

Online shopping and platform design with ex ante registration requirements

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Abstract

We study platform design in online markets in which buying involves a (non-monetary) cost for consumers caused by privacy and security concerns. Firms decide whether to require registration at their website before consumers learn the price and all relevant product information. We show that a monopoly seller requires ex ante registration in equilibrium if and only if the consumers' registration cost is sufficiently low. The result is reinforced when incorporating future purchases or an informational value of consumer registration to the firm, and it is robust to introducing price competition. We also show that discounts (store credit) can increase the share of consumers who register and hence a firm's profit even though discounts distort the equilibrium price.

Keywords: E-commerce; Privacy concerns; Security concerns; Registration cost; Platform design; Monopoly; Price competition; Information

JEL Codes: D42; D43; D82; D83; L81

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1 Introduction

Online shopping has become more and more popular in recent years and represents a sizeable share of product sales in most countries. In online markets, the interactions between firms and consumers exhibit many new characteristics which are not present in traditional shopping at brick and mortar stores. This raises new questions concerning firms' platform design. In particular, while traditional shopping typically does not require consumers to reveal personal information, shopping online often requires creating a user account and entering detailed contact and payment information. Therefore, shopping online can involve costs caused by privacy and security concerns which are less important in traditional markets.¹

This paper considers firms' platform choices when buying involves a non-monetary cost for consumers which we call 'cost of registration.' In our baseline model, a firm selling online faces a mass of consumers who are *ex ante* uncertain about the price of the product that the firm offers and about the exact product characteristics. This information can be revealed to the consumers. The types of products that we have in mind are 'inspection goods': When inspecting the good, consumers learn their valuation. Firms are able to credibly reveal information to the consumers, for instance, by providing a preview of a song, or of a book, or by releasing various product photos and details. The firm can decide to make this information accessible to its consumers upon visiting its online shop, or to require the consumers to set up an account before they can learn all relevant product details and, hence, their valuation. In other words, the firm decides whether to require *ex ante* registration, in which case each consumer who registers incurs a non-monetary registration cost (independently of buying), or to require registration only *ex post* (only if the consumer actually wants to buy). Moreover, the firm can offer the option of guest checkout, in which case the consumers need to provide less personal information. The firm cannot, however, completely remove the consumers' privacy and security concerns, as even the use of guest checkout usually requires the provision of shipping and payment information as well as some contact information such as an e-mail address, and does not remove all security concerns.

There are many examples in which firms require some kind of 'registration' before consumers obtain all relevant information. Shopping at iTunes, for instance, requires the down-

¹Privacy concerns include concerns about the collection and use of personal information by firms and advertisers, but also by governments. They are often closely related to security concerns such as the fear of the misuse of information (personal information as well as password and credit card information, for instance) and concerns about the security of communication channels. In their survey on identity theft, Anderson et al. (2008, p.181) state: "Concerns about maintaining the security of personal data may lead consumers to avoid online transactions, make them less willing to shop around for credit, or otherwise cause them to spend resources to protect their personal records." For a review on the collection and use of personal information by companies and data brokers see also Alice E. Marwick, "How your data are being deeply mined," available at: <http://www.nybooks.com/articles/archives/2014/jan/09/how-your-data-are-being-deeply-mined/>.

load and installation of the software, together with the setup of a user account.² The same is true for many music and video streaming services such as Spotify or Netflix for which consumers can only browse the catalogue of available titles when having created a user account and, in some cases, installed a software or app; here, consumers are often offered a free trial period in which they can learn their valuation before deciding whether to buy (that is, not to terminate their subscription). Moreover, directing consumers on mobile devices to the respective app stores and making them install the app on their device and set up an account has become increasingly popular.³ Other online stores offer certain features of their website only after registration and for users signed in to the website.⁴ Sometimes, detailed delivery information and services and total costs (including shipping fees and/or credit card fees) are only disclosed after signing in and at the very end of the checkout process.⁵

The non-monetary registration costs may deter consumers from buying. We show that it can be profitable for firms to detach the registration costs from the actual buying decision and shift it forward in the shopping process. Then, the registration costs are already sunk at the point in time where the consumer decides whether to buy, and thus do not matter for the purchase decision anymore. We demonstrate this ‘sunk cost’ effect in a baseline model in Section 3. Here, the firm strictly prefers an ex ante registration policy whenever the consumers’ non-monetary registration costs are sufficiently low; in this case it can sell its product to a larger share of consumers and at a higher price, compared to the case without ex ante registration requirement where all information is released immediately and the cost of registration is only incurred by consumers who finally buy.

The baseline model points out, in a parsimonious way, that the sunk cost effect of registration requirements is an important determinant of the profit-maximizing platform design of online sellers in the presence of privacy concerns. It abstracts away, however, from several other important aspects of registration policies of online sellers, and is, in principle, also applicable to other situations where consumers face purchase-related costs (such as search or transportation costs) and where the firm can influence whether these costs have to be incurred before or after learning information about the product.⁶ In Sections 4 to 6 we

²In older versions of iTunes, setting up a user account also required the provision of credit card or other valid payment information.

³According to the Economist’s Special Report on Advertising and Technology (Sep. 13th 2014), “Ads that encourage people to download apps account for a large proportion of mobile-ad spending.”

⁴For instance, the search inside books at amazon.com is only available to registered customers (and “recognized customers,” respectively); see <http://www.amazon.com/Search-Inside-Book-Books/b?node=10197021>.

⁵In addition, online shops often keep uncertainty about the ‘registration cost’ by not making transparent ex ante which information is required when setting up an account. High registration cost and privacy and security concerns are also considered a reason for why consumers may not complete an online transaction but abandon their shopping cart before the final purchase stage (see, e.g., Cho et al. 2006).

⁶Indeed, related effects play a role also in the literature on ‘bait-and-switch’ tactics, on informative

study how the sunk cost advantage of registration requirements plays out when taking into account further specific features of online shopping.

Section 4 extends the baseline model to a multi-period framework to analyze how the choice of the registration policy is affected by aspects of future purchases. Repeat purchases and customer loyalty are important determinants of the success of online sellers (see Reichheld and Scheffer 2000 for seminal insights and Toufaily et al. 2013 for a review of the literature). Once a consumer has registered with the seller, he can use his existing account for future purchases, without having to incur the costs of registration again.⁷ We show that the prospect of future purchases strengthens both the consumers' willingness to set up an account, and the firm's advantage of ex ante registration policies. Moreover, when ex ante registration requirements are not feasible, the firm can be strictly better off by requiring that consumers who want to buy set up an account at checkout, instead of allowing the option of guest checkout. While such an ex post registration requirement tends to reduce current profits, it increases future profits since the firm can achieve higher profits when selling to consumers who already have an account at the firm (again due to the sunk cost effect).

Section 5 discusses another aspect of registration requirements: Firms may value the information that consumers provide when setting up an account and making their buying decision. Brokering consumer information is an important source of revenue for online sellers (see, e.g., Lambrecht et al. 2014). Moreover, one reason for consumers' privacy concerns is the sellers' economic incentive to use the information revealed by the customer, either by selling it to third parties, or by targeting ads or personalizing offers. We show that there are two effects that make ex ante registration requirements even more profitable in case the firm values the user information. First, since ex ante registration requirements increase demand by detaching the registration costs from the purchase decision, they also increase the informational benefit that the firm may get from the consumers' buying decisions. Second, they increase the share of consumers who register but do not buy, which can still provide valuable information to the firm.

Sections 4 and 5 show that the sunk cost effect illustrated in the benchmark model of Section 3 interacts in interesting ways with specific features of online shopping. The takeaway insight is that requiring early registration has advantages, but may backfire because

advertising, and on auctions with valuation discovery costs; we review this literature below. There are, however, also fundamental differences between the different types of purchase-related costs. For instance, registration costs also apply in situations in which consumers know all product and price details, whereas search costs are irrelevant in this case.

⁷In this respect, registration costs clearly differ from other purchase-related costs. For instance, incurring transportation or search costs once does not typically lower the transportation or search costs for future purchases. In the multi-period model, registration costs rather resemble a start-up cost, which also lead to economies of scope in purchases from a single seller.

consumers may be deterred from registration when registration costs are high. In Section 6, we consider discount policies as a means to increase consumers’ incentives to register. Discounts, promotional codes or (digital) coupons are a widely used instrument, in particular in e-commerce where they can be specifically targeted to certain groups of consumers, and are a way to induce consumers to reveal personal information (compare Shapiro and Varian 1999 and OFT 2010). For example, Google recently offered a \$25 Google Play credit for its Play Store to consumers “who have, or add, a valid form of payment to your Google Wallet account.” Such a discount increases a consumer’s surplus from registration as long as it is not offered to all registered consumers (otherwise, the equilibrium price increases by the discount, which consumers anticipate). We show that even though discounts distort the firm’s pricing decision, discount policies can make ex ante registration requirements more profitable for the firm. This result holds even when the firm offers discounts to consumers on a purely random basis and becomes stronger the better the firm can target discounts to consumers with high registration costs.

Finally, Section 7 shows that the insights from our baseline model are robust when introducing competition. There, we study optimal platform design in a model with N firms, assuming that each firm has some loyal consumers who only consider buying at this firm. As argued by Smith and Brynjolfsson (2001) for online shopping, “brand is an important determinant of consumer choice,” possibly out of concerns for non-contractible service quality such as shipping reliability, or cognitive lock in.⁸ We show that the firms’ incentive to require ex ante registration carries over to a model with price competition; in equilibrium, at most one firm does not require ex ante registration. Intuitively, ex ante registration requirements are a means to avoid fierce price competition and yield higher profits at least from selling to the loyal consumers (due to the sunk cost advantage).

2 Related literature

Our paper contributes to the literature on market structures, platform design, and consumer behavior in online markets; for surveys on internet markets and their characteristics see, for instance, Bakos (2001), Ellison and Ellison (2005) and Levin (2013). There are many studies that document the importance of privacy concerns and trust in online markets. In a recent paper, Goldfarb and Tucker (2012) empirically investigate consumers’ privacy concerns and document an increasing trend to refuse the revelation of information as well as clear

⁸See also the survey by Toufaily et al. (2013) on consumer loyalty online. In the context of music streaming services, brand loyalty to the recently launched *Apple Music*, for instance, need not be a pure preference of consumers for a certain brand but can also emerge due to complementarities with other products (iPhones) which consumers already own.

differences between age cohorts. According to surveys by the Pew Research Center (2013, 2014), 91% of American adults agree that consumers have lost control over the collection and use of private information; at the same time, 61% say that they would like to do more to protect their privacy.⁹ Moreover, 21% of internet users reported that they had an e-mail or social networking account compromised or taken over and 11% had important information stolen (such as Social Security Number or credit card information).¹⁰

Privacy and security concerns as a main difference between online shopping and traditional shopping have, so far, received only little attention in the literature. An early paper in this context is Kahn et al. (2005) who discuss the role of cash payments as a means to preserve privacy and anonymity, as compared to credit-based transactions used in online-shopping. For recent reviews of the literature on consumer attitudes and behavior as well as many more important aspects in the context of privacy see Acquisti et al. (2015) and Acquisti et al. (forthcoming).

One aspect of this literature that has received growing attention is the increased ability to process large amounts of consumer information and its impact for business models. Lambrecht et al. (2014) emphasize the value of user information in their discussion of different business strategies in the context of digital goods. Our analysis of how the value of user information affects registration policies (in Section 5) is closely related to Akçura and Srinivasan (2005). While we focus on registration policies, they analyze price-setting decisions of a monopolist who sells a good to consumers and, in addition, the consumers' information to a third party. Casadeus-Masanell and Hervás-Drane (2015) study competition between sellers in a setting related to Akçura and Srinivasan (2005). Bergemann and Bonatti (2013) consider the demand for information and pricing decisions of data providers (who collect data, for instance, via third-party cookies). Chellappa and Shivendu (2010) analyze the economics of personalization for free goods and services when consumers have privacy concerns.¹¹

An aspect related to security concerns is the question of trust and reputation in online markets; see, for instance, the survey on online reputation mechanisms by Dellarocas (2006) and the experiments by Bolton et al. (2013). The registration cost, however, differs from

⁹Around 90% of the respondents have taken steps at least once to keep anonymity online and to avoid being tracked (see Pew Research Center 2013, 2014 for further details). According to the surveys conducted by Milne et al. (2004), around two third of respondents had decided not to purchase at a website due to uncertainty about the use of personal information.

¹⁰The U.S. Department of Justice (2013) reports that 7% of Americans (age 16 or older) were victims of identity theft in 2012. See also Miyazaki and Fernandez (2001) and Zhou et al. (2007) on the impact of perceived privacy and security risks on online shopping behavior and the survey by Anderson et al. (2008) on costs and implications of identity theft.

¹¹For a study on how privacy regulations in the European Union changed the effectiveness of banner ads (measured as consumers' purchase intent) see Goldfarb and Tucker (2011). See also Shy and Stenbacka (forthcoming) who study privacy protection from a competition policy point of view.

the reputation aspect in that it is not caused by classic adverse selection problems (being afraid of receiving a low-quality product or not receiving the purchased product at all). Even if the consumer can perfectly observe the quality of the product (his valuation) before deciding whether to buy, there remain privacy concerns regarding the revelation of personal information which comes along with the buying/registration decision. Moreover, the cost of registration may, at least partly, be unrelated to the reputation of the firm.

Methodologically, the registration costs considered in our model share some similarities with other purchase-related costs, such as transportation costs, search costs, and set-up or switching costs. It is well known that even arbitrarily small search costs can lead to equilibrium prices that drastically differ from the marginal cost pricing obtained under perfect competition (Diamond 1971). We derive a related result in the presence of arbitrarily small registration costs, but the logic differs in subtle respects, as our result also requires the presence of an arbitrarily small mass of loyal customers (see Section 7). Moreover, when consumers are aware of the quality (their valuation) of a product but have to incur a cost to learn its price, a hold-up problem emerges: Any consumer who incurs the cost to visit a shop reveals that his willingness to pay is at least equal to the expected price plus the search cost; therefore, the seller should increase the price up to this amount. The hold-up problem may even result in a complete market breakdown (Stiglitz 1989, Section 2), and the literature on informative advertising (surveyed by Bagwell 2007 and Renault 2015) has studied several ways to deal with this hold-up problem. In our setting, having to incur a cost to learn the price as in the case of ex ante registration requirements also leads to higher prices. Registration requirements are, however, feasible and there is no market breakdown unless registration costs are prohibitively high, since consumers are unaware of some product characteristics of the good prior to registration and need to ‘inspect’ the product in order to learn their valuation.

In our baseline model, ex ante registration requirements can be seen as a light form of ‘bait-and-switch’ strategies which are used to increase the share of consumers who visit the store and who, once they are there, are more willing to buy (Gerstner and Hess 1990; Lazear 1995). Anderson and Renault (2006) analyze a related effect in a search cost model in which a monopoly firm can advertise price and/or match information before the consumer decides whether to visit the store. Koessler and Renault (2012) derive conditions for full disclosure of product and match information for the case of a monopoly firm which can commit to an observable price.¹² Moreover, a recent literature considers firms’ incentives

¹²Further recent work on disclosure of product information includes Sun (2011), Anderson and Renault (2009, 2013) and Celik (2014). Related issues arise also in the literature on auctions with valuation discovery costs. A seminal paper is McAfee and McMillan (1987). See Lu and Ye (2014) for a recent contribution.

to use ‘obfuscation strategies’ to make it more difficult to compare products and prices (Ellison and Ellison 2009; Carlin 2009; Wilson 2010; Ellison and Wolitzky 2012). Such obfuscation may be particularly relevant in online markets where search costs are low and the price elasticity of demand is high.¹³ The literature on switching costs as another prominent type of purchase-related costs has been surveyed by Chen and Hitt (2006) and Farrell and Klemperer (2007). We contribute to the literature on purchase-related costs by considering privacy concerns and non-monetary registration costs as one of the key features of online shopping. Our focus is on the consequences for platform design in e-commerce, comparing the options of ex ante and ex post registration requirements as well as guest checkout policies.

3 The logic of ex ante registration requirements

In this section we demonstrate why firms can benefit from making their customers register early: Ex ante registration requirements detach any (non-monetary) cost of registration/buying from the actual buying decision; this increases a firm’s profit whenever some information about product characteristics and prices is only revealed during the process of shopping. We first show this ‘sunk cost’ effect in a baseline one-period model in which any other motivations for requiring ex ante registration are absent.

Suppose there is one firm and a mass of consumers of size one. The firm offers a product to the consumers; without loss of generality we assume the marginal production cost to be zero. Each consumer has single unit demand. Denote a consumer’s valuation of the good by θ . It is commonly known that the valuations are independent draws from a cumulative distribution function F with support $[0, \infty)$; we assume that F is twice differentiable.

Initially, consumers do not know their valuation; they can inspect the product and learn their θ prior to the purchase decision. In order to purchase the product, a buyer needs to provide personal information such as payment and address details, which causes a non-monetary cost $k > 0$. This cost comprises the opportunity cost of the time needed to set up an account and the disutility due to privacy and security concerns; it depends on the firm’s registration requirements, as explained next.

The firm makes a platform choice consisting of a decision $r \in \{ExA, ExP, G\}$ on the

¹³There is also a growing line of research that considers how consumers search (Arbatskaya 2007; Armstrong et al. 2009; Armstrong and Zhou 2011; Branco et al. 2012) and the consequences of differences in search behavior for market design choices, pricing and the role of information intermediaries (Baye and Morgan 2001; Hagiu and Jullien 2011; Eliaz and Spiegler 2011; Bar-Isaac et al. 2012; White 2013; de Cornière 2013). Despite the low search cost, many studies have found substantial price dispersion on the internet. See, for instance, Smith and Brynjolfsson (2001), Baye et al. (2004), and Baye et al. (2006) for a survey. See also Dinerstein et al. (2014) for a measurement of mark-ups in online retail markets.

registration requirement, and chooses a price p (per unit of the product).¹⁴ If the firm requires ex ante registration ($r = ExA$) then in order to learn his valuation and to observe the price, a consumer has to register and incur a registration cost $k_R > 0$. If the firm requires registration only ex post ($r = ExP$) then consumers learn their valuation and the price without having to register. Consumers who want to buy have to set up an account at the firm; hence, the cost k_R is incurred if and only if a consumer decides to buy. As an additional option, the firm can allow guest checkout: If $r = G$, consumers learn their valuation and the price without having to register. If a consumer wants to buy, he can either set up an account (at cost k_R) or use the option of guest checkout, which causes a non-monetary cost k_G where

$$0 < k_G < k_R.$$

The non-monetary cost k_G of using guest checkout is strictly lower than the registration cost k_R , because consumers have to provide less information and privacy concerns are less important. But k_G is strictly positive: Even when using the guest checkout, consumers have to provide some personal information such that privacy and security concerns do not become completely irrelevant.¹⁵

The timing of the game is as follows. At the beginning of stage 1, nature draws each consumer's valuation θ independently from the distribution F . Then, the firm decides on the registration requirements and this platform choice becomes common knowledge. In stage 2, the firm chooses a price $p \geq 0$. The sequence of events in stage 3 depends on whether or not the firm has chosen to require ex ante registration. If $r = ExA$ then, in stage 3, each buyer decides whether to register at cost $k_R > 0$. Registered consumers can observe the price p and their valuation θ and decide if they want to buy one unit of the good; non-registered consumers cannot buy. If $r \neq ExA$, all consumers observe p and their θ and then decide whether or not to buy. If $r = ExP$, a consumer who wants to buy has to set up an account at cost $k_R > 0$; if $r = G$, consumers can choose between setting up an account (at cost k_R) and buying as a guest (at cost k_G). The firm's profit is equal to the share of consumers who buy, multiplied by the price p . A buyer's utility is equal to (i) $-k_R$ if he registers but does not buy, (ii) $\theta - p - k_R$ if he buys with an account, (iii) $\theta - p - k_G$ if he buys as guest, and (iv) zero otherwise. We assume the tie-breaking rules that indifferent consumers

¹⁴We do not consider upfront payments made upon registration and independent of eventual purchase, such as up-front subsidies or registration fees. These may be misused, and are rarely found in practice at online shops. A feasible and profitable form of subsidies are discounts or store credits that can be cashed in upon purchase, which we discuss in Section 6.

¹⁵We will see that since $k_G < k_R$, offering guest checkout dominates requiring ex post registration in the benchmark model of this section. Interesting trade-offs between these two options arise, however, when considering dynamic aspects (Section 4) or an informational value of consumer registration (Section 5).

set up an account, and buy when indifferent between buying and not buying. Moreover, unless explicitly noted otherwise, we break ties between $r = ExA$ and $r \neq ExA$ in favor of $r = ExA$, and ties between $r = ExP$ and $r = G$ in favor of $r = ExP$. The equilibrium concept is perfect Bayesian equilibrium.

Before turning to the equilibrium of the game, we pause to discuss the informational aspects, and an alternative interpretation of the setup. The model assumes that with an ex ante registration requirement, consumers cannot learn their valuation without setting up an account. In reality, for some types of products it may be difficult for firms to “hide” the relevant product characteristics. For example, the consumer may learn about the *search qualities* (Nelson 1974) of the product from reviews or discussion boards. We point out, however, that the information obtained in this way will typically not be complete. In particular, in order to find out how much he values the *experience qualities* of the good, a consumer will have to inspect the product (or a sample thereof) himself, and no other channels can reliably transmit all of the relevant information. Our model applies whenever some information provision remains under the control of the seller; formally, the cumulative distribution function F captures the residual uncertainty. Moreover, obtaining information from other sources than the seller is not costless for the consumers; we determine a consumer’s maximum willingness to pay for such information below.

Apart from unit demand for one product, the model also reflects markets such as music or video streaming services with a continuum of goods. The price p can be interpreted as the price for a subscription, and θ as a measure for the share of goods a consumers likes where he derives a utility of one if he likes the good and zero utility otherwise; hence, θ is equal to the expected utility from subscribing.

No ex ante registration Suppose that the firm does not require ex ante registration. Then, in stage 3, each buyer learns the price p and his valuation θ . For a non-monetary cost of buying k (where $k \in \{k_G, k_R\}$), the share of consumers who buy is equal to

$$\Pr(\theta \geq p + k) = 1 - F(p + k).$$

In stage 2, the firm anticipates the consumers’ buying decisions and chooses a price p as the solution to

$$\max_p (1 - F(p + k)) p.$$

Define $p(k)$ as the solution to¹⁶

$$p(k) = \frac{1 - F(p(k) + k)}{F'(p(k) + k)} \quad (1)$$

and the corresponding profit $\pi(k)$ as

$$\pi(k) := (1 - F(p(k) + k))p(k). \quad (2)$$

Then, if the firm chooses $r = G$ and a price p , all consumers who want to buy will use the guest checkout (due to $k_G < k_R$). Hence, the firm's optimal price is $p(k_G)$, with a corresponding profit of $\pi(k_G)$. If instead $r = Exp$ then all consumers who want to buy have to register at cost k_R , which yields an optimal price of $p(k_R)$ and a corresponding profit of $\pi(k_R)$. With

$$\bar{u}(k) := \int_{p(k)+k}^{\infty} (\theta - p(k) - k) dF(\theta), \quad (3)$$

expected consumer surplus is equal to $\bar{u}(k_G)$ if $r = G$ and equal to $\bar{u}(k_R)$ if $r = Exp$.

Ex ante registration Suppose that the firm requires ex ante registration. Then, in stage 3, only registered consumers learn p and their θ . A (registered) consumer buys if and only if $\theta \geq p$.

If a buyer knew the price p (but not yet his valuation θ), he would register if and only if his expected utility from registration is sufficient to cover the registration cost, that is,

$$\int_p^{\infty} (\theta - p) dF(\theta) \geq k_R. \quad (4)$$

The buyers, however, do not know the price when deciding on registration. They therefore have to form beliefs about the price set by the firm. In a perfect Bayesian equilibrium, these beliefs must be consistent with the firm's price setting behavior and derived from Bayes rule wherever possible.

Consider the firm's pricing decision. Suppose that the firm believes that all buyers register. Then, the firm chooses a price as the solution to

$$\max_p (1 - F(p))p.$$

¹⁶To simplify the notation, we assume here that there is a unique solution to the firm's maximization problem given by the first-order condition, which can be guaranteed under additional assumptions on F . For example, Assumption 1 introduced below is sufficient for the profit-maximizing price to be unique and given by (1).

This yields an optimal price equal to $p(0)$ and a corresponding profit of $\pi(0)$ (where $p(k)$ and $\pi(k)$ are defined in (1) and (2), respectively). Anticipating this price, a buyer registers if and only if $k_R \leq \bar{u}(0)$ where

$$\bar{u}(0) = \int_{p(0)}^{\infty} (\theta - p(0)) dF(\theta). \quad (5)$$

Therefore, if $k_R \leq \bar{u}(0)$, the continuation game has an equilibrium in which the firm chooses $p = p(0)$; all buyers register, and they buy if and only if $\theta \geq p(0)$.¹⁷ If instead $k_R > \bar{u}(0)$ then in the equilibrium of the continuation game no buyer registers. To see why, suppose that, in stage 3, a buyer registers with some probability $\mu \in (0, 1]$. Anticipating this registration decision, the firm will choose the price $p(0)$.¹⁸ But if a buyer's beliefs about the price p are consistent with this choice, it is optimal for the buyer not to register in case of $k_R > \bar{u}(0)$: Anticipating the firm's choice of the price, the expected surplus from registration is too low. Comparing the firm's expected profits under the different registration requirements yields our first main result.

Proposition 1 *In equilibrium, a monopoly firm requires ex ante registration if and only if $k_R \leq \bar{u}(0)$ (where $\bar{u}(0)$ is given in (5)). Otherwise, the firm chooses $r = G$ and offers the option of guest checkout.*

Proof. Suppose that $k_R \leq \bar{u}(0)$. If the firm requires ex ante registration, it chooses the price $p(0)$. Since all consumers register, the firm's expected profit is

$$\pi(0) = (1 - F(p(0)))p(0),$$

which is (weakly) larger than $(1 - F(p))p$ for all $p \neq p(0)$. In particular, for any $k > 0$,

$$\pi(0) \geq (1 - F(p(k) + k))(p(k) + k) > (1 - F(p(k) + k))p(k) = \pi(k).$$

Hence, the firm's profit under $r = ExA$ is strictly higher than (i) its profit under $r = ExP$ (which is $\pi(k_R)$) and (ii) its profit under $r = G$ (which is $\pi(k_G)$).

If $k_R > \bar{u}(0)$, the firm makes zero profits if it requires ex ante registration but strictly positive profits if it does not require ex ante registration. Under $r = G$, it chooses $p = p(k_G)$

¹⁷There is an additional set of equilibria in which the firm sets a (high) price at which (4) is violated and all buyers believe that the firm sets this high price and hence do not register. In the following, we ignore these equilibria which can be eliminated by an appropriate equilibrium refinement.

¹⁸Since buyers do not know their valuation when registering and are symmetric ex ante, the distribution of types that the firm faces in stage 3 is still described by the distribution F , leading to a price choice that is independent of μ (as long as $\mu > 0$).

and must be (weakly) better off than when choosing $p' = p(k_R) + k_R - k_G$, thus,

$$\begin{aligned}\pi(k_G) &\geq (1 - F((p(k_R) + k_R - k_G) + k_G)) (p(k_R) + k_R - k_G) \\ &> (1 - F(p(k_R) + k_R)) p(k_R) = \pi(k_R).\end{aligned}$$

■

The intuition for Proposition 1 is straightforward. If the consumers' costs of registration are sufficiently small ($k_R \leq \bar{u}(0)$), consumers are willing to register ex ante. In this case, requiring ex ante registration is optimal for the firm. With ex ante registration, the registration costs k_R are sunk when a consumer decides whether to purchase; ex ante registration detaches the registration costs from the purchase decision. Consequently, with ex ante registration, the firm can choose a higher price and still sell to a larger share of consumers. If, however, the consumers' registration costs are high relative to the expected consumer surplus, no one would be willing to register ex ante; therefore the firm does not require it. Here, the firm prefers to keep the cost of registration as low as possible since having to set up an account when buying may deter some consumers. Therefore, if k_R is high, the firm offers the option of guest checkout.

To gain a better understanding of pricing decisions and consumer surplus, we make the following assumption on the probability distribution F .

Assumption 1 F has a strictly monotone hazard rate:

$$\frac{d}{d\theta} \frac{F'(\theta)}{1 - F(\theta)} > 0.$$

Assumption 1 implies the following ranking of the candidate equilibrium prices:¹⁹

$$p(k_R) < p(k_G) < p(0) < p(k_G) + k_G < p(k_R) + k_R.$$

The higher the consumers' registration costs k , the lower is the price $p(k)$ that the firm charges. But the sum of the price and the registration cost, $p(k) + k$, is increasing in k , which implies that higher registration costs reduce the equilibrium probability of trade. Therefore, if the firm requires ex ante registration, its equilibrium price is higher ($p(0) > p(k)$ for all $k > 0$); nevertheless, its demand goes up ($1 - F(p(0)) > 1 - F(p(k) + k)$ for all $k > 0$). Each of these two effects makes the firm benefit from shifting the registration cost to the ex

¹⁹Assumption 1 guarantees that the pass-through rate of the registration costs takes an interior value between 0% and 100%; compare also Bulow and Pfleiderer (1983) and Weyl and Fabinger (2013). Related questions on pass-through rates arise in the literature on tax incidence (see Fullerton and Metcalf 2002 for a survey).

ante stage. The effect of ex ante registration on consumer surplus is, however, exactly the opposite. With ex ante registration, the consumers pay a higher price; in addition, they pay k_R independently of whether they buy. Both effects reduce consumer surplus compared to the case of no ex ante registration and cause consumer surplus to be highest when the firm offers the option of guest checkout ($r = G$).

Defining welfare as the sum of the firm's expected profits and the consumers' expected utility, the effect of an ex ante registration requirement on welfare can be separated into two effects: (i) changes in the surplus from trade caused by changes in the equilibrium price, and (ii) changes in the total expected non-monetary cost of registration. The second effect is always welfare-reducing since $k_R > k_G$ and since under ex ante registration requirements the cost of registration is incurred independently of whether a consumer actually buys. The first effect can, however, be positive: If Assumption 1 holds, there is more trade with ex ante registration requirements, which is welfare improving since there is inefficiently low trade in equilibrium.²⁰ If F is a uniform distribution, for instance, the total welfare effect of ex ante registration requirements is negative even when $k_R \rightarrow k_G$ (the second, negative effect outweighs the first, positive effect). But there are also examples for distributions F for which welfare is higher with than without ex ante registration.²¹

To conclude this section we discuss the informational assumptions of the model as well as possible heterogeneity in consumers' privacy concerns.

Registration requirements, information provision, and consumer search As discussed above, with an ex ante registration requirement, consumers may try to obtain relevant information through other channels such as product reviews or discussion forums. Searching for information is likely to be time-consuming or costly in other ways, however. Suppose that with $r = ExA$ consumers can learn their θ by investing search effort. A consumer is willing to invest up to

$$\begin{aligned} & \int_{p(0)+k_R}^{\infty} (\theta - p(0) - k_R) dF(\theta) - (\bar{u}(0) - k_R) \\ &= F(p(0)) k_R + \int_{p(0)}^{p(0)+k_R} (p(0) + k_R - \theta) dF(\theta) \end{aligned} \quad (6)$$

to learn θ and p . This amount is strictly positive because the information acquisition allows the consumer to avoid (i) the registration costs when not buying (the first term in (6)) and

²⁰Since marginal production costs are assumed to be zero, all consumers with $\theta > k_G$ should buy in the welfare optimum, but in case of $r = G$, for instance, consumers buy only if $\theta > p(k_G) + k_G$.

²¹This can most easily be shown by using discrete distribution functions F ; however, smooth examples can also be constructed. Details are available upon request.

(ii) buying at a total (monetary and registration) cost higher than θ (the second term). The firm can keep using ex ante registration requirements whenever the consumers' costs of learning the information through other channels are larger than the amount in (6).

Search costs are likely to be high for experience and inspection goods where learning one's valuation essentially requires trying out the good or a sample of it, and for specialized goods and services for which only a few other buyers exist from whom one could gather relevant information. On the other hand, for highly standardized mass products with mainly search characteristics which can easily be communicated by other customers, search costs are likely to be low, and hence ex ante registration policies may be undermined by consumers' search behavior. In this case, the firm would be willing to pay up to its profit increase under ex ante registration, $\pi(0) - \pi(k_G)$, in order to implement 'obfuscation strategies' that raise the consumers' search costs above the amount in (6).

Our model also abstracted away from any direct costs of the firm to provide information to consumers such as offering product samples or designing the website accordingly. Moreover, registration often includes installing some software or app, in which case providing product information to non-registered consumers may be more costly for the firm. A lower cost of information provision to registered as compared to non-registered consumers would make ex ante registration requirements relatively more profitable.

A related issue is the credibility of the information provided by the firm. For experience qualities, the main uncertainty is about the match between the product and the consumer's idiosyncratic tastes; the firm may be unable to directly communicate anything about the match but needs to let the consumers inspect or try out the product, for instance, through book previews, song samples or free trial memberships. Here, credibility is less an issue because providing information is letting the consumer test (some aspects of) the product itself. Conversely, credibility may be more of a concern with respect to search qualities. Any issue of credibility of the firm's information provision, however, will arise in all types of registration policies discussed above and is therefore orthogonal to our main research objective.

Finally, the analysis above assumes that in case of an ex ante registration requirement, the price will only be revealed upon registration. This assumption is most restrictive for making ex ante registration profitable since a firm which requires ex ante registration cannot commit to a lower price but will always choose $p = p(0)$ in equilibrium, which the consumers anticipate. Moreover, if $k_R \leq \bar{u}(0)$, the firm has no incentive to deviate and reveal its price and commit to it before consumers have to make their registration choice (and the consumers correctly anticipate the price in equilibrium). If k_R is, however, slightly above $\bar{u}(0)$ then by committing to a price slightly below $p(0)$ together with its platform choice the firm could

guarantee that the consumers register ex ante even in case of $k_R > \bar{u}(0)$. Another way of enlarging the range of registration costs for which consumers register is the use of discounts (store credit); in Section 6 we demonstrate the effectiveness of such discounts even when commitment on prices is not possible.

Heterogeneity in registration costs While the profitability of ex ante registration requirements is most visible in the case where all consumers face the same registration cost k_R , it carries over to situations in which there is heterogeneity in the consumers' registration costs. We briefly discuss how the main proposition of this section changes if consumers differ in their cost of registration, for instance, because some consumers care more about privacy than others. For this purpose, suppose that a consumer's costs of registration k_R and k_G are drawn from two continuous probability distributions $H_R(k_R)$ and $H_G(k_G)$, respectively, with support $[0, \infty)$. k_R and k_G may be (positively) correlated and we assume that $k_R \geq k_G$ for each consumer (with strict inequality for a positive mass of consumers), but k_R and k_G are independent of the valuation θ . Each consumer privately knows his registration costs k_R and k_G .

Corollary 1 *If the consumers' costs of registration k_R and k_G are distributed according to $H_R(k_R)$ and $H_G(k_G)$, respectively, the firm requires ex ante registration if and only if*

$$H_R(\bar{u}(0)) \geq \frac{\tilde{\pi}_G}{\pi(0)} \in (0, 1),$$

where

$$\tilde{\pi}_G := \max_p \int_0^\infty (1 - F(p + k_G)) p dH_G(k_G).$$

Otherwise, the firm offers the option of guest checkout ($r = G$).

The proof of Corollary 1 as well as the proofs of all subsequent results are relegated to the appendix. If a sufficiently high share of consumers have registration costs k_R below $\bar{u}(0)$ and are willing to register, the firm requires ex ante registration, accepting that it will not sell to some consumers who have a high cost of registration. Here, the additional gain from selling to consumers who are already registered outweighs the loss from not selling at all to some other consumers. If, however, the share of high-cost consumers is increased then the firm is better off by not requiring ex ante registration and offering the option of guest checkout.

4 A dynamic perspective

This section analyzes how the monopoly firm’s choice of its registration policy is affected by aspects of future purchases. We first show that consumers expect a higher future surplus in case they already have an account at the firm and do not need to register again when buying; this increases the range of registration costs for which ex ante registration requirements are feasible. Second, we consider the firm’s decision whether to offer the option of guest checkout in situations in which ex ante registration requirements are not feasible, either because the consumers’ cost of registration is high or because the consumers can learn their valuation through other channels at comparably low cost (compare the discussion in Section 3). Here, we show that the firm may prefer to require registration ex post (instead of offering guest checkout). This result is again due to a sunk cost advantage when selling in future periods to consumers who are already registered.²²

Suppose that there are two periods, t and $t + 1$. Each consumer has unit demand in each period; his valuations in the two periods are denoted by θ_t and θ_{t+1} and are independent draws from the probability distribution F .²³ The sequence of actions within period $\tau \in \{t, t + 1\}$ is as in the baseline model. At the beginning of each period $\tau \in \{t, t + 1\}$, the firm chooses its registration requirement r_τ as well as its price policy. The choice r_τ determines whether the consumers need a user account in order to observe θ_τ and the price in period τ . As above, registration involves a cost k_R . Consumers who have, in t , set up an account at the firm (at cost k_R) can, in $t + 1$, use their existing account to inform themselves about the product and its price, and can also buy, without incurring additional registration costs. In contrast, for each purchase using guest checkout consumers incur a cost k_G .

We assume that the firm can charge different prices to registered and to non-registered consumers.²⁴ More precisely, the firm can condition its price offer in period $t + 1$ on a

²²Note that this section does not rely on a “switching cost” argument since we consider a monopoly firm. Effects of registration requirements in competitive environments are analyzed in Section 7.

²³To save on notation, we assume the valuations in the two periods to be identically distributed, but the results easily extend to the case where θ_t and θ_{t+1} are drawn independently from distribution functions F_t and F_{t+1} , respectively. For the same reason we also abstract from discounting of future profits/surplus. The assumption of independence of θ_t and θ_{t+1} rules out some forms of price discrimination; we discuss this issue further below.

²⁴Since θ_t and θ_{t+1} are independent, the firm cannot gain from discriminating between registered costumers based on their purchase behavior in t . This allows us to focus on the choice of registration policies and to abstract from many additional aspects which have been extensively discussed in the literature on behavior-based price discrimination; see, for instance, Hart and Tirole (1988) and Villas-Boas (2004) for the case of a monopoly seller, Villas-Boas (1999) and Fudenberg and Tirole (2000) for oligopolistic competition, and the surveys by Fudenberg and Villas-Boas (2006) and Stole (2007). Aspects of e-commerce and improved information technologies in this context are discussed, for instance, by Taylor (2004), Acquisti and Varian (2005) and in the survey by Fudenberg and Villas-Boas (2012). In our model, the use of behavior-based price discrimination would also be complicated by the possibility for consumers to set up new accounts or

consumer’s registration decision in period t . This assumption simplifies the analysis considerably; it implies that a consumer’s expected future gain from being registered does not depend on the other consumers’ registration choices.²⁵ The assumption is also reasonable since the consumers identify themselves when visiting the website and signing in; thus, in order to pursue such a strategy, the firm does not need to know more about the consumers than they reveal themselves. Moreover, charging different prices for “existing” and “new” consumers is a widely established strategy in practice (Caillaud and De Nijs 2014). Finally, we assume in what follows that Assumption 1 holds (F has a monotone hazard rate).

Proposition 2 *In the two-period model, the firm requires ex ante registration in period t if and only if*

$$k_R \leq 2\bar{u}(0) - \bar{u}(k_G). \quad (7)$$

Proposition 2 confirms that if the firm has the option of using ex ante registration requirements, it prefers to do so as long as the consumers’ costs of registration are sufficiently low. Moreover, the sunk cost effect of ex ante registration does not only make the firm benefit in the current period but also in future periods, even though registered consumers can observe their valuation and the price in future periods without having to incur any cost.

Including the option of multiple purchases also increases the consumers’ value of registering: If a consumer already has an account, he realizes a higher expected surplus since he does not have to incur again the cost of setting up an account. This holds even though the consumer (correctly) anticipates a higher price if he is registered. Therefore, the range of registration costs for which ex ante registration requirements are profitable for the firm is enlarged compared to the baseline model (Assumption 1 implies that $\bar{u}(0) > \bar{u}(k_G)$).

For high registration costs k_R such that (7) is violated, no consumer would register under $r_t = ExA$. In this case, the firm is strictly better off by not requiring ex ante registration, and it has to decide whether or not to offer the option of guest checkout. To solve for the firm’s optimal platform choice, we first compare the firm’s per-period expected profits conditional on its platform choice in period t . If the firm chooses $r_t = G$, the consumers may nevertheless prefer to set up an account when deciding to buy; they prefer buying with an

use guest checkout.

²⁵If the firm charges the same price to all consumers, the price in period $t+1$ turns out to be an increasing function of the share of consumers who already have an account. But a higher price in $t+1$ reduces the consumers’ incentive to register in period t since they expect a lower future benefit from already having an account. Therefore, the price in t affects the price in $t+1$ and the share of consumers who register, and vice-versa, and an individual consumer’s period t choice depends on all other consumers’ choices in t . This generates considerable technical complexities in the analysis, without affecting the main economic insights. Note that in the analysis below we also allow registered consumers to set up a new account (again at cost k_R) or use guest checkout if offered (at cost k_G), instead of buying with their existing account.

account over buying as a guest if and only if their additional expected future surplus from already having an account ($\bar{u}(0) - \bar{u}(k_G)$) is larger than the additional cost of registration ($k_R - k_G$). We show in the appendix (see Proof of Lemma 1) that there exists a critical value $\check{k}_G \in (0, k_R)$ such that, in period t , consumers prefer guest checkout over setting up an account if and only if $k_G < \check{k}_G$. If $k_G \geq \check{k}_G$, the option of guest checkout becomes irrelevant (since no consumer uses it) and the firm's profits are the same under $r_t = G$ and $r_t = ExP$.²⁶

Lemma 1 *Suppose that (7) is violated and $k_G < \check{k}_G$.*

(i) *The firm's expected profit in period $t+1$ is strictly lower if, in period t , the firm offers the option of guest checkout ($r_t = G$) than if, in period t , consumers can only buy when setting up an account ($r_t = ExP$).*

(ii) *The firm's expected profit in period t is strictly higher if, in period t , the firm offers the option of guest checkout ($r_t = G$) than if, in period t , consumers can only buy when setting up an account ($r_t = ExP$).*

The economics behind Lemma 1(i) is closely related to Proposition 1 in Section 3. With the probability that consumers are registered and, hence, the registration cost is sunk, the firm achieves higher expected profits. For this effect, it is not crucial that the firm requires registration at the beginning of a period, before consumers can observe their valuation and the price. Lemma 1(i) shows that the same result is obtained vis-à-vis future expected profits: The firm benefits from registration requirements since this yields higher profits in future periods when consumers can buy without having to incur the cost of setting up an account. Since the firm's future profits are increasing in the share of consumers who already have an account, the firm's optimal price under $r_t = ExP$ is lower than the price $p(k_R)$ in the baseline model (for details see the proof of Lemma 1). Of course, requiring registration also affects current expected profits. Lemma 1(ii) demonstrates a countervailing effect of ex post registration requirements on the firm's profits: today's profits are reduced. Overall, the firm faces a trade-off between lower profits today and higher profits in the future when deciding whether to require ex post registration.

Proposition 3 *Consider the two-period model and suppose that $k_R > 2\bar{u}(0) - \bar{u}(k_G)$. There exists a threshold $\bar{k}_G \in (0, \check{k}_G)$ such that the firm offers the option of guest checkout in period t ($r_t = G$) if and only if $k_G < \bar{k}_G$. Otherwise, the firm requires ex post registration in period t such that consumers who buy have to set up an account ($r_t = ExP$).*

²⁶In this case consumer surplus and total welfare would be lower if user registration is not possible or allowed.

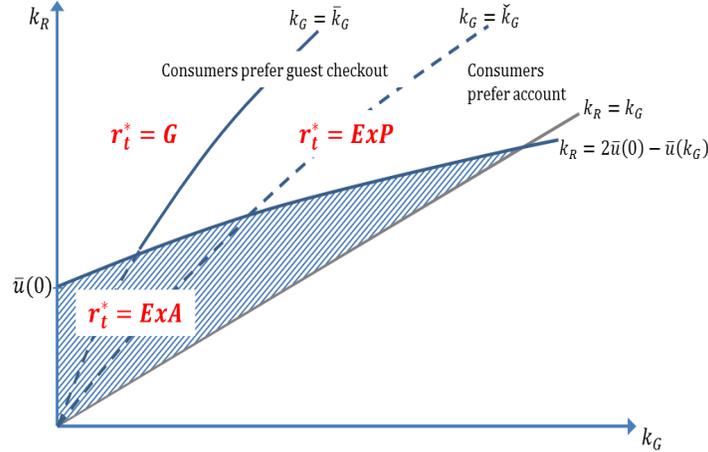


Figure 1: Optimal registration requirements in the two-period model (example for uniformly distributed valuations).

Proposition 3 states that the firm prefers to make consumers register when they want to buy, unless the advantage of guest checkout in terms of lower transaction costs is sufficiently strong. Formally, if k_G is much lower than k_R , the cost k_G of using guest checkout does not play an important role for the consumers' purchasing decision; hence, the firm is better off by providing this option even though this results in a situation in which no consumer is registered in future periods. But if k_G is increased and the consumers' additional cost of setting up an account (compared to using guest checkout) becomes lower, ex post registration becomes relatively more attractive. If k_G is above a threshold $\bar{k}_G \in (0, \check{k}_G)$, the firm is strictly better off when it does not offer the option of guest checkout and forces consumers to set up an account whenever they want to buy. Here, the firm's gain in future profits from customers who are already registered (as in Lemma 1(i)) is sufficient to outweigh the reduction in today's profits caused by a lower demand today (as in Lemma 1(ii)). Also note that when $k_G \in (\bar{k}_G, \check{k}_G)$, consumers would prefer buying with a guest account, but the firm forces them to register. Figure 1 illustrates the results of Propositions 2 and 3 by showing the firm's optimal platform choice for parameter combinations (k_G, k_R) .²⁷

Besides incorporating repeat purchases as a particular feature of online shopping into our analysis, this section also served a theoretical aim. We point out that even when the firm releases all information about current prices and products, consumers will nevertheless face some uncertainty about their future expected surplus from registering (their future product valuations), for instance because they cannot fully anticipate all technology enhancements

²⁷The critical value \bar{k}_G below which the firm offers the option of guest checkout is increasing in k_R since the firm's profit under $r = Exp$ is decreasing in k_R , while its profit under $r = G$ does not depend on k_R .

and product developments, or because of unpredictable fluctuations of future income. In particular for the latter type of uncertainty, it is clear that the firm has no possibility to influence the precision of information that a consumer holds. In this sense, this section also demonstrated that the benefit of registration requirements does not depend on the ability of the firm to “hide” product and price information but emerges whenever consumers are not completely sure about the value they derive from shopping at the firm, in the current period or with respect to future periods.

5 Value of consumer information

This section considers the firm’s optimal registration policy when consumer registration generates an informational value to the firm, either because the firm can make direct use of the information that consumers provide when they register (for instance, when targeting certain types of consumers), or because it sells this information to other firms. We show that the value of user information to the firm adds to, and interacts with, the benefit from ex ante registration requirements identified in the previous sections. Moreover, informational benefits from user information can provide a rationale for why firms may prefer not to offer the option of guest checkout even when aspects of future purchases are absent.

Consider the baseline model of Section 3 but suppose that, in addition to the profit from selling its product, the firm values the information that the consumers provide when registering and/or buying. Specifically, we assume that the firm gets an additional value $v_R \geq 0$ from each consumer who sets up an account (independently of the buying decision). In addition, the firm derives an informational value $v_B \geq 0$ from each consumer who buys with an account. Finally, the firm gets an informational value $v_G \geq 0$ from each consumer who buys as a guest (if this option is offered). We assume that $v_R + v_B \geq v_G$, that is, the informational gain for the firm is higher if consumers set up an account and buy with their account than if consumers buy using guest checkout since in the former case the firm learns more about the consumers’ preferences together with their personal characteristics.²⁸

Taking into account an additional benefit from consumer information changes the firm’s

²⁸In what follows, we take the registration cost k_R and the distribution F of consumer valuations as given and analyze the impact of changes in v_R , v_B , and v_G . In general, there might also be a (positive or negative) correlation between v_R and/or v_B on the one hand and k_R and/or θ on the other hand. For instance, privacy concerns may be strengthened when consumers anticipate that the firm sells their personal information at high prices to third parties, which would lead to a higher k_R . If v_R represents the firm’s benefit from targeted advertising, θ may be increasing and/or k_R may be decreasing in v_R . In addition, consumers may also be not fully aware of the consequences of the use of their information; in this context see also Norberg et al. (2007) on divergences of consumers’ opinions and behavior and the survey by Acquisti et al. (2015) on privacy concerns and consumer behavior.

pricing decision. Define by $p(k, v)$ the solution to the optimization problem

$$\max_p (1 - F(p + k))(p + v).$$

In case of an interior solution, $p(k, v)$ is given by

$$p(k, v) = \frac{1 - F(p(k, v) + k)}{F'(p(k, v) + k)} - v. \quad (8)$$

The solution $p(k, v)$ is the price that the firm sets if the consumers' non-monetary cost of buying is k and the firm gets an informational benefit v in case a consumer buys. Hence, if the firm requires ex ante registration, the optimal price is $p(0, v_B)$; the value v_R from user registration is already 'sunk' in this case and not relevant for the firm's pricing decision. If instead the firm requires registration only ex post, it sets a price $p(k_R, v_R + v_B)$, taking into account both the registration cost k_R and the informational benefit $v_R + v_B$ per purchase with an account.

With Assumption 1 on the probability distribution F , $p(k, v)$ as given in (8) is strictly decreasing in k and strictly decreasing in v . The informational benefit v generated if a consumer buys (with an account or as guest) leads to a lower equilibrium price since the firm derives an additional value from increased demand. Note that the optimal price can become zero or even negative: Intuitively, if the value of user information is very large, the firm does not charge any positive price (or even subsidizes the non-monetary registration costs) but lets the consumers "pay" through their information provision.²⁹ The following proposition characterizes the equilibrium registration policy.

Proposition 4 (i) *Suppose that*

$$k_R \leq \int_{p(0, v_B)}^{\infty} (\theta - p(0, v_B)) dF(\theta). \quad (9)$$

Then, the firm requires ex ante registration ($r = ExA$) in equilibrium.

(ii) *Suppose that (9) is violated. Then, in equilibrium the firm requires ex post registration ($r = ExP$) if and only if $v_R + v_B \geq \tilde{v}$ and offers the option of guest checkout ($r = G$) otherwise, where $\tilde{v} \in (v_G, v_G + k_R - k_G]$.*

Proposition 4 confirms the firm's incentive to make use of ex ante registration require-

²⁹To be precise, denoting the price solving (8) by $\hat{p}(k, v)$, the optimal price is given by $\max\{\hat{p}(k, v), -k\}$. In case of $r = ExA$, for instance, the firm sets a price equal to $\max\{\hat{p}(0, v_B), 0\}$, while in case of $r = ExP$ the optimal price is $\max\{\hat{p}(k_R, v_R + v_B), -k_R\}$ (at a price $p = -k_R$ all consumers register/buy; hence, the optimal price will never be lower).

ments and offers insights into how the informational value of consumer registration interacts with the ‘sunk cost’ advantage of ex ante registration requirements. First, the threshold for k_R below which the firm requires ex ante registration (the right-hand side of the inequality in (9)) is strictly increasing in the value of consumer information v_B . A higher value of consumer information leads to a lower price and, thus, makes consumers more willing to register ex ante due to the higher surplus they expect (Proposition 4(i)). Second, while ex post registration requirements are never profitable in the baseline model (Proposition 1), this changes when the firm values the information that consumers provide when registering. If ex ante registration requirements are not feasible but the informational benefit from consumer registration is sufficiently strong (v_R and v_B are large relative to v_G) then the firm is strictly better off when requiring consumers to set up an account in case they want to buy (Proposition 4(ii)).

With a positive value of user information, ex ante registration requirements become relatively more profitable for the firm.

Corollary 2 *The firm’s advantage from requiring ex ante registration as opposed to requiring registration only ex post, or to allowing guest checkout, is larger when the firm derives a value from consumer information (that is, when $v_B > 0$ or $v_R > 0$ or both, and $0 \leq v_G \leq v_R + v_B$) than in the baseline model (where $v_B = v_R = v_G = 0$).*

The higher profitability of ex ante registration requirements ($r = ExA$) is due to two effects. First, more consumer register in case of $r = ExA$ (provided that (9) holds); thus, the advantage of ex ante registration requirements (that is, the difference in profits under $r = ExA$ and under $r = ExP$ and $r = G$, respectively) is increasing in v_R . Second, since ex ante registration requirements increase the willingness of registered consumers to buy, an informational value v_B attached to the buying decision makes policy $r = ExA$ relatively more profitable. In other words, the sunk cost effect of ex ante registration requirements reinforces the informational value of consumer registration. To see this, suppose that $v_R = 0$. If $k_R \rightarrow 0$ then the firm is indifferent between ex ante and ex post registration requirements for all $v_B \geq 0$. If $k_R > 0$, however, the firm is strictly better off by choosing $r = ExA$, for all $v_B \geq 0$, and the advantage of using ex ante registration requirements becomes stronger the higher v_B since more consumers buy under $r = ExA$. An equivalent argument applies to the comparison of $r = ExA$ and $r = G$.

By reducing the equilibrium price, an increasing value of user information for the firm also affects consumer surplus. While it still holds that consumers are better off if the firm requires registration only ex post than if the firm requires registration ex ante, consumer surplus is higher under $r = ExA$ than under $r = G$ if v_B is sufficiently large compared to v_G

and, hence, the price under $r = ExA$ is low. This is, however, true only if the consumers' privacy concerns captured by k_R do not strongly react to an increase in v_B .

The additional incentive to require ex ante registration due to the value of consumer information carries over to the dynamic model of Section 4; moreover, when ex ante registration requirements are not feasible, the firm's incentive to require ex post registration in period t of the two-period model is strengthened if the firm also values the information consumers provide when registering. More precisely, the larger v_R and v_B (relative to v_G), the smaller becomes the range in Proposition 3 in which the firm offers the option of guest checkout; for sufficiently high $v_R + v_B$, this interval becomes empty and the firm always requires consumers to set up an account in period t .

6 Discount policies and registration

This section analyzes discounts as a means to affect the consumers' registration decision. Discounts (store credit) offered conditional on buying are a widely used instrument in online markets, not least because behavior-based targeting has been facilitated by the increased information collection in the internet.³⁰ We show that discounts can be used to make even those consumers register who have high costs of registration and can, thus, be part of a successful registration policy.

If the firm requires ex ante registration but offers price discounts to consumers who register, this affects the firm's equilibrium posted price and the consumers' beliefs about the price. In particular, if all consumers who register are offered a discount then the firm will simply increase its posted price by the amount of the discount.³¹ Therefore, in the baseline model of Section 3 with homogeneous registration costs, discounts have no net effect on the profitability of ex ante registration requirements since all of the consumers who register (or none of them) will have obtained a discount.³² But discounts have an effect when consumers differ in their concerns about registration, which is a reasonable assumption and which we make in the remainder of this section.

Suppose that there are two types of consumers: a share $1 - q$ of consumers have registration costs equal to k_{RH} ; and a share q of consumers have registration costs of k_{RL} where $k_G \leq k_{RL} < k_{RH}$. An interpretation of this assumption is that a share q of the consumers

³⁰The OFT (2010, p.29) reports that "the most common form of online price targeting is to offer vouchers or discounts to internet users based on their online behavior."

³¹Recall that in case of ex ante registration requirement the price is observed by consumers only after they have registered.

³²In the baseline model the firm would only use discounts in case of $k_R > \bar{u}(0)$ to make some of the consumers register. When consumers with discounts decide on registration, they anticipate that all consumers who would actually register must have been offered a discount.

have only an opportunity cost k_{RL} of registration while the remaining share $1 - q$ has higher costs k_{RH} of registration due to privacy and security concerns.

Consider the modified game in which the firm offers a discount $d \geq 0$ (store credit) to a share $\delta \geq 0$ of consumers. The discount policy (d, δ) is chosen and announced in stage 1, together with the platform choice. In stage 2, when consumers learn about the registration requirement, they also learn if they are offered a discount d . The discount d is offered conditional on buying. Hence, for consumers who have obtained a discount, the price to be paid is reduced from p to $p - d$. But as explained above the discount policy also affects the equilibrium price p charged by the firm. If the firm requires ex ante registration and the share of consumers who register consists both of consumers with discount and consumers without discount, the optimal price p_d is a function of d (and of δ) and fulfils

$$p_d - d < p(0) < p_d,$$

that is, the optimal price net of discount ($p_d - d$) is smaller than the price $p(0)$ without discounts, but the posted price p_d is increased.³³ In other words, discounts are added to the price but to less than 100%. This leads to a price distortion: Instead of selling at the optimal price $p(0)$ to registered consumers, the firm sells at effective prices $p_d - d < p(0)$ and $p_d > p(0)$ to consumers with discount and without discount, respectively.

The most interesting case emerges when $k_{RL} < \bar{u}(0) < k_{RH}$ (where consumer surplus $\bar{u}(0)$ is given in (5)). In this case, if the firm requires ex ante registration and no discounts are offered ($\delta = 0$) then only consumers with low registration costs are willing to register. In the candidate equilibrium in which the firm offers discounts to make high-cost consumers willing to register, consumers correctly anticipate the price p_d for a given policy (d, δ) . Therefore, high-cost consumers with discount register if and only if

$$\int_{p_d - d}^{\infty} (\theta - (p_d - d)) dF(\theta) \geq k_{RH}, \quad (10)$$

while low-cost consumers without a discount register if and only if

$$\int_{p_d}^{\infty} (\theta - p_d) dF(\theta) \geq k_{RL}. \quad (11)$$

The firm's incentive to offer discounts depends on the degree to which it is able to target the discount to consumers who would not register without discount. In the worst case for the firm, discounts are allocated purely randomly to the consumers such that the probability

³³This ranking follows from Assumption 1 and is similar to the ranking $p(k) < p(0) < p(k) + k$. For details see the proof of Proposition 5.

that a consumer with registration cost k_{RH} receives a discount is equal to $1 - q$ (that is, equal to the probability that $k = k_{RH}$), and the probability that a consumer with low registration cost k_{RL} receives a discount is equal to q . We first show that offering discounts can be profitable for the firm even when the firm offers the discounts on a purely random basis.

Proposition 5 *Consider the case of random discounts and suppose that $k_{RL} < \bar{u}(0) < k_{RH}$ where $\bar{u}(0)$ is defined as in (5). If k_{RH} is sufficiently close to $\bar{u}(0)$, the firm can achieve strictly higher profits if it requires ex ante registration and offers a discount to a random share of consumers than (i) if it requires ex ante registration and offers no discounts and (ii) if it does not require ex ante registration.*

Discounts distort the firm's pricing decision. Moreover, if the firm cannot target the discounts to consumers with high registration costs, they are also paid to consumers who would register even without discount. Nevertheless, even randomly offered discounts can increase the firm's expected profit. The intuition for Proposition 5 is as follows. When k_{RH} is close to $\bar{u}(0)$, only a small discount is needed in order that high-cost consumers with discount register.³⁴ The firm can give such a small discount to almost all consumers. Moreover, the price p_d is close to $p(0)$; thus, all low-cost consumers will register, including those who have not received a discount, and the price distortion effect is small. Therefore, the profit of the firm is almost equal to $\pi(0)$ (where $\pi(0)$ is given in (2)). The proof of Proposition 5 shows that for any fixed $\delta \in (0, 1)$, the firm's profit converges to $q\pi(0) + \delta(1 - q)\pi(0)$ if $k_{RH} \rightarrow \bar{u}(0)$ (since all low-cost types and a share δ of the high-cost types register). Thus the firm can achieve a profit that is close to $\pi(0)$ when k_{RH} is close to $\bar{u}(0)$.

The case of purely random discounts is the most unfavorable case for the profitability of discounts. The better the firm is able to target the discounts to consumers with high registration costs, the less costly becomes the use of discounts, and the more attractive becomes the ex ante registration policy with discounts. We model targeting such that it reduces the probability that a low-cost type receives a discount to $q' < q$, and increases the probability that a high-cost type receives a discount to $1 - q' > 1 - q$. Of course, the share of discounts received by high-cost types cannot be higher than the share of high-cost consumers in the population. Formally, in order that a discount policy (d, δ) is feasible with targeting technology q' , it must satisfy $(1 - q')\delta \leq 1 - q$.

³⁴The optimal choice of d is such that high-cost types are just willing to register (such that (10) holds with equality); due to the price distortion effect, the firm will not increase the discount any further. Since p_d depends on the share δ of consumers with discount, d can be expressed as a continuous function of δ . Note that the discount $d(\delta)$ necessary to induce high-cost types to register is increasing in δ since the price p_d also increases in δ : The more consumers get a discount, the stronger is the price increase, and the higher must be the discount to make a high-cost consumer willing to register.

Proposition 6 *The firm's profit in case of ex ante registration requirements with discounts is strictly increasing in the ability to target the discount to consumers with high registration cost).*

The intuition behind Proposition 6 is straightforward. In the extreme case in which discounts can be perfectly targeted to high-cost consumers, each additional discount offered attracts an additional consumer who registers, while in the case of purely random discounts the probability of an additional consumer is only $1 - q$ (the probability that a high-cost consumer gets the discount). Moreover, keeping the number of discounts δ fixed, improved targeting (a decrease in q') leads to a smaller price distortion since there will be more consumers without discount among the registered consumers. Both effects increase the profitability of using discounts. If the cost of making use of targeting is increasing in the 'targeting quality' $q - q'$, there exists an optimal targeting technology which takes some interior value if the first unit of targeting is sufficiently cheap but perfect targeting is prohibitively costly.

In reality, targeting will be typically imperfect, even though firms do certainly better than just randomly offering discounts. To improve the targeting, firms can use similar instruments as in the context of targeted advertising and will attach discounts to certain consumer characteristics which they can observe and which they expect to be correlated with the registration costs. This includes socioeconomic information but also information about consumer attitudes and interests and about previous purchases at this or other firms obtained, e.g., through cookies. For instance, the firm may attach the discount to the purchase of another product. Moreover, firms sometimes offer discounts to consumers who started but then canceled the registration process but already provided an e-mail address, for instance, or offer a price reduction to buyers in case they set up an account. Similarly, the use of a mobile device or the web browser a consumer uses typically allows to conclude on certain consumer characteristics (such as age cohort or income group). Thus, improved information about the consumers can also be valuable in that it makes it cheaper to target certain groups of consumers and increase their willingness to register ex ante by offering discounts.

To conclude this section we note that the incentive for using discounts to attract additional consumers is stronger if the firm also values the information that consumers provide when they register (as in Section 5). Moreover, the incentive to use discounts carries over to the dynamic model: Offering discounts at the beginning of period t can increase the firm's profits and enlarge the range in which ex ante registration requirements are optimal. In the dynamic model, if ex ante registration requirements are not feasible, the firm also has an incentive to offer discounts to consumers in case they register when buying in period t . As long

as not all consumers are offered such a discount (valid in period $t + 1$), such discounts make consumers more willing to set up an account (compared to buying with a guest checkout).

7 Competition

In the baseline model of the previous sections, the firm benefits from requiring ex ante registration, but the consumers would prefer that the firm does not require ex ante registration. Therefore, competitors that do not require ex ante registration may attract (some of) the consumers, which may change the profitability of ex ante registration requirements. This section shows, however, that the logic of ex ante registration requirements can prevail even when firms face price competition.

To analyze the impact of competition on the optimal platform choice, suppose that there are N firms that all produce an identical product at marginal cost of zero. The mass of consumers consists of a share of ‘loyal’ consumers who only consider to buy at a particular firm and a remaining share of non-committed consumers.³⁵ For notational simplicity we assume that a share β of the consumers is loyal to each firm $i \in \{1, \dots, N\}$ where $0 \leq \beta \leq 1/N$; the share of non-committed consumers is denoted by $\beta_0 := 1 - N\beta$. Each consumer has unit demand and a valuation θ of the product which is distributed according to F , both for loyal and for non-committed consumers.

The three-stage game of the Section 3 only needs slight modifications. In stage 1, the firms simultaneously and independently make their platform choice $r \in \{ExA, ExP, G\}$. In stage 2, the platform choices become common knowledge and firm $i \in \{1, \dots, N\}$ chooses a price $p_i \geq 0$. For stage 3, we have to distinguish between loyal and non-committed consumers. Loyal consumers decide whether to trade with one particular firm, just as in the previous sections. If this firm does not require ex ante registration, loyal consumers observe the price and their valuation θ and decide whether to buy. If this firm requires ex ante registration, loyal consumers decide whether to register, in which case they learn θ and the price and may buy.³⁶ Non-committed consumers observe the prices from the firms that do not require ex ante registration. Moreover, if there is a firm with $r \neq ExA$, non-committed consumers can learn their valuation θ . Non-committed consumers decide whether to register at a firm (if

³⁵For early papers on price competition with brand loyalty see Rosenthal (1980) and Narasimhan (1988). A similar structure emerges when a share of consumers is uninformed about the existence of other firms (Varian 1980). Brand loyalty can be explained by switching cost, more specifically, for instance, by costly learning how to use new products, complementarities to other purchased products and network effects; for an overview of reasons for brand loyalty see Klemperer (1995). See also Baye and Morgan (2009) for a model of price competition when consumer loyalty is endogenous and affected by advertising.

³⁶Thus, if $\beta \rightarrow 1/N$, the firms’ decisions become completely independent and the equilibrium platform choices are exactly as characterized in Proposition 1.

required) and decide whether and where to buy.³⁷ As before, consumers who register incur a cost k_R ; consumers who buy using the guest checkout (if offered) incur a cost k_G .

The equilibrium analysis builds on the following observations. First, if a firm requires ex ante registration ($r = ExA$), the optimal price choice in stage 2 is $p(0)$ (where $p(k)$ is defined in (1)).³⁸ Anticipating this price, consumers would register at this firm only if $k_R \leq \bar{u}(0)$; moreover, non-committed consumers expect the same surplus $\bar{u}(0)$ at either firm that requires ex ante registration. Second, if a firm does not require ex ante registration, its profit is higher under $r = G$ than under $r = ExP$; as in the baseline model, firms have no incentive to require registration ex post but prefer to offer the option of guest checkout. Third, and most importantly, if two or more firms do not require ex ante registration, there is price competition for the non-committed consumers; this yields equilibrium prices below $p(0)$ such that non-committed consumers are strictly better off when trading with a firm that chooses $r = G$ than when registering at a firm with $r = ExA$. These observations lead to the following main result of this section.

Proposition 7 (i) *Suppose $k_R \leq \bar{u}(0)$, where $\bar{u}(0)$ is defined as in (5). If*

$$\beta \geq \frac{1}{N-1} \left(1 - \frac{\pi(0)}{N\pi(k_G)} \right), \quad (12)$$

then in equilibrium all firms choose $r = ExA$. If

$$0 < \beta < \frac{1}{N-1} \left(1 - \frac{\pi(0)}{N\pi(k_G)} \right), \quad (13)$$

there are N equilibria with platform choices in pure strategies such that exactly one firm chooses $r = G$ and all $N - 1$ other firms choose $r = ExA$.

(ii) *If $k_R > \bar{u}(0)$, all firms choose $r = G$.*

Price competition between firms lowers their expected profits if two or more firms do not require ex ante registration.³⁹ All profits from selling to the non-committed consumers are

³⁷In case two or more firms require ex ante registration, consumers can register at one firm first and observe this firm's price but are allowed to register at another firm afterwards and finally decide where to buy.

³⁸There are again subgame equilibria in which consumers believe that the firm chooses a very high price such that it never pays off to register at this firm and therefore, this firm has indeed no incentive to deviate from a very high price. As in the monopoly case, proper refinements can eliminate these equilibria.

³⁹In the proof of Proposition 7 we show that in this case, the equilibrium pricing decisions are in mixed strategies whenever $\beta > 0$. Intuitively, prices do not drop down to marginal costs since firms can make positive profits by selling to their loyal consumers only. Nevertheless, firms would like to marginally undercut their competitors in order to gain all non-committed consumers. The equilibrium of Bertrand price competition with a share of loyal consumers has been derived and applied by Narasimhan (1988) for the case of two firms, and similar structures have been analyzed, for instance, in the context of price competition with informed and uninformed consumers (Varian 1980; Baye et al. 1992).

competed away, and firm i that chooses $r = G$ ends up with an expected equilibrium payoff equal to $\beta\pi(k_G)$ (which is what it can guarantee itself when selling to its loyal consumers only; where $\pi(k)$ is defined in (2)). But if firm i requires ex ante registration, it gets a profit $\beta\pi(0) > \beta\pi(k_G)$: Even though only loyal consumers consider buying at firm i in this case, the same argument as in the baseline model (Proposition 1) shows that firm i is strictly better off when those consumers register ex ante.

If the firms' share of loyal consumers is sufficiently high then all firms choose an ex ante registration requirement in equilibrium and set prices equal to $p(0)$. The non-committed consumers register at one randomly selected firm and only consider buying at this firm since they correctly anticipate that the prices at the other firms will not be lower.⁴⁰ If a firm deviates to 'no ex ante registration' and chooses $r = G$, it optimally sets a price $p(k_G) < p(0)$ and gets all non-committed consumers; but it loses the advantage of ex ante registration of its loyal consumers. Hence, a deviation to $r = G$ is profitable only if β becomes small such that the gain from additional non-committed consumers outweighs the lower profit extracted from the loyal consumers. Such a deviation is, however, profitable for at most one firm: Price competition about non-committed consumers distracts a second firm from choosing $r = G$ whenever $\beta > 0$ (however small). In other words, there is no equilibrium in pure strategies in which two or more firms do not require ex ante registration.⁴¹

The fact that some consumers do not compare prices but consider buying at one particular firm only makes the firms strictly better off under ex ante registration requirements, which enable firms to achieve at least some profits from selling to the loyal consumers. Brand loyalty can be a consequence of complementarities with other products, for instance, or of switching costs, network effects, consumption choices of friends, or simple unawareness of the presence of competitors. As long as $\beta > 0$, Proposition 7 characterizes the complete set of equilibria involving registration policy choices in pure strategies, even when β is infinitesimally close to zero. The type of equilibrium in which $N - 1$ firms choose $r = ExA$ continues to exist for $\beta = 0$, but in this case there are (multiple) additional equilibria since firms make zero profits

⁴⁰Proposition 7 is similar to the Diamond (1971) paradox that arbitrarily small search costs imply equilibrium prices that differ drastically from marginal costs. Similarly, in our setting, arbitrarily small frictions in the form of registration costs lead to equilibrium prices above marginal costs. If (13) holds, however, prices paid by the uncommitted consumers are smaller than the monopoly price (but still strictly higher than marginal costs). Moreover, our result is different from Diamond (1971) since it relies on both registration costs ($k_R > 0$) and committed consumers ($\beta > 0$). Intuitively, while firms may not want to deviate in prices given that all firms choose $r = ExA$, the registration requirements add another dimension in which firms may deviate, which would have its analogy in Diamond's model (though being substantially different) when allowing firms to reduce the search costs to zero and in this way attract all consumers and restore price competition in equilibrium.

⁴¹Under the conditions of Proposition 7(ii), there exists also equilibria in mixed strategies, including a symmetric equilibrium in which all N firms randomize their registration requirement (choosing between $r = G$ and $r = ExA$).

both in case of $r = ExA$ and when deviating to $r = G$ (provided that at least one other firm chooses $r = G$, as none of the consumers would register at a firm if there is another firm with $r = G$). Therefore, the case of $\beta = 0$ is a special case in which there are multiple equilibria characterized by $m \in \{1, \dots, N\}$ firms choosing $r = G$ and the remaining $N - m$ firms choosing $r = ExA$.

A general message of the case of price competition is that firms with a high share of loyal consumers will choose ex ante registration requirements while firms with no (of few) loyal consumers will not require ex ante registration, which can be most easily seen in the following example.

Remark 1 *Let $1 \leq n \leq N - 2$ and suppose that firms $i \in \{1, \dots, n\}$ each have a share $\beta \in (0, 1/n]$ of loyal consumers but firms $j \in \{n + 1, \dots, N\}$ do not have any loyal consumers. If $k_R \leq \bar{u}(0)$, there is an equilibrium in which firms $1, \dots, n$ choose $r = ExA$ and all other firms choose $r = G$.*

If two or more firms do not have any loyal consumers, they choose $r = G$ and prices equal to marginal costs and, hence, realize zero profits, but they cannot do better by deviating to $r = ExA$ since in this case none of the non-committed consumers would register at their shop. Firms with loyal consumers are, thus, strictly better off when choosing $r = ExA$ (in which case they get a profit of $\beta\pi(0) > 0$).

While Section 6 considered the incentive of a monopoly firm to use discounts as a means to increase the consumers' willingness to register, very similar effects can be derived vis-à-vis the loyal consumers in the case of competition. In the latter case, discounts may also be used to attract the non-committed consumers.⁴² As a simple illustration, consider the case of Proposition 7(i) and suppose that firms $j \neq i$ do not use discounts. Then, firm i can attract all the non-committed consumers by offering them an arbitrarily small discount. This will increase firm i 's profit even when it cannot target the discount specifically to the non-committed consumers. As in Section 6, the firm cannot offer discounts to all consumers since this would lead to a price increase by the same amount. But since under the assumptions of Proposition 7(i) loyal consumers will register even without discounts, the registered consumers will consist of consumers with and without discounts; hence, non-committed consumers who are offered a discount anticipate that their effective price at firm i is reduced and will prefer to register at firm i .

In a multi-period model with non-monetary costs of registration, some degree of consumer loyalty can also emerge endogenously. Intuitively, if a consumer already has an account at

⁴²See also Shaffer and Zhang (2002) on price competition with loyal consumers when, after setting their prices, firms can target promotions to certain customers and induce consumers to switch to their brand.

a firm, he is willing to pay a higher price at that firm if, at other firms, he needs to register (or use guest checkout) when buying. This generates a lock-in effect which mitigates the price competition and is, hence, profitable for the firms. In fact, when extending the two-period model of Section 4 to the case of N firms (without exogenously loyal consumers, that is, $\beta = 0$), there can be an equilibrium in which all N firms do not offer the option of guest checkout in period t but require registration ex post. Although deviating could attract additional consumers in the current period, requiring consumers to register leads to higher profits in future periods. Moreover, if firms derive an informational value from consumer registration (as in Section 5), this strengthens their incentive to require registration also in the presence of competition. In Proposition 7(i), the range of β for which all firms require ex ante registration in equilibrium would be enlarged if firms value the information that consumers provide when registering. Overall, the incentive to use ex ante registration requirements caused by the sunk cost advantage of registration carries over to the case of competition and its value is reinforced when incorporating dynamic aspects and repeat purchases or a pure informational value of consumer registration.

8 Discussion and conclusions

This paper highlights an important aspect of online shopping: When buying at online shops, consumers incur a non-monetary ‘registration cost’ caused by privacy and security concerns and by the time it needs to set up a user account. Privacy concerns have become increasingly important in e-commerce where buying usually requires the disclosure of personal information such as address and payment details. Privacy concerns of consumers in online shopping open up new questions of platform design and market competition, which played no role in traditional brick-and-mortar shopping. We show that firms have an incentive to shift the registration cost to an earlier stage of the shopping process and to detach it from the actual buying decision, which has implications for the firms’ platform design.

In our baseline model, consumers are ex ante uncertain about the price and their product valuation. This information can, however, be released by the firm at zero cost; hence, we assume that search costs do not play a role in this market. Firms decide *when* to release this information: before or after the consumer has signed in to the website. Our model can also be interpreted such that some information is already released ex ante (which is incorporated in the probability distribution of consumer valuations) and the firm decides when to release the residual information. We consider the case of a monopoly firm and show that the firm’s equilibrium platform choice involves an ex ante registration requirement whenever the consumers’ registration cost is sufficiently low. In other words, unless privacy

and security concerns are very important for consumer behavior, the firm should require user registration at an early stage whenever possible: Making the registration costs ‘sunk’ at the point when consumers decide whether to buy makes the marginal consumers more willing to buy, for instance, when credit card information is already entered and stored in the consumer’s user account. This leads to higher demand and higher profits for the firm.

Then, we incorporate important additional features of online markets into the baseline model and show that the logic of ex ante registration requirements prevails and may be strengthened. First, we consider a simple multi-period model, taking into account the possibility of repeat purchases. Here, we show that if consumers consider purchasing repeatedly at a given firm, they expect a higher surplus from setting up an account at the firm. Therefore, the higher the likelihood that a consumer returns, the larger becomes the range in which the firm can profitably implement ex ante registration requirements. This holds even though registered consumers can observe price and product information without any additional registration costs in future periods. Put differently, the logic of ex ante registration requirements established in the baseline model based on ‘within-period’ uncertainty about the product characteristics also applies vis-à-vis future transactions, which become more likely, and therefore more profitable for the firm, if consumers are already registered. The multi-period setup also derives conditions under which the firm prefers to offer the option of guest checkout (letting consumers buy without user account).

The higher demand with ex ante registration is particularly profitable for firms if they also care about the information that consumers provide when they register. In addition, firms may value user information from consumers who register but do not buy. Both aspects make ex ante registration requirements relatively more profitable and, hence, interact with the ‘sunk cost’ advantage of ex ante registration, as we show in Section 5. Due to the value of consumer registration, firms may want to give consumers additional incentives to register if their privacy concerns distract them from setting up an account. Section 6 shows that discounts (store credit) offered conditional on buying can increase the share of consumers who are willing to register even though discount policies distort the firm’s pricing decision and even when the firm’s ability to target these discounts to the marginal consumers is low. Therefore, the optimal platform choice can involve both ex ante registration requirements and discounts offered to a share of consumers. Since discount policies become more profitable if the firm is able to target these discounts to consumers with strong privacy concerns who would not register without discount, firms may want to invest in improved targeting by offering the discounts based on observable consumer characteristics which they expect to be correlated with their registration costs.

Finally, we show that the firms’ incentives to require ex ante registration carry over to

the case of competition between firms by mitigating price competition. In particular, firms with loyal consumers (incumbent firms) may choose ex ante registration requirements as part of their business strategy; given that a sufficiently high share of consumers registers, they benefit from an increase in turnover as well as in the price they can charge. In contrast, ex ante registration requirements are less advisable for firms with no loyal consumers. They compete for the non-committed consumers and achieve higher profits when reducing the amount of personal information to be revealed by consumers ex ante.

The degree to which firms may want to influence the consumers' cost of registration depends on the trade-off between changes in demand and changes in the benefits from increased information revelation of the consumers, although it will hardly be possible to completely remove all consumers' privacy and security concerns. In particular, the 'registration cost' is at least partly independent of the firm at which a consumer considers to buy since privacy concerns are also caused by data collection and the use and abuse of personal information by third parties. But the profitability of the different registration policies can also interact with behavioral aspects of consumer decision-making. On the one hand, consumers may strongly dislike certain types of registration requirements and 'boycott' such online shops, an aspect which may be reflected in high rates of shopping cart abandonment. On the other hand, the well-documented 'sunk-cost fallacy' could make ex ante registration requirements even more profitable when the feeling of having already incurred some costs makes consumers more willing to buy once they have already gone through the process of registration.

A Appendix

A.1 Proof of Corollary 1

Under $r = ExA$, the firm's optimal price is independent of k_R and equal to $p(0)$. Anticipating this price, all consumers with $k_R \leq \bar{u}(0)$ register, which leads to a profit of $H_R(\bar{u}(0))\pi(0)$ (as $H_R(\bar{u}(0))$ is the share of consumers who register and $\pi(0)$ is the firm's expected profit per consumer). If $r \neq ExA$, the firm prefers $r = G$ over $r = ExP$ due to $k_G \leq k_R$ (and $k_G < k_R$ with strictly positive probability), just as in Proposition 1. Since for a given k_G a consumer buys with probability $1 - F(p + k_G)$, the firm's expected profit under $r = G$ is

$$\tilde{\pi}_G = \max_p \int_0^\infty (1 - F(p + k_G)) p dH_G(k_G).$$

Thus, the firm prefers $r = ExA$ over $r = G$ if and only if $H_R(\bar{u}(0)) \geq \tilde{\pi}_G/\pi(0)$. Obviously, $\tilde{\pi}_G/\pi(0) > 0$. It remains to show that $\tilde{\pi}_G/\pi(0) < 1$. As in the proof of Proposition 1, with

\tilde{p} being the optimal price in case of $r = G$, we have

$$\begin{aligned}\pi(0) &= \int_0^\infty (1 - F(p(0))) p(0) dH_G(k_G) \\ &\geq \int_0^\infty (1 - F(\tilde{p} + k_G)) (\tilde{p} + k_G) dH_G(k_G) \\ &> \int_0^\infty (1 - F(\tilde{p} + k_G)) \tilde{p} dH_G(k_G) = \tilde{\pi}_G.\end{aligned}$$

A.2 Proof of Proposition 2

Suppose first that $k_R \leq \bar{u}(0)$. (Recall that $p(k)$, $\pi(k)$, and $\bar{u}(k)$ are defined in (1), (2), and (3), respectively.) In period $t + 1$, the firm's optimal policy is as in Proposition 1: It chooses $r_{t+1} = ExA$ and charges a price $p(0)$. Consumers who already have an account from period t can buy using this discount; all other consumers register due to $k_R \leq \bar{u}(0)$. Hence, a consumer's expected period $t + 1$ utility is equal to $\bar{u}(0)$ if he already has an account and equal to $\bar{u}(0) - k_R \geq 0$ otherwise. In period t , if the firm chooses $r_t = ExA$ and a price $p(0)$, a consumer's total expected utility is equal to $2\bar{u}(0) - k_R$ in case he registers and equal to only $0 + \bar{u}(0) - k_R$ in case he does not register. Thus, all consumers register in period t and the firm's total profit is equal to $2\pi(0)$, which is strictly higher than what the firm can get for any $r_t \neq ExA$ (where the profit in period t is strictly less than $\pi(0)$, and the profit in $t + 1$ is at most $\pi(0)$).

Now suppose that $\bar{u}(0) < k_R \leq 2\bar{u}(0) - \bar{u}(k_G)$. In period $t + 1$, since $\bar{u}(0) < k_R$, consumers who do not yet have an account would not register. Therefore, the firm chooses $r_{t+1} = G$ (it does not gain anything from forcing the consumers to register ex post in the last period; compare the proof of Proposition 1), charges a price $p(0)$ to consumers who buy with an existing account, and a price $p(k_G)$ to consumers who buy as a guest.⁴³ All consumers can observe their valuation at no cost. Registered consumers buy using their accounts at the price $p(0)$ because under Assumption 1, $p(0) < p(k_G) + k_G$ (where the latter is a consumer's total cost of buying with a guest account). Consumers who are not yet registered in period $t + 1$ buy using the guest checkout (since $p(k_G) + k_G < p(0) + k_R$). Therefore, registered consumers expect a period $t + 1$ utility of $\bar{u}(0)$, while non-registered

⁴³Strictly speaking, if all consumers already register in period t , the firm is indifferent between $r_{t+1} = G$ and $r_{t+1} = ExA$. With a continuum of consumers, if a single consumer deviates in period t and does not register, he has mass zero from the point of view of the firm; thus, the firm may still choose $r_{t+1} = ExA$. With a finite (but possibly very large) number of consumers, this does no longer hold and a consumer who does not register in period t can (correctly) anticipate that the firm will choose $r_{t+1} = G$. Therefore, we assume the tie-breaking rule in favor of $r_{t+1} = G$ at this point to guarantee that the range under which ex ante registration requirements are chosen in equilibrium corresponds to the case of a finite number of consumers (and, in case of a continuum of consumers, is robust to small trembles in the consumers' period t registration decisions).

consumers expect a period $t + 1$ utility of $\bar{u}(k_G) < \bar{u}(0)$. In period t , if the firm sets $r_t = ExA$, the total expected utility of consumers who register in t is equal to $2\bar{u}(0) - k_R$, while the total expected utility of consumers who do not register in t is equal to $0 + \bar{u}(k_G)$. Hence, if (7) holds, all consumers register in t and the firm realizes its maximum profit of $2\pi(0)$.

If (7) is violated, no consumer registers in t and the firm's total profits under $r_t = ExA$ are $0 + \pi(k_G)$ (since all consumers use the guest checkout offered in period $t + 1$); the firm can get, however, a total profit of (at least) $2\pi(k_G)$ if $r_t = G$. Therefore, the firm will require ex ante registration in t if and only if (7) holds.

A.3 Proof of Lemma 1

Consider first period $t + 1$. Since $r_t = ExA$ is not feasible, there will be a strictly positive mass of consumers who are not yet registered in period $t + 1$ (those consumers with low θ_t). The firm sets $r_{t+1} = G$ (which, due to $\pi(k_G) > \pi(k_R)$, yields higher profits than $r_{t+1} = ExP$), charges a price $p(k_G)$ to consumers without an account, and a price $p(0)$ to consumers who buy with an existing account. Consumers with an account (from period t) prefer to sign in with their account and buy at $p(0) < p(k_G) + k_G$; consumers without an account buy using guest checkout.

Now consider period t . A consumer with valuation θ_t who sets up an account and buys in period t gets a total expected utility of

$$\theta_t - p_t - k_R + \bar{u}(0), \quad (14)$$

since he expects a surplus of $\bar{u}(0)$ in period $t + 1$ where he is already registered. A consumer with valuation θ_t who buys in t using guest checkout gets a total expected utility of

$$\theta_t - p_t - k_G + \bar{u}(k_G), \quad (15)$$

since he expects a surplus of $\bar{u}(k_G)$ in period $t + 1$ where he does not have an account. Comparing (14) and (15) shows that a consumer prefers using guest checkout over buying with an account if and only if

$$k_R - k_G > \bar{u}(0) - \bar{u}(k_G). \quad (16)$$

If $k_G \rightarrow 0$, the right-hand side of (16) approaches zero and (16) holds. Moreover, the right-hand side of (16) strictly increases in k_G and the left-hand side of (16) strictly decreases in

k_G . If $k_G \rightarrow k_R$ then (16) is violated. Thus, there exists a unique $\check{k}_G \in (0, k_R)$ such that (16) holds if and only if $k_G < \check{k}_G$.

To prove Lemma 1, assume in the following that $k_G < \check{k}_G$.

Part (i). In period $t + 1$, the firm makes a profit of $\pi(0)$ per registered consumer and a profit of $\pi(k_G) < \pi(0)$ per non-registered consumer; hence, its total period $t + 1$ profit is strictly increasing in the share of consumers who are already registered. In period t , however, strictly more consumers will register under $r_t = ExP$ than under $r_t = G$. To see this, note that under $r_t = G$, no consumer registers in t since $k_G < \check{k}_G$. In contrast, if $r_t = ExP$, consumers with a sufficiently high θ_t will register in t . To be precise, those consumers register for whom the total expected surplus in (14) is larger than the expected total surplus from not buying in t ($0 + \bar{u}(k_G)$), that is, the share of consumers who register in t under $r_t = ExP$ is equal to

$$1 - F(p_t + k_R - (\bar{u}(0) - \bar{u}(k_G))) > 0.$$

Part (ii). Suppose first that $r_t = ExP$. The firm's total expected profits $\pi_t + \pi_{t+1}$ when choosing a price p_t are

$$[1 - F(p_t + k_R - (\bar{u}(0) - \bar{u}(k_G)))](p_t + \pi(0)) + F(p_t + k_R - (\bar{u}(0) - \bar{u}(k_G)))\pi(k_G) \quad (17)$$

since the firm expects total profits of $p_t + \pi(0)$ from consumers register/buy in period t and expects total profits of $0 + \pi(k_G)$ from the remaining consumers who do not register/buy in t . The optimal choice of p_t is the solution to the first order condition

$$p_t = \frac{1 - F(p_t + k_R - (\bar{u}(0) - \bar{u}(k_G)))}{F'(p_t + k_R - (\bar{u}(0) - \bar{u}(k_G)))} - (\pi(0) - \pi(k_G)). \quad (18)$$

Ignoring the term $\pi(0) - \pi(k_G)$, the optimal choice p_t would be the price that takes into account a consumer's adjusted registration costs $k_R - (\bar{u}(0) - \bar{u}(k_G))$ (adjusted by the expected future surplus from registration). The term $\pi(0) - \pi(k_G)$ in (18), however, causes the firm's optimal price in t to be lower: A lower price in period t increases the probability that consumers register, in which case the firm's future profits increase; $\pi(0) - \pi(k_G)$ represents the relative increase in future profits if the share of registered consumers goes up. Denoting the solution to (18) by $p_{t,ExP}^*$, the period t profit of the firm is

$$\pi_t(r_t = ExP) = [1 - F(p_{t,ExP}^* + k_R - (\bar{u}(0) - \bar{u}(k_G)))] p_{t,ExP}^*.$$

Suppose that $r_t = G$. Since $k_G < \check{k}_G$, consumers buy in period t using guest checkout.

Then the price p_t has no implications for the period $t + 1$ profit, and will be chosen by the firm to maximize the period t profit, which is

$$\begin{aligned}
\pi_t(r_t = G) &= \max_p \{[1 - F(p + k_G)] p\} \\
&\geq [1 - F(p_{t,ExP}^* + k_R - (\bar{u}(0) - \bar{u}(k_G)))] (p_{t,ExP}^* + k_R - (\bar{u}(0) - \bar{u}(k_G)) - k_G) \\
&> [1 - F(p_{t,ExP}^* + k_R - (\bar{u}(0) - \bar{u}(k_G)))] p_{t,ExP}^* \\
&= \pi_t(r_t = ExP).
\end{aligned}$$

The strict inequality follows from $k_G < \check{k}_G$ (i.e., (16) holds).

A.4 Proof of Proposition 3

If $k_G \geq \check{k}_G$, consumers prefer ex post registration over using guest checkout and the firm's total profits are the same under $r_t = G$ and under $r_t = ExP$. By our tie breaking rule, the firm chooses $r_t = ExP$ in this case. Thus, suppose in the following that $k_G < \check{k}_G$, and consider the firm's profits under the two platform design choices $r_t = ExP$ and $r_t = G$. The firm's total profits in case of $r_t = ExP$ are

$$\begin{aligned}
\sum_{\tau=t,t+1} \pi_\tau(r_t = ExP) &= \max_p \{[1 - F(p + k_R - (\bar{u}(0) - \bar{u}(k_G)))] (p + \pi(0)) \\
&\quad + F(p + k_R - (\bar{u}(0) - \bar{u}(k_G))) \pi(k_G)\}.
\end{aligned} \tag{19}$$

The firm's total profit in case $r_t = G$ are $\sum_{\tau=t,t+1} \pi_\tau(r_t = G) = 2\pi(k_G)$. Let

$$\Delta := \sum_{\tau=t,t+1} \pi_\tau(r_t = ExP) - \sum_{\tau=t,t+1} \pi_\tau(r_t = G).$$

If $k_G \rightarrow 0$, total profits under $r_t = G$ approach $2\pi(0)$, while total profits under $r_t = ExP$ are strictly smaller than $2\pi(0)$; thus $\Delta < 0$ if $k_G \rightarrow 0$. Now suppose that $k_G \rightarrow \check{k}_G$ which is equivalent to $k_R - (\bar{u}(0) - \bar{u}(k_G)) \rightarrow k_G$. With (19), total profits under $r_t = ExP$ approach

$$\begin{aligned}
&\max_p \{[1 - F(p + k_G)] (p + \pi(0)) + F(p + k_G) \pi(k_G)\} \\
&\geq [1 - F(p(k_G) + k_G)] (p(k_G) + \pi(0)) + F(p(k_G) + k_G) \pi(k_G) \\
&> [1 - F(p(k_G) + k_G)] (p(k_G) + \pi(k_G)) + F(p(k_G) + k_G) \pi(k_G) \\
&= 2\pi(k_G),
\end{aligned}$$

where the latter is equal to total profits under $r_t = G$ (the second inequality follows from $\pi(0) > \pi(k_G)$). Therefore, $\Delta > 0$ if $k_G \rightarrow \check{k}_G$.

Finally, differentiate (19), denote the profit maximizing period price in period t under $r_t = ExP$ by $p_{t,ExP}^*$, and use the envelope theorem, to obtain

$$\begin{aligned} \frac{\partial}{\partial k_G} \sum_{\tau=t,t+1} \pi_\tau(r_t = ExP) &= -F'(p_{t,ExP}^* + k_R - (\bar{u}(0) - \bar{u}(k_G))) (p_{t,ExP}^* + \pi(0)) \frac{\partial \bar{u}(k_G)}{\partial k_G} \\ &\quad + F'(p_{t,ExP}^* + k_R - (\bar{u}(0) - \bar{u}(k_G))) \pi(k_G) \frac{\partial \bar{u}(k_G)}{\partial k_G} \\ &\quad + F(p_{t,ExP}^* + k_R - (\bar{u}(0) - \bar{u}(k_G))) \frac{\partial \pi(k_G)}{\partial k_G}. \end{aligned}$$

Thus, with $\partial \left(\sum_{\tau=t,t+1} \pi_\tau(r_t = G) \right) / \partial k_G = 2\partial \pi(k_G) / \partial k_G$, we get

$$\begin{aligned} \frac{\partial \Delta}{\partial k_G} &= -F'(p_{t,ExP}^* + k_R - (\bar{u}(0) - \bar{u}(k_G))) (\pi(0) - \pi(k_G) + p_{t,ExP}^*) \frac{\partial \bar{u}(k_G)}{\partial k_G} \\ &\quad + (F(p_{t,ExP}^* + k_R - (\bar{u}(0) - \bar{u}(k_G))) - 2) \frac{\partial \pi(k_G)}{\partial k_G}, \end{aligned}$$

which is strictly positive since $\pi(0) > \pi(k_G)$, $\partial \bar{u}(k_G) / \partial k_G < 0$, and $\partial \pi(k_G) / \partial k_G < 0$. It follows that there exists $\bar{k}_G \in (0, \check{k}_G)$ such that the firm strictly prefers $r_t = G$ over $r_t = ExP$ if and only if $k_G < \bar{k}_G$.

A.5 Proof of Proposition 4

Denote the solution to (8) by $\hat{p}(k, v)$. The optimal price $p(k, v)$ is given by (8) if $\hat{p}(k, v) \geq -k$, and is equal to $-k$ otherwise.

(i) Suppose that the firm chooses $r = ExA$ and that inequality (9) holds. Then, anticipating the price $p(0, v_B)$, all consumers register, and the firm's profit is equal to

$$(1 - F(p(0, v_B))) (p(0, v_B) + v_B) + v_R, \quad (20)$$

which must be (weakly) larger than the profit when choosing a price $p = p(k_R, v_R + v_B) + k_R$, that is, larger than

$$\begin{aligned} &(1 - F(p(k_R, v_R + v_B) + k_R)) (p(k_R, v_R + v_B) + k_R + v_B) + v_R \\ &> (1 - F(p(k_R, v_R + v_B) + k_R)) (p(k_R, v_R + v_B) + v_B + v_R), \end{aligned}$$

where the latter is the firm's profit when choosing $r = ExP$. Similarly, the firm's profit

under $r = ExA$ is (weakly) larger than when choosing a price $p = p(k_G, v_G) + k_G$, that is, larger than

$$\begin{aligned} & (1 - F(p(k_G, v_G) + k_G)) (p(k_G, v_G) + k_G + v_B) + v_R \\ > & (1 - F(p(k_G, v_G) + k_G)) (p(k_G, v_G) + v_B + v_R) \\ \geq & (1 - F(p(k_G, v_G) + k_G)) (p(k_G, v_G) + v_G), \end{aligned}$$

where the latter is the firm's profit when choosing $r = G$.

(ii) Suppose that inequality (9) is violated. Then, the firm's profit under $r = ExA$ is zero since no consumer registers. The profit under $r = ExP$ is equal to

$$(1 - F(p(k_R, v_R + v_B) + k_R)) (p(k_R, v_R + v_B) + v_B + v_R). \quad (21)$$

Note that (21) is strictly increasing in the value of consumer information $v_R + v_B$.⁴⁴ Under $r = G$, the firm gets a profit equal to

$$(1 - F(p(k_G, v_G) + k_G)) (p(k_G, v_G) + v_G). \quad (22)$$

If $v_R + v_B$ approaches v_G , (21) approaches

$$\begin{aligned} & [1 - F(p(k_R, v_G) + k_R)] (p(k_R, v_G) + v_G) \\ < & [1 - F((p(k_R, v_G) + k_R - k_G) + k_G)] ((p(k_R, v_G) + k_R - k_G) + v_G) \\ \leq & \max_p \{ [1 - F(p + k_G)] (p + v_G) \} \end{aligned}$$

where the latter is the profit under $r = G$ (as given in (22)). If instead $v_R + v_B$ approaches $v_G + k_R - k_G$, the profit under $r = ExP$ approaches

$$\begin{aligned} & \max_p [1 - F(p + k_R)] (p + v_G + k_R - k_G) \\ \geq & [1 - F((p(k_G, v_G) + k_G - k_R) + k_R)] ((p(k_G, v_G) + k_G - k_R) + v_G + k_R - k_G), \end{aligned}$$

where the latter is equal to the profit under $r = G$ (as given in (22)). Since (21) is strictly increasing in $v_R + v_B$, there exists a threshold $\tilde{v} \in (v_G, v_G + k_R - k_G]$ such that the firm chooses $r = ExP$ if and only if $v_R + v_B \geq \tilde{v}$ and chooses $r = G$ otherwise.

⁴⁴Intuitively, if the value of consumer information increases to $v'_R + v'_B > v_R + v_B$, the firm's profit goes up even if it leaves the price unchanged (equal to $p(k_R, v_R + v_B)$).

A.6 Proof of Corollary 2

We first compare the profits under ex ante and ex post registration requirements. Denote by $\Delta(v_R, v_B)$ the difference in profits under $r = ExA$ (as given in (20)) and under $r = ExP$ (as given in (21)), that is,

$$\begin{aligned} \Delta(v_R, v_B) &= (1 - F(p(0, v_B))) (p(0, v_B) + v_B) + v_R \\ &\quad - (1 - F(p(k_R, v_R + v_B) + k_R)) (p(k_R, v_B) + v_R + v_B). \end{aligned}$$

Step 1: Suppose that $v_R = 0$. Using the envelope theorem, we get

$$\frac{\partial \Delta(0, v_B)}{\partial v_B} = (1 - F(p(0, v_B))) - (1 - F(p(k_R, 0 + v_B) + k_R)) \geq 0,$$

with strict inequality whenever v_B is sufficiently small such that $p(k_R, v_B) + k_R > p(0, v_B)$. (The latter is true by Assumption 1 as long as $p(k_R, v_B) > -k_R$. Note also that $p(k_R, v_B) = -k_R$ implies that $p(0, v_B) = 0$, in which case we get $\partial \Delta(0, v_B) / \partial v_B = 0$.)

Step 2: For any $v_B \geq 0$, using again the envelope theorem,

$$\frac{\partial \Delta(v_R, v_B)}{\partial v_R} = 1 - (1 - F(p(k_R, v_B + v_R) + k_R)) \geq 0,$$

with strict inequality whenever v_B and v_R are sufficiently small. *Step 3:* If $v_B = 0$, it follows by Step 2 that $\Delta(v_R, v_B) > \Delta(0, 0)$ if $v_R > 0$. If $v_B > 0$, then by Steps 1 and 2, $\Delta(0, 0) < \Delta(0, v_B) \leq \Delta(v_R, v_B)$.

Next, denote the difference in profits under $r = ExA$ and under $r = G$ (as given in (22)) by $\tilde{\Delta}(v_R, v_B, v_G)$. Note first that due to $v_G \leq v_R + v_B$, we get $\tilde{\Delta}(v_R, v_B, v_G) \geq \tilde{\Delta}(v_R, v_B, v_R + v_B)$, that is, the difference in profits is weakly larger than if the value of user information under $r = G$ is as in case of $r = ExP$ above. Since the result above for the comparison of $r = ExA$ and $r = ExP$ holds for any $k_R > 0$, it follows analogous to Steps 1-3 above that $\tilde{\Delta}(0, 0, 0) < \tilde{\Delta}(v_R, v_B, v_G)$ for any $(v_R, v_B) \neq (0, 0)$.

A.7 Proof of Proposition 5

Let $r = ExA$ and suppose that all consumers with registration cost k_{RL} register independently of whether they are offered a discount, but consumers with registration cost k_{RH} register if and only they are offered a discount. For a discount policy (d, δ) , the firm's expected profit is

$$\pi_d(p; r = ExA) := \delta (1 - F(p - d)) (p - d) + (1 - \delta) q (1 - F(p)) p. \quad (23)$$

This profit function takes into account (i) that a share δ of consumers register with discount and may buy at an effective price $p - d$ and (ii) that a share $(1 - \delta)q$ of consumers register without having a discount (all being low-cost types) and may buy at price p . The price p_d that maximizes (23) is given by the first order condition

$$\delta [-F'(p_d - d)(p_d - d) + 1 - F(p_d - d)] + (1 - \delta)q [-F'(p_d)p_d + 1 - F(p_d)] = 0. \quad (24)$$

Under Assumption 1 on F , p_d is increasing in d and $p_d - d$ is decreasing in d , which can be verified by implicit differentiation of (24). Hence, p_d is larger than the price $p(0)$ (for $d = 0$ as given in (1)) but $p_d - d$ is smaller than $p(0)$. Higher discounts d lead to a stronger price distortion, which reduces the firm's profits (taking as given the share of consumers who register). Therefore, if the firm decides to offer a discount, it will choose d such that high-cost types are just willing to register. (The left-hand side of the inequality in (10) is increasing in d . The firm will choose d such that (10) holds with equality; due to the price distortion effect, the firm will not increase the discount any further.) Since p_d depends on the share δ of consumers with discount, d can be expressed as a continuous function of δ .⁴⁵ Note that the discount $d(\delta)$ necessary to induce high-cost types to register is increasing in δ since the price p_d also increases in δ : The more consumers get a discount, the stronger is the price increase, and the higher must be the discount to make a high-cost consumer willing to register.⁴⁶

Fix any $\delta \in (0, 1)$ and let $k_{RH} \rightarrow \bar{u}(0)$, holding δ constant. Suppose the firm chooses the discount d such that (10) holds with equality. (If k_{RH} is close to $\bar{u}(0)$, such a discount clearly exists.) Then, by (10), $(p_d - d) \rightarrow p(0)$. By definition of $p(0)$, it follows that

$$[-F'(p_d - d)(p_d - d) + 1 - F(p_d - d)] \rightarrow 0.$$

By (24) this implies that

$$[-F'(p_d)p_d + 1 - F(p_d)] \rightarrow 0,$$

which means $p_d \rightarrow p(0)$. Since $(p_d - d) \rightarrow p(0)$, we conclude that $d \rightarrow 0$.

Since $p_d \rightarrow p(0)$ if $k_{RH} \rightarrow \bar{u}(0)$, the right-hand side of condition (11) approaches $\bar{u}(0)$, which is by assumption strictly greater than k_{RL} . Therefore, (11) holds for k_{RH} sufficiently

⁴⁵For general distributions F no closed form solution for d can be obtained; for a uniform distribution on $[0, 1]$, for instance, we obtain $d(\delta) = \frac{\delta + (1 - \delta)q}{2(1 - \delta)q} (\sqrt{k_{RH}/\bar{u}(0)} - 1)$ for $k_{RH} \geq \bar{u}(0) = 1/8$.

⁴⁶This again follows from implicit differentiation and the assumptions on F . If $\delta \rightarrow 1$ then $p_d \rightarrow p(0) + d$: If all registered consumers have a discount, the price in the discount case just increases by the value of the discount such that the net-of-discount price remains unchanged; the discount has no effect. (By the same argument, if all consumers have the same registration costs and only consumers with discount register then $p_d = p(0) + d$ and there is no effect of offering discounts.)

close to $\bar{u}(0)$. Moreover, with $k_{RH} \rightarrow \bar{u}(0)$, the profit (23) approaches

$$\delta\pi(0) + (1 - \delta)q\pi(0) = q\pi(0) + \delta(1 - q)\pi(0),$$

where $\pi(0)$ is as defined in (2). For any $\delta > 0$, this profit is strictly greater than $q\pi(0)$, which is the profit the firm achieves when it requires ex ante registration and does not offer any discounts (since in this case only consumers with registration cost k_{RL} register). This proves part (i).

For part (ii), if the firm does not require ex ante registration, it chooses $r = G$ and realizes a profit $\pi(k_G)$ (as given in (2); compare Proposition 1). Here, the firm would not want to offer a discount since discounts distort the pricing decision. Since $\pi(0)$ and $\pi(k_G)$ do not depend on k_{RH} , there exists $\bar{\delta} < 1$ such that

$$q\pi(0) + \delta(1 - q)\pi(0) > \pi(k_G)$$

for all $\delta > \bar{\delta}$ and all $k_{RH} \geq \bar{u}(0)$. Suppose the firm chooses $\delta \in (\bar{\delta}, 1)$. Then, for k_{RH} sufficiently close to $\bar{u}(0)$, the profit from the discount scheme is sufficiently close to $q\pi(0) + \delta(1 - q)\pi(0)$ and hence strictly larger than $\pi(k_G)$.

A.8 Proof of Proposition 6

Under targeting technology $q' \leq q$, if the firm requires ex ante registration and chooses a discount policy (d', δ') , the optimal price is the solution to

$$\max_p \delta' (1 - F(p - d')) (p - d') + (q - q'\delta') (1 - F(p)) p$$

since (i) a share δ' of consumers register with discount and may buy at an effective price $p - d'$ and (ii) a share $q - q'\delta'$ of consumers register without having a discount (all being low-cost types) and may buy at price p . (Since the share of low types with discount is $q'\delta'$, the share of low types without discount in the population must be $q - q'\delta'$.) Anticipating this optimal price, which we denote by $p'(q', \delta')$, the size of the discount will be such that a high-cost consumer is just willing to register, that is, for given (q', δ') , the optimal discount $d(q', \delta')$ fulfills

$$\int_{p' - d(q', \delta')}^{\infty} (\theta - (p' - d(q', \delta'))) dF(\theta) = k_{RH}.$$

Consider two possible targeting technologies q' and q'' with $q'' < q'$. For targeting technology q' , let δ' be part of the profit-maximizing discount policy. The total share of

consumers who registers is equal to $\delta' + q - q'\delta'$ (where $q - q'\delta'$ is the share of low-cost consumers without discount). For targeting technology q'' , suppose that the firm chooses $\delta'' = \delta' (1 - q') / (1 - q'')$.⁴⁷ The total share of consumers who register under q'' is equal to

$$\delta'' + q - q''\delta'' = \delta' (1 - q') + q$$

and is, hence, the same as under targeting q' . However, due to $1 - q'' > 1 - q'$, we get $\delta'' < \delta'$, that is, the share of consumers with discount is strictly lower under (q'', δ'') than under (q', δ') ; consequently, more consumers must register/buy without discount under q'' . This leads to a weaker price distortion under q'' than under q' ; that is, $p(q'', \delta'') < p(q', \delta')$. Thus, the discount necessary to make consumers with high registration costs willing to register is lower under q'' (with $\delta'' < \delta'$) than under q' (with δ'). These effects (weaker price distortion, lower discount, higher share of consumers who register without discount) cause the firm's profit to be strictly higher under q'' when choosing $\delta'' = \delta' (1 - q') / (1 - q'')$ than under q' (with the optimal δ'). If under technology q'' the optimal $\delta \neq \delta''$, profits must be even higher.

A.9 Proof of Proposition 7

First we derive the equilibrium prices and profits for given platform choices (r_1, \dots, r_N) . Using the same argument as in the proof of Proposition 1, firm i is strictly better off under $r_i = G$ than under $r_i = ExP$, independent of the other firms' platform choices.⁴⁸ Therefore, we can ignore the option $r = ExP$ in what follows.

Suppose first that all firms choose $r = ExA$. Then, given that a positive share of consumers register, it is optimal for each firm to choose a price $p(0)$. Anticipating the firms' pricing decisions, loyal consumers register if and only if $k_R \leq \bar{u}(0)$. Non-committed consumers are indifferent between registration at either firm and randomly select one of the firms. Thus, if $k_R \leq \bar{u}(0)$, firm i gets its loyal consumers and a share $1/N$ of the non-committed consumers and, hence, a profit of $(\beta + \beta_0/N) \pi(0) = \pi(0)/N$. If $k_R > \bar{u}(0)$, no consumer registers and the firms' profits are zero.

Now suppose that exactly one firm chooses $r = G$ and all other firms choose $r = ExA$. For firm i with $r_i = G$, it is optimal to set $p_i = p(k_G)$, which is strictly smaller than $p(0)$. Observing p_i and anticipating the prices at all other firms, all non-committed consumers

⁴⁷If, with targeting technology q' , δ' satisfies the feasibility requirement $(1 - q')\delta' \leq 1 - q$ then $(1 - q'')\delta'' = (1 - q'')\delta'(1 - q') / (1 - q'') \leq 1 - q$; thus δ'' fulfills the corresponding feasibility requirement with targeting technology q'' .

⁴⁸If p' denotes a price which is optimal under $r_i = ExP$ then the firm can set a higher price $p'' = p' + k_R - k_G > p'$ under $r_i = G$ and still sell to the same share of consumers. Note that this share is always strictly positive due to the loyal consumers.

consider only buying at firm i . Therefore, firm i has no incentive to deviate to another price ($p(k_G)$ is the optimal price even in the absence of competition) and gets a profit of $(\beta + \beta_0)\pi(k_G)$ from selling to its loyal consumers and to the non-committed consumers. All other firms (with $r = ExA$) may only sell to their loyal consumers; they realize a profit of $\beta\pi(0)$ if $k_R \leq \bar{u}(0)$ and a profit of zero otherwise.

Finally, suppose first that $m \geq 2$ firms choose $r = G$ and the remaining firms choose $r = ExA$. The resulting subgame equilibrium is summarized in the following lemma.⁴⁹

Lemma 2 *Let $2 \leq m \leq N$ and suppose that firms $1, \dots, m$ choose $r = G$ and the remaining firms choose $r = ExA$. In the symmetric equilibrium, firm $i \in \{1, \dots, m\}$ randomizes according to*

$$B(p_i) = \begin{cases} 0 & \text{if } p_i \leq \underline{p} \\ 1 - \left(1 - \frac{\beta + \beta_0}{\beta_0} + \frac{\beta\pi(k_G)}{\beta_0(1 - F(\underline{p} + k_G))p_i}\right)^{\frac{1}{m-1}} & \text{if } \underline{p} < p_i < p(k_G) \\ 1 & \text{if } p_i \geq p(k_G) \end{cases} \quad (25)$$

where \underline{p} is defined as the solution to

$$(1 - F(\underline{p} + k_G))\underline{p} = \frac{\beta}{\beta + \beta_0}\pi(k_G) \quad (26)$$

that fulfills $\underline{p} < p(k_G)$. Firm $j \in \{m + 1, \dots, N\}$ chooses $p_j = p(0)$. The expected equilibrium profit of firm $i \in \{1, \dots, m\}$ is equal to $\beta\pi(k_G)$. The expected equilibrium profit of firm $j \in \{m + 1, \dots, N\}$ is equal to $\beta\pi(0)$ if $k_R \leq \bar{u}(0)$ and equal to zero otherwise.

Proof. Consider first firms $j \in \{m + 1, \dots, N\}$ with $r_j = ExA$. For those firms, equilibrium prices and profits follow as in Proposition 1. If a positive mass of consumers register then j 's optimal price is $p(0)$. If $k_R \leq \bar{u}(0)$, all loyal consumers register at firm j , which yields a profit of $\beta\pi(0)$; otherwise, no consumer registers and j gets zero profit. Due to $p(0) > p(k_G) > p_i$ for $i \in \{1, \dots, m\}$, non-committed consumers never consider registering/buying at firms $j \in \{m + 1, \dots, N\}$.

Firms $i \in \{1, \dots, m\}$ randomize according to $B(p_i)$ on the support $[\underline{p}, p(k_G)]$. Using (26), it is straightforward to verify that $B(\underline{p}) = 0$; moreover, $B(p_i)$ is strictly increasing on $(\underline{p}, p(k_G))$ with $B(p(k_G)) = 1$. Due to the regularity assumptions on F , \underline{p} is uniquely defined by (26); it approaches zero for $\beta \rightarrow 0$ and approaches $p(k_G)$ for $\beta \rightarrow 1/N$.

⁴⁹Baye et al. (1992) show that the game of price competition with uninformed (loyal) and informed (non-committed) consumers has a unique symmetric equilibrium as well as a continuum of asymmetric equilibria in mixed strategies. Since the equilibria are payoff-equivalent, the following lemma focuses on the equilibrium in which the firms with $r = G$ use symmetric mixed strategies, without affecting the consequences for the equilibrium platform choices.

Consider firm $i \in \{1, \dots, m\}$ and suppose that all other firms $l \in \{1, \dots, m\}$, $l \neq i$ randomize according to $B(p)$ in (25). If i chooses a price $p_i \in [\underline{p}, p(k_G)]$, it sells to its loyal consumers at this price; in addition, it sells to all non-committed consumers if and only if p_i is lower than the prices of all other firms, that is, with probability $(1 - B(p_i))^{m-1}$. (Recall that firms $j \in \{m+1, \dots, N\}$ choose a price $p(0) > p(k_G) \geq p_i$ and will never sell to the non-committed consumers.) Thus, firm i 's expected profit when choosing $p_i \in [\underline{p}, p(k_G)]$ is equal to

$$\begin{aligned} & (\beta + (1 - B(p_i))^{m-1} \beta_0) (1 - F(p_i + k_G)) p_i \\ = & \left(\beta + \left(1 - \frac{\beta + \beta_0}{\beta_0} + \frac{\beta \pi(k_G)}{\beta_0 (1 - F(p_i + k_G)) p_i} \right) \beta_0 \right) (1 - F(p_i + k_G)) p_i \\ = & \beta \pi(k_G) \end{aligned}$$

and is, hence, independent of p_i . In particular, if $p_i = \underline{p}$, i sells to a share $\beta + \beta_0$ of the consumers; with (26) this yields a profit of $\beta \pi(k_G)$. If $p_i = p(k_G)$, i only sells to its loyal consumers which, again, yields a profit of $\beta \pi(k_G)$. Moreover, prices below \underline{p} and above $p(k_G)$ lead to a strictly lower profit. Since i is indifferent between all $p_i \in [\underline{p}, p(k_G)]$, randomization according to $B(p_i)$ is a best reply. ■

If two or more firms choose $r = G$, these firms' equilibrium prices cannot be in pure strategies. To see why, suppose that $m = 2$ and that $p_1 = \tilde{p} > 0$. Firm 2's best reply is $p_2 = p(k_G)$ if $\tilde{p} > p(k_G)$ and $p_2 = \tilde{p} - \varepsilon$ otherwise, $\varepsilon > 0$ infinitesimally small.⁵⁰ But then, firm 1 strictly prefers $p_1 = p_2 - \delta$, $\delta > 0$ infinitesimally small, over $p_1 = \tilde{p}$. Moreover, p_1 cannot be zero in a pure strategy equilibrium. If $p_1 = 0$, firm 1 has zero profits, but it can achieve at least $\beta \pi(k_G) > 0$ by setting $p_1 = p(k_G)$. Thus, the equilibrium must be in mixed strategies. In any equilibrium, firms will not choose prices higher than $p(k_G)$, which is the price a firm would choose in the absence of competition, or if the other firms' prices are higher. Using standard techniques in auction theory, it can be shown that in the unique symmetric equilibrium, the firms randomize continuously on an interval $[\underline{p}, p(k_G)]$ with $\underline{p} < p(k_G)$.⁵¹ Since $p(k_G) < p(0)$, the non-committed consumers never register at a firm j with $r_j = ExA$ since they correctly anticipate the higher price of this firm. The firms' expected profits depending on the number of firms with $r = G$ are summarized in Table 1.

We are now in a position to prove Proposition 7. Part (ii) (the case where $k_R > \bar{u}(0)$) is straightforward: the profit of any firm j choosing $r_j = ExA$ is zero, $r_j = G$ leads to a profit

⁵⁰To be precise, due to the continuous strategy space, we have to interpret the best reply as an ε -best reply.

⁵¹Technically, \underline{p} is obtained such that a firm's expected profit when choosing $p = \underline{p}$ is exactly equal to its expected profit when choosing $p = p(k_G)$ and selling only to its loyal buyers.

| | Number of firms with $r = G$ | | |
|---------------------------------|------------------------------|------------------------------|------------------|
| | 0 | 1 | ≥ 2 |
| Profit of a firm with $r = G$ | - | $(\beta + \beta_0) \pi(k_G)$ | $\beta \pi(k_G)$ |
| Profit of a firm with $r = ExA$ | $(\beta + \beta_0/N) \pi(0)$ | $\beta \pi(0)$ | $\beta \pi(0)$ |

Note: $\pi(k)$ is defined in equation (2). β is firm i 's share of loyal consumers, $\beta_0 = 1 - N\beta$ is the share of non-committed consumers.

Table 1: Summary of the firms' expected profits conditional on the stage 1 platform choices, for the case of $k_R \leq \bar{u}(0)$.

of at least $\beta \pi(k_G) > 0$, thus all firms offer the guest account.

It remains to prove part (i) (where $k_R \leq \bar{u}(0)$). Suppose that inequality (12) holds, and all firms $j \neq i$ choose $r_j = ExA$. Consider the choice of firm i . Under $r_i = ExA$, i gets an expected profit of $(\beta + \beta_0/N) \pi(0) = \pi(0)/N$. If i deviates to $r_i = G$, its expected profit is $(\beta + \beta_0) \pi(k_G) = (1 - (N - 1)\beta) \pi(k_G)$. Thus, i has no incentive to deviate if and only if

$$\pi(0)/N \geq (1 - (N - 1)\beta) \pi(k_G),$$

which is equivalent to (12). Since under (12), firm i has a dominant strategy to choose $r_i = ExA$ in stage 1, the equilibrium is unique.⁵²

Now suppose (13) holds, and suppose that firm 1 chooses $r = G$ and firms 2, ..., N choose $r = ExA$. As shown above, since (12) is violated, firm 1's profit is strictly higher under $r = G$ than when deviating to $r = ExA$. Moreover, firm $j \in \{2, \dots, N\}$ gets an expected profit of $\beta \pi(0)$ under $r_j = ExA$ but gets only $\beta \pi(k_G) < \beta \pi(0)$ when deviating to $r_j = G$ (the proof of the inequality uses the same argument as the proof of Proposition 1). Hence, exactly one firm chooses $r = G$ and all other firms choose $r = ExA$ in equilibrium.

Since a firm strictly prefers $r = ExA$ over $r = G$ (or $r = ExP$) as soon as the number of firms with $r = G$ is strictly greater than zero, there can be no further equilibria with platform choices in pure strategies. If inequality (13) holds, however, there are additional equilibria in which firms randomize their choice of registration requirement. In particular, there is a symmetric equilibrium in which firms choose $r = ExA$ with probability α and $r = G$ with probability $1 - \alpha$, where

$$\alpha = \left(\frac{\beta N (\pi(0) - \pi(k_G))}{(1 - \beta N) (N \pi(k_G) - \pi(0))} \right)^{\frac{1}{N-1}}.$$

⁵²If (12) holds with equality, all firms choose $r_i = ExA$ by our tie-breaking rule.

References

- [1] Acquisti, A., Brandimarte, L., and Loewenstein, G. (2015). Privacy and human behavior in the age of information. *Science*, 347(6221), 509-514.
- [2] Acquisti, A., Taylor, C., and Wagman, L. (forthcoming). The economics of privacy. *Journal of Economic Literature*, forthcoming.
- [3] Acquisti, A., and Varian, H. R. (2005). Conditioning prices on purchase history. *Marketing Science*, 24(3), 367-381.
- [4] Akçura, M. T., and Srinivasan, K. (2005). Research note: Customer intimacy and cross-selling strategy. *Management Science*, 51(6), 1007-1012.
- [5] Anderson, K. B., Durbin, E., and Salinger, M. A. (2008). Identity theft. *Journal of Economic Perspectives*, 22(2), 171-192.
- [6] Anderson, S. P. and Renault, R. (2006). Advertising content. *American Economic Review*, 96(1), 93-113.
- [7] Anderson, S. P., and Renault, R. (2009). Comparative advertising: disclosing horizontal match information. *RAND Journal of Economics*, 40(3), 558-581.
- [8] Anderson, S. P., and Renault, R. (2013). The advertising mix for a search good. *Management Science*, 59(1), 69-83.
- [9] Arbatskaya, M. (2007). Ordered search. *RAND Journal of Economics*, 38(1), 119–26.
- [10] Armstrong, M., Vickers, J. and Zhou, J. (2009). Prominence and consumer search. *RAND Journal of Economics*, 40(2), 209-233.
- [11] Armstrong, M., and Zhou, J. (2011). Paying for prominence. *The Economic Journal*, 121(556), F368-F395.
- [12] Bagwell, K. (2007). The economic analysis of advertising. *Handbook of Industrial Organization*, Volume 3, Chapter 28, 1701-1844.
- [13] Bakos, Y. (2001). The emerging landscape for retail e-commerce. *Journal of Economic Perspectives*, 15(1), 69-80.
- [14] Bar-Isaac, H., Caruana, G., and Cuñat, V. (2012). Search, design, and market structure. *American Economic Review*, 102(2), 1140-1160.

- [15] Baye, M. R., Kovenock, D., and de Vries, C. G. (1992). It takes two to tango: Equilibria in a model of sales. *Games and Economic Behavior*, 4(4), 493-510.
- [16] Baye, M. R. and Morgan, J. (2001). Information gatekeepers on the Internet and the competitiveness of homogeneous product markets. *American Economic Review*, 91(3), 454-474.
- [17] Baye, M. R. and Morgan, J. (2009). Brand and price advertising in online markets. *Management Science*, 55(7), 1139-1151.
- [18] Baye, M. R., Morgan, J., and Scholten, P. (2004). Price dispersion in the small and in the large: Evidence from an internet price comparison site. *Journal of Industrial Economics*, 52(4), 463-496.
- [19] Baye, M. R., Morgan, J., and Scholten, P. (2006). Information, search and price dispersion. In: T. Hendershott (ed.), *Handbook on Economics and Information Systems*, 323-376, Amsterdam: Elsevier Press.
- [20] Bergemann, D., and Bonatti, A. (2013). Selling cookies. Cowles Foundation Discussion Paper No. 1920.
- [21] Bolton, G., Greiner, B., and Ockenfels, A. (2013). Engineering trust: Reciprocity in the production of reputation information. *Management Science*, 59(2), 265-285.
- [22] Branco, F., Sun, M., and Villas-Boas, J. M. (2012). Optimal search for product information. *Management Science*, 58(11), 2037-2056.
- [23] Bulow, J. I., and Pfleiderer, P. (1983). A note on the effect of cost changes on prices. *The Journal of Political Economy*, 182-185.
- [24] Caillaud, B., and De Nijs, R. (2014). Strategic loyalty reward in dynamic price discrimination. *Marketing Science*, 33(5), 725-742.
- [25] Carlin, B. I. (2009). Strategic price complexity in retail financial markets. *Journal of Financial Economics*, 91(3), 278-287.
- [26] Casadesus-Masanell, R., and Hervas-Drane, A. (2015). Competing with privacy. *Management Science*, 61(1), 229-246.
- [27] Celik, L. (2014). Information unraveling revisited: Disclosure of horizontal attributes. *Journal of Industrial Economics*, 62(1), 113-136.

- [28] Chellappa, R. K., and Shivendu, S. (2010). Mechanism design for “free” but “no free disposal” services: The economics of personalization under privacy concerns. *Management Science*, 56(10), 1766-1780.
- [29] Chen, P.-Y., and Hitt, L. M. (2006). Information technology and switching costs. In: T. Hendershott (ed.), *Economics and Information Systems*, 437-470, Amsterdam: Elsevier Press.
- [30] Cho, C. H., Kang, J., and Cheon, H. J. (2006). Online shopping hesitation. *CyberPsychology & Behavior*, 9(3), 261-274.
- [31] De Cornière, A. (2013). Search advertising. Working paper, available at SSRN: <http://ssrn.com/abstract=1967102>.
- [32] Dellarocas, C. (2006). Reputation mechanisms. In: T. Hendershott (ed.), *Economics and Information Systems*, 629-660, Amsterdam: Elsevier Press.
- [33] Diamond, P. A. (1971). A model of price adjustment. *Journal of Economic Theory*, 3(2), 156-168.
- [34] Dinerstein, M., Einav, L., Levin, J., and Sundaresan, N. (2014). Consumer price search and platform design in internet commerce. Working Paper.
- [35] Eliaz, K., and Spiegler, R. (2011). A simple model of search engine pricing. *Economic Journal*, 121(556), F329-F339.
- [36] Ellison, G. and Ellison, S. F. (2005). Lessons about markets from the Internet. *Journal of Economic Perspectives*, 19(2), 139-158.
- [37] Ellison, G., and Ellison, S. F. (2009). Search, obfuscation and price elasticities on the Internet. *Econometrica*, 77(2), 427-452.
- [38] Ellison, G., and Wolitzky, A. (2012). A search cost model of obfuscation. *RAND Journal of Economics*, 43(3), 417-441.
- [39] Farrell, J., and Klemperer, P. (2007). Coordination and lock-in: Competition with switching costs and network effects. *Handbook of Industrial Organization*, Volume 3, Chapter 31, 1967-2072.
- [40] Fudenberg, D., and Tirole, J. (2000). Customer poaching and brand switching. *RAND Journal of Economics*, 31(4), 634-657.

- [41] Fudenberg, D., and Villas-Boas, J. M. (2006). Behavior-based price discrimination and customer recognition. In: T. Hendershott (ed.), *Economics and Information Systems*, 377-436, Amsterdam: Elsevier Press.
- [42] Fudenberg, D., and Villas-Boas, J. M. (2012). Price discrimination in the digital economy. In: M. Peitz and J. Waldfogel (eds.), *The Oxford Handbook of the Digital Economy*, 254-272.
- [43] Fullerton, D., and Metcalf, G. E. (2002). Tax incidence. *Handbook of Public Economics*, Volume 4, Chapter 26, 1787-1872.
- [44] Goldfarb, A., and Tucker, C. E. (2011). Privacy regulation and online advertising. *Management Science*, 57(1), 57-71.
- [45] Goldfarb, A., and Tucker, C. (2012). Shifts in privacy concerns. *American Economic Review*, 102(3), 349-353.
- [46] Hagiu, A., and Jullien, B. (2011). Why do intermediaries divert search?. *RAND Journal of Economics*, 42(2), 337-362.
- [47] Hart, O. D., and Tirole, J. (1988). Contract renegotiation and Coasian dynamics. *The Review of Economic Studies*, 55(4), 509-540.
- [48] Kahn, C. M., McAndrews, J., and Roberds, W. (2005). Money is privacy. *International Economic Review*, 46(2), 377-399.
- [49] Klemperer, P. (1995). Competition when consumers have switching costs: An overview with applications to industrial organization, macroeconomics, and international trade. *Review of Economic Studies*, 62(4), 515-539.
- [50] Koessler, F., and Renault, R. (2012). When does a firm disclose product information?. *RAND Journal of Economics*, 43(4), 630-649.
- [51] Lambrecht, A., Goldfarb, A., Bonatti, A., Ghose, A., Goldstein, D. G., Lewis, R., Rao, A., Sahni, N, and Yao, S. (2014). How do firms make money selling digital goods online?. *Marketing Letters*, 25(3), 331-341.
- [52] Levin, J. (2013). The economics of internet markets. In: D. Acemoglu, M. Arellano, E. Dekel (eds.), *Advances in Economics and Econometrics*, Tenth World Congress, Volume 1, Economic Theory.

- [53] Lu, Jingfeng, and Lixin Ye (2014). Optimal two-stage auctions with costly information acquisition. Ohio State University Discussion paper. 2014.
- [54] McAfee, R. P., and McMillan, J. (1987). Auctions with entry. *Economics Letters*, 23(4), 343-347.
- [55] Milne, G. R., Rohm, A. J., and Bahl, S. (2004). Consumers' protection of online privacy and identity. *Journal of Consumer Affairs*, 38(2), 217-232.
- [56] Miyazaki, A. D., and Fernandez, A. (2001). Consumer perceptions of privacy and security risks for online shopping. *Journal of Consumer Affairs*, 35(1), 27-44.
- [57] Narasimhan, C. (1988). Competitive promotional strategies. *Journal of Business*, 61(4), 427-449.
- [58] Nelson, Phillip (1974). Advertising as information. *The Journal of Political Economy*, Vol. 82, No. 4, 729-754.
- [59] Norberg, P. A., Horne, D. R., and Horne, D. A. (2007). The privacy paradox: Personal information disclosure intentions versus behaviors. *Journal of Consumer Affairs*, 41(1), 100-126.
- [60] Office of Fair Trading (2010). Online targeting of advertising and prices: A market study. Report, Office of Fair Trading, London.
- [61] Pew Research Center (2013). Anonymity, privacy, and security online. Available at: <http://www.pewinternet.org/2013/09/05/anonymity-privacy-and-security-online>.
- [62] Pew Research Center (2014). Public perceptions of privacy and security in the post-Snowden era. Available at: <http://www.pewinternet.org/2014/11/12/public-privacy-perceptions>.
- [63] Reichheld, F. F., and Schefter, P. (2000). E-loyalty. *Harvard Business Review*, 78(4), 105-113.
- [64] Renault, R. (2015). Advertising in markets. Forthcoming in: S. P. Anderson, J. Waldfoegel, D. Stromberg (eds.), *Handbook of Media Economics*, Elsevier: North Holland.
- [65] Rosenthal, R. W. (1980). A model in which an increase in the number of sellers leads to a higher price. *Econometrica*, 48(6), 1575-1579.
- [66] Shaffer, G., and Zhang, Z. J. (2002). Competitive one-to-one promotions. *Management Science*, 48(9), 1143-1160.

- [67] Shapiro, C., and Varian, H. R. (1999). Information rules: A strategic guide to the network economy. Boston, Mass.: Harvard Business School Press.
- [68] Shy, O., and Stenbacka, R. (forthcoming). Customer privacy and competition. *Journal of Economics & Management Strategy*, forthcoming.
- [69] Smith, M. D., and Brynjolfsson, E. (2001). Consumer decision-making at an Internet shopbot: Brand still matters. *Journal of Industrial Economics*, 49(4), 541-558.
- [70] Stiglitz, J. E. (1989). Imperfect information in the product market. *Handbook of Industrial Organization*, Volume 1, Chapter 13, 769-847.
- [71] Stole, L. A. (2007). Price discrimination and competition. *Handbook of Industrial Organization*, Volume 3, Chapter 34, 2221-2299.
- [72] Sun, M. (2011). Disclosing multiple product attributes. *Journal of Economics & Management Strategy*, 20(1), 195-224.
- [73] Taylor, C. R. (2004). Consumer privacy and the market for customer information. *RAND Journal of Economics*, 35(4), 631-650.
- [74] Toufaily, E., Ricard, L., and Perrien, J. (2013). Customer loyalty to a commercial website: Descriptive meta-analysis of the empirical literature and proposal of an integrative model. *Journal of Business Research*, 66(9), 1436-1447.
- [75] U.S. Department of Justice (2013). Victims of identity theft, 2012. Bureau of Justice Statistics, December 2013, available at: <http://www.bjs.gov/content/pub/pdf/vit12.pdf>.
- [76] Varian, H. R. (1980). A model of sales. *American Economic Review*, 70(4), 651-659.
- [77] Villas-Boas, J. M. (1999). Dynamic competition with customer recognition. *The Rand Journal of Economics*, 30(4), 604-631.
- [78] Villas-Boas, J. M. (2004). Price cycles in markets with customer recognition. *RAND Journal of Economics*, 35(3), 486-501.
- [79] Weyl, E. G., and Fabinger, M. (2013). Pass-through as an economic tool: Principles of incidence under imperfect competition. *Journal of Political Economy*, 121(3), 528-583.
- [80] White, A. (2013). Search engines: Left side quality versus right side profits. *International Journal of Industrial Organization*, 31(6), 690-701.

- [81] Wilson, C. M. (2010). Ordered search and equilibrium obfuscation. *International Journal of Industrial Organization*, 28(5), 496-506.
- [82] Zhou, L., Dai, L., and Zhang, D. (2007). Online shopping acceptance model: A critical survey of consumer factors in online shopping. *Journal of Electronic Commerce Research*, 8(1), 41-62.