sales are τ_H and do not buy if they are τ_L, where $\tau_t = (1 - \frac{1}{2}\beta)\alpha_t + \frac{1}{2}\beta N$ for $t \in \{H, L\}$.*

(ii) *The deal revenue is* $R_t^D|^D_{s0} = \alpha_t(\alpha_t + N)$ for $t \in \{H, L\}$.

(iii) *The website's expected profit is* $\Pi^W|^D_{s0} = (1-\lambda)\cdot(\bar{\theta}\alpha_H(\alpha_H + N) + (1-\bar{\theta})\alpha_L(\alpha_L + N))$.

Proof (by Construction). We construct a distortionless separating PBE and show that it exists iff $\alpha_L \geq \alpha_2$. We then show that it survives the SUE refinement and that it is sufficient to focus on this distortionless separating equilibrium without loss of generality. Consider a PBE in which the type t merchant sets a deal price $d_t = \alpha_t$, and consumers adopt the following strategies:

- Matched consumers buy the deal at either deal price (α_H or α_L) regardless of the merchant's type, with frequent-matched consumers buying the deal in period 1.
- At the deal price α_L, all new consumers buy the deal, with frequent visitors buying in period 1.
- At the deal price α_H, early-new consumers buy in period 1, and frequent-new consumers wait till

period 2. In period 2, frequent- and late-new consumers buy iff period 1 deal sales are not less than a threshold τ, where $\tau \in (\tau_L, \tau_H]$ and $\tau_t = (1-\frac{1}{2}\beta)\alpha_t + \frac{1}{2}\beta N$ for $t \in \{H, L\}$.

The above specification of consumer strategies ensures that frequent- and late-new consumers buy the deal at the deal price α_H only if the merchant is type H. Specifically, observe that if the type t merchant sets a deal price α_H, then early- and frequent-matched consumers and early-new consumers will buy the deal in period 1. Therefore, period 1 sales are given by τ_t. We remark that $\tau_H > \tau_L$ since the type H merchant has more matched consumers. Therefore, frequent- and late-new consumers can infer the merchant's type from period 1 sales and avoid buying the deal if the merchant is type L.

Clearly, consumer strategies are optimal given the merchant strategies. Matched consumers buy the deal and obtain a positive surplus $p - d_t$. New consumers also buy, and their ex ante surplus is zero. Consumers cannot obtain a higher utility by deviating from their strategies. Further, the type H merchant can also not do any better. It cannot sell to new consumers at any price higher than α_H, and offering a deal is profitable since $N > 1$ and condition (5) holds. Similarly, it is also profitable for the type L merchant to offer a deal. It remains to be seen whether the type L merchant can profit from mimicking the type H merchant.

Suppose that the type L merchant deviated to $d_L = \alpha_H$. Period 1 sales are then τ_L. Consequently, frequent- and late-new consumers will not buy in period 2, resulting in total deal sales of $\alpha_L + \frac{1}{2}N\beta$. The corresponding deal revenue is

$$R'_L = \alpha_H\left(\alpha_L + \tfrac{1}{2}\beta N\right). \tag{7}$$

The equilibrium deal revenue for the type L merchant is

$$R_L^D = \alpha_L(\alpha_L + N). \tag{8}$$

Mimicking is unattractive iff $R_L^D \geq R'_L$, from which we obtain the following no-mimicking constraint:

$$\alpha_L^2 + (N - \alpha_H)\alpha_L - \tfrac{1}{2}\alpha_H \beta N \geq 0. \tag{9}$$

In condition (9), the left-hand side (LHS) is continuous and convex in α_L, negative if $\alpha_L \to 0$, and positive if $\alpha_L \to \alpha_H$. It follows that the LHS has a unique positive root $\alpha_L = \alpha_2 \in (0, \alpha_H)$, where α_2 is as defined in the statement of the lemma. Further, the no-mimicking constraint holds iff $\alpha_L \geq \alpha_2$.

We now show that the candidate PBE survives the SUE refinement and that it is sufficient to focus on this PBE for a distortionless separating equilibrium. As shown in the proof of Lemma 1, $d_H \leq \alpha_H$ and $d_L = \alpha_L$ in any separating PBE, and $d_t \leq \bar{\alpha}$ in any pooling PBE. Three observations follow immediately. First, the type H merchant cannot derive higher profit in any other PBE than in the candidate equilibrium. Therefore, the candidate equilibrium is a SUE. Second, any other (separating) PBE that yields the same profit for the type H merchant as the candidate PBE (and hence survives the SUE refinement) cannot lead to a different outcome.[13] Hence, the equilibrium outcome is unique. Finally, any such PBE that leads to the same outcome cannot exist for a wider range of parameters (e.g., for $\alpha_L < \alpha_2$) than the candidate PBE. This is because the no-mimicking constraint cannot be made stronger than in Equation (9). □

Lemma 4 offers several useful insights. Experienced consumers are necessary for observational learning to occur. Period 1 sales are higher for the type H merchant because it has more experienced consumers willing to buy its product. In equilibrium, early- and frequent-matched consumers always buy the deal in period 1 irrespective of the merchant's type because they obtain a positive surplus $p - d_t$. They contribute to period 1 sales of $(1-\frac{1}{2}\beta)\alpha_t$. Early-new consumers also always buy the deal because they believe that the merchant's type is t if the deal price is α_t, and their expected surplus is nonnegative. They contribute to period 1 sales of $\frac{1}{2}\beta N$. Thus, period 1 sales are given by $\tau_t = (1-\frac{1}{2}\beta)\alpha_t + \frac{1}{2}\beta N$. Period 1 sales depend on the merchant's type because of the matched (experienced) consumers. Without experienced consumers, period 1 sales will not be informative, and as a result, mimicking will occur since frequent- and late-new consumers cannot infer the merchant's type.

Observational learning is important because it enables frequent- and late-new consumers to detect mimicking and avoid buying from the type L merchant. If they observe deal sales of τ_L at the deal price α_H, which is possible only if the type L merchant is mimicking, then they update their belief to $\theta = 0$ and their expected surplus is negative. Therefore, they do not buy. By contrast, they buy on the equilibrium path, because they observe deal sales of τ_H, which indicates that the merchant is type H, and their expected surplus is nonnegative.

For the type L merchant, mimicking involves a trade-off between gaining a higher margin (α_H versus α_L) and losing demand from frequent- and late-new consumers. The no-mimicking constraint in Equation (9) captures this trade-off. All else equal, mimicking is less attractive if the type H merchant's fit (α_H) is lower or if type L merchant's fit (α_L) is higher, because the gain in margin from mimicking is then lower. Mimicking is also less attractive if there are more frequent visitors (β is lower) or the number of new consumers (N)

[13] For instance, it may be possible to construct a separating PBE in which the no-mimicking constraint is enforced only by the late-new consumers conditioning their buying decisions on deal sales.

is higher, since more consumers then condition their purchase on period 1 deal sales and the loss in demand from mimicking is higher. Lemma 4 shows that the no-mimicking constraint holds if $\alpha_L \geq \alpha_1$. We remark that $\alpha_1 \to 0$ if $\beta \to 0$. In other words, mimicking is unattractive if there is a sufficient number of frequent visitors to the website.

It is important to note that observational learning has force in the separating equilibrium. Even though the merchant types set different deal prices in equilibrium, frequent- and late-new consumers must still condition their buying decisions on period 1 sales to ensure that the type L merchant does not mimic. In other words, mimicking is unattractive and separation occurs only because of observational learning. We remark that the off-equilibrium strategy of frequent- and late-new consumers is both sequentially rational and credible in that it is robust to a small tremble by the type L merchant. Specifically, given any arbitrarily small probability that the type L merchant deviates to $d_L = \alpha_H$, it is the strictly dominant strategy for frequent-new consumers to wait till period 2 and for frequent- and late-new consumers to buy only if period 1 sales are higher than a threshold τ, where $\tau \in (\tau_L, \tau_H]$.[14]

Displaying deal sales can thus offset the effect of asymmetric information and lead to an outcome that resembles the symmetric information benchmark outcome. In equilibrium, the type H merchant can credibly separate and acquire new consumers at the deal price α_H. As a result, the website attains the upper bound Π_{SI}^W for its expected profit. The following proposition states this finding.

Proposition 2. *If deal sales are displayed, then the website attains the same expected profit as under symmetric information iff* $\alpha_L \in [\alpha_2, \alpha_H)$.[15]

Proof. Follows from Lemmas 1 and 4. □

We have thus identified a role for the website to display deal sales under asymmetric information. Displaying deal sales can enable the type H merchant to credibly separate and charge a deal price that reflects its fit α_H. Therefore, it acquires new consumers at a higher deal price than if deal sales are not displayed. Consequently, the website can attain the upper bound profit level, which is not possible without displaying deal sales. This role of displaying deal sales is different from the role it can play in coordinating consumer choices in the presence of a minimum limit in Hu et al. (2013). An interesting point is that though the two merchant types charge different deal prices, they can do so credibly only if deal sales are displayed by the website. In other words, what sustains a separating equilibrium is not the merchant types choosing different prices, but it is the website's decision to display deal sales. This separating equilibrium has an additional interesting feature—namely, there is no distortion in the deal price or demand compared with the symmetric information benchmark. This differs from what we commonly encounter in signaling models, where signaling entails a distortion to ensure mimicking does not occur.[16] This can be understood better in our model, by noting that the frequent- and late-new consumers, whose buying decisions are responsible for making mimicking unattractive, learn the merchant's types not from prices but through observational learning from deal sales.

Intuitively, displaying deal sales leverages sales to experienced consumers to attract new consumers at a higher price, thereby benefiting the type H merchant and the website.[17] Offering a deal cannibalizes revenue from experienced consumers, who would have otherwise bought the product at the regular price. Such cannibalization is common in many forms of discount promotions. What is different in this case is that sales to experienced consumers is leveraged to attract new consumers at a higher price, thereby minimizing the costs due to cannibalization. In other words, experienced consumers have informational value that is unlocked by displaying deal sales. This mechanism is made possible by the fact that consumers purchase the deal upfront, and this can be monitored by the website. The idea of paying existing consumers (through a discount) to help acquire new consumers has some resemblance to selling mechanisms examined before by Biyalogorsky et al. (2001) and Jing and Xie (2011). In our setting, however, there are no direct interactions between experienced consumers and new consumers. Instead, new consumers are influenced indirectly through observational learning. The idea of leveraging experienced consumers to extract more surplus from new consumers is also related to the mechanism studied by Despotakis et al. (2014) in an auction setting. They find that certain auction rules result in experienced buyers paying lower prices, but

[14] The equilibrium strategy of frequent- and late-new consumers can be made robust to trembles by an arbitrarily small measure of consumers in period 1 by specifying a τ suitably in the interior of $(\tau_L, \tau_H]$. We thank the associate editor and an anonymous reviewer for this suggestion. The alert reader will note that for the equilibrium to be trembling-hand perfect, the type H merchant should set a deal price $\alpha_H - \epsilon$, where $\epsilon > 0$ is arbitrarily small. This ensures that, for a sufficiently small tremble by the type L merchant, early-new consumers still buy from the type H merchant in period 1. Thus, the equilibrium that we have constructed in Lemma 4 is the limit of the trembling-hand perfect equilibrium as $\epsilon \to 0$.

[15] We note that α_2 was previously defined in Lemma 4. Here and in the rest of the paper, it is understood that parameter thresholds that are not explicitly defined have been defined previously.

[16] Separation without distortion in prices through the use of multiple instruments also occurs in Moorthy and Srinivasan (1995) and Stock and Balachander (2005).

[17] We thank an anonymous reviewer for suggesting this intuition.

their participation causes inexperienced buyers to bid more aggressively and pay higher prices, which more than compensates the auction website's loss of revenue from experienced buyers.

3.3.2. Pooling Equilibrium. We find that observational learning occurs in the pooling equilibrium because period 1 sales are displayed. But mimicking occurs in equilibrium despite observational learning. The equilibrium deal price is $d_H = d_L = \bar{\alpha}$. Frequent- and late-new consumers infer the merchant's type from period 1 deal sales. They do not buy from the type L merchant since the deal price $\bar{\alpha} > \alpha_L$. Consequently, the type L merchant sells only to matched consumers and early-new consumers. Lemma 5 describes this equilibrium. Let $R_t^D|_p^D$ denote the deal revenue for a type t merchant, and let $\Pi^W|_p^D$ denote the website's expected profit in the pooling equilibrium.

Lemma 5. *In the subgame with deal sales displayed, there is a pooling equilibrium in which both merchant types offer the deal at the same price. This equilibrium occurs iff* $\alpha_L \in (0, \alpha_2)$ *and* $\bar{\theta} \in (\max\{\theta_1, \theta_2\}, 1)$, *where* $\theta_2 = (N\alpha_L(1-\frac{1}{2}\beta))/((\alpha_L + \frac{1}{2}\beta N)(\alpha_H - \alpha_L)) \in (0, 1)$. *In this equilibrium, we have the following*:

(i) *The deal price is* $d_H = d_L = \bar{\alpha}$.

(ii) *At the deal price* $\bar{\alpha}$, *frequent- and late-new consumers buy the deal in period* 2 *only if period* 1 *sales is* τ_H *and do not buy if period* 1 *sales is* τ_L, *where* $\tau_t = (1-\frac{1}{2}\beta)\alpha_t + \frac{1}{2}\beta N$ *for* $t \in \{H, L\}$.

(iii) *Deal revenues are* $R_H^D|_p^D = \bar{\alpha}(\alpha_H + N)$ *and* $R_L^D|_p^D = \bar{\alpha}(\alpha_L + \frac{1}{2}\beta N)$.

(iv) *The website's expected profit is* $\Pi^W|_p^D = (1-\lambda) \cdot \bar{\alpha}(\bar{\alpha} + N(\bar{\theta} + \frac{1}{2}\beta(1-\bar{\theta})))$.

Intuitively, the loss in demand from mimicking for the type L merchant is offset by the gain in margin. If the type L merchant does not mimic the type H merchant and separates, then it must set a deal price α_L. If α_L is low, then the type L merchant's margin without mimicking is low. If $\bar{\theta}$ is high, then the margin from mimicking is high. Lemma 5 shows that if α_L is sufficiently low and $\bar{\theta}$ is sufficiently high, then mimicking is attractive.

3.3.3. Separating Equilibrium with Price Distortion. In a separating equilibrium with price distortion, mimicking is unattractive both because of observational learning and because the type H merchant sets a deal price sufficiently lower than α_H. From Lemma 4, observational learning alone is not sufficient to make mimicking unattractive if $\alpha_L < \alpha_2$. This is because the gain in margin from mimicking at a deal price α_H offsets the loss of demand from observational learning. However, mimicking is not attractive if d_H is sufficiently below α_H. Specifically, it is not attractive if $d_H \le d_H^* = (\alpha_L(\alpha_L + N))/(\alpha_L + \frac{1}{2}\beta N)$, where $d_H^* < \alpha_H$ iff $\alpha_L < \alpha_2$. We find that the separating equilibrium with price distortion occurs if it is profitable for the type H merchant to offer a deal at the deal price d_H^*. In particular, we require that $d_H^* \ge \bar{\alpha}$. If $d_H^* < \bar{\alpha}$, then the type H merchant is better off in a pooling PBE in which $d_H = d_L = \bar{\alpha}$ than in the separating PBE in which $d_H < \bar{\alpha}$. Hence, the separating PBE does not survive the SUE refinement. Intuitively, if $d_H^* < \bar{\alpha}$, then the type H merchant prefers to accommodate mimicking rather than deter it by lowering its deal price. Lemma 6 derives the conditions under which the separating equilibrium with price distortion occurs and describes the equilibrium deal revenue $R_t^D|_{s1}^D$ and expected website profit $\Pi^W|_{s1}^D$.

Lemma 6. *In the subgame with deal sales displayed, there is a separating equilibrium with price distortion in which* $d_H = d_H^* \in [\bar{\alpha}, \alpha_H)$ *and* $d_L = \alpha_L$, *where* $d_H^* = \alpha_L(\alpha_L + N)/(\alpha_L + \frac{1}{2}\beta N)$. *This equilibrium occurs iff* $\alpha_L \in (\alpha_3, \alpha_2)$ *and* $\bar{\theta} \in (0, \theta_2]$, *where* $\alpha_3 = (\sqrt{(N^2 + (N-p)\alpha_H)^2 + 2p\beta N\alpha_H(N+\alpha_H)} + p\alpha_H - N(N+\alpha_H))/(2(N+\alpha_H)) \in (0, \alpha_2)$. *In this equilibrium, we have the following*:

(i) *At the deal price* d_H^*, *frequent- and late-new consumers buy the deal in period* 2 *only if period* 1 *sales is* τ_H *and do not buy if it is* τ_L, *where* $\tau_t = (1-\frac{1}{2}\beta)\alpha_t + \frac{1}{2}\beta N$ *for* $t \in \{H, L\}$.

(ii) *Deal revenues are* $R_H^D|_{s1}^D = d_H^*(\alpha_H + N)$ *and* $R_L^D|_{s1}^D = \alpha_L(\alpha_L + N)$.

(iii) *The website's expected profit is* $\Pi^W|_{s1}^D = (1-\lambda) \cdot (\bar{\theta} d_H^*(\alpha_H + N) + (1-\bar{\theta})\alpha_L(\alpha_L + N))$.

3.4. Website's Incentive to Display Deal Sales

Having examined the subgames, we now analyze the website's equilibrium decision to display deal sales. For each of the equilibrium outcomes in the subgame with deal sales displayed described in Lemmas 4–6, we compare the website profit with that in the subgame with deal sales not displayed. We find that the website displays deal sales in equilibrium if doing so leads to separation without too much distortion. Proposition 3 provides the conditions under which the website displays deal sales in equilibrium. The proofs for all remaining results are deferred to Appendix C.

Proposition 3. *The website displays deal sales in equilibrium iff one of the following conditions are met*: (i) $\alpha_L \in [\alpha_2, \alpha_H)$, (ii) $\alpha_L \in (\alpha_4, \alpha_2)$ *and* $\bar{\theta} \in (0, \theta_3]$, *or* (iii) $\alpha_L \in (\alpha_3, \alpha_1)$ *and* $\bar{\theta} \in (0, \theta_1]$, *where* $\alpha_4 \in (\alpha_3, \alpha_2)$ *is the unique positive root of the equation*

$$\alpha_L^3 + ((N-\alpha_H) + \tfrac{1}{2}N\beta)\alpha_L^2 + N(N-\alpha_H\beta)\alpha_L - \tfrac{1}{2}N^2\alpha_H\beta = 0, \tag{10}$$

and $\theta_3 = (d_H^*(N+\alpha_H) - N\alpha_H - (2\alpha_H - \alpha_L)\alpha_L)/(\alpha_H - \alpha_L)^2 < \theta_2$.

To understand the website's incentive to display deal sales, it is useful to consider in turn each of the equilibrium outcomes in the subgame with deal sales displayed. We start with the distortionless separating equilibrium. From Propositions 1 and 2, we can conclude that the website will display deal sales if doing so results in a distortionless separating equilibrium. This is because the website can attain the upper bound Π_{SI}^W for its profit only in a distortionless separating equilibrium, and this occurs iff the website displays deal sales and $\alpha_L \geq \alpha_1$.

Next, we find that if displaying deal sales will result in a pooling equilibrium, then the website will not display deal sales. Comparing the pooling equilibrium in each subgame from Lemmas 2 and 5, we observe that the deal revenue for the type L merchant is strictly lower in the subgame with deal sales displayed, whereas that of the type H merchant is the same in both subgames; i.e., $R_L^D|_p^D < R_L^D|_p^{ND}$ and $R_H^D|_p^D = R_H^D|_p^{ND}$. This is because, with deal sales displayed, frequent- and late-new consumers do not buy from the type L merchant. The lower deal revenues with deal sales displayed leads to two implications. First, the condition under which a pooling equilibrium occurs is more stringent in the subgame with deal sales displayed; i.e., the condition for equilibrium in Lemma 5 is stricter than that in Lemma 2. Therefore, if a pooling equilibrium occurs in the subgame with deal sales displayed, then a pooling equilibrium also occurs in the subgame with deal sales not displayed. Second, the website's expected profit is higher in the latter subgame; i.e., $\Pi^W|_p^D < \Pi^W|_p^{ND}$. Consequently, the website will not display deal sales. The following corollary states this result.

Corollary 1. *The website will not display deal sales if displaying deal sales results in a pooling equilibrium in which both merchant types set the same deal price* (*as described in Lemma* 5).

Thus, observational learning can be a double-edged sword: if it does not make mimicking unattractive, then it causes a loss of demand and hurts the website. New consumers benefit from observational learning since they can avoid buying from the type L merchant. However, it is not in the interest of the website to display deal sales.

Last, consider the separating equilibrium with price distortion. Intuitively, if there is not much price distortion, i.e., if d_H^* is close to α_H, then the website's expected profit is close to the upper bound Π_{SI}^W, and the website will display deal sales. Instead, if there is considerable distortion, i.e., d_H^* is close to $\bar{\alpha}$, then the website is better off not displaying deal sales. This is because not displaying deal sales leads to a pooling equilibrium in which the type H merchant revenue is slightly lower, and the type L merchant revenue is considerably higher (since its margin is $\bar{\alpha}$ in the pooling equilibrium). We remark that the type H merchant is always better off in a separating equilibrium, since it can acquire new consumers at a higher deal price. However, the website may prefer to induce pooling by not displaying deal sales since separation hurts the type L merchant revenue. The following corollary states this result.

Corollary 2. *The website may not display deal sales even if displaying sales would benefit the better merchant*.

Thus, the website has a part in determining whether the merchant types can separate in equilibrium. Moreover, its incentives are distinct from that of the merchant. Our analysis of a strategic website brings this out clearly. The website's strategy maximizes its profit from both merchant types. Consequently, it may suppress separation by not displaying deal sales even if this hurts the better merchant.

To summarize, the website displays deal sales if doing so leads to a distortionless separation or separation without too much distortion in deal price. If displaying deal sales results in too much distortion in deal price, or in a pooling equilibrium, then the website will not display deal sales. We remark that if displaying sales results only in the type L merchant offering a deal, then the website cannot benefit from displaying deal sales. In this case, there are two possibilities in the subgame in which deal sales are not displayed. Either there is a pooling equilibrium in which both merchant types offer a deal resulting in higher expected website profit or only the type L merchant offers a deal, in which case the website is indifferent between displaying and not displaying deal sales, and we assume that it does not.

4. Should the Website Offer the Merchant an Up-front Subsidy?

Some daily deal websites such as Groupon and LivingSocial offer considerable support to a merchant in designing the promotional material for the deal and employ a substantial team of copywriters and editorial staff for this purpose (e.g., Streitfeld 2011, LivingSocial 2013). But they do not charge the merchant for this service. Hence, it could be thought of as a subsidy. This raises the question whether it can be optimal for the website to offer a subsidy. To examine this question, we endogenize the revenue-sharing contract. We assume that the contract consists of the revenue-sharing rate $\lambda \in [0, 1]$, which is the merchant's share of revenue and a fixed-fee F that the merchant must pay the website to offer a deal, with $F < 0$ denoting a subsidy. In stage 1 of period 0, the website decides whether to implement the deal counter and the revenue-sharing contract. In stage 2, the merchant must accept the contract to offer a deal. The rest of the game proceeds as before.

Given the contract terms (λ, F), the type t merchant will accept the contract iff

$$\lambda R_t^D - F \geq R_t^O. \tag{11}$$

We refer to the incremental revenue $R_t^D - R_t^O$ as the *surplus* generated by the type t merchant. If the merchant accepts the contract, then it retains a portion $\lambda R_t^D - F - R_t^O$ of the surplus while the website captures a portion $(1-\lambda)R_t^D + F$. If only one of the merchant types accepts the contract in equilibrium, then the equilibrium contract is not unique; i.e., there is a range of (λ, F) that will lead to the same outcome. Therefore, for our analysis to be meaningful, we focus on situations in which the website offers a contract that both merchant types accept in equilibrium.[18] As in our main analysis, the contract terms do not affect the merchant's pricing decision conditional on offering a deal. Therefore, the equilibrium deal price and revenue are the same as in our main analysis.

We first show in Lemma 7 that it is optimal to provide a subsidy iff the type H merchant's deal generates sufficiently more surplus than the type L merchant's. Then, in Proposition 4, we examine when this condition can hold in equilibrium.

Lemma 7. *The equilibrium revenue-sharing contract will involve a subsidy iff* $R_H^D - R_H^O > (\alpha_H/\alpha_L)(R_L^D - R_L^O)$.

Intuitively, the revenue-sharing component allows the website to capture more surplus from the type H merchant than from the type L merchant. This is because $R_H^D > R_L^D$ in any equilibrium; the type H merchant realizes higher deal revenue since its deal price is weakly higher and its deal sales is strictly higher. Consequently, if the type H merchant's deal generates considerably more surplus than the type L merchant's, we find that it is optimal for the website to offer a subsidy in conjunction with taking a larger share of deal revenue (low λ). The low λ extracts the higher surplus of the type H merchant's deal, and the subsidy ensures that the type L merchant offers a deal despite a low λ. Without the subsidy, the website cannot fully capture the higher surplus of the type H merchant while also serving the type L merchant.

We find that a subsidy is not optimal if the website does not display deal sales in equilibrium. Specifically, in the pooling equilibrium in the subgame with deal sales not displayed, the type H merchant's deal generates lower surplus than the type L merchant's. Although both merchant types obtain the same revenue from new consumers, the type H merchant faces higher cannibalization because it has more matched consumers. Consequently, the equilibrium contract does not involve a subsidy. By contrast, a subsidy can be optimal if the website displays deal sales in equilibrium. Displaying deal sales allows the type H merchant to attract new consumers at a higher margin than the type L merchant. As a result, its deal can generate higher surplus. In particular, a subsidy is always optimal under distortionless separation. Proposition 4 describes the conditions under which the website provides a subsidy.

Proposition 4. *The equilibrium revenue sharing contract will involve a subsidy iff the website displays deal sales in equilibrium and* $\alpha_L > \alpha_5$, *where* $\alpha_5 = \frac{1}{2}\beta\alpha_H$.

A daily deal website's ability to monitor deal purchases does not preclude it from charging the merchant an up-front fee for the service it provides. Proposition 4 shows that it can, nevertheless, be in the interest of the website not to charge an up-front fee and, in fact, provide a subsidy. This is because it enables the website to better capture the surplus generated by the high-type merchant. In practice, there may be other reasons why the website does not charge the merchant an up-front fee. For instance, this could be a means for the website to differentiate itself from traditional forms of promotional advertising, such as coupon mailers or newspapers that charge the merchant up front for their service. In other words, it can be a cost of doing business. Setting aside such considerations, we find that it can actually be a means for the website to extract more surplus from the merchant, but only if it displays deal sales.

5. Discussion and Conclusion

Daily deal websites have become a popular means for small merchants to attract new consumers. Our work contributes to the understanding of this emerging business model. Unlike traditional coupon mailer companies, a daily deal website functions as a marketplace enabling transactions between a merchant and consumers. Consequently, it can monitor consumer purchases linked to a deal. We show how the website can capitalize on this capability. By tracking and displaying deal sales, the website can enable a merchant to leverage its sales to experienced consumers to attract new consumers. Thus, although a daily deal promotion cannibalizes the merchant's revenue from experienced consumers, displaying deal sales can unlock the informational value of these consumers and minimize the costs from cannibalization. Displaying deal sales is, however, not a dominant strategy. In particular, the website may not implement this feature even if doing so will enable the high-type merchant to credibly signal its type to attract new consumers. Thus, the incentives of the website are distinct from that of the merchant.

[18] We note in passing that it will be optimal for the website to offer a contract that both merchant types accept if $\alpha_L \geq \alpha_6 \in (0, \alpha_5)$, where α_5 is defined in Proposition 4. Otherwise, the website offers a contract that only the type L merchant accepts. We do not include an analysis of this outcome because it does not provide any additional insights.

5.1. Managerial Implications

Managers of daily deal websites have been concerned about the implication of displaying deal sales and how to improve its effectiveness. For instance, Groupon and TroopSwap conducted field experiments to determine how displaying sales influenced consumer behavior (Julie M 2011, Vasilaky 2012a). Our work examines the implications while explicitly considering the strategic behavior of the merchant as well as consumers within an equilibrium framework. Our findings lead to some managerial implications.

First, daily deal websites have been criticized both for the high share of revenue that they take and the deep discounts that merchants offer (Mulpuru 2011, Bice 2012, Kumar and Rajan 2012). These criticisms essentially question the viability of the business model. Our results provide guidance to daily deal websites on how the depth of discounts offered on the website can be managed so as to maximize the profitability of daily deals. In essence, this occurs in a separating equilibrium. We show that it can be necessary to display deal sales to obtain a separating equilibrium. One might conjecture that a daily deal website could instead sort the merchants by individually verifying their characteristics or by offering a menu of contracts. However, given that daily deal websites typically market their services to a large number of small merchants through a relatively low-skilled sales force, these approaches can be impractical because they can make the selling task more effortful and complex. In this context, displaying deal sales can play an important role in inducing the merchant to provide the right level of discount and increasing industry profitability.[19]

A second implication is the important role of experienced consumers buying the deal. In the case of traditional promotions, there is no benefit if experienced consumers who would have bought at the regular price buy the deal, because this only results in cannibalization and lowers profit. Based on this logic, industry experts recommend that daily deals should include restrictions to ensure that they are availed mainly by new consumers (Mulpuru 2011, Bice 2012, Kumar and Rajan 2012). But observational learning cannot occur if experienced consumers do not buy the deal. Thus, based on our analysis, we can conclude that such restrictions can hurt in the case of a daily deal website that displays deal sales and lead to lower industry profitability.

Third, a website can benefit from offering the merchant an up-front subsidy. Not charging the merchant an upfront fee or providing costly services free of charge are typically thought of as the website's "costs of doing business" to attract merchants. Our analysis, however, shows that providing a subsidy can help the website capture more of the merchant's profit by retaining a higher share of deal revenues. This is the case only if the website displays deal sales such that the high-type merchant earns sufficiently higher margin and, therefore, higher profit than the low-type merchant.

Finally, a daily deal website should also explore ways to promote observational learning. As our model suggests, the website benefits if more consumers visit the website frequently. One way to attract consumers to the website frequently is by choosing the appropriate assortment of goods and services. Another way would be to use additional communication methods such as targeted emails and advertisements. For instance, Groupon found that including deal sales information in their emails significantly increased website traffic. Keeping the duration of the deal longer can also enhance the opportunities for observational learning.

5.2. Caveats and Directions for Future Work

We showed that experienced consumers can be leveraged to acquire new consumers. One reason to acquire new consumers is that they may make repeat purchases in the future. Our analysis did not explicitly consider repeat purchases. In the online appendix, we analyze a setting in which new consumers can make a repeat purchase at the regular price. It turns out that incorporating repeat purchases strengthens the signaling role of displaying deal sales; i.e., it increases the range of model parameters for which displaying deal sales enables the website to attain the upper bound for its expected profit level. Repeat purchases make mimicking less attractive for the type L merchant in a separating equilibrium, but only if deal sales are displayed. This is because, in the presence of observational learning, the type L merchant loses not only current sales but also future sales from frequent- and late-new consumers if it mimics the type H merchant. Thus, our results are robust to incorporating repeat sales in our model.

We assumed that $p > \alpha_H$ such that the regular price does not restrict the deal price at which the merchant can acquire new consumers. How the regular price is determined is not the focus of our paper. Therefore, to determine the boundary conditions for our results, we examine the implication if $p \leq \alpha_H$ in the online appendix. In this case, we show that the regular price can restrict the deal margin of the type H merchant in a separating equilibrium with deal sales displayed. Consequently, displaying deal sales can be less profitable for the website than in our main analysis. We obtain the lower bound $\bar{p}$ for the regular price below which

[19] In the initial period of the daily deal industry, some deal websites listed only one deal a day and may have engaged in ex ante screening of merchants. Currently, however, daily deal websites can list hundreds of deals every day. As mentioned before, in our discussion with Groupon, we found that their sales team does not spend time qualifying merchants.

the website will not display deal sales in equilibrium and above which the website will display deal sales if there is a sufficient number of frequent visitors and the insights from our main analysis continue to hold qualitatively.

We assumed that the merchant's deal price is fixed during the duration of the deal, which is the common practice on daily deal websites such as Groupon, LivingSocial, and Amazon Local. We suspect that this is because allowing prices to vary dynamically over the relatively short duration of a daily deal may cause consumer confusion and may discourage consumers from using the website. There may also be significant "menu costs" associated with keeping consumers updated about dynamically changing prices over the short duration of the deal. Dynamic prices may, however, be feasible in other online e-retailing settings. We leave it for future research to examine the implications of displaying sales in other online contexts.

We showed that deal sales can convey private information about the merchant to consumers through observational learning, which is consistent with prior empirical research (e.g., Zhang and Liu 2012, Luo et al. 2014). Displaying deal sales may also serve other purposes such as conveying private information about the website (e.g., its ability to attract merchants and consumers). However, unlike merchants, the website has more visible market presence and can use advertising and brand building activities to signal its private information. Future research can examine whether and how a daily deal website can jointly employ these different means to convey its private information.

Competition between daily deal websites may provide an additional motive for a daily deal website to display deal sales. Displaying deal sales may allow a website to differentiate itself from a rival website that does not display deal sales by enabling consumers to make better-informed decisions. It may also enable the website to attract high-type merchants away from the rival website, since they benefit from signaling their type. An interesting question for future research is whether this can result in asymmetric outcomes, wherein only one of the website displays deal sales in equilibrium.

Finally, our analysis provides market conditions under which displaying deal sales is profitable for the website. As mentioned in the introduction, some daily deal websites display deal sales whereas others do not. Future empirical research could determine whether the market conditions faced by these websites are consistent with our model results.

Supplemental Material

Supplemental material to this paper is available at https://doi.org/10.1287/mnsc.2015.2298.

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Appendix A. Notation

t	Merchant's type, $t \in \{H, L\}$
r	Consumer utility if product fits consumer need, normalized to 1
α_t	Probability of fit for type t merchant
$\bar{\theta}$	Prior belief that merchant's type is H
N	Number of new consumers on the website
β	Proportion of infrequent visitors on the website
p	Merchant's regular price
θ	New consumers' posterior belief that merchant's type is H
d_t	Deal price of type t merchant
R_t^D	Deal revenue for type t merchant
R_t^O	Revenue from regular sales for type t merchant
λ	Merchant's share of deal revenue
F	Fixed fee paid by merchant to website ($F = 0$ in the main analysis)
Π^W	Website's expected profit

Appendix B. Proofs of Lemmas

Lemma 8. *In the subgame with deal sales not displayed, only the type L merchant offers a deal in equilibrium iff* $\alpha_L \in (0, \alpha_1]$ *and* $\bar{\theta} \in (0, \theta_1)$, *where* $\alpha_1 = \alpha_H/(N+\alpha_H) < \alpha_H$ *and* $\theta_1 = (\alpha_H - \alpha_L(N+\alpha_H))/((N+\alpha_H)(\alpha_H - \alpha_L)) \in (0,1)$. *In this equilibrium, we have the following*:

(i) *The deal price is* $d_L = \alpha_L$.

(ii) *The deal revenue is* $R_L^D|_l^{ND} = \alpha_L(\alpha_L + N)$.

(iii) *The website's expected profit is* $\Pi^W|_l^{ND} = (1-\lambda) \cdot (1-\bar{\theta})\alpha_L(\alpha_L + N)$.

Proof. From Lemma 3, if $\alpha_L \in (0, \alpha_1]$ and $\bar{\theta} \in (0, \theta_1)$, then the pooling equilibrium does not occur. An equilibrium in which only the type H merchant offers a deal does not exist because it is profitable for the type L merchant to offer a deal at the deal price α_L (since condition (5) holds if $N > 1$). Consider an equilibrium in which only the type L merchant offers a deal. We require $d_L = \alpha_L$ since new consumers must correctly believe that only the type L merchant offers a deal. All new consumers and matched consumers will buy the deal. If the type H merchant offers a deal at a deal price $d_H > \alpha_L$, then new consumers do not buy because they believe that the merchant is type L. Given that the pooling equilibrium does not occur, it is also not profitable for the type H merchant to offer a deal at the deal price α_L. It is profitable for the type L merchant to offer a deal since condition (5) holds. Moreover, this is the unique equilibrium. The equilibrium deal revenue and expected website profit are then as described in the lemma. □

Proof of Lemma 1. We show that $\Pi^W \le \Pi^W_{\text{SI}}$ in any potential PBE in either subgame. First, consider a separating PBE in which both merchant types offer a deal and $d_H \ne d_L$. In this PBE, new consumers must believe that the merchant's type is t if the deal price is d_t and be willing to pay α_t. If $d_t > \alpha_t$, then new consumers will not buy the deal, and the deal cannot generate incremental revenue. Hence, it must be that $d_t \le \alpha_t$ for $t \in \{H, L\}$ in any separating PBE. Further, it must be that $d_L = \alpha_L$, since all new consumers will buy the deal at this price even if they hold pessimistic beliefs $\theta = 0$. Now, if in a separating PBE both merchant types set $d_t = \alpha_t$ and all matched consumers and new consumers buy the deal, then $R^D_t = \alpha_t(\alpha_t + N)$ and $\Pi^W = \Pi^W_{\text{SI}}$. It follows that website's expected profit cannot exceed Π^W_{SI} in any other potential separating PBE since neither the deal price nor the demand can be higher than in the benchmark; i.e., $R^D_t \le \alpha_t(\alpha_t + N)$ for $t \in \{H, L\}$. Following similar arguments, it can also be shown that if only one of the merchant types offers a deal in a PBE, then $R^D_t \le \alpha_t(\alpha_t + N)$ for that merchant type and $R^D_t = 0$ for the other merchant type. Therefore, $\Pi^W < \Pi^W_{\text{SI}}$ in any potential PBE in which only one of the merchant types offers a deal.

Next, consider a pooling PBE in which both merchant types offer a deal and $d_H = d_L = d$. At the deal price d, new consumers must maintain their prior belief that $\theta = \bar{\theta}$ in period 1. Suppose that $d > \bar{\alpha}$. In period 1, frequent- and early-new consumers will not buy the deal because their expected surplus is $\bar{\alpha} - d < 0$. Only frequent- and early-matched consumers will buy the deal. The resulting period 1 sales of $(1 - \frac{1}{2}\beta)\alpha_t$ for $t \in \{H, L\}$ depends on the merchant's type. In period 2, in the subgame with deal sales not displayed, frequent- and late-new consumers will maintain their prior belief $\bar{\theta}$ and will not buy the deal. In the subgame with deal sales displayed, frequent- and late-new consumers will correctly identify the merchant's type from period 1 sales. They will not buy the deal if the merchant's type is L, since their expected surplus will be $\alpha_L - d < 0$. Thus, whether or not deal sales are displayed, new consumers will not buy the deal from the type L merchant if $d > \bar{\alpha}$, and its deal cannot generate any incremental revenue. Therefore, it must be that $d \le \bar{\alpha}$ in any potential pooling PBE. If $d = \bar{\alpha}$ in a pooling PBE and all matched consumers and new consumers buy, then the website's expected profit will be

$$\Pi^W = (1 - \lambda)\bar{\alpha}(\bar{\theta}\alpha_H + (1 - \bar{\theta})\alpha_L + N). \tag{B1}$$

The above profit is strictly lower than Π^W_{SI} since

$$\Pi^W_{\text{SI}} - \Pi^W = (1 - \lambda)\bar{\theta}(1 - \bar{\theta})(\alpha_H - \alpha_L)^2. \tag{B2}$$

It follows that in any other potential pooling PBE $\Pi^W < \Pi^W_{\text{SI}}$ since $d \le \bar{\alpha}$. Therefore, $\Pi^W = \Pi^W_{\text{SI}}$ only in a separating PBE in which $d_t = \alpha_t$ and all matched consumers and new consumers buy the deal, and $\Pi^W < \Pi^W_{\text{SI}}$ in any other PBE.

Proof of Lemma 2. We prove this by contradiction. Suppose that there exists a separating equilibrium in which both merchant types offer a deal. Then, $d_H \ne d_L$. As shown in the proof of Lemma 1, it must be that $d_L = \alpha_L$ and $d_H \le \alpha_H$. Further, $d_H > \alpha_L$ since the reservation price of new consumers cannot be below α_L irrespective of their beliefs. In this equilibrium, new consumers must believe that the merchant's type is t if the deal price is d_t and be willing to pay α_t. Consequently, new consumers will buy the deal at either equilibrium deal price. Matched consumers will also buy the deal at either equilibrium deal price regardless of the merchant's type because the deal price is below the regular price. But this implies that the type L merchant can increase its margin by deviating to $d_H > \alpha_L$ without affecting its demand. New consumers will still buy its deal as they mistakenly believe it to be a type H merchant. Matched consumers will also buy the deal since the deal price is below the regular price. Therefore, the type L merchant can profitably mimic the type H merchant, which contradicts the existence of a separating equilibrium.

Proof of Lemma 3. We first show that $d_H = d_L = \bar{\alpha}$ in a pooling equilibrium. Let d denote the deal price in a pooling PBE. In the proof of Lemma 1, we showed that $d \le \bar{\alpha}$, as otherwise, new consumers will not buy. Also, $d \ge \alpha_L$ since the reservation price of new consumers cannot be below α_L irrespective of their beliefs. Therefore, $d \in [\alpha_L, \bar{\alpha}]$. All matched consumers and new consumers will buy the deal in equilibrium, as they obtain an expected surplus $\bar{\alpha} - d \ge 0$. Deal revenue is then

$$R^D_t = d(\alpha_t + N) \quad \forall\, t \in \{H, L\}. \tag{B3}$$

The pooling PBE exists iff offering a deal can be profitable for the merchant. Therefore,

$$R^D_t > R^O_t \quad \Longrightarrow \quad d(\alpha_t + N) > p\alpha_t \tag{B4}$$

for $t \in \{H, L\}$. Since R^D_t is increasing in d, if condition (B4) holds for $d < \bar{\alpha}$, then it also holds for $d = \bar{\alpha}$. Therefore, if a pooling PBE in which $d < \bar{\alpha}$ exists, then a pooling PBE in which $d = \bar{\alpha}$ must also exist. Moreover, the latter PBE leads to higher revenue and profit for the type H merchant. Hence, a pooling PBE in which $d < \bar{\alpha}$ cannot be a SUE. Therefore, $d = \bar{\alpha}$ in a pooling equilibrium.

We next obtain the conditions under which the pooling equilibrium occurs. The pooling PBE in which $d = \bar{\alpha}$ exists iff condition (B4) holds for $t \in \{H, L\}$. This condition holds for $t = L$; condition (5) holds for $t = L$ and $\bar{\alpha} > \alpha_L$. It is straightforward to show that the condition holds for $t = H$ under the conditions stated in the lemma. Since there is no separating PBE, the pooling PBE is the SUE whenever it exists. Therefore, these conditions are both necessary and sufficient for the pooling equilibrium. Since all matched consumers and new consumers will buy the deal in this equilibrium, $R^D_t|^{ND}_p$ and $\Pi^W|^{ND}_p$ are as in the statement of the lemma.

Proof of Lemma 5. The proof consists of three steps that show that (i) $d_H = d_L = \bar{\alpha}$ in a pooling equilibrium; (ii) if the pooling PBE in which $d_H = d_L = \bar{\alpha}$ exists, then it is the SUE; and (iii) the pooling equilibrium occurs under the conditions stated in the lemma.

Step 1 (*$d_H = d_L = \bar{\alpha}$ in a pooling equilibrium*). Let d denote the deal price in a pooling PBE. Following the same arguments as in the proof of Lemma 3, we have $d \in [\alpha_L, \bar{\alpha}]$ in any pooling PBE. We show that a pooling PBE in which $d < \bar{\alpha}$ cannot survive the SUE refinement. First, consider a pooling PBE in which $d \in (\alpha_L, \bar{\alpha}]$; i.e., $d > \alpha_L$. In this PBE, early-new consumers will maintain their prior belief $\bar{\theta}$ and buy the deal as they obtain an expected surplus $\bar{\alpha} - d \geq 0$. All matched consumers will also buy the deal as they obtain a positive surplus, with frequent-matched consumers buying in period 1. Therefore, period 1 sales are informative about the merchant's type. Consequently, frequent-new consumers will wait till period 2 to learn the merchant's type. This is because their expected surplus from buying from a type L merchant is $\alpha_L - d < 0$, and they can avoid buying from the type L merchant by waiting till period 2. In period 2, frequent- and late-new consumers will buy if period 1 sales equal τ_H, which would indicate that the merchant's type is H, and will not buy if it equals τ_L, which would indicate that the merchant's type is L. Therefore, the deal revenues for a type H and type L merchant in this PBE are

$$R_H^D = d(\alpha_H + N), \quad R_L^D = d\left(\alpha_L + \tfrac{1}{2}\beta N\right). \tag{B5}$$

We note that the deal revenues in Equation (B5) are increasing in d. Therefore, if a pooling PBE in which $d \in (\alpha_L, \bar{\alpha})$ exists, then a pooling PBE in which $d = \bar{\alpha}$ must also exist. Furthermore, the latter PBE leads to higher revenue and profit for the type H merchant. Hence, a pooling PBE in which $d < \bar{\alpha}$ cannot be a SUE.

Next, consider a pooling PBE in which $d = \alpha_L$. In this case, the expected surplus of new consumers is nonnegative even if they believe that the merchant's type is L. Therefore, all matched consumers and new consumers will buy in equilibrium. Deal revenue is then

$$R_t^D = \alpha_L(\alpha_t + N) \quad \forall\, t \in \{H, L\}. \tag{B6}$$

This pooling PBE exists iff $R_t^D > R_t^O$ for $t \in \{H, L\}$. We show that this candidate PBE cannot be a SUE because, whenever it exists, one of the following alternative PBE that yields strictly higher profit for the type H merchant also exists: (i) the pooling PBE in which $d = \bar{\alpha}$, or (ii) a separating PBE in which $d_H = \bar{\alpha}$ and $d_L = \alpha_L$. Consider first the alternative pooling PBE. Let $R_t^{D'}$ denote the deal revenue for a type t merchant in this PBE. We have $R_H^{D'} = \bar{\alpha}(\alpha_H + N)$ and $R_L^{D'} = \bar{\alpha}(\alpha_L + \frac{1}{2}\beta N)$ from Equation (B5) (for $d = \bar{\alpha}$). We note $R_H^{D'} > R_H^D$. Given that the candidate pooling PBE exists, the alternative pooling PBE exists iff $R_L^{D'} \geq R_L^D$; i.e., $\bar{\alpha}(\alpha_L + \frac{1}{2}\beta N) \geq \alpha_L(\alpha_L + N)$. Moreover, the alternative pooling PBE yields higher profit for the type H merchant. Therefore, the candidate pooling PBE cannot be the SUE.

If instead $\bar{\alpha}(\alpha_L + \frac{1}{2}\beta N) < \alpha_L(\alpha_L + N)$, then we can construct the alternative separating PBE that yields higher profit for the type H merchant as follows. If the deal price is α_L, then all matched consumers and new consumers buy. If the deal price is $\bar{\alpha}$, then all matched consumers and early-new consumers buy, with frequent-new consumers buying in period 1. Frequent- and late-new consumers buy in period 2 if deal sales are τ_H and do not buy if deal sales are τ_L. Let $R_t^{D'}$ denote the deal revenue for a type t merchant in this separating PBE. We have $R_H^{D'} = \bar{\alpha}(\alpha_H + N)$ and $R_L^{D'} = \alpha_L(\alpha_L + N)$. Since $\bar{\alpha}(\alpha_L + \frac{1}{2}\beta N) < \alpha_L(\alpha_L + N)$, the type L merchant does not have an incentive to mimic the type H merchant. Moreover, $R_H^{D'} > R_H^D$ and $R_L^{D'} = R_L^D$. Therefore, if the candidate pooling PBE exists and $\bar{\alpha}(\alpha_L + \frac{1}{2}\beta N) < \alpha_L(\alpha_L + N)$, then the alternative separating PBE exists and yields higher profit for the type H merchant. As a result, the candidate pooling PBE cannot be the SUE.

Thus, the pooling PBE in which $d = \bar{\alpha}$ is the unique candidate for a pooling equilibrium. The equilibrium deal revenue $R_t^D|_p^D$ and expected website profit $\Pi^W|_p^D$ are as in the statement of the lemma.

Step 2 (*if the pooling PBE in which $d_H = d_L = \bar{\alpha}$ exists, then it is the SUE*). The pooling PBE exists iff we have the following:

(i) Offering a deal is profitable for both merchant types. Therefore, we have

$$R_H^D|_p^D \geq R_H^O \implies \bar{\alpha}(\alpha_H + N) \geq p\alpha_H, \tag{B7}$$

$$R_L^D|_p^D \geq R_L^O \implies \bar{\alpha}\left(\alpha_L + \tfrac{1}{2}\beta N\right) \geq p\alpha_L. \tag{B8}$$

(ii) The type L merchant does not deviate to $d_L = \alpha_L$ to sell to all new consumers, which yields

$$\bar{\alpha}\left(\alpha_L + \tfrac{1}{2}\beta N\right) > \alpha_L(\alpha_L + N). \tag{B9}$$

We now show that there is no other separating PBE in which $d_H > \bar{\alpha}$ such that the type H merchant earns a higher profit. We note that there is no separating PBE in which only the type H merchant offers a deal. This is because, from condition (5), it is always profitable for the type L merchant to offer a deal at a deal price α_L even if new consumers knew its type. Consider instead a separating PBE in which both merchant types offer a deal. As shown in the proof of Lemma 1, in this PBE we require that $d_L = \alpha_L$ and $d_H \leq \alpha_H$. On the equilibrium path, all matched consumers and new consumers will buy the deal as they obtain nonnegative surplus. Hence, $R_L^D = \alpha_L(\alpha_L + N)$. If the type L merchant mimics the type H merchant, early-new consumers will still buy the deal because they (incorrectly) believe that the merchant is of type H, whereas frequent- and late-new consumers can avoid buying the deal by observing deal sales. Therefore, a necessary condition for mimicking to be unprofitable in a separating PBE is

$$\alpha_L(\alpha_L + N) \geq d_H\left(\alpha_L + \tfrac{1}{2}\beta N\right). \tag{B10}$$

But conditions (B9) and (B10) cannot both hold for $d_H \in [\bar{\alpha}, \alpha_H]$. Therefore, if the pooling PBE exists, then a separating PBE in which the type H merchant realizes a higher profit does not exist.

Step 3 (*conditions under which the pooling equilibrium occurs*). We note that condition (B9) is sufficient for condition (B8) because of condition (5). Conditions (B7) and (B9) are linear in $\bar{\theta}$. Condition (B7) holds iff $\bar{\theta} > \theta_1 = (p\alpha_H - \alpha_L(N + \alpha_H))/((N + \alpha_H)(\alpha_H - \alpha_L))$, where $\theta_1 < 1$. Condition (B9) holds iff $\bar{\theta} > \theta_2 = (N\alpha_L(1 - \frac{1}{2}\beta))/((\alpha_L + \frac{1}{2}\beta N)(\alpha_H - \alpha_L))$. We note that if $\bar{\theta} \to 0$, then $\bar{\alpha} \to \alpha_L$, and condition (B9) must hold. Also, if $\bar{\theta} \to 1$, then $\bar{\alpha} \to \alpha_H$, and condition (B9) will hold only if $\alpha_L < \alpha_2$ (as shown in the proof of Lemma 4, $\alpha_L(\alpha_L + N) < \alpha_H(\alpha_L + \frac{1}{2}\beta N)$ iff $\alpha_L < \alpha_2$ because the no-mimicking constraint (9) will not hold). Therefore, $\theta_2 \in (0, 1)$ if $\alpha_L < \alpha_2$. Thus, the pooling equilibrium occurs iff $\alpha_L < \alpha_2$ and $\bar{\theta} > \max\{\theta_1, \theta_2\}$.

Proof of Lemma 6. We construct a candidate separating PBE with price distortion if $\alpha_L < \alpha_2$. We show that this candidate PBE exists iff $\alpha_L > \alpha_3$, it is the unique SUE iff $\bar{\theta} \leq \theta_2$, and no other separating PBE can be a SUE. As shown in the proof of Proposition 4, $\alpha_L(\alpha_L + N) < \alpha_H(\alpha_L + \frac{1}{2}\beta N)$ if $\alpha_L < \alpha_2$, because the no-mimicking constraint (9) will not hold. Therefore, there exists a deal price $d \in (\alpha_L, \alpha_H)$ such that $\alpha_L(\alpha_L+N)=d(\alpha_L+\frac{1}{2}\beta N)$. This deal price d equals d_H^* defined in the statement of the lemma. Consider a separating PBE in which $d_H=d_H^*$ and $d_L=\alpha_L$ and consumers adopted the following strategies:

- Matched consumers buy the deal at either deal price regardless of the merchant's type, with frequent-matched consumers buying the deal in period 1.
- At the deal price α_L, all new consumers buy the deal with frequent visitors buying in period 1.
- At the deal price d_H^*, early-new consumers buy in period 1, and frequent-new consumers wait till period 2. In period 2, frequent- and late-new consumers buy iff period 1 deal sales are not less than a threshold τ, where $\tau\in(\tau_L,\tau_H]$.

In equilibrium, all matched consumers and new consumers buy the deal. It is straightforward to verify that given the merchant strategies, consumers do not have an incentive to deviate. By construction, the type L merchant will not have an incentive to mimic the type H merchant. Merchant revenue and website expected profit are as given in the statement of the lemma. This separating PBE exists iff $R_t^D|_{s1}^D>R_t^O$ so that it is profitable to offer a deal. Therefore

$$d_H^*(N+\alpha_H)>p\alpha_H, \tag{B11}$$

$$\alpha_L(N+\alpha_L)>p\alpha_L. \tag{B12}$$

Condition (B12) holds because of condition (5). If $\alpha_L\to\alpha_2$, then $d_H^*\to\alpha_H$, and condition (B11) holds because of condition (5). If $\alpha_L\to 0$, then $d_H^*\to 0$, and condition (B11) cannot hold. Also, d_H^* is strictly increasing in α_L. Therefore, by continuity, there exists $\alpha_3\in(0,\alpha_H)$ such that condition (B11) holds iff $\alpha_L>\alpha_3$. Further, condition (B11) must hold as an equality if $\alpha_L=\alpha_3$, from which we obtain α_3 as defined in the statement of the lemma.

We next show that no other separating PBE can be a SUE. As shown in the proof of Lemma 1, in any separating PBE we require that $d_L=\alpha_L$ and $d_H\le\alpha_H$. By our construction of the candidate PBE, a separating PBE in which the type H merchant charges a higher price than d_H^* cannot exist (since the corresponding no-mimicking constraint will not hold). Also, if a separating PBE in which $d_H<d_H^*$ exists, then the separating PBE in which $d_H=d_H^*$ will also exist and yields higher profit for the type H merchant. Therefore, a separating PBE in which $d_H<d_H^*$ cannot be the SUE. Finally, there is no separating PBE in which only the type H merchant offers a deal. This is because, from condition (5), it is always profitable for the type L merchant to offer a deal at a deal price α_L even if new consumers knew its type.

Finally, we show that the candidate PBE is an SUE iff $d_H^*\ge\bar{\alpha}$. As shown in the proof of Lemma 5, if $d_H^*\ge\bar{\alpha}$, then the pooling PBE in which $d_t=\bar{\alpha}$ for $t\in\{H,L\}$ cannot exist. This is because the mimicking condition (B9) will not hold, and the type L merchant will prefer to separate than to pool with the type H merchant. Conversely, if $d_H^*<\bar{\alpha}$, then the pooling PBE will exist whenever the separating PBE exists. This is because the mimicking condition (B9) will be satisfied, and condition (B7) holds if condition (B11) holds. Moreover, the type H merchant's profit is higher in the pooling PBE since $d_H^*<\bar{\alpha}$. Therefore, the separating PBE we constructed is an SUE iff $d_H^*\ge\bar{\alpha}$. Moreover, no other PBE that leads to a different equilibrium outcome can be a SUE if $d_H^*\ge\bar{\alpha}$. It is straightforward that $d_H^*\ge\bar{\alpha}$ if $\bar{\theta}\le\theta_2=(N\alpha_L(1-\frac{1}{2}\beta))/((\alpha_L+\frac{1}{2}\beta N)(\alpha_H-\alpha_L))$, where $\theta_2\in(0,1)$ was derived in Lemma 5.

Proof for Lemma 7. The equilibrium contract is one that maximizes the website's expected profit subject to the IR constraints (11) for both merchant types and the feasibility constraint $\lambda\in[0,1]$. There are two possible equilibrium scenarios depending on whether the IR constraint (11) binds for one or both merchant types. We will show that the equilibrium contract involves a subsidy in the latter case under certain conditions. Two observations will be useful in our analysis. First, $R_H^O>R_L^O$, since the type H merchant has more matched consumers. Second, in any equilibrium, $R_H^D>R_L^D$ since the type H merchant sets a (weakly) higher deal price and realizes (strictly) higher deal sales in any equilibrium.

First, consider the case in which the IR constraint (11) binds for both merchant types. By solving the resulting pair of simultaneous equations, we obtain

$$\lambda R_t^D-F=R_t^O\quad\forall t\in\{H,L\}$$
$$\Longrightarrow\quad\lambda=\frac{R_H^O-R_L^O}{R_H^D-R_L^D},\quad F=\frac{R_L^DR_H^O-R_H^DR_L^O}{R_H^D-R_L^D}. \tag{B13}$$

The contract in Equation (B13) is feasible if $\lambda\in[0,1]$. Since $R_H^O>R_L^O$ and $R_H^D>R_L^D$, we have $\lambda>0$. We have $\lambda\le 1$ iff $R_H^D-R_H^O\ge R_L^D-R_L^O$. The contract is optimal, since it fully extracts the surplus of both merchant types. The contract involves a subsidy ($F<0$) if $R_H^D/R_H^O>R_L^D/R_L^O$. In fact, we also have that $\lambda<1$ if $R_H^D/R_H^O>R_L^D/R_L^O$ since,

$$\frac{R_H^D}{R_H^O}>\frac{R_L^D}{R_L^O}\quad\Longrightarrow\quad\frac{R_H^D-R_H^O}{R_H^O}>\frac{R_L^D-R_L^O}{R_L^O}$$
$$\Longrightarrow\quad R_H^D-R_H^O>R_L^D-R_L^O, \tag{B14}$$

where the last step follows because $R_H^O>R_L^O$. Therefore, if $R_H^D/R_H^O>R_L^D/R_L^O$, then the optimal contract is given by Equation (B13) and involves a subsidy.

Next, consider the case in which the IR constraint (11) binds for only one of the merchant types. From our analysis above, this can occur iff $R_H^D-R_H^O<R_L^D-R_L^O$. We note that

$$\lambda R_H^D-F\ge R_H^O\quad\Longrightarrow\quad(R_H^D-R_H^O)-(1-\lambda)R_H^D-F\ge 0$$
$$\Longrightarrow\quad(R_L^D-R_L^O)-(1-\lambda)R_L^D-F>0$$
$$\Longrightarrow\quad\lambda R_L^D-F>R_L^O, \tag{B15}$$

where the penultimate step follows because $R_H^D>R_L^D$ and $R_H^D-R_H^O<R_L^D-R_L^O$. Therefore, the IR constraint can be binding only for the type H merchant. Consequently, the optimal contract in this case can fully extract the surplus of only the type H merchant. Now consider a revenue-sharing contract that fully extracts the surplus of the type H merchant in which $\lambda\in(0,1)$. We can construct an alternative contract with a higher revenue-sharing rate $\lambda'>\lambda$ and a higher fixed-fee $F'=F+(\lambda'-\lambda)R_H^D$. This contract also fully extracts the surplus of the type H merchant. Moreover, it will extract a higher portion of the type L merchant's surplus since $R_H^D>R_L^D$. Therefore, the website's expected profit is higher under the alternative contract. It follows that the optimal contract is one in which $\lambda=1$ and $F=R_H^D-R_O^D>0$, which does not involve a subsidy. Hence, a subsidy occurs iff $R_H^D/R_H^O > R_L^D/R_L^O$. Subtracting 1 from both sides of this condition and noting that $R_t^O = p\alpha_t$, we obtain the condition in the statement of the lemma.

Appendix C. Proofs of Propositions and Corollaries

Proof of Proposition 3. From Propositions 1 and 2, the website displays deal sales if $\alpha_L \geq \alpha_2$. Next, consider the conditions for a pooling equilibrium in Lemmas 3 and 5. It is straightforward to verify that $\alpha_2 < \alpha_1$. Therefore, if the pooling equilibrium occurs in the subgame with deal sales displayed, then it also occurs in the subgame with deal sales not displayed. Moreover, $\Pi^W|_p^D < \Pi^W|_p^{ND}$. Therefore, the website will not display deal sales.

Finally, we determine the conditions under which the website displays deal sales given that the equilibrium in the subgame with deal sales displayed is the separating equilibrium with price distortion described in Lemma 6. The equilibrium in the subgame with deal sales not displayed is either (i) the equilibrium in which only the type L merchant offers a deal (described in Lemma 8 in Appendix B) or (ii) a pooling equilibrium (described in Lemma 3). In the first case, the website will display deal sales since $\Pi^W|_{s1}^D > \Pi^W|_l^{ND}$. From Lemma 8, this occurs iff $\alpha_L < \alpha_1$ and $\bar{\theta} \leq \theta_1$.

In the second case, we require that $\Pi^W|_{s1}^d \geq \Pi^W|_p^{ND}$ for the website to display deal sales. This condition yields

$$(1-\lambda)\bar{\theta}[d_H^*(N+\alpha_H) - N\alpha_H - (2\alpha_H - \alpha_L)\alpha_L - (\alpha_H - \alpha_L)^2\bar{\theta}] \geq 0. \quad \text{(C1)}$$

The above condition holds iff $\bar{\theta} \leq \theta_3$, where $\theta_3 = [d_H^* \cdot (N+\alpha_H) - N\alpha_H - (2\alpha_H - \alpha_L)\alpha_L]/(\alpha_H - \alpha_L)^2 < \theta_2$. We still need to determine that $\theta_3 > 0$. Substituting for d_H^* in the expression for θ_3, we have

$$\theta_3 = \frac{\alpha_L^3 + \big((N-\alpha_H) + \frac{1}{2}N\beta\big)\alpha_L^2 + N(N-\alpha_H\beta)\alpha_L - \frac{1}{2}N^2\alpha_H\beta}{(\alpha_H-\alpha_L)^2\big(\alpha_L + \frac{1}{2}N\beta\big)}. \quad \text{(C2)}$$

By the Descartes sign-change rule, the numerator in the right-hand side of Equation (C2) has at most one positive root for α_L. We note that if $\alpha_L \to \alpha_2$, then $d_H^* \to \alpha_H$ (see condition (9) in proof of Lemma 4) and $\theta_3 > 0$. If $\alpha_L \to \alpha_3$, then $d_H^* \to p\alpha_H/(N+\alpha_H)$ (see condition (B11) in proof of Lemma 6) and $\theta_3 < 0$. Therefore, by continuity, there exists $\alpha_4 \in (\alpha_3, \alpha_2)$ such that $\theta_3 > 0$ iff $\alpha_L > \alpha_4$, where α_4 is the unique positive root of the Equation (10) in the proposition.

Proof of Corollary 1. Follows from the proof of Proposition 3.

Proof of Corollary 2. Follows from the proof of Proposition 3.

Proof of Proposition 4. Consider the subgame with deal sales not displayed. In this case, the only equilibrium in which both merchant types offer a deal is the pooling equilibrium that is described in Lemma 3. In this equilibrium, we have

$$\frac{R_H^D}{R_H^O} - \frac{R_L^D}{R_L^O} = -\frac{N\bar{\alpha}(\alpha_H - \alpha_L)}{p\alpha_H\alpha_L} < 0. \quad \text{(C3)}$$

Therefore, from Lemma 7, the contract will not involve a subsidy. Next, consider the subgame with deal sales displayed. The website displays deal sales only in a separating equilibrium. From Lemma 4, if $\alpha_L \geq \alpha_2$, then the equilibrium is a distortionless separating equilibrium. We have

$$\frac{R_H^D}{R_H^O} - \frac{R_L^D}{R_L^O} = \frac{\alpha_H - \alpha_L}{p} > 0. \quad \text{(C4)}$$

Therefore, the contract always involves a subsidy. If $\alpha_L < \alpha_2$ and the equilibrium is a separating equilibrium as described in Lemma 6, we have

$$\frac{R_H^D}{R_H^O} - \frac{R_L^D}{R_L^O} = \frac{N(N+\alpha_L)\big(\alpha_L - \frac{1}{2}\beta\alpha_H\big)}{p\alpha_H\big(\alpha_L + \frac{1}{2}\beta N\big)}, \quad \text{(C5)}$$

which is positive iff $\alpha_L > \alpha_5 = \frac{1}{2}\beta\alpha_H$.

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